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C O N T E N T

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AN ANALYSIS OF ACCESS TO CREDIT AND FACTORS INFLUENCING CREDIT UTILIZATION AMONG CASSAVA FARMERS IN SOUTHWEST, NIGERIA

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Abstract

This study analyses access to credit and factors influencing credit utilization among cassava farmers in Southwest, Nigeria. Multi-stage sampling procedure was used to select 210 small holder cassava farmers for the study. A structured questionnaire was used to collect data on respondents' access to credit, sources and volume of credit granted, and factors influencing amount of credit utilized by cassava farmers. Results show that 49.5% of the cassava farmers had access to credit, 23.3% obtained credit from cooperatives, 33.3% requested for less than ₦100,000.00 credit while the mean amount of credit requested and granted were ₦125,923.08 and ₦105,346.15 respectively. Ordinary least squares regression results show that farm experience (α = 2.8609, p<0.05), educational level (α = 4.7334, p<0.01), farm size (α = 9.6706, p<0.05) and membership of cooperative society (α = 47.9905, p<0.05) significantly influenced the amount of credit utilized by the smallholders cassava farmers. The study determined that the credit use of cassava farmers in southwest Nigeria is influenced by several characteristics, including their level of farm experience, educational attainment, farm size, and participation in a cooperative organization. Therefore, it is imperative for farmers to actively seek out opportunities to get further expertise, expand their land holdings, pursue adult education, and establish cooperative societies. These actions will enable them to secure financial support from stakeholders and enhance their ability to obtain and effectively utilize loans in the study area.

Key words: *credit, credit utilization, cassava, smallholder farmers, Ogun State, Nigeria*

INTRODUCTION

Nigeria, located in Africa, has the highest population among all countries, estimated at 170 million. It is followed by Ethiopia and Egypt. This indicates that Nigeria possesses a significant quantity of human resources [30]. Based on the reference [30], the agricultural sector accounted for 37% of the Gross Domestic Product (GDP) from 1960 to 2008. It then increased to 40.87% in 2010, highlighting the significant importance of agriculture in the Nigerian economy.

Cassava is a highly significant food crop in Tropical Africa due to its efficient production of food energy and compatibility with current farming and food systems in Africa [24]. As stated in reference [10], cassava is a prominent provider of sustenance and financial resources in the damp forest regions of West and Central Africa. Nigeria was identified as the world's leading producer of cassava in 2000, with an output of 32,010,000 metric tonnes, as demonstrated by [11].

The production of metric tonnes increased from 32,068,000 in 2001 to 34,120,000 in 2002. It further increased to 36,304,000 in 2003 and 38,845,000 in 2004. In 2005, there was a further increase to 41,565,000. The production continued to rise to 45,721,000 in 2006, but declined to 43,410,000 in 2007. There was a significant increase of 44,582,000 in 2008, followed by a decline to 36,822,250 in 2009. However, it increased again to 42,533,180 in 2010 and further to 46,190,250 in 2011. The production continued to rise to 50,950,291 in 2012 and reached 53,000,000 in 2013 [11].

By year 2017, Nigeria production was 59,000,000 metric tonnes [10] (Figure 1).

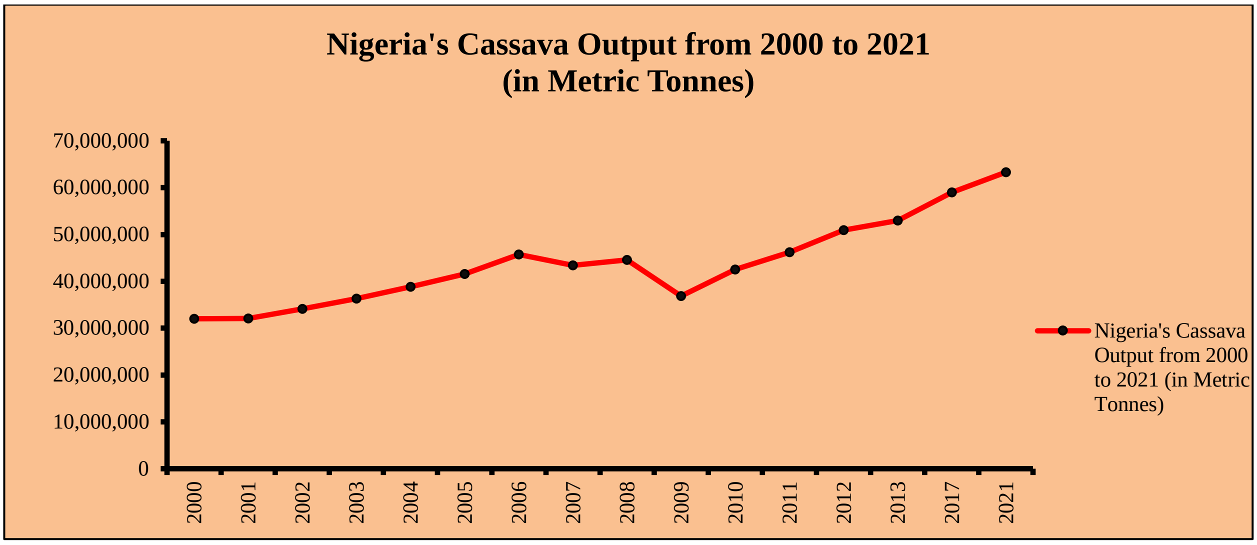


Fig. 1. Line Chart showing Nigeria's cassava output from 2000 to2021
Source: FAO, 2023 [10].

In year 2021, Nigeria production had increased to 63,300,000 metric tonnes, leading the world [31]. Within the last 3 years (2021-2023), Nigeria have averagely produced approximately 61 million metric tonnes of cassava making it to still be recognized has the highest producer of cassava in the world [10][31].

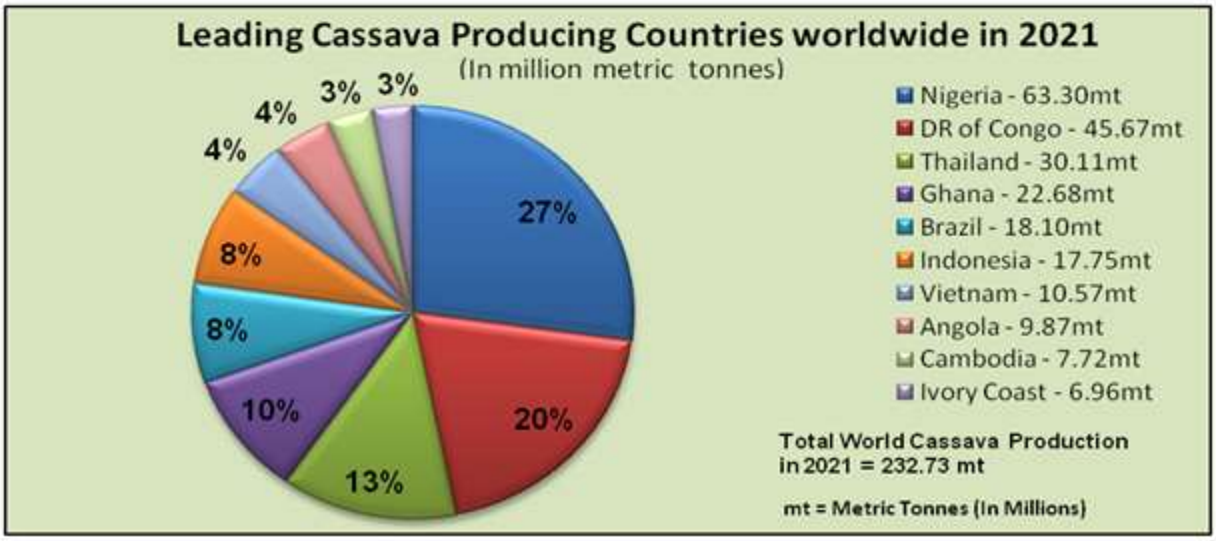


Fig. 2. Pie Chart showing leading cassava producing countries in 2021
Source: Statista 2024 [31].

Figure 2 illustrates Nigeria's position among the primary cassava producing nations.
Cassava is crucial for ensuring food security in rural economies because to its ability to produce crops in poor soil conditions and its resilience to drought, as shown by [18]. It is commonly acknowledged that this crop is the most extensively planted in Nigeria, primarily by smallholder farmers. According to a study conducted by [20], cassava possesses specific natural qualities that make it particularly appealing to small-scale farmers in Nigeria.
[27] stated that the primary factors influencing the productivity of cassava farmers are farming experience, farm size, farmer's age, availability to loans, and growing method.
Based on [28], there was a widespread agreement that agricultural credit was crucial for the development of the agricultural sector. However, the lack of resources among most farmers, caused by a cycle of low income, low

savings, inadequate infrastructure, insufficient collateral security, and limited access to sufficient credit, has impeded productivity. This is despite the significant potential of farmers in the country. [16] observed that the majority of smallholder farmers, particularly those cultivating cassava, are consistently excluded from financial participation in agricultural output.

[2] confirmed that approximately 86% of farmers utilize their own capital, whereas only 14% of farmers rely on credit from diverse sources due to limited credit accessibility, exorbitant interest rates, and the division of farm holdings.

The study conducted by [23] identified several key factors that influence farmers' demand for and participation in the loan market. These factors include age, gender, family size, level of training, and membership in a cooperative.

Despite the government's initiatives to raise awareness among farmers about engaging in small-scale cassava growing through various cassava multiplication programs, it seems that Nigeria's current agricultural sector is unable to fulfill the anticipated demand for cassava. Several interventions appear to be inadequate and are negatively impacting cassava agricultural production [16]. Prior research has demonstrated that the production cost of one metric ton of cassava in Nigeria was higher in comparison to costs in other nations [7].

The study by [26] found that the high cost of cassava production can be attributed to the lack of essential inputs such as investment capital and loans for acquiring current technologies for increased production. It is crucial for cassava farmers in Nigeria to secure investment capital that is adequate to address the issues they face by utilizing agricultural loans. [9] observed that credit functions as a catalyst that stimulates production. This highlights the importance of small-scale farmers' access to finance and their use of credit in relation to their farming activities. [9] believed that financing is necessary for the functioning of small-scale farmers, regardless of the practicality and necessity of land reform. A farmer who is highly driven but lacks financing cannot acquire essential resources such as high-quality seeds, fertilizers, animal feeds, and pesticides. Therefore, small-scale farmers typically allocate less than 20 percent of the necessary funds towards these things due to their lack of access to credit and credit facilities [9].

According to [25], the current supply of agricultural loans from institutions is insufficient, which hinders the transfer of technology and investment into agriculture. [9] argued that if production financing is not made accessible under favorable conditions, the bulk of small farmers will face significant obstacles in adopting contemporary and lucrative technologies. [4] observed that the availability of financing hinders agricultural production and agricultural progress. Only a small minority of farmers have access to financing, while the majority are consistently impeded [4]. According to [8], a mere 47% of adults in Nigeria have access to credit, leaving the majority without this privilege. [4] contended that the absence of a solution will persistently exert a significant impact on agricultural production and development. This demonstrates the significance of finance access and its substantial impact on agricultural production, particularly for staple food crops such as cassava.

Studies by [3], [16], and [29] have identified multiple instances of inadequate credit availability among smallholder farmers in Nigeria. Additionally, research conducted in [12] and [32] has highlighted various limitations and challenges associated with accessing credit, which subsequently have negative impacts on farm production, profitability, and overall benefits, particularly in Nigeria.

Therefore, the aim of this study was to address the following research inquiries:

(i) What is the credit access rate among cassava farmers in the research area?

(ii) What were the credit sources accessible to cassava farmers in the study area?

(iii) What is the magnitude of the credit granted to the cassava farmers in the study region?

(iv) What were the determinants impacting the amount of credit utilized by cassava farmers in the study area?

In Nigeria, smallholder farmers predominantly oversee cassava production, but they face a shortage of essential resources needed to upgrade their farms and increase their productivity [17]. Cassava, as a lucrative crop, has consistently been a priority in government initiatives aimed at enhancing production due to its economic worth and significant importance [30]. Nevertheless, in order to enhance its production, it is crucial for farmers to obtain loans and the necessary input in a timely manner. While credit may not be often recognized as an input, it is essential because of its impact on increasing the output of cassava farmers [9].

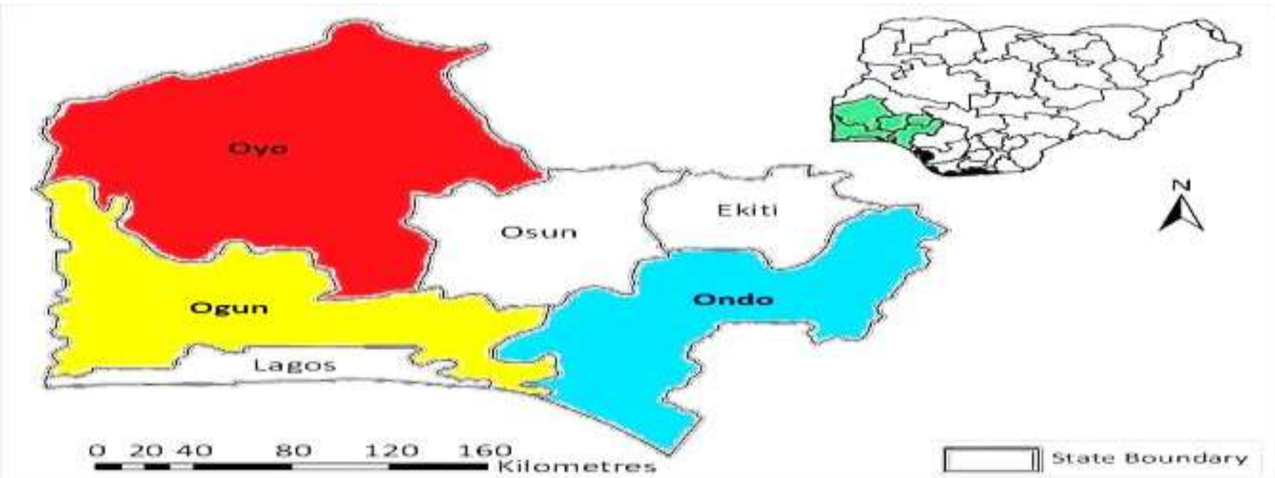
Moreover, this study aims to thoroughly investigate the credit utilization of cassava farming and determine whether farmers who have access to credit are able to effectively combine their resources to achieve optimal output. Previous research has shown that an increase in output is directly linked to improving farmers' income and earning potential from their production [5]. The aim of this study was to investigate: (i) the rate at which cassava farmers in the study area can obtain credit; (ii) the sources of credit that are available to cassava farmers in the study area; (iii) the amount of credit that is given to cassava farmers in the study area; and (iv) the factors that affect the amount of credit utilized by cassava farmers in the study area.

The findings of this study will greatly benefit farmers and other stakeholders in the agricultural industry. It will enhance our understanding of how credit contributes to ensuring that farmers have access to sufficient resources, including credit. Additionally, it will identify specific variables that can be effectively managed to improve the utilization of credit among cassava farmers in the study area.

MATERIALS AND METHODS

The study area

The research was carried out in the southwestern region of Nigeria. Primarily, the area is predominantly inhabited by Yoruba speakers, however there are other dialects present, even within the same state. The selection of this area for the study was based on the significant concentration of cassava farmers in the region [22]. The regions are situated within the latitudes of 60 and 80 degrees North and the longitudes of 20 and 60 degrees East of the Greenwich meridian. The region is delimited by the Atlantic Ocean to the south, Kwara and Kogi States to the north, Edo State to the south, and the Republic of Benin to the west. The land area measures around 77,818 square kilometers [33] (Map 1).



Map 1. MAP of the Study Area
Source: Ogunleke and Baiyegunhi, 2019 [21].

Data collection and sampling technique

This study utilized primary data. The questionnaire provided to the cassava farmers in the research areas collected data on the rate of access, source of credit, volume of credit requested and amount granted, as well as the factors that influenced credit utilization. This study employed a multi-stage sampling technique. In the first stage, three states in the southwest region were purposefully selected based on their involvement in cassava production, processing, and marketing activities [13].

In the second stage, a purposive selection was made of a significant zone known for its cassava production in each state. In the third stage, the highest cassava producing block was purposefully selected from each of the chosen zones. During the fourth step, the cell that produced the highest amount of cassava was intentionally chosen among the selected blocks. In the fifth stage, a total of 96 farmers were picked at random from each of the chosen cells using the sample selection formulas described in reference [14].

$$n_o = \frac{Z^2pq}{e^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

where:

n_o = sample size,

Z^2 = abscissa of the normal curve,

e = precision level,

p = estimated proportion of character present in the population (i.e. smallholder cassava farming),

q = 1 – p.

$$\therefore n_o = \frac{(1.96)^2(0.5)(0.5)}{(0.1)^2}$$

$$\Rightarrow n_o = 96.04 \approx 96$$

Table 1. Sampling procedure

Stages	Selection	Procedure	Size	Selection Method	Criteria
1	Southwest State	Ondo, Ogun and Oyo	3 states	Purposive Sampling	Highest producer
2	ADP Zone	1 zone × selected state	3 zones	Purposive Sampling	Highest producer
3	ADP blocks	1 block × selected zone	3 blocks	Purposive Sampling	Highest producer
4	ADP cells	1 cell × selected block	3 cells	Purposive Sampling	Highest producer
5	96 farmers	96 farmers × selected cell	288 farmers	Random Sampling (without replacement)	Small holders
TOTAL				288 farmers	

Source: Field Survey, 2019.

However, 59 farmers turn down their participation while the remaining 229 consented. Although, 210 out of 229 responses were acceptably useful for data analysis given a response rate of 91.7%.

Analytical techniques

The tools of analysis used to achieve the objectives of this study were descriptive statistics and ordinary least squares (OLS).

Descriptive Statistics

Descriptive statistics was used to describe the rate of access, source of credit, volume of credit requested and amount granted to cassava farmers.

Ordinary Least Squares (OLS)

Following [12], [19] and [1] Ordinary Least Squares (OLS) method of analysis was used to analyze objective iv, which is to determine the factors influencing amount of credit utilized by cassava farmers in the study area.

The regression model is specified as follows:

Implicit form:

$$Y_i = f(\alpha_i\, x_i\, e_i\,) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Explicit form:

$$Y = \alpha_o + \alpha_1x_1 + \alpha_2x_2 + \alpha_3x_3 + \alpha_4x_4 + \alpha_5x_5 + \ldots + \alpha_9x_9 + e \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (6)$$

where:

Y = amount of credit utilized (₦)

X_1 = Age (years)

X_2 = Sex (1 if male, 0 otherwise)

X_3 = Marital Status (1 if married, 0 otherwise)

X_4 = Farming Experience (years)

X_5 = Education Level (years of formal schooling)

X_6 = Farm size (hectares)

X_7 = Cooperatives society (Yes = 1, No = 0)

X_8 = Had saving (Yes = 1, No = 0)

X_9 = Extension contact (number of extension visit)

e = Stochastic error term

$\alpha_0, \alpha_i, \ldots\ldots\ldots, \alpha_9$ = Parameter estimates

Table 2. The a priori expectation of parameter estimates of the variables

Variable	Expected Sign	Literature
Volume of credit granted (₦)		
Age	-	Shadrack, 2017.
Sex	+	Awotide *et al.*, 2015.
Marital Status	-	Shadrack, 2017.
Farming Experience	-	Samson and Obademi, 2018.
Education Level	+	Samson and Obademi, 2018.
Farm Size	+	Shadrack, 2017.
Cooperatives Society	-	Samson and Obademi, 2018.
Saving	+	Samson and Obademi, 2018.
Extension Contact	+	Shadrack, 2017.

Source: Made by authors based on [29, 6, 28].

RESULTS AND DISCUSSIONS

Access to credit and sources of credit

The findings indicated that 49.5% of the cassava farmers had access to financing, but the remaining 50.5% did not. The implication of this result is that certain farmers may have higher productivity compared to others due to their access to finance facilities, which might potentially raise their scale of output [15]; [6]; [29]. The findings revealed that 50.5% of the cassava farmers did not utilize credit, while 0.5% obtained credit from commercial banks. Additionally, 6.7% and 23.3% of the cassava farmers obtained credit from microfinance banks and cooperatives, respectively. Furthermore, 16.2%, 1.4%, and 1.4% of the cassava farmers obtained credit from money lenders, family/relatives, and friends, respectively. The findings closely align with those reported in [15], which indicated that 13.3% of the result came from cooperative societies, 3.3% from money lenders, 2.5% from commercial banks, and 1.7% from friends and relatives. Moreover, the findings indicated that cooperative groups provide a greater amount of credit compared to financial institutions [24].

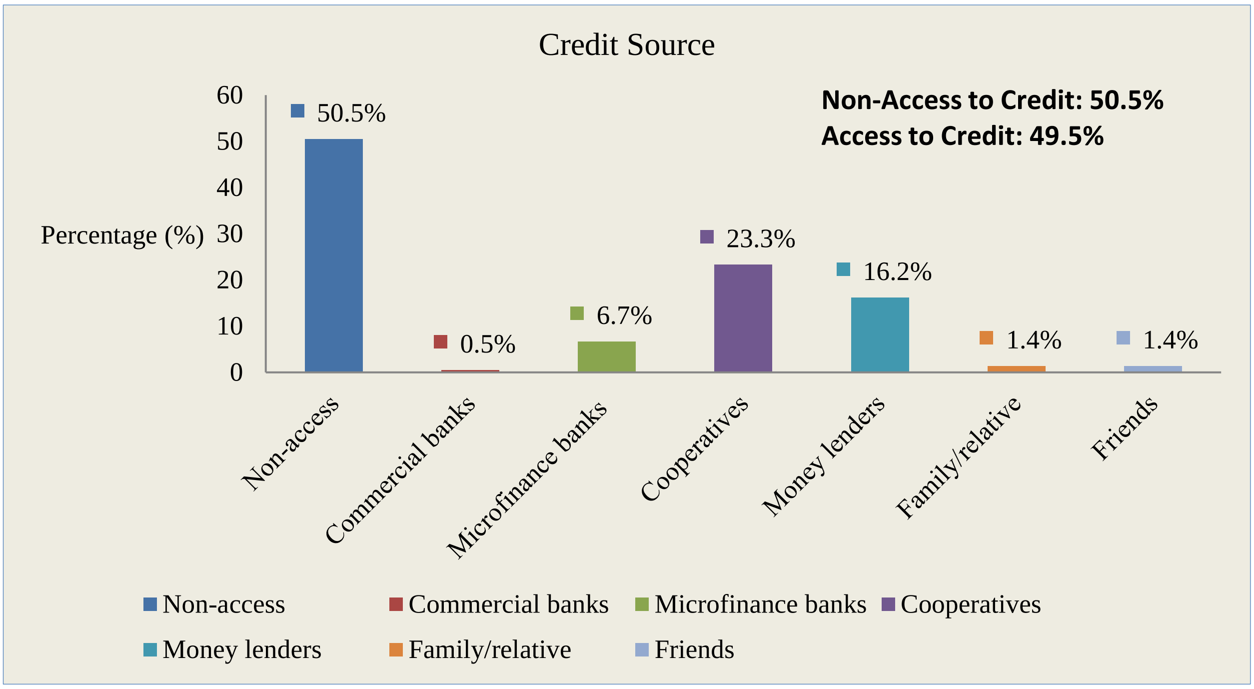


Fig. 3. A Column showing the Percentage of those that have access to credit with their Credit source.
Source: Field Survey Data Analysis, 2019.

Volume of credit granted to cassava farmers

The findings showed that most (33.3%) of cassava farmers who had access to credit sought amounts below ₦100,000. Additionally, 10%, 2.4%, 1%, and 2.9% of farmers requested credit within the ranges of ₦100,001 to ₦200,000, ₦200,001 to

₦300,000, ₦300,001 to ₦400,000, and above ₦400,000, respectively. The average amount of credit requested was ₦125,923.08 [6]. The findings indicated that the largest proportion (37.6%) of cassava farmers who had the opportunity to obtain credit were given amounts less than ₦100,000. Additionally, smaller percentages (6.2%, 2.4%, 2.4%, 1%) were granted credit within the ranges of ₦100,001 to ₦200,000, ₦200,001 to ₦300,000, ₦300,001 to ₦400,000, and above ₦400,000, respectively. The average credit provided had a volume of ₦105,346.15 [6].

Table 3. Volume of credit requested and amount granted to cassava farmers

Variable	Frequency	Percentage
Amount requested		
Non-access	106	50.5
≤₦100,000	70	33.3
₦100,001- ₦200,000	21	10.0
₦200,001- ₦300,000	5	2.4
₦300,001- ₦400,000	2	1.0
>₦400,000	6	2.9
Total	**210**	**100.0**
Mean	**125,923.08**	
Amount granted		
Non-access	106	50.5
≤₦100,000	79	37.6
₦100,001- ₦200,000	13	6.2
₦200,001- ₦300,000	5	2.4
₦300,001- ₦400,000	5	2.4
>₦400,000	2	1.0
Total	**210**	**100.0**
Mean	**105,346.15**	

Source: Field Survey Data Analysis, 2019.

Factors influencing amount of credit utilized by the cassava farmers

Multiple regression analysis was used to determine factors influencing the amount of credit utilized by the cassava farmers, the diagnostic statistics revealed that the model is fit, the R squared revealed that 29.8% variation in amount of credit utilized by the cassava farmers was jointly explained by the explanatory variables, the F-statistics showed that the model is fit at 1% ($p<0.01$). The result revealed that farm experience ($\alpha = 2.8609$, $p<0.015$), educational level ($\alpha = 4.7334$, $p<0.01$), farm size ($\alpha = 9.6706$, $p<0.05$) and membership of cooperative society ($\alpha = 47.9905$, $p<0.05$) significantly influence the amount of credit utilized by cassava farmers. The coefficient of farm experience revealed that if the experience of the farmer increases by 1 year, the amount of credit utilized by the farmer will increase by ₦2.86k as shown in Table 4.

This implies that the more the years of experience, the higher the amount of credit utilized. The coefficient of educational level revealed that the amount of credit utilized by cassava farmers that are more educated increase by ₦4.73k compared to their counterparts that are not educated, this implies that education exposes the farmers to new innovative practices in cassava production [20].

Table 4. Multiple regression estimates of factors influencing amount of credit utilized by cassava farmers

Variable	Coefficient	Standard Error	P-value
Constant	-26.97654	32.86583	0.414
Age	-0.6518532	0.5348642	0.226
Sex	-13.60089	19.74646	0.493
Marital status	-10.34743	10.54892	0.329
Farming experience	2.860995**	1.153413	0.015
Educational level	4.733351*	1.633767	0.005
Farm size	9.670624**	4.525927	0.035
Cooperative society	47.99045**	20.13068	0.019
Savings	36.30968	23.04969	0.119
Extension contact	-16.74176	19.44659	0.391
Diagnostic Statistics			
R squared	0.2981		
F (9, 94)	3.15		
Prob of F	0.0023		

*Source: Field Survey Data Analysis, 2019..
*** Significant at 1%   ** Significant at 5%   *Significant at 10%

The coefficient of farm size revealed that if the size of the farm increases by 1 hectare, the amount of credit utilized by the farmer will increase by ₦9.67k as shown in Table 4.

This implies that the larger the size of farmland, the higher the amount of credit utilized, this is so because the larger the size of the farm the more the area of farmland cultivated thereby prompting the use of credit. This is found to be the same with the result of [26].

The coefficient of cooperative society revealed that the amount of credit utilized by the cassava farmers that are members of cooperative society increases by ₦47.99k compared to their counterparts that did not belong to cooperative society, this implies that cassava farmers that belong to cooperative society utilized more credit than their counterparts that did not belong to cooperative society, this is so because cooperative society hold the potential to improve access to production resource such as credit [15].

CONCLUSIONS

The study aimed to evaluate the determinants of credit utilization among cassava farmers in Southwest, Nigeria. The study determined that the credit use of cassava farmers in southwest Nigeria is influenced by several characteristics, including their level of farm experience, educational attainment, farm size, and membership in a cooperative group. The study's findings led to the following recommendations for enhancing the credit use of cassava farmers in the study area:

(a) Cassava farmers should establish a cooperative society in order to facilitate the mobilization of funds from stakeholders and enhance their access to credit and efficient utilization of credit.

(b) Increasing the availability of land for cassava producers will enhance their credit accessibility.

(c) Cassava farmers should prioritize gaining further expertise and explicitly communicate their knowledge when seeking finance, as this will enhance their chances of obtaining credit.

(d) Encouraging cassava farmers to pursue adult education can enhance their credit use by increasing their level of education.

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FACTORS ASSOCIATED WITH ADOPTION OF SUSTAINABLE CASSAVA WEED MANAGEMENT TECHNOLOGY FOR CASSAVA SYSTEMS IN NIGERIA

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Abstract

The study was conducted to investigate the factors associated with adoption of sustainable cassava weeds management technology for cassava systems (SCWMTCS) in Nigeria. A total of 384 respondents were selected through a multi-stage sampling procedure for the study using a well-structured interview schedule. Data were analysed with the use of descriptive and inferential statistical tools such as means percentages, and regression analysis. Results revealed that the mean age of respondents was 44.55 ± 10.79. the means of household size, years of formal schooling, years of farming experience, farm size and annual income were 7.3±4.69, 9.74 ± 7.30, 17.71 ± 10.33, 1.89 ± 1.99, N356,013.02 ± N1,099,998.61 respectively. Majority (65.88%) were male and the respondents were of high orientation. Among the factors that contributed to adoption of SCWMTCS included household size (β =2.05, Oyo State; β = 2.51, Abia State), income (β = 3.25, Oyo State;β = 4.14, Abia State), farm size (β = 3.98, Oyo State, β = 4.62, Abia State), frequency of farm visits (β =2.88, Benue State), external orientation (β =2.93, Oyo State, β = 1.70, Abia State) social- cultural related factors (β = 3.30, Benue State) institutional related factors (β = 3.28. Abia State, β = 5.70, Benue State). Overall regression model summary shows that R2 value of (0.276 Oyo State, 0.382 Abia State and 0.512 Benue State) was obtained in the analysis. Also, F value of (3.084 in Oyo State, 5.166 in Abia State and 7.277 in Benue State) obtained was significant at $P \leq 0.01$. Thus, R^2 value of (0.276 Oyo State) indicates that significant variables among the selected variables could only explain (27.6 percent Oyo State, 38.2 percent Abia State and 51.2 percent Benue State) of the variation in the level of adoption of SCWMTCS.

Key words: *adoption, weed management, cassava systems, sustainability, factors, technology*

INTRODUCTION

For Nigeria to be self-sufficient and food secured, genuine efforts must be made by institutions responsible for the promotion of agricultural innovation and modern technology to encourage and sustain the adoption of appropriate technologies [10]. This is because modern technology in agriculture is a key factor in enhancing productivity, promoting sustainable rural development, and stimulating economic growth, making it a vital component of a thriving agricultural sector. Various technologies have been employed in the agricultural sectors in the past to accelerate economic growth and reduce drudgery associated with farming. These were often designed to solve the prevailing problems of farmers within certain agro-ecosystems and farming systems.

Cassava holds significant value, not only as a staple food source but also as a vital income-generating crop for rural communities. With an impressive annual production of over 34 million tonnes of tubers, Nigeria stands out as the world's leading producer of cassava, underscoring its critical role in the country's agricultural sector.

The determinant items influencing cassava production and farmers' income have been studied by [2, 3, 12] who pointed out that technologies applied, farm size, education level, the behaviour versus the adoption of new modern technologies are among the main constraining factors.

One of such technologies is the Sustainable Cassava weed Management Technology for Cassava Systems (SCWMTCS) [8]. This technology offers a comprehensive approach to managing weeds in cassava farms, incorporating a range of techniques and good agricultural practices, including the judicious use of agro-chemicals, to minimize the harmful impact of weeds and reduce the laborious task of manual weeding. The development of this technology was a collaborative effort between scientists from the International Institute of Tropical Agriculture (IITA) in Ibadan and partner institutions, including the University of Agriculture in Makurdi, National Root Crops Research Institute (NRCRI) in Umudike, and Federal University of Agriculture in Abeokuta (FUNAAB), as well as regulatory bodies such as NAFDAC, SON, and NESREA, and extension service providers. The project was made possible through funding from the Bill and Melinda Gates Foundation. In the dissemination of the innovation, Participatory Research and Extension (PRE) was employed and this was accomplished by grouping farmers into Farmers Field Schools under the supervision of researchers and extension agents in different communities, local government areas and states to participate fully in evaluating and selecting the best set of weed control strategy in their farming school. The best set of practices selected was packaged into the one technology and named Sustainable Cassava Weed Management Technology for Cassava System (SCWMTCS).

Concerted efforts were made by NGO and government institutions to transfer modern agricultural technologies to farmers over the years but the rate and intensity of adoption has not been very remarkable. To accelerate agricultural development, it is essential to identify and comprehend the key factors influencing the swift adoption of technologies. This research seeks to explore and elucidate these factors, providing valuable insights for future development.

The main objective of the study was to assess the factors associated with adoption of Sustainable Cassava Weed Management technology for Cassava systems (SCWMTCS) in Nigeria. The study intends to investigate the following specific objectives:

(i)described selected personal and social-economic characteristics of the respondents

(ii)examine the factors influencing the adoption of SCWMTCS.

MATERIALS AND METHODS

Study area

The study area was the three main cassava agro-ecosystems in Nigeria. One state was selected in each agro-ecosystem as follows; Abia state located in the forest zone, Benue state located in the Southern guinea savannah and Oyo State located in the forest-savannah transition zone of the country.

Sampling Technique

In choosing respondents, a multistage sampling technique was employed. The initial stage involved purposive selection of three states with each located in the three cassava agro-ecological zones of Nigeria. This was followed by random selection of eight local government areas (LGAs) in each state giving a total of twenty-four LGAs. The next stage involved random selection of four communities from each LGA which gives a total of thirty-two communities. In each of the thirty-two communities, a farmer's field school (FFS) having twenty participating farmers were selected. Finally, in each farmer's field school, twenty percent or four of the participating farmers were selected as respondents and administered with interview schedule. This gives a total of 384 respondents.

Data Collection and Analysis

Using a structured questionnaire, data on famers' age, sex, household size, years of formal schooling, years of farming, farm size, annual income, external orientation were the selected personal and socio-economic characteristics, technological variable, economic variable, social cultural and institutional variable were collected to determine the extent of their influence on the adoption of SCWMTCS.

Data generated in this study were analysed using descriptive statistics such as simple frequency distribution, percentages, means and standard deviations while inferential statistics were accomplished using multiple linear regression analysis.

Measurement of variables

The independent variables considered in this study included selected personal socio-economic characteristics of respondents such as age, sex, household size, year of formal schooling, year of farming experience, farm size, annual income and external orientation. Also, the dependent variable considered for the study consists of five groups of factors and some selected socio-economic variables identified as variables associated with the adoption of SCWMTCS. This included human capital related factors, technological related factors, economic related factors, community related factors and institutional related factors. Also, age, sex, years of formal schooling, income, farm size, perception-total, years of farming experience, frequency of farm visits and external orientation were also collected.

RESULTS AND DISCUSSIONS

Socio-economic characteristics of respondents

Table 1 reveals that more than half (55.43%) of the respondents in the study area are in their prime productive years, aged between 41 and 60. The mean age of the respondents is 44.55 years, with a standard deviation of 10.79, highlighting a concentration of middle-aged individuals. This implies that most of the respondents were in their active years and as such participated effectively in the Farmers Field School (FFS) that evaluated SCWMTCS in their respective community. According to [6], age is usually considered as one of the major parameters for evaluating the level of biological and intellectual maturity and experience. Older farmers are assumed to have gained knowledge and experience over time and are better able position to evaluate the qualities of new technologies than younger farmers. This could also suggest that older farmers are more risk averse than younger farmers subsequently reluctant to adopt new agricultural technologies [5]. It was also revealed that 65.88% of the respondents were male while 34.12% are female. This might be due to the fact that women are not usually much involved at this stage in the cassava value chain. This might also have to do with culture, women are considered as vulnerable and are not expected to take leadership or unilateral decision or role in accepting or rejecting an innovation. This finding confirms the assertion by [7] which explains that gender variable is associated with embedded norms, behaviour and practices in the society that encourage or discourage the adoption of a particular technology by members of the society. Table 1 shows that the average household size is 7.3, with a standard deviation of 4.69, suggesting a moderate size, which is often associated with adequate labour availability. The mean number of years of formal schooling is 9.74, with a standard deviation of 7.30, indicating a moderate level of educational attainment in the household. The result also shows that respondents in the study area were moderately educated with 64.30% having more than primary education. Farmers' education has been assumed to have a positive influence on farmers' decision to adopt new technologies [6], [11]. This is because education increases their ability to obtain, process and utilize information relevant to the adoption of new technology [1]. The results indicate that the respondents in the study area have a substantial amount of farming experience, with an average of 17.71 years and a standard deviation of 10.33 years. This level of experience suggests that they are well-equipped to evaluate the effectiveness of SCWMTCS and make sound decisions. Furthermore, the average farm size in the area is 2.15 hectares, with a standard deviation of 2.26 hectares. By [4] classification, most of the farmers in the study area falls within medium scale classification.

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Table 1. Distribution of respondents by socio-economic characteristic (n=384)

Variables	**Freq.**	**%**
Age (Years)		
21-40	143	37.24
41-60	214	55.73
61+	27	7.03
Mean±SD 44.55±10.70		
Sex		
Male	252	65.88
Female	131	34.12
Household size		
0-6	198	51.5
7-12	175	45.60
12 and above	11	2.90
Mean± SD=7.30±4.69		
Years of formal schooling		
1-6	137	36.68
7-12	113	29.43
13+	134	34.90
Mean±SD=9.74±7.30		
Years of farming experience		
1-10	121	31.51
11-20	238	61.98
21+	25	6.51
$\bar{x} \mp SD$ Mean= 17.71	384	100.0
Farm size 2019/2020		
0-5	376	97.92
6-10	5	1.30
11+	3	0.78
Total X±SD	384	100.0
Farm size 2020/2021		
0.5	376	97.92
6-10	5	1.30
11+	3	0.78
Total X±SD	2.15	±2.26
Annual income 2018/2019		
<360,000	349	90.89
360,001-764,000	34	8.85
>760,000	1	.0.26
Total	384	108.0
Annual income 2020/2021	Total (n=384) X = 356,013.02 SD = ±1,019,998.61 Freq %	
<360,000	371	96.62
361,000-760,000	11	2.86
>760,000	2	0.52
Social status in comm dev association		
Comm. Dev. Org.	228	59.37
Cultural Org.	93	24.12
Descendant Org.	46	11.98
Political Org.	212	55.21

Source: Field Survey, 2021.

The implication of farm size on adoption is that it can enable farmers to test or evaluate the benefits of technology because farmer can devote part of their farm to test the technology. The study area's mean annual income from cassava farming using SCWMTCS showed a significant increase over the three-year period. In 2018/2019, the mean annual income was N148,973.96, followed by a slight increase to N149,360.68 in 2019/2020. However, in 2020/2021, the mean annual income more than doubled to N356,013.02, indicating a substantial rise in earnings from cassava farming in the study area.

This implies that SCWMTCS impacted positively on cassava farming in the study area.

[9] posited that income determines access to inputs required for adoption of new technology.

Access to credit or more income suggests that respondents could be motivated to adopt SCWMTCS as a result of increase in their annual income. The respondents participated in multiple social organizations and served at various capacities. The respondents that participated in political organization, community development organization, cultural organization and descendant organization were 55.21%, 59.37%, 24.12% and 11.98% respectively implying that the respondents in the study area possess a moderate level of social standing and engage in various forms of community involvement. As suggested by [6], participation in community-based organizations can have either a positive or negative impact on the adoption of new technologies, highlighting the complex relationship between social engagement and technological uptake.

The results also revealed that the respondents have high external orientation in the past one year in the study area. Majority (85.40%) of the respondents have travelled to other communities in the last one year. Also, majority (76.82%) have travelled to other LGAs in the last one year, about 21.61% have travelled to other regions in the last one year while 4.17% have travelled out of the country in the last one year. This indication of high orientation of the respondents suggests access to cheap information source among the respondents. The extent to which farmers interact and learn from each other and the influence of social network play a vital role in accepting and disseminating new agricultural technology to a large population. The main source of information for farmers are other farmers because information is easily available and it is not too costly to utilized it [13].

Factors influencing adoption of SCWMTCS

The results in Table 2 shows that household size (β = 2.05; p < 0.05 in Oyo state and β = 2.51; p < 0.01 in Abia state), income (β = 3.25; p < 0.00 in Oyo state and β = 4.14; p < 0.00 in Abia state), farm size (β = 3.98; p< 0.01 in Oyo state and β = 4.62; p< 0.01 in Abia state), frequency of farm visits (β = 2.88; p < 0.01 in Benue state), external orientation (β = 2.93; p< 0.00 in Oyo state β = 1.70; p < 0.10 in Abia state), social-cultural related variable (β = 3.30; p< 0.00 in Benue state), institutional related factor (β = 3.28; p< 0.00 in Abia state and β = 5.70; p < 0.00 in Benue state), were positive and significantly contributed to adoption of SCWMTCS in the study area at p< 0.01. The analysis reveals that in Oyo state, a one-person increase in household size is associated with a 0.22 increase in the likelihood of adopting SCWMTCS, while in Abia state, the same increase in household size is linked to a 0.24 rise in adoption likelihood. Furthermore, a one-unit increase in income is tied to a 0.33 increase in adoption likelihood in Oyo state, and a 0.40 increase in Abia state, indicating a positive relationship between income and SCWMTCS adoption in both regions.

Table 2. Factors influencing adoption of SCWMTCS
Regression analysis between variables and adoption of SCWMTCS in Nigeria

Variable	Regression Coefficient (b)	β-Value	ABIA P-Value	Regression Coefficient (b)	β-Value	P-Value	Regression Coefficient (b)	β-Value	P-Value
Age	0.24	0.161	0.872	0.029	0.193	0.847	-0.048	-0.281	0.780
Household Size	0.223	2.047	0.043*	0.235	2.508	0.014*	0.024	0.200	0.842
Years of Residence	0.029	-0.319	0.750	0.043	0.468	0.641	0.067	0.696	0.488
Sex	0.102	1.139	0.257	0.103	1.018	0.311	0.052	0.680	0.498
Years of formal schooling	-0.083	-0.937	0.351	-0.087	-1.007	0.316	-0.015	-0.170	0.866
Income	0.332	3.248	0.002**	0.403	4.137	0.000**	-0.015	-0.166	0.869
Farm size	0.269	3.978	0.011*	0.298	4.624	0.011*	0.161	1.363	0.176
Perception total	-0.176	-1.996	0.048	-0.073	-0.804	0.423	0.041	0.577	0.565
Years of farming experience	-0.027	-0.188	0.851	-0.027	-0.188	0.851	0.031	0.224	0.823
Frequency of farm visit	-0.118	-1.045	0.298	-0.118	-1.045	0.298	0.221	2.882	0.005**
Social status	-0.168	-1.454	0.149	-0.168	-1.454	0.149	-0.026	-0.288	0.774
External Orientation	0.304	2.933	0.004**	0.199	1.701	0.092*	0.005	0.047	0.963
Human Capital related	-0.120	-1.190	0.237	-0.120	-1.190	0.237	-0.036	-0.387	0.699
Technological related	-0.019	-0.200	0.842	-0.019	-0.200	0.842	-0.008	-0.093	0.926
Economic related	0.045	0.376	0.708	0.045	0.376	0.708	0.129	1.447	0.150
Social culture related	0.170	1.498	0.137	0.170	1.498	0.137	0.337	3.304	0.001**
Institutional related	0.162	1.262	0.210	0.291	3.283	0.001**	0.465	5.694	0.000**

** Significant at $\leq$ 0.01; * Significant at p $\leq$ 0.05
Model summary: F = Oyo State = 3.084; Abia State = 5.166; Benue State = 7.277, sig = 0.000
R^2 = Oyo State = 0.382; Abia State = 0.382; Benue State = 0.572
R = Oyo State = 0.525; Abia State = 0.618; Benue State = 0.716
Source: Field Survey, 2021.

Moreover, the regression coefficient (b) for farm size also reveals that for a unit increase in farm size, there will be a 0.27 unit increase in adoption of SCWMTCS in Oyo state, while for Abia state a unit increase in farm size will lead to a 0.30 in adoption of SCWMTCS. The regression coefficient (b) for perception total reveals that a unit increase in perception total will lead to a 0.18 increase in adoption of SCWMTCS in Oyo state. The regression coefficient (b) also for frequency of farm visits reveals that for a unit increase in frequency of farm visits there will be a 0.22 increase in adoption of SCWMTCS in Benue state. The regression coefficient (b) for external orientation reveals that a unit increase in external orientation will lead to a 0.30 increase in adoption SCWMTCS in Oyo state, while for Abia state, a unit increase in external orientation will lead to a 0.20 increase in adoption of SCWMTCS. The regression coefficient (b) for social- cultural related factor reveals that a unit increase in social-cultural related factor will lead to a 0.34 increase in adoption of SCWMTCS in Benue state. The regression coefficient (b) for institutional- related factor also reveals that a unit increase in institutional-related factor will lead to a 0.29 increase in adoption of SCWMTCS in Abia state, while for Benue state, a unit increase in institutional-related factor will lead to a 0.47 increase in adoption of SCWMTCS.

The implications of the significant relationship between adoption of the SCWMTCS and selected factor such as household size, income, farm size, frequency of farm visits, external orientation, social-cultural related factor and institutional-related factor that household size could suggest availability of labour or heavy toll on spending and unavailability of funds to purchase necessary inputs for adoption, income determines access to farm inputs required for adoption, farm size could enable farmers to test or evaluate benefits of technology, hence decision to adopt, frequency of farm visits allow effective performance of the various practices contained in the technology package, external orientation could determine access of farmers to information on technology, social-cultural related factor could suggests the strength of community decision-making standards and institutional-related factors may suggests farmers access to infrastructures, loans, extension services and participation in technology testing.

The study finds that institutional-related factors, including access to funding, markets, and infrastructure, have the greatest influence (b = 0.465 in Benue state) on the adoption of SCWMTCS, while frequency of farm visits has the smallest impact (0.221 in Benue state). Institutional factors are the key predictors of SCWMTCS adoption, and frequency of farm visits has no significant predictive power. This indicates that the higher the level of institutional support, the greater the likelihood of adopting SCWMTCS, emphasizing the importance of a supportive institutional environment for technology adoption. Hence, the higher the level of institutional-related factor consisting of access to funds from financial institutions, all-season markets, public and private infrastructures, land preparation and processing equipment, road transportation, the higher the level of adoption of SCWMTCS in the study area.

Overall regression model summary show that R^2 value of (0.276 Oyo state, 0.382 Abia state and 0.512 Benue state) was obtained in the analysis. Also, F value of (3.084 Oyo state, 5.166 Abia state and 7.277 Benue state) obtained was significant at $p \leq 0.01$. Thus, R^2 of (0.276 Oyo state) indicates that significant variables among the selected variables could only explain (27.6 percent Oyo state, 38.2 percent Abia state and 51.2 percent Benue state) of the variation in the level of adoption of SCWMTCS in the study area.

CONCLUSIONS

The study concluded that the factors that determines adoption of SCWMTCS were household size, income, farm size, frequency of farm visits, external orientation, social-cultural factors and institutional factors. The study recommended that farmers need institutional provisions and empowerments such as farm inputs, and extension services to enable them to adopt SCWMTCS and other appropriate technologies for maximum returns.

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THE USE OF *MISCANTHUS* SP. MULCH IN THE TECHNOLOGICAL PROCESS OF GRAPEVINE CULTIVATION

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Abstract

Evaluating the climatic factors within the limits of the sector, where the respective researches were carried out, their tendency to change, towards the creation of arid conditions, was found. The change of climatic factors imposes the need to review the cultivation technologies of agricultural plants. An element of the technological cultivation process was used mulch from plant residues, Miscanthus sp. The experiment was carried out with the laying of mulch with a layer thickness of about 5 cm, the width of the strip about 50 cm and the length in a row of 15 meters. In order to measure the parameters, sensors were fixed in the soil, which determine, in the layer of 10-15 cm: the temperature in the soil, the temperature at the surface of the soil, the humidity of the soil, the electrical conductivity of the soil, as well as the amount of sunlight that falls on the surface of the soil. The respective sensors were placed both in the mulched and non-mulched area. At the time of initiation of the experiment, the soil moisture in the layer of 10-15 cm from the surface was about 20.48%. After covering the soil with mulch throughout the vegetation period, it was found that the soil moisture, in the case with mulch, is practically twice as high as in the case without mulch. The layer of mulch from plant residues contributes to: maintaining moisture in the soil, regulating the thermal regime of the soil, preventing erosion processes, stopping the development of weeds, enriching the soil with mineral nutrients, etc. Also, the use of mulch contributes to reducing the financial and human resources for maintaining plantations by about 25%. The productivity of the plants was about 25.5–29.5% compared to the control, the amount of sugars is about 2-3% higher compared to the case without mulch.

Key words: *electrical conductivity, mulch, temperature, vines, moisture*

INTRODUCTION

Agriculture is highly vulnerable to the ever-increasing variability of extreme climate factors and phenomena. The change in climatic factors will affect the productivity of agricultural crops, in the sense of reducing it. In order to improve the situation, it is necessary to use resources efficiently and motivate the use of technologies to increase the productivity of agricultural crops [1, 3].
Based on the situation created, it is necessary to promote a green economy policy by motivating, stimulating through various aspects (economic-financial, technologies, products, etc.) those who, as a result of the economic activity, cause an impact on the environment. The co-interest of economic agents is required in order to carry out a sustainable activity, both from an economic point of view and the impact on the environment and be minimal. Otherwise, without the promotion of such a policy, the expected results will be minimal and the state of natural resources and the environment will continue to degrade [2, 5].
The aim of the present study was to use mulch from plant residues *(Miscanthus* sp.) in grapevine cultivation. Mulching is an agricultural procedure, which consists in covering the soil surface under the plants with various materials to improve the conditions for the development and productivity of the plants [1, 2, 3, 4].
Two main types of mulches are known - inorganic and organic. Inorganic mulch consists of various types and sizes of stone, gravel, geotextile fabric, etc. These materials do not decompose, they do not contribute to the improvement of the soil structure, so it is necessary to administer organic matter. However, inorganic mulch due to the light

spectrum can influence plant development and productivity. For example, potato (*Solanum tubersosum* L.), sweet pepper *(Capsicum* sp.) demonstrate increased productivity in the case of white mulch, tomatoes (*Solanumlycopersicum*) preferred mulch, etc. [3]

Organic mulch, in general, represents remains of plant origin. Depending on the material and climatic factors it breaks down, therefore it requires regular renewal [3, 6].

MATERIALS AND METHODS

Five varieties of grapevines served as the study object. Planting scheme 3 meters between rows and 1.5 meters between plants in a row. Sawdust from the vegetable mass of Miscanthus sp served as mulch. The thickness of the mulch layer was about 10 cm, the width of the strip about 50 cm and the length in a row 15-20 meters.In order to measure the parameters, sensors were fixed in the soil, which determine, in the 10-15 cm layer: the temperature in the soil, the temperature at the surface of the soil, the humidity of the soil, the electroconductivity of the soil, as well as the amount of sunlight that falls on the surface of the soil.

With the help of the weather station, the amount of precipitation, relative air humidity, air temperature was determined: average, minimum and maximum [1,2, 3, 4, 6, 8, 10].

Photo 1. The sensor in the mulch sector.
Source: Original photo.

Photo 2. The sensor in the sector without mulch
Source: Original photo.

RESULTS AND DISCUSSIONS

In the conditions of the change of climatic factors, it is necessary to review the cultivation technologies of agricultural crops.

Evaluating the climatic factors within the limits of the sector, where the respective researches were carried out, their tendency to change, towards the creation of arid conditions, was found [1, 5, 6, 12, 13].

The average monthly temperature (^{0}C), period 2014-2021 (Chisinau) is shown in Fig. 1.

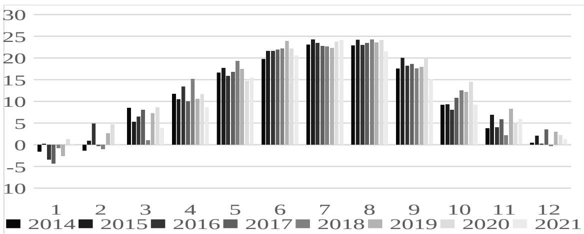

Fig. 1. Average monthly temperature (^{0}C), period 2014-2021 (Chisinau)
Source: Own calculation.

The monthly and annual temperature indices during the years 2014-2021, registered an increasing trend of these indicators (Fig. 2 and Fig. 3).

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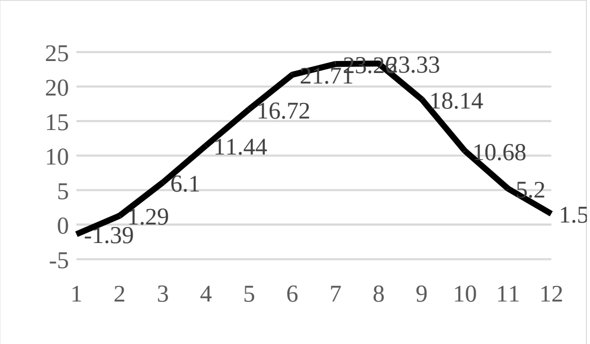

Fig. 2. The trend of the average monthly temperature (^{0}C) in the period 2014-2021 (Chisinau city)
Source: Own calculation.

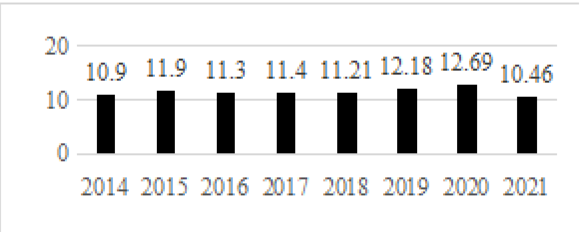

Fig. 3. Average annual temperature (^{0}C), period 2014-2021 (Chisinau)
Source: Own calculation.

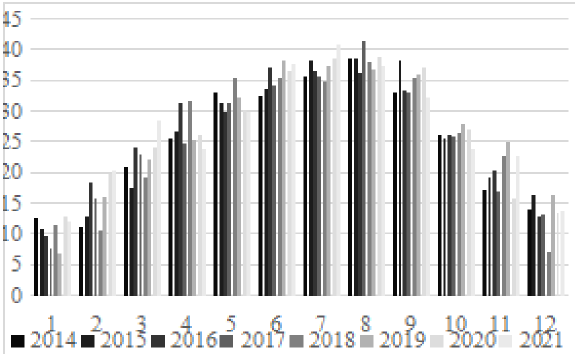

Fig. 4. Monthly maximum temperature (^{0}C), period 2014-2021 (Chisinau)
Source: Own calculation.

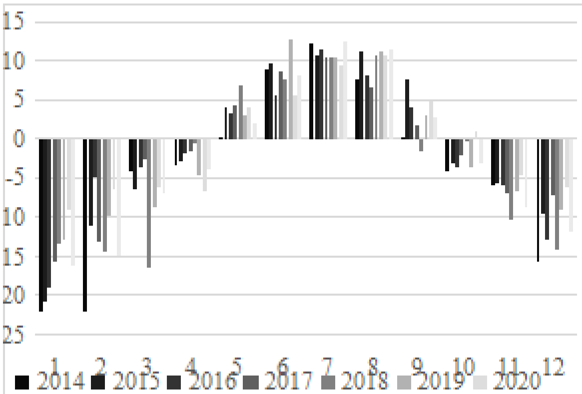

Fig. 5. Minimum temperature (^{0}C) monthly, period 2014-2021 (Chisinau)
Source: Own calculation

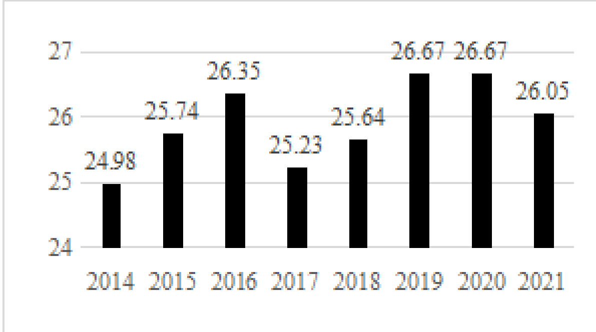

Fig. 6. Maximum temperature trend, (annual average), period 2014-2021 (Chisinau city)
Source: Own calculation.

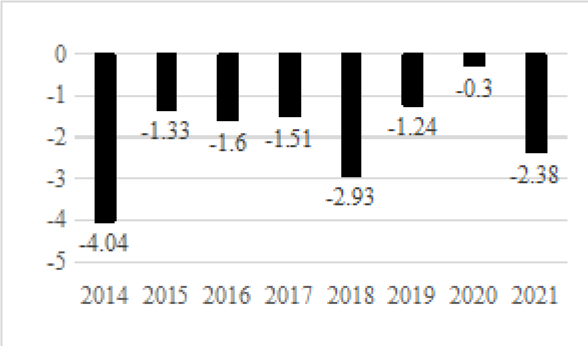

Fig. 7. Minimum temperature trend, (annual average), period 2014-2021 (Chisinau city)
Source: Own calculation.

Maximum and minimum temperature (annual average) during the period 2014-2021 it was observed that in 2014, the maximum annual average was 24.9 0C, and the minimum annual average was -4.04 0C, while in 2021, the maximum annual average was 26.5 0C, and the minimum annual average was - -2.38 0C (Fig. 6). So, the trend of maximum and minimum temperature for the period 2014-2021 is increasing (Fig. 7.).

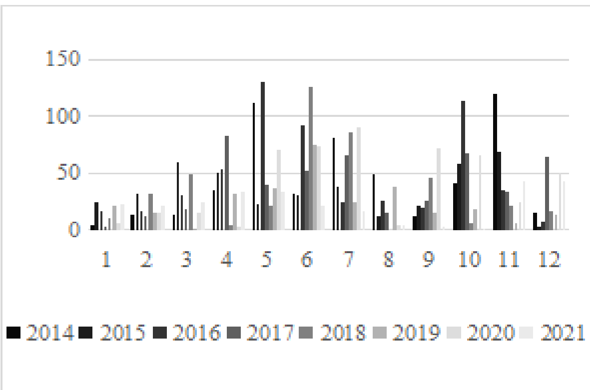

Fig. 8. Monthly amount (mm) of precipitation, period 2014-2021 (Chisinau)
Source: Own calculation.

Analyzing the amount of atmospheric precipitations that fell between 2014 and 2021, it was found that the maximum was 566.8 mm in 2016, and the minimum was 268.4 mm in 2021. Based on the indicators of the precipitation trend for this period, we come to the conclusion that the precipitation trend is decreasing (Fig. 8., Fig. 9. and Fig. 10).

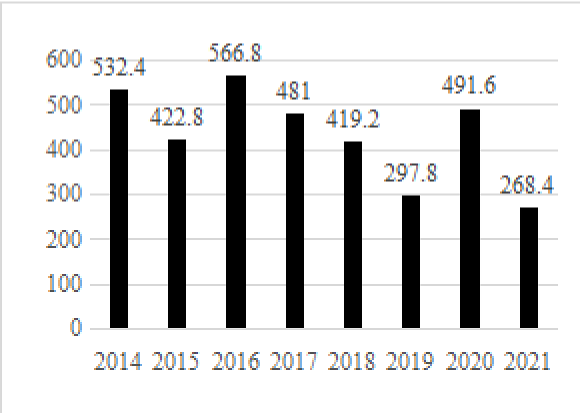

Fig. 9. Annual quantity (mm) of precipitation, period 2014-2021 (Chisinau)
Source: Own calculation.

The amount of annual precipitation has a diverse character. In the future this diversification will be quite accentuated. Calculating the total amount of annual precipitations, we arrive at the fact that we have the annual precipitation norm. If we distribute this amount of precipitation over a certain period (days, weeks, months), we find that in a long period of time (4-6 months) there is no atmospheric precipitation, but in a very short time an amount of abundant precipitation (rain showers), far exceeding the norm for that period.

Based on the fact that atmospheric precipitation has a diverse character and in the future it will intensify even more, actions are required to suppress the process of water evaporation and its preservation in the soil.

Soil mulching contributes to reducing the evaporation process and maintaining moisture in the soil, suppresses the growth of grasses, stops surface runoff and accelerates the penetration of rainwater into the soil, thus preventing the erosion process. However, the mulch helps to improve the soil structure, ensures the development of the activity of microorganisms and the root system, etc. Ultimately, all this leads to good plant growth and productive development.

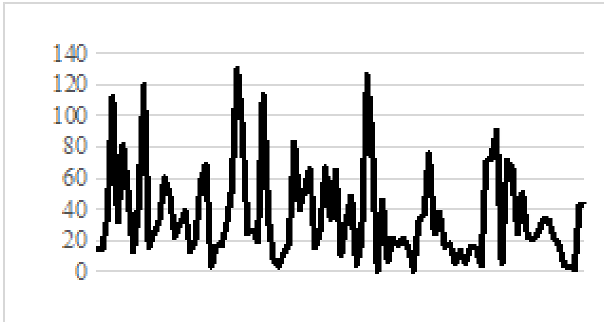

Fig. 10. Precipitation trend (mm), period 2014-2021 (Chisinau)
Source: Own calculation.

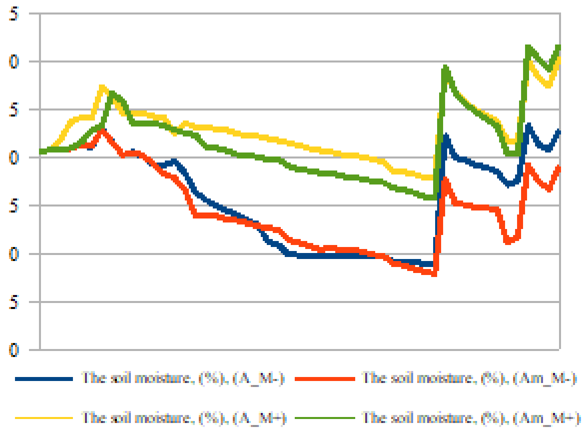

Fig. 11. The soil humidity (10-15 cm layer). (A_M- - without mulch; A_M+ - with mulch)
Source: Own calculation.

At the time of setting up the experiment, the soil moisture in the 10-15 cm layer from the surface was about 20.48%. After covering the soil with mulch throughout the vegetation period, it was found that the soil moisture, in the case with mulch, is practically twice as high as in the case without mulch (Fig. 11.).

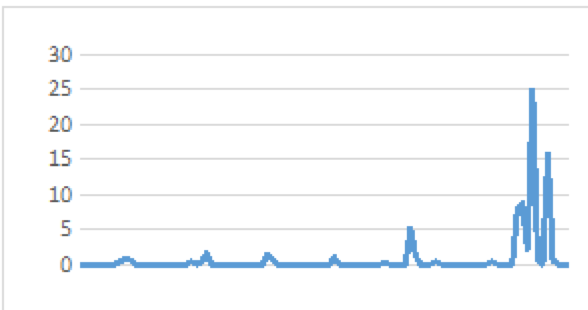

Fig. 12. The amount of precipitation.
Source: Own calculation.

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During the period May - August 2022 atmospheric precipitation was insignificant. In January there were 14.6 mm of precipitation, February and March 5.0 mm and 6.0 mm respectively, April – 40.8 mm, May and June each 4.4 mm and 3.0 mm, July – 26.2 mm and in August 87.0 mm (Fig. 12.).

The soil structure of lands with insufficient water, as a rule, differs essentially compared to the soil structure of lands with abundant water. The water holding capacity is easily determined due to the electrical conductivity of the soil. The average level of electrical conductivity indicates that the soil has an average structure and, consequently, has an average drainage capacity. Such soils are the most fertile. Because water holding capacity has a major impact on cereal crop productivity [5, 13].

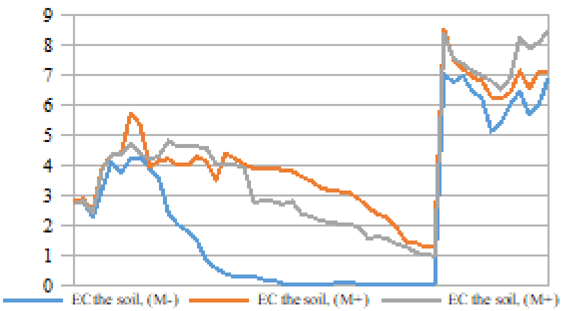

Fig. 13. The electrical conductivity of the soil. (A_M- - without mulch; A_M+ - with mulch)
Source: Own calculation.

Electroconductivity is a method of determining soil fertility (granulometric and mineralogical, pH, humidity, absorption capacity, etc.), which allows to determine the need and the necessary quantity of introducing fertilizers into the soil.

Using electroconductivity techniques allows not only determining the potential of soil fertility, but also ensuring the development of sustainable agriculture, determining the ability to provide plants with mineral substances necessary for the development and maintenance of vital processes, determining the level of soil pollution with toxic substances, assessing the cultivation capacity of certain crops on different types of soil, etc.

As a result of the mounted experiences, it was found that the electroconductivity of the soil in the case with mulch demonstrates much higher indices than in the case without mulch (Fig. 13).

Thus, by improving soil conditions, mulch has a positive effect on plant development and productivity. So, if the soil was covered with mulch, the annual shoot growth was 12-20% higher and the plant productivity was 25.5-29.5% compared to the control. Also, the content of sugars, in the case with mulch, is 2-3% higher compared to the case without mulch. The financial resources needed to carry out agrotechnical works, related to soil processing, are reduced by approx. 25-35%.

During the course of the experience, it was found that in the case of covering a respective layer with mulch, the growth of grasses is stopped one by one and the process of soil erosion is prevented (Photo 3, 4, 5, 6) [8, 9].

Photo 3. the process of soil erosion in the case without mulch.
Source: Own photos.

Photo 4. the process of soil erosion in the case of mulch.
Source: Own photos.

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Photo 5. Mulching of the grapevine, the beginning of the period of active vegetation.
Source: Own photos.

Photo 6. Mulching of the grapevine, ripening of berries.
Source: Own photos.

According to estimates, it was found that about 40% of agricultural lands are degraded and give harvests lower than their productive capacity, and the continuous degradation of agricultural lands drastically reduces the possibilities of obtaining adequate harvests [1]. So, it is necessary to undertake rigorous measures to rectify the situation.

The costs related to the establishment of wine plantations, the exploitation of the fruitful vineyard and the deforestation expenses are recognized on the basis of the accounting of commitments in the period in which they were borne by the entity [11].

The use of mulch from the vegetable mass allows obtaining the benefits, which ultimately leave a significant economic imprint on the final product.

The inclusion of mulch in the technological process of growing vines also contributes significantly to the reduction of the carbon footprint in the atmosphere (the total emissions of greenhouse gases produced in a certain period of time). This footprint is manifested by the exclusion or partial reduction of some technological stages of plantation maintenance.

Excluding expenses for herbicides, machinery, fuels, performing treatments and manual work, all of these contribute to the elimination of weeds, because they compete for water and food, at the same time, they also create a microclimate favorable to the emergence and development of pathogens.

As a result of soil processing, it contributes to the degradation of the structure, which generates a deficient aero-hydric ratio, anaerobiosis conditions, poor development of the root system, crust formation and hindering the circulation of water in the soil, which in turn can trigger water and wind erosion of ground surface etc. In order to improve the soil structure, it is necessary to reduce the number of mechanical soil mobilization works (superficial and semi-deep), their performance, but also their passage, to ensure optimal soil moisture.

As a result of the rotting of the plant mass, which serves as mulch, it contributes to the improvement of the soil structure, the biota, ensures the replenishment of the soil with nutrients, etc. By decomposition, the mulch contributes to the restoration of the humus layer which, together with the clay in the soil, particles form the glomeruli of the soil. In structured soil, the aerohydric regime is made up of 2/3 water and 1/3 air. The mulch layer reduces the settlement-compaction process, keeping the soil structured.

Excluding the need for irrigation. The vine has a strongly developed root system that allows it to explore a large volume of soil. However, the lack of moisture has a negative effect on the development and productivity of the vine. In some cases vine irrigation is applied. As a guideline, during the period of active vegetation, it is recommended to use about 1,000 - 2,500 m^3 of water per hectare. This volume is applied as a result of carrying out 2-4 watering procedures, during the months of July - August, in one irrigation procedure 400-800 m^3 of water is used per hectare. In the irrigation expenses, it is also necessary to include the cost of the irrigation equipment (pump, irrigation network, etc.), the cost of electric energy, the remuneration of the person responsible for maintaining the irrigation system in operation, etc.

The layer of mulch prevents the loss of water through evaporation from the soil, this phenomenon being reduced 3 times.

When the soil was covered with mulch, annual shoot growth was 12–20% higher and plant productivity was 25.5–29.5% compared to the control. Also, the content of sugars, in the case with mulch, is 2-3% higher compared to the case without mulch. The financial resources needed to carry out agrotechnical works, related to soil processing, are reduced by about 25%.

CONCLUSIONS

Use of the Miscanthus sp. mulch layer:
- maintains soil moisture;
- stops the growth of grassy plants;
- contributes to the restoration of the fertile layer;
- reduces soil temperature;
- prevents soil erosion;
- reduces the financial and human resources for maintaining the plantations by about 25%;
- plant productivity increases by 25-29%.

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API-TOURISM, AN IMPORTANT COMPONENT OF THE SUSTAINABLE DEVELOPMENT OF THE ROMANIAN VILLAGE - CASE STUDY: THE LOCALITY OF SIBIEL (MĂRGINIMEA SIBIULUI), ROMANIA

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Abstract

The ever-accelerating dynamics of the evolution of human civilization requires that the role of beekeeping be accentuated and diversified in proportion to the needs of man and the environment. Bees provide a wide range of ecosystem services and human well-being, contributing greatly to sustaining life on Earth. Currently, in the context of globalization, beekeeping takes on new values, with a role in biology, ecology, economy, social life and, finally, in maintaining the health of the population. In this context, api-tourism, as a niche tourism, appears as a new phenomenon, supporting the culture and traditions of rural communities in a sustainable way. Api-tourism, as an innovative form of tourism, plays an important role in maintaining the health of human society, starting from the consumption of beehive products to the prevention and amelioration of human diseases. The purpose of the work is to promote the village of Sibiel, as a locality conducive to the practice and expansion of beekeeping, with the stimulation of api-tourism. Its geographical location, floristic biodiversity, with the famous orchards of fruit trees with local varieties, deciduous and resinous forests, special spontaneous flora support the practice of beekeeping at the local level. The beekeeping in the area combines harmoniously and profitably with the agritourism activities carried out in the dozens of guesthouses in the village of Sibiel, where the local honey has a place of honour.

Key words: *apiculture, Api-tourism, Sibiel village, Mărginimea Sibiului, Romania*

INTRODUCTION

Beekeeping is a branch of animal husbandry that studies the rational rearing and care of bees in order to obtain high yields of hive products (honey, wax, pollen) and to obtain broodstock [25]. Through their activity, bees contribute to 15 of the 17 Sustainable Development Goals (SDGs) set by the United Nations Sustainable Development Goals for the well-being of people and the protection of the environment by 2030 [23].

Beekeeping is an important activity for the area in which it is carried out due to its social, economic, scientific, human health and environmental protection role [3], [4].

The aim of the paper is to promote the village of Sibiel, as a locality suitable for practicing and expanding beekeeping, with the stimulation of beekeeping tourism.

The following question is asked: Does the locality of Sibiel have the potential to develop beekeeping tourism as a tourist product?

In order to answer this question, the following objectives were taken into account: to analyse the literature on beekeeping and to analyse the conditions necessary for the development of beekeeping tourism in the locality

Nowadays beehives are increasingly visited by tourists, becoming attractive destinations for them. This is the basis of bee tourism or api-tourism, which is considered a new trend in international tourism and is integrated into agricultural tourism or agro-tourism.

The name api-tourism comes from the Latin word "apis" meaning bee (*Apis mellifera*).

Beekeeping tourism is a new dimension of tourism that promotes beekeeping and bee life, culture, traditions of rural communities in a sustainable way. It is a niche, selective form of tourism that revitalizes the countryside, creatively combining nature's biodiversity and travel, thus ensuring green, ecological and healthy tourism. It successfully combines physical and cognitive activity [25].

The beehive becomes the finale of the unique experience, where tourists are involved in the bee story. They are informed about the morphology, biology, ethology of the bee, about the hive and its products, as well as about many of the benefits to human health of spending leisure time in the beekeeping area.

In this context, the paper aimed to promote Sibiel Village from Mărginimea Sibiului, Sibiu county, Romania as a locality where beekeeping is flourishing in a continuous expanding grace to its geographical position, flora diversity from wild flowers to orchards and forests, which are an important source of nectar for bee families and also honey and other bee products could enlarge the offer of agri-tourism products for visitors.

Literature review on apiturism

The literature emphasizes that beekeeping tourism fulfills several functions:

(a) *Educational* with the promotion of ecological activities through which tourists gain a much better understanding of the flora-bees symbiotic relationship and the role of beekeeping in protecting the environment;

(b) *Tourism* through which visitors become aware of the importance of the beekeeping ecosystem and the specific traditions related to it;

(c)*Health* through which both natural treatments and bee hive products with major benefits for human health are promoted;

(d) *Social*, through which the rural population, in turn, could have a job as such or an additional job. Practically, beekeeping tourism can be considered as an alternative employment for the unemployed [30].

(e)*Economical* through which beekeeping tourism can generate income, increased honey and fruit production at low cost, influencing economically the whole community.

(f)*Ecological* through which beekeeping could assure a clean environment and preserve biodiversity and the beauty of the landscapes.

The foundations for api-tourism were laid in Slovenia in 2016, and it is considered a market leader in this sector [30]. It is the first country to certify its api-tourism providers and known as the "green piece of Europe" [11].

The dynamics of this sector have intensified in recent years in Europe and the field has become extremely popular. Countries such as Poland, Czech Republic, Germany, Spain, Lithuania, Ukraine, Portugal, Slovakia, Hungary, Slovakia, Greece present a developed beekeeping tourism [30]. In Poland in order to protect nature, especially forest ecosystems and local traditions, wild beehives are used to promote this form of tourism. The bees support the forest eco-system and stimulate the seed production of trees, shrubs and herbaceous flora [20].

Another paper points out that countries such as Slovenia, Hungary, Romania, Chile and Indonesia practice bee tourism characterized by a close link between sustainable beekeeping, historical heritage and health. Turkey is also mentioned as a country with great potential for beekeeping tourism, but lack of public awareness, poor promotion and poor marketing result in underdeveloped niche tourism. The study also refers to Bulgaria, presented as a country with an adequate infrastructure but with beekeepers with little information on the subject [28].

In another study on beekeeping tourism in Slovenia, the author states that this form of tourism fits into the new concept of sustainable creative tourism that offers tourists opportunities for self-development and creative experiences [19].

Another publication [11] analyzes the beekeeping tourism offer for visitors, focusing on the observation of different activities in the apiary: the ritual of the beekeeper's work, beekeeping methods and techniques used by the farmer with an emphasis on ecological ones, the ethology of the bee family, honey production and, last but not least, how to protect ourselves from counterfeit products. The tourist is also informed about obtaining other products of the hive and their importance in human health.

Beekeeping tourism offers the opportunity to participate in round tables, workshops on the following topics: the importance of the plant-bee binomial, the selection and improvement of honey bees, identification of the latest methods in beekeeping;

In the bee farms visitors learn about bee-therapy, aero-therapy and their role in the treatment of medical conditions.

Romanian beekeeping is successful thanks to two important factors: first, the biodiversity of the spontaneous and cultivated honey flora in our country and second, the Apis mellifera carpatica breed, with its 5 ecotypes (Western Plain, Transylvania, Mountain, Moldavian, Steppe, Moldavian Plateau), perfectly adapted to the conditions of our country [25].

In addition to the flower - bee binomial, beekeeping in our country has also developed thanks to the progress of beekeeping inputs. Among these we mention: equipment, specific tools and new technologies with a role in making beekeepers' work more efficient and increasing the productivity of bee colonies [18]. The convergence of all these factors results in high yields, diversity and superior quality of products offered by the bee family and, last but not least, secure jobs for the rural population. The revival of beekeeping encourages the local rural population to identify new activities in the apiaries which ultimately lead to the development of beekeeping in the area and new sources of income for the farmer.

In our country, beekeeping tourism is a new branch of tourism, which seeks to develop a variety of services and products centered on the beehive and beekeeping activity. Beekeeping is an important source of income for rural inhabitants and encourages the city-dweller to visit the apiary, to harvest the products of the hive or to experience the authentic taste of honey straight from the source, without processing.

A number of activities and good practices on bee tourism have been identified in Romanian hives.

1. *The concept of the "Tourist Hive"* has emerged, a concept developed by the association "Mierea Sinceră" from Câmpina (Prahova). It is a social business that creatively combines education, beekeeping, tourism and social entrepreneurship. Basically, it is a traditional Romanian farm where tourists of all ages can discover the secrets of beekeeping. Visitors discover, step by step, how honey is produced and learn to distinguish natural honey from counterfeit honey. In the apiculture school of the beehive, disadvantaged people are trained in the beekeeping profession and are also helped to develop their own business [10].

2. *Beekeeping tourism* has stimulated the emergence of *beekeeping trails*. In the case of the county of Sălaj, the Intercommunal Development Association (ADI) Sălaj Plus has created a tourist map with trails offering visitors culinary and beekeeping experiences, bringing together beekeeping and gastronomic tourism in a single product [1].

3. Beekeeping tourism in Romania offers *beekeeping enthusiasts* the opportunity to participate in *round tables* on various beekeeping topics, including the selection and improvement of the native bee, Apis melifera Carpatica [6]. The Hamba apiary of the Melikoleg Association, through its beekeeping school, offers courses in which professionals and amateurs alike are introduced to the latest developments in the field by lecturers, beekeeping specialists from Romania, Germany, Denmark, Austria, Switzerland and other countries. Some of the courses are also shared with the younger generation.

Beekeeping tourism can also be supported by visits to beekeeping museums where visitors come into contact with collections of traditional equipment and art related to bees [11]. The number of museums varies from country to country. Thus, Austria has 3 museums, Belgium 4, Switzerland 3, France 12, Germany 15, Italy 8, the Netherlands 3, and also Poland with 3 museums. In Romania there is only one permanent beekeeping exhibition in Bucharest and one beekeeping museum in the village of Minis, Arad county. According to the beekeeper, the aim of this museum was to support beekeeping and the hive products used in apitherapy [12].

4. Apitherapy is defined as the science, and also the art, of maintaining health through the use of hive products. The products, rich in minerals, vitamins, essential amino acids, proteins, carbohydrates, organic acids,

enzymes, are perfectly assimilable without any processing by the human body [9].

Api-Air, a method using the air in the hive, belongs to this category of treatment. The hive aerosol is rich in active substances that characterize the peak period of bee activity and saturated with essential oils from honey ripening. Api-Air can be compared with other natural treatments: mopheas, salines, saunas, marine or mountain bioclimates. A first step in this therapy was initiated in 1950 by Hungarian beekeepers who had gone pastoral. The second step was taken in 1987 with the advent of the hive air extractor (Pilstein, Austria) [8]. As a treatment method, the use of hive air was first implemented in Germany. The procedure is also authorized in other European countries such as Austria, Slovenia and Hungary. Hive aerosol treatment is effective in various respiratory tract diseases [28]. Slovenian beekeepers, innovators in the procedure, have installed beds inside the beehive and tourists inhale the "scent of the hive" [11]. Another experiment using hive aerosol is being carried out in the HoneyHouse in Trușeni, Republic of Moldova. In wooden hives with beehives inside, the hive air is inhaled by the visitors [15].

In our country, this type of unconventional therapy can be found in Silagiu (Buziaș city) in the Timessian locality of Silagiu. The business started with two wooden cottages where tourists can sleep and inhale the perfect combination of propolis, honey, wax, flowers, pheromones of the Nasonov gland, atmospheric air with its components, which have a role in relieving respiratory ailments. The aerosol is complemented by the buzzing of bees, which invites calm and relaxation [24]. The same type of therapy is also found in Sântana de Mureș, at Nutri Terapii Apicole S.R.L., a company established in 2017 with the aim of introducing and understanding the fascinating world of bees [8]. Hive air therapy is suitable for all age groups, except for people allergic to bee products.

In Romanian hives the form of bee-air therapy has also been identified. This beehive product refers to the humming of hymenoptera hives captured in their natural environment and used to treat hypoacusis. The method involves the construction of a wooden cottage with a structured bed of four horizontal beehives, the patient being interconnected to an audio headset [8].

All this has led to the development of bee wellness, which is a philosophy and way of life aimed at maintaining good health through relaxation, movement, spiritual balance, harmonization with nature and a balanced diet [17] Apitherapy Romania Tour successfully follows this philosophy, our country being recognized as rich in honey flora that provides a diversity of clean hive products of high health value, perfect for apitherapy [7].

MATERIALS AND METHODS

The investigations conducted between 2022 and 2024 had two main objectives:

1. To analyze the literature on apiturism;
2.To identify the factors influencing the development of bee tourism as a tourist product in Sibielvillage.

The following factors were analyzed in the research: the local bee breed in the agro-ecosystem studied, the requirements necessary for the beekeeper to become a successful beekeeping guide, the honey base and honey quality in the agro-ecosystem, the historical-cultural and natural heritage of thelocality, the development of infrastructure and services in Sibiel, the options for tourist recreation in the area and the organization of local fairs.

RESULTS AND DISCUSSIONS

Analysis of the necessary steps for the development of beekeeping tourism in Sibiel (Sibiu Marginimea) is essential for harnessing local resources and stimulating sustainable, sustainable development in the area.

The first step is to protect the local breed of bee in the agroecosystem, i.e. Apis mellifera carpatica, the mountain subpopulation. The hilly and mountain honeybee has smaller body dimensions compared to other ecotypes, but shows a much higher nectar accumulation instinct [25]. Research shows that local bee breeds strengthen the links between beekeepers, tour operators and local businesses. The honeybee, an inexhaustible source of legends and myths, brings moments of inner peace to modern man, and its story, told by the beekeeper in a beautiful natural setting, creates a unique tourism product [26]. The bee farm offers tourists a wide range of services and products with moderate investment, providing the beekeeper with financial comfort. Apiturism, through the promotion of the local bee breed and its integration into tourism activities, contributes to the sustainable development of the area by supporting the local economy, preserving biodiversity and creating sustainable and educational tourism experiences.

The second step is the need to transform the beekeeper into a beekeeping guide. Following discussions with various beekeepers in the area, we have found that they need to have knowledge of: entomology and bee ethology. For the business to run smoothly, knowledge of: management, marketing and first-aid skills are also necessary, in case a tourist is stung by a bee. The farmer's ability to communicate and be able to express himself in an international language will add value to the business. Diversifying the beekeeper's skills allows for a responsible use of natural resources and thus the generation of a stable income for the beekeeper and the local community.

The third step is to identify Sibiel's honey production base

We cannot talk about bees and the products they provide without pointing out that they depend to a large extent on the plant world. Knowledge of this resource is important in beekeeping, as it is the key to success in obtaining high quality, high yields.

The village of Sibiel, with its geographical location, floristic biodiversity, famous orchards of fruit trees with local varieties, deciduous and resinous forests, and outstanding spontaneous flora, is a suitable location for practicing and expanding beekeeping and stimulating beekeeping tourism.

The investigations of the meliferous base of the area under study were carried out during the vegetation period of 2022 [5], [29], and the vegetative surveys identified habitats with predominantly mesophytic-hygrophilous species (meadows / orchards / gardens - moderately humid), with numerous species of straw species. These habitats have a double value for the landowner: forage and honey. In the two works, 47 species with honey-bearing potential were identified, which were classified in terms of their beekeeping economic importance into the following categories: plants with a very high beekeeping weight, representing 4.26% of the total number of species analyzed; plants with a high beekeeping weight, representing 6.38% of the honey-bearing flora studied; plants with a medium beekeeping weight, the most important, which provide constant nectar and pollen harvests, necessary for the maintenance and development of bee families, representing 72.34% of the honey-bearing flora analyzed. The last category is represented by plants with a small beekeeping weight, of no importance and not supporting honey production. They represent 17.02% of the total. The beekeepers have understood the importance of the honey bee base of the studied area in the spirit of the ecological, biological, economic, and quality products in a healthy environment that are the basis for the development of beekeeping tourism in the area with the support of the local economy. In this context, an even more efficient utilization of the honey resources of the locality is necessary, since the productive performance, measurable in quantities of honey and other hive products, is determined by it and with implications for the niche, beekeeping tourism.

The fourth step. Honey quality in the Sibiel area. The laboratory analyses carried out in 2022 showed that all the honey samples tested from the Sibiel locality meet the quality standards required by the legislation, complying with the requirements for moisture content, pH, free acidity, electrical conductivity and total alkalinity. None of the samples contained sugar syrup and the Sibiel varieties are of high quality and completely natural [5]. Thanks to its quality, honey from the "Marginimea Sibiului" has even found its way into Pope Francis' cupboards at the Vatican. Its internationally recognized quality supports the creation of a local, authentic brand that can stimulate the local economy. Promoting organic practices can attract more tourists interested in natural and sustainable products.

The fifth step. Analyze the historical-cultural and natural heritage of the locality. Sibiel is a small and relatively isolated community, a corner of Heaven, which has withstood the vicissitudes of time through all its most precious assets: its historical and cultural heritage and its natural heritage. Their quintessence has made Sibiel the first rural tourist resort in our country to receive the Golden Apple in 2009, a trophy awarded by the International Federation of Journalists and Travel Writers. In recent years, the quality of tourism in Sibiel has undergone major changes. An interconnection has been created between entertainment, exploitation of nature and getting to know the local culture. Locals have fully understood that the countryside, the state of the economy and the low infrastructure costs can take the development of agritourism to a new level by including beekeeping activities. This is the genesis of niche tourism, beekeeping tourism, which harmoniously combines sustainable beekeeping, cultural and historical heritage, nature and health tourism.

a. Historical and architectural monuments. In Sibiel, the visitor makes an incursion into different historical epochs, materially represented by historical and ethnographic remains. The town's most prized tourist attraction is the Museum of Glass Icons, founded in 1983 by Father Zosim Oancea, and cataloged as the largest museum of glass icons in the world. It holds authentic pieces of inestimable cultural and historical value, contributing to Sibiel's inclusion in UNESCO's cultural heritage. Over 15,000 tourists visit the museum every year. This tourist attraction is joined by the Church of the Holy Trinity, 1765, which still bears the frescoes painted by the brothers Stan and Iacob Zugravu. In the church courtyard stands a richly ornamented wooden cross, a reminder of the heroes who fell in the War of Independence. Three stone trophies have watched over the village from the 19th century. A point of interest in the village is the cultural hostel built by talented stonemasons from Italy. History also leads the tourist to the monastery "La Chilii", where book-loving priests and teachers were trained. On the top of the Wall, 2 km from the village, you can see the stone walls of the medieval fortress "Salgo", whose origins are lost in the mists of time. Last but not least, the 19th century pompiri shed is worth a visit.

It is important to emphasize that the historical remains of Sibiel are located close to main roads and popular tourist routes, which significantly increases their value and attractiveness**.**

b.Sibiel's natural monuments are the traditional apple and pear orchards in individual households. The foundations for practicing orcharding in the area were laid in 1862 by the priest Alexandru Lebu, who made a pioneering contribution in this field. Between 1850-1900, as transhumant herding declined, Sibielul found in fruit-growing an important complementary economic source [13]. Today, 40 apple varieties and more than 10 pear varieties, all well adapted to climatic changes, are still cultivated in the traditional orchards of the Sibiu Margin. In his work 'Botanica populară în Mărginimea Sibiului', Professor Drăgulescu Constantin identifies 16 apple varieties in the locality of Sibiel, namely: de Banat, Butul, păpăscuță, cacovenești, cisnădești, boscove, Bel-fleor, florine, Mașanschi, Parmen auriu, Auriu, Brauman, căsale, stetine, de ghiață, Jonatan and 8 varieties of pears: Cengheamenghea, chiurele, Cu miez Roșu, Cu coada strâmbă, de vară, Sînchetrești, Pergamute, Prăsare [16].

The traditional orchards of Sibiel are home to numerous apiaries where the bees benefit from several advantages: early nectar and pollen harvests, which ensure good development of the bee families and a good honey harvest. Sibiel honey, thanks to its orchards, is of superior quality, has a pleasant taste, crystallizes finely and takes on the consistency of sherbet.

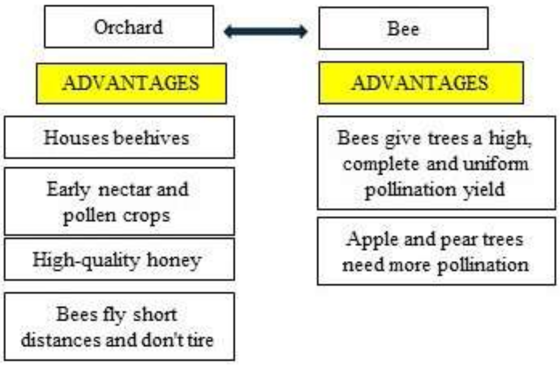

Fig. 1. The benefits of fruit trees and bees
Source: Own design.

Another advantage is that the bees move short distances in the orchard and do not wear out very much. The bees, in turn, provide the trees with a higher yield of fruit by pollinating them completely and uniformly. It is known that apple and pear trees require much more intense pollination than other fruit tree species (Fig. 1).

The landscape potential of the Mărginimea Sibiului relief is given by the main ridge of the Cindrel Mountains from which three secondary buttress-type ridges are derived, identified with wide levelling platforms: the upper platform (1,700-2,244 m) dominated by alpine and subalpine pastures, the middle platform (1,650-1,350 m) with meadows and coniferous forests and the lower platform (800-1,200 m). The latter, characterized by wide and undulating interfluves, is heavily anthropized, with hill top settlements including Sibiel [14].

Through its historical and cultural monuments of the past and today's natural monuments, Sibiel is becoming more and more attractive for visitors, stimulating niche tourism, the beekeeping tourism. It contributes to heritage conservation, stimulates environmental education and promotes sustainable practices in tourism, increasing local well-being.

The sixth step

The development of infrastructure and services in Sibiel can stimulate the bee tourism sector.

The rural community of Sibiel has the great advantage of being located in a region which is extremely attractive for both Romanian and foreign tourists.

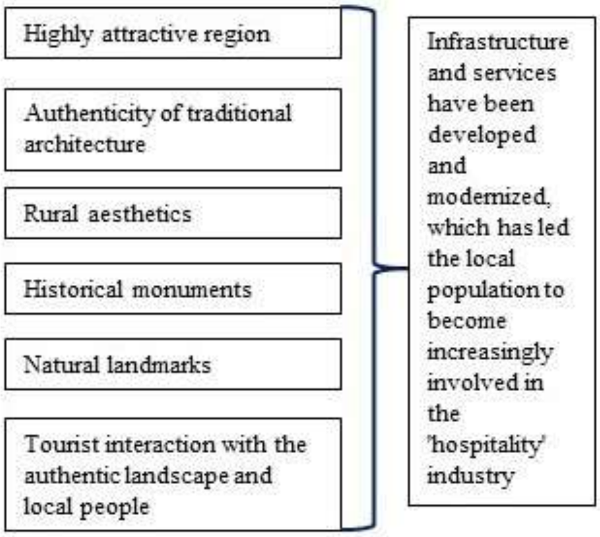

Fig.2. Infrastructure development in Sibiel - Community benefits
Source: Own design.

Tourists visiting the locality are enchanted by the authenticity of the traditional architecture and rural aesthetics, the historical and natural monuments of the area, the interaction with the authentic landscape and the local people (Fig. 2).

Over the years, the local infrastructure and services have been developed and modernized, which has led the local population to be more and more involved in the "hospitality" industry, proving to be an additional source of income for both the inhabitants and the local budget. The number of tourists visiting Sibiel is constantly increasing, which has led to a steady growth in the number of places to stay. After 1990, as a result of a favourable legislation for the development of private tourism initiatives in the countryside, especially in the mountain area, an increase in the number of accommodation units in Sibiel was observed [14].

The current data on accommodation facilities in the locality of Sibiel were summarized by a group of researchers in 2023 [22]. They identified 5 types of tourist structures: Tourist pension, Agrotouristic guesthouse, Hotel, Camping cottages, Rooms for rent.

The dominant tourist structure in Sibiel is the tourist pension with 26 establishments. Agrotouristic guesthouse, camping cottages and hotel are represented by one establishment each. There are also rooms for rent (2 units).

As regards the structure of the accommodation structure, by comfort categories, in Sibiel, the units classified with two daisies/stars (14 units) predominate, followed by those with three daisies/stars (12 units), with four stars/star/star 3 units, and with 5 stars/star 2 units.

The largest number of places is found in tourist guesthouses (290 places), the second place is occupied by hotels (42 places), the third place is occupied by agrotouristic guesthouses and camping cottages (16 places each). The smallest number of places are in rooms for rent.

In Sibiel, tourist pensions are preferred by tourists who appreciate the originality of the place rather than comfort**.**

The seventh step. Tourist Agrement in Sibiel

The leisure stimulates the movement of tourists, it is an important source of revenue with increased economic profitability. Several types of recreation have been identified in the area of the locality:

Cycling. Through the "Ecomuseum circuit of the treasure of old varieties" tourists visit the traditional fruit orchards in the Sibiel-Fântânele area [27].

Eco-entertainment. Through the adventure park "Almontes" tourists of all ages are outdoor activities such as: zip-line, tree circuit, climbing, team-building, orienteering, tourist trails [2].

Mountain tourism is also in great demand with its trails:

1."Sat Sibiel - Valea Cetății - vf. Cetatea (La zid) - former Fântânele hut";

2. "Sat Sibiel - Valea Cetății - hill of the Citadel - former Fântânele hut";

3. "Sat Sibiel - Valea Sibiel - la Mânăstire - Valea Sibielaș - former Fântânele hut".

Recreational activities in the area can be an advantage for beekeeping tourism [21].

The eighth step Organization of fairs

Every year, the inhabitants of Sibiel organize the "Apple Fair". The offer is generous: buying and tasting old varieties of apples and pears of good quality, together with other traditional village products: honey, walnuts, apple must, apple vinegar, apple brandy; short walks in the village surroundings admiring the rural landscape rich in meadows, orchards and apiaries. All of this ensures the preservation of local genetic wealth and promotes the concept of the short food chain, with the purchase of traditional, authentic products right on the door steps of the villagers.

We can say that bee tourism in Sibiel is a complex and multidisciplinary concept. It combines elements from tourism, agriculture and horticulture, ecology, education and health, promoting tourist activities centered around bees and bee products (Fig. 3).

Therefore, bee tourism is not just a simple tourist activity, but a field that interconnects several disciplines, offering a rich and diversified experience for those interested.

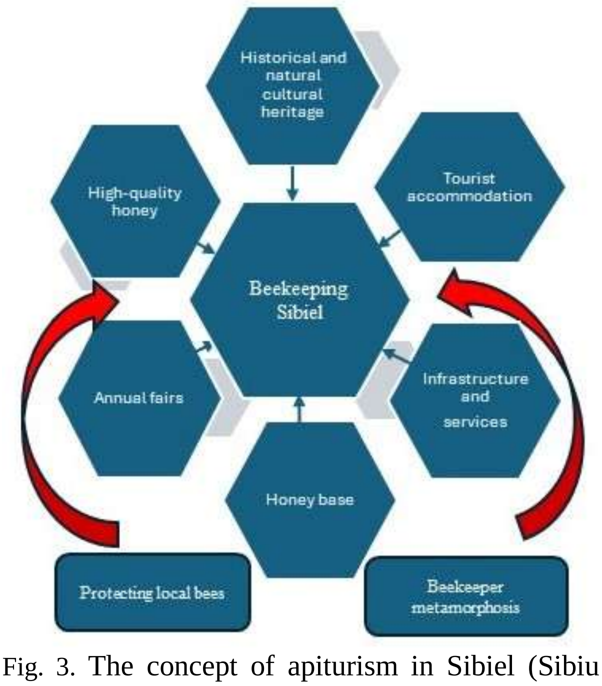

Fig. 3. The concept of apiturism in Sibiel (Sibiu Marginimea)
Source: own design.

CONCLUSIONS

Nowadays the demand for healthy living and natural products is growing and the interest in bee tourism has intensified.

The honey-bearing base, quality honey, the historical and cultural monuments of the past, today's monuments of nature, the development of infrastructure and services in the area, the diversification of forms of recreation, fairs with traditional products increase the natural and anthropic potential of Sibiel, which plays a determining role in the development of beekeeping tourism in the locality.

The learning of best practices regarding apiary activities offers the prospect of increasing the number of holdings and developing niche beekeeping tourism.

The inclusion in the "short food chain" of hive products that can be marketed at fairs organized in the local community also stimulates beekeeping tourism.

Farmers are encouraged to find out about the stages in the processing of hive products and the certification of their products as organic, with a view to their approval as a local community brand: ”Mierea de Sibiel” (Sibiel honey).

It is hoped that bee-keeping in the area will combine harmoniously and profitably with the agro-tourism activities carried out in the dozens of guesthouses in the locality of Sibiel, where local honey will be the pride of place.

The study highlights the significant role of this form of tourism in the sustainable development of Sibiel.

Economic. It contributes to increasing local incomes by capitalizing on beekeeping products, organizing educational activities in apiaries and attracting visitors.

Social. Supports the revitalization of the rural community, may lead to more jobs, stimulates the preservation of local traditions and culture.

Ecological. Supports the protection of bees and biodiversity by educating tourists about the importance of environmental conservation.

Through these contributions, bee tourism becomes an essential element for the sustainable progress of the region.

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MANAGEMENT OF ATMOSPHERIC HEAT IN THE CONDITIONS OF WHEAT GROWTH WARMING ENVIRONMENT IN SOUTHERN ROMANIA

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Abstract

In the south part of Romania, researches were and are performed on the influence of air temperatures (of droughts) on the development, fruiting and productivity of wheat crops. The growing season of wheat varieties starts around October 10-15, they get 40-50 days in the fall to reach tillering, and then enter in the vernalization stage. It returns at the beginning of February and is harvested until July 10-15. The wheat vegetation period was, on average, for the 10 studied agricultural years (2012-2022), 236 days, out of which 50 days in autumn, 46 days in winter and 185 days in spring-summer. Our own observations and calculations highlighted the fact that there were no significant correlations between the useful spring-summer precipitation and the wheat productions obtained during the study period, nor between the varieties considered drought tolerant and the level of harvests. There was, however, a positive correlation between the time when the rain came and the vegetation phase in which the crop was at that moment – if the precipitation reappeared near the beginning of the formation of the reproductive organs, the yields could go up to 80-85% of the potential of the variety. From technological point of view, the introduction of straw or other organic residues into the soil reduced its temperature, in hot summers, by 1.5-2.0℃, when the soil moisture was below 50%. If straws were used as mulch, the reduction in soil temperature was 1.7-2.2℃. The use, by breeding, of the genes that generate desiccation grains to wheat and corn could stop plants growing during periods of severe drought and re-vegetate with the onset of moisture, but this gene transfer is not yet accepted in Europe.

***Key words*: *wheat, atmospheric heat, precipitation, yields, correlation*.**

INTRODUCTION

Since 1965, the area cultivated with wheat worldwide has exceeded 200 million ha, in recent years stabilizing at around 220 million ha/year. Production, however, increased continuously, reaching approximately 765 million t [4]. Romania cultivates around 2 million ha every year, with productions between 6-8 million t/year [11]. Globally, in the years 2019-2022, stocks remained around 775 million t, and consumer demands were increasing, slightly exceeding annual production [4]. Degradation of climate conditions, through rising temperatures, generated by CO_2 pollutant emissions are among the reasons and culprits [1, 3, 13, 16].

Leaving aside the numerous crises present in the current economic and agricultural space, and which will certainly influence especially in the future the production of wheat and food in general, it is absolutely necessary for specialized research to look for solutions to avoid stagnation and relaunch growth, especially as the world's population continues to grow and consume. According to the approved literature [12, 14], the natural system of the atmosphere has in its composition 0.028-0.03% CO_2.

This very small amount, from a percentage point of view, can also be expressed as 280-300 ppm or 280-300 mg. Currently, an increase up to 400 ppm CO_2 is foreseen, an amount considered polluting. The specific gravity of CO_2 is similar to that of air, so their density is 1.205 kg/m^3.

Starting from this information, we calculated the amount of CO_2 for 1 ha cultivated with wheat, at a height of 1 m:

→ 1 m = 10,000 m^3 air = 2.8 m^3 CO_2 (normal) ⇒ 2.8 x 1.205 = 3.37 kg CO_2;

→ 1 m = 10.000 m^3 air = 4.0 m^3 CO_2 (polluted) ⇒ 4.0 x 1.205 = 4.82 kg CO_2.

The height of the atmosphere is 110 km, of which only the first 300 m correlates with the absorption capacity of plants. Correlation coefficients between height and CO_2 utilization by plants decrease from 0.78 at 0-100 m, to 0.52 at 200 m, and 0.40 at 300 m [9]. CO_2 is also found in the atmosphere at higher altitudes, but its concentration decreases by about 3.75 ppm for every 100 m of height.

Various authors [6, 15] state that the temperature of the decade 1991-2000 would be 0.14-0.57°C/year higher than in the previous decade. They also consider that, in 2020, +1°C has been reached, after which corrections follow to +0.7-0.8°C.

According to Friedlingstein et al. (2023) [7], who provide us with an annual balance of CO_2 in the atmosphere, show that during the period 2013-2022 the atmosphere was enriched by 3.3 Gt CO_2/year, a large part of this amount coming from the use of geological reserves of hydrocarbons. Agriculture also contributes 0.9 Gt CO_2/year to this increase.

Conservation of water in the soil can also be done through other processes, among which we mention the ones currently being researched:

→ creating cultivars with greater drought tolerance, using own desiccation genes [5, 8, 10];

→ use of dew water resulting from temperature differences between soil and atmosphere [2];

→ the use of protective curtains, either forest or tall plants (corn, sunflower);

→ introduction of soil loosening at 50 cm, so that water can penetrate deeply in conditions of heavy rains [2].

MATERIALS AND METHODS

In the period 2012-2022, experiences, measurements and observations were carried out in wheat crops in the south of the country (Modelu locality, Calarasi county) regarding:

→ The physiological moments that suffer the most as a result of climate changes, manifested by the presence of humidity or vegetation heat, have been determined and monitored.

→ Three tillage systems were organized to determine to what extent they can limit the physiological effects generated by soil heating. Effects on production were measured.

→ We worked on rotations with four crops, and simultaneously monitored the influence of the environment (drought, temperatures, etc.) on the symbiotic fixation of nitrogen in the soil, as an alternative to the use of synthetic nitrogen, which has become extremely expensive.

→ Four varieties of wheat, one of rapeseed, a corn hybrid and a pea variety were used - the pea was the predecessor of the wheat and the rapeseed of the corn.

→ The meteorological data were collected through the own weather station, and the moisture determinations of the samples were made in the own ovens for the period 2016-2022. The Calarasi Weather Station was also contacted to complete the data (years 2012-2015).

→ The technology used was the usual one at the farm level, and the calculation and interpretation of the data was carried out statistically by dispersion analysis and ratios (r2) and correlation functions.

To determine the amount of carbon, combustion is carried out in ovens (furnaces) or spectrophotometric methods are used. In both wheat straw and corn, canola and sunflower stalks, the carbon content is C = 42-44% or C = 0.42-0.44. This also applies to roots. Up to 45-47% carbon can be found in wheat grains, depending on their carbohydrate content.

To simplify the calculations, we can consider C = 0.44, which is the carbon in dry biomass, at constant weight. For a production of 6,000 kg of wheat and 7,000 kg of straw per ha (ratio 1:1.16), the total amount of carbon extracted is:

13 x 0.44 = 5.72 t C/ha = 20.9 t CO_2/ha wheat

RESULTS AND DISCUSSIONS

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Figure 1a and 1b show the annual averages of temperatures and the amount of precipitation during the years of experimentation, 2012-2022. Comparing the two graphs, we observe a negative correlation between the volume of precipitation and atmospheric temperatures, a normal phenomenon in a forest-steppe climate zone. The annual temperature variations did not indicate to us, through the figures provided, reasons to observe significant climate change influences.

Even in the driest years (2016, 2019, 2020 and 2022), monthly temperatures during flowering and grain filling did not exceed 30°C (May and June), so we cannot have evidence of climatic deviations on this parameter.

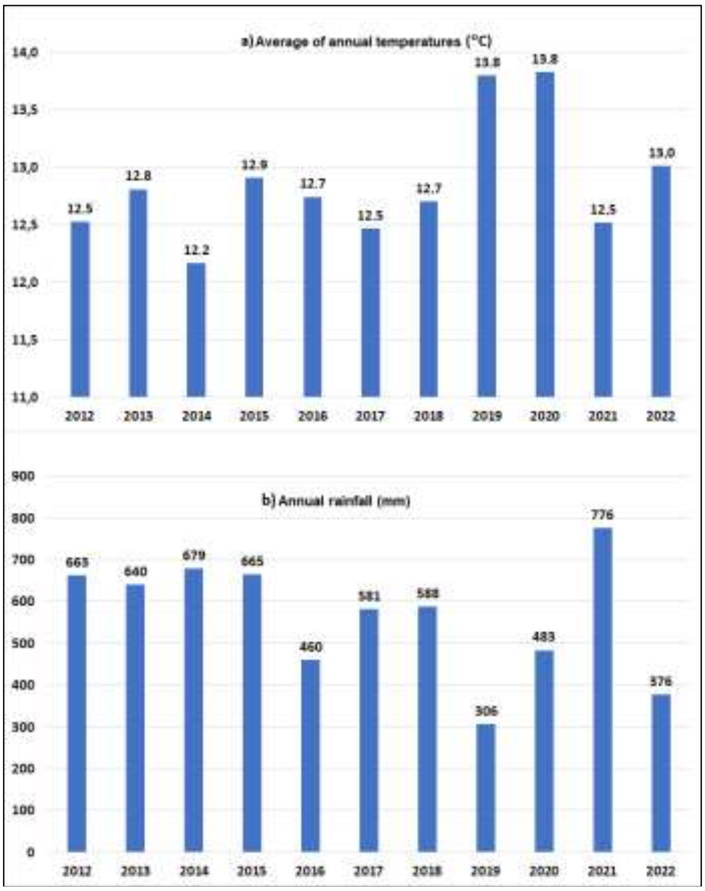

Fig. 1. Average annual temperatures (a) and annual precipitation (b) recorded in the experimental field during 2012-2022
Source: Own original data.

Precipitation, in most years, was well above average. The most frequent rains were recorded at the end of June and during July, preventing the harvest and forcing the crop to offer a smaller yield and of poorer quality. A series of correlation analyzes were undertaken to enable us to ascertain which of the rains were most favorable to the wheat crop, which were favorable and why.

It should be noted that in all the years of research (2012-2022), the initial soil moisture was deficient, without exception. The existing water reserve in the soil at wheat sowing was between the withering coefficient (in the fall of 2020) and 50-150 m^3 of useful water in the other years. With few exceptions (the year 2022), the production was carried out "in anticipation", that is, in the hope of the rains.

Figure 2 shows the correlation between the average productions of the four wheat varieties analyzed and the precipitation that fell in the first part of the year, the water on which the harvest was based. There is an increasing polynomial correlation of yields and rainfall, which placed the overall average of the experiment at about 52 q/ha. All this time there was work under the specter of drought, but almost total production losses were only in the year 2020, which led us to search and find an explanation.

The enormous amplitude between the years 2020 and 2022 is observed, with a production difference of approximately 50 q/ha, in the conditions where humidity intervened decisively only in April. In the rest of the years the production settles around 52 q/ha, regardless of whether 100 or 300 mm of precipitation fell in the summer wheat season. It depends a lot on when and how the rains fall. Sequencing the rainfall regime, Figure 3 shows the correlation between the rainfall in April-July and the harvest level. We encounter the same situation at a correlation ratio of 0.54. The phenomenon is repeated for two months, namely the months of April and May, according to the model in Figure 4, which expresses the correlation between the precipitation that fell exclusively in the month of April and the wheat production achieved, with a fault indicating the collapse of the 2020 harvest (0.9 - 20 .0 q/ha).

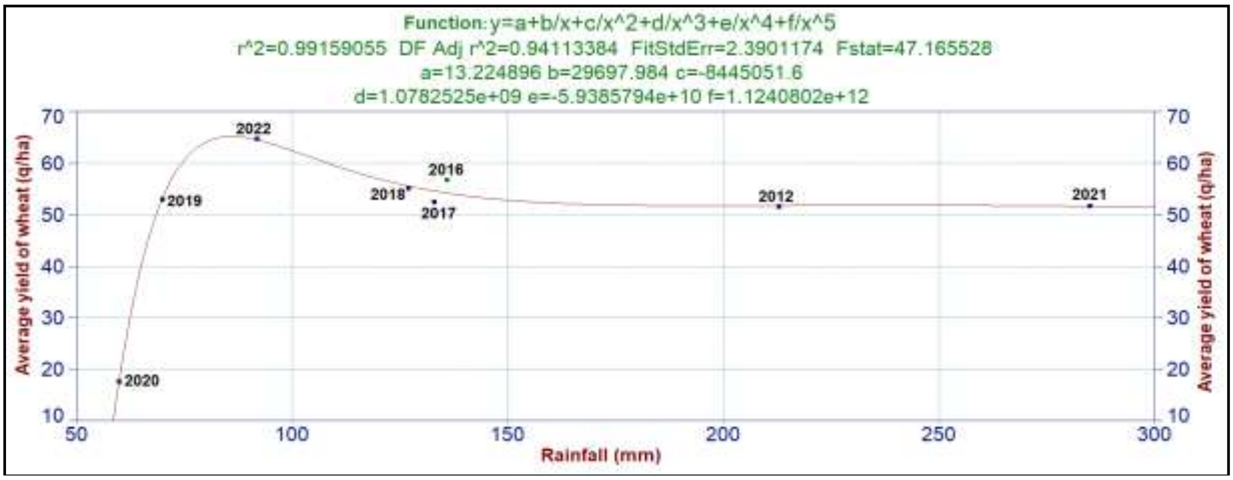

Fig. 2. Correlation between wheat production (average of 4 varieties) and rainfall in the months of January-April 2012-2022 in the research field - Modelu, Calarasi county
Source: Own original data.

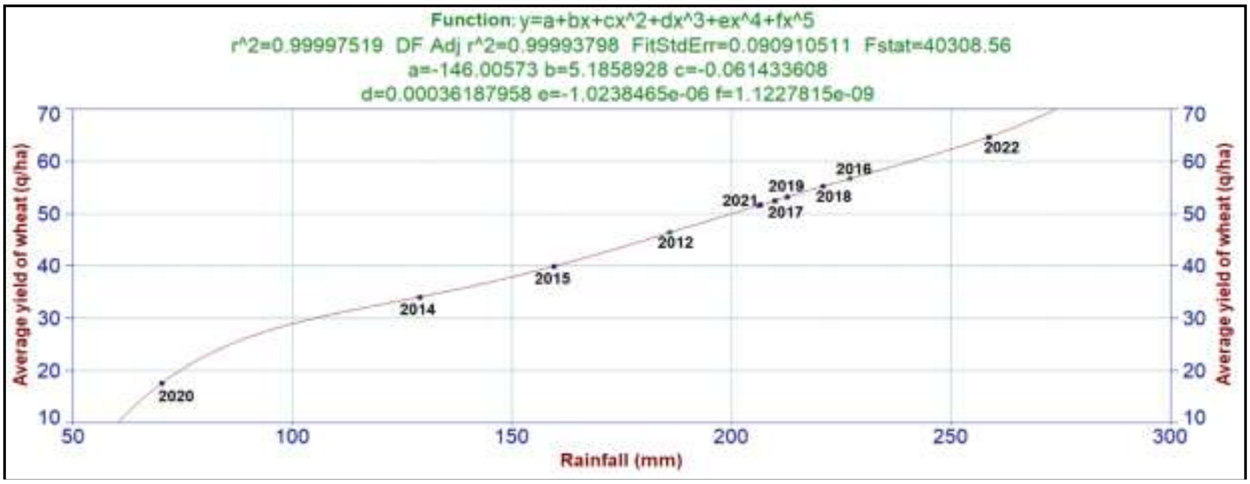

Fig. 3. Correlation between wheat production (average of 4 varieties) and rainfall in the months of January-July 2012-2022 in the research field - Modelu, Calarasi county
Source: Own original data.

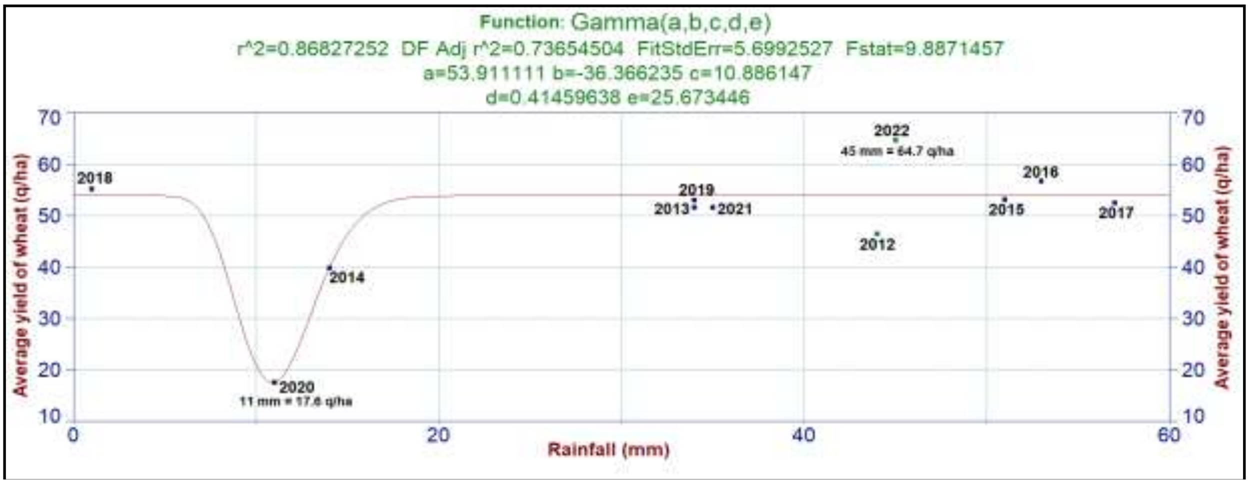

Fig. 4. Correlation between wheat production (average of 4 varieties) and rainfall in April of the years 2012-2021 in the research field - Modelu, Calarasi county
Source: Own original data.

Similar to the other graphs, except for this year, the average yields remain constant for the four varieties, with sometimes significant variations from one variety to another. This is also the reason why it is recommended in agricultural practice to use several winter wheat varieties for grain wheat crops.

Figure 4 confirms the other calculations and observations, showing that the lack of rainfall in April will lead to a drastic drop in wheat production. The statistical processing of the data is supported by a very high correlation ratio (r^2 = 0.8682), which indicates a determination of 86.8%, which is the probability of repeatability of the results, against the background of the same external factors.

Resuming the analysis of the state of soil moisture, we found that the sudden decreases in yield in all varieties studied in 2020 were generated by:

-the very low rainfall in the fall of 2019, which did not allow wheat plants to sprout in the fall;

-the maximum frequency of sunrise occurred in December 2019 – January 2020 (warm months) and was mainly due to the reduced rains of November-December 2019 and spring rains (46 mm);

-vernalization was carried out due to the low temperatures in the first part of February and partly in March;

-in the second part of April, the plants were supposed to go into the reproductive phase, but exactly then there was no water in the soil reserve and there were no rains either (11 mm in April);

-the return of precipitation in May and June was late;

-the lack of precipitation in April, against the background of a reserve of water in the soil very close to the withering coefficient, led to the compromise of the crop, even if after that there was water from the precipitation.

A similar situation was that of the 2021-2022 agricultural year, when the water reserve was slightly higher, but spring precipitation was lacking. In March, for example, it rained only 3 mm. In contrast, April, when plants need sufficient moisture to activate the winterization-to-flowering switch, brought 45 mm of precipitation. The physiological-genetic phenomenon was supported, then, by the precipitation in May and June, decisive for filling the grain, and the production was the highest in this series of years of experimentation, respectively 64.7 q/ha, on average.

Big problems could also have been created in April 2018, in which no rain fell at all, but it benefited from a water reserve of about 60%, generated by the rains that fell especially in autumn 2017 (over 190 mm) and spring 2018 (130 mm).

From these observations it emerged that, in order to ensure water moisture in the soil at the time of wheat plants transition from vegetative to reproductive growth, the specific consumption of the crop can decrease by about 10-50%, depending on the thermal conditions, especially those after blooming.

Through the three systems of works, followed for 10 agricultural years (2012-2022) in the southern part of Romania, we looked for solutions to conserve water in the soil, to maintain crops. In order to observe the differences, we performed periodic, comparative measurements.

From Table 1 it can be seen that in November (average for the entire interval), at the depth of 30 cm, compared to the conventional system, soil mulching brings temperatures higher by 1.7°C, while the incorporation of organic matter gives +0 ,9°C. Similarly, +1.2°C and +0.6°C were recorded in May, and +1.5°C and +1.4°C in June. The precursor plant was canola, and the incorporated biological material was canola stalks. By comparing the three work systems, it was observed that an increase of 113 m^3 water/ha was obtained in the version with incorporation and 238 m^3 water/ha in the system with mulching, according to the measurements made in October. For the month of March, the differences compared to the control are significantly higher, respectively +400 m^3 water/ha in the system with the incorporation of biomass and +538 m^3 water/ha in the case of mulched soil.

The effect of special works on the level of productions was not spectacular. Production increments do not overcome random environmental variations.

Table 1. The influence of the tillage system on the soil temperature at a depth of 30 cm and on the useful water reserve in Modelu - Calarasi county

Crt.	Working system	Soil temperature at 30 cm depth		
		November	May	June
1.	Conventionally tilled soil	mt 7.2	16.4	23.2
2.	Soil worked with minimum tillage – chopped straw introduced into the soil	0.9; mt 8.1; 1.7	0.6; 17.0; 1.2	1.4; 24.6; 1.5
3.	Uncultivated mulched soil - straws remain on the surface	0.8; mt 8.9	0.8; 17.6	24.7

Useful humidity = 1875 m^3/ha

Crt.	%		t/ha useful water		Average yield(q/ha)		
	October	March	October	March	m	Dif.	%
1.	6.1 20.1	4.1 19,1	762	512	54.0	Mt.	-
2.	7.0 22,0	7.3 22,3	+ 113 875	+400 912	54.6	0.6	+1.1
3.	8.0 23,0	8.4 23,4	+ 238 1000	+538 1050	55.1	1.1	+2.0

Source: authors' calculations, based on results obtained in experimental fields.

On average, production increased by 1.1% when incorporating plant residues and by 2.0% when mulching. There was a more visible tendency to increase yield only in the first 2-3 years, after which prolonged droughts, but also the appearance of dangerous pests, such as mice, led to a new conclusion, namely that the two alternative systems are very good, provided they are not permanent.

CONCLUSIONS

The main conclusions of our own research are the following:

-The climate changes announced for several decades and generated by the increase of CO_2

in the atmosphere, in the conditions of wheat cultivation in the south of the country (Calarasi area), did not lead to significant changes in the evolution of growth, development and production of premium wheat varieties.

-The amount of CO_2 absorbed by the wheat crop from the atmosphere is about 440 kg/t grain and straw (together), provided that the grain/straw ratio is 1:1. A production of 5 t grains + 5 t straw absorbs 4.4 t CO_2 or 1.20 t C.

-CO_2 emissions into the atmosphere represent 1/3 of absorption and are due to respiration, to which carbon stored through harvesting is partially added = 0.45 (P).

-The final balance is favorable for wheat cultivation, even under classic tillage conditions. The tillage system, on average over 10 years, insignificantly influences the accumulation of water and heat in the soil and environment. Covering with mulch is more conducive to keeping the soil warmer, especially in colder periods.

-Soil drought significantly affects wheat production, especially if it occurs during the "double crest" phase of the transition from the vegetative to the reproductive phase. It is important to find sources of water supply, especially in this phase, which is most frequently encountered in the 2nd and 3rd decades of April.

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NAVIGATING DIGITAL FRONTIER: CONSUMERS' WILLINGNESS TO PURCHASE FRESH VEGETABLES THROUGH MOBILE COMMERCE IN PAKISTAN

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Abstract

The study seeks to develop understanding of determinants affecting consumers' buying behavior for fresh vegetables through information and communication technology (ICTs) mainly the use of mobile application in the study area. In this regard, those drivers which trigger consumer's willingness to purchase these vegetables by using mobile commerce were identified. It might be greatly reduced the intermediate links of vegetable distribution and simplify the food purchasing in people's daily life. This application of mobile technology would have an enormous potentials in marketers, food industries, farming community, decision makers, and consumers. Enabling consumers more informed about the novel innovative technologies for receiving and sharing information about market trends, prices, and avenues, among the ICTs smart phone applications are usually considered a quick method to approach markets, attain information about agricultural commodities and their prices in an effective and desired manner. In order to assess consumers' willingness to pay for the fresh produce by using mobile commerce as it is critical to understand factors that affect its consumption. A sample size of 600 respondents including two metropolitan cities of Punjab viz. Lahore and Multan were selected purposively. According to the findings of research, income of the consumer, education of the consumer, distance of fresh vegetable from store outlet/mart, advertisement of fresh vegetables, prices of fresh vegetables, cognition of mcommerce and availability of fresh vegetables were significantly influencing consumers' willingness to buy fresh vegetables by using mobile commerce whereas taste of fresh vegetables, age of consumer, no use of synthetic pesticide residue on fresh vegetables, availability of produce were affecting non significantly towards consumers willingness to buy fresh vegetables in the study area. There is a dire need to inculcate the importance of technology as well as the benefits of purchasing fresh vegetables to consumers through proper advertisement by employing information and communication (ICTs) gadgets.

Key words: *market potential, mobile commerce, fresh vegetables, ICTs gadgets, consumer's willingness to purchase, synthetic pesticide residue*

INTRODUCTION

Agriculture is the one of the leading sectors as well as considered as pillar of the country's economy. Beside the structural modifications in the agrarian economy, since the Pakistan's independence, contribution of this sector in Gross Domestic Product (GDP) is decreasing but it remains the leading sector & accounting for almost 24.0 percent towards GDP. Almost it accounts for 40.0 percent of the workforce employment [2]. Main responsibility of agriculture sector is food crops harvesting and production. Vegetables are the main source of the fibers and nutrition, helping the country's population to live healthy [2, 3].

Food security is priority agenda for the economies and important issue of almost all countries in the world. The trend is changing as consumers have concerns related to food safety, as well as these concerns have also observed in Pakistan. Market of natural food has been growing and is more popular rapidly [2, 6]. Carbon-based agricultural is helps to maintain supportable environment because it avoids the usage of reproduction organic fertilizers insecticides that produces healthy crops and livestock [3, 19].

Pakistan has been blessed by fertile land and compatible climate to produce more vegetables and meet the growing demand of dispensation manufacturing. The main problem has been faced by the farmers is reasonable price during production season due to abundance/flooded supply. Increase usage of insecticides and biochemical composts in manufacturing of the produce is also main concerns for consumers now a days.

The natural agricultural production is an environment and eco-friendly as it prevents usage of those elements that are danger to human health [2]. Environmental threats and food safety are encouraging customer to buy fresh foodstuffs. [3] concluded that usage of organic commodities is the best for fitness as compared to usage of non-organic foodstuff. Thus, there should be an existence of proper marketplace of fresh foodstuff mainly of vegetables so that the interested customers may buy the required foodstuff from the market [22].

Vegetables are an important food items as they provide us vital nutrients, minerals, and vitamins to humans [2, 3, 23, 24]. Every actor in the supply chain of vegetables, right from production, transportation, value addition, and distribution to consumers, influences the efficacy and gains of the entire movement process to a various extent. Final consumers, as the last player of the entire vegetable circulation process, are of distinct significance, and their requirement orientation will remarkably restrict the conduct of the arduous of the supply chain. Though, the large number of players in the vegetable supply chain process, including farmers, commission agents, pharias, wholesalers, retailers and then consumers [2, 15, 24] creates concerns such as an inefficient vegetable movement, high supply chain cost and ultimately existence of bad connectivity between production traceability and marketing [14].

Moreover, the seasonal physical characteristics of vegetable farming are evident, and quantity and type of vegetables cannot be efficiently assured during the off-season [4]. Nonetheless, making complete employment of advanced information technology to build mobile commerce (mcommerce) and other online trading techniques [24] may dissolve the conventional vegetable growing and distribution model, abridge the distance of vegetables from the production origin or farm to the fork, and improve the efficiency of vegetables supply chain to cater the diverse requirements of vegetable customers for various seasons and locations of the vegetables [3].

With the expansion and commercialization of the internet and the advancement of information technology mainly mobile commerce [23], all over the world’s fresh food electronic commerce has altered rapidly. The fast-food e-commerce industry has a large amount of financing in the world but the frequency of customers employing vegetable electronic commerce to buy vegetables is not as great as expected [8]. As, fresh food electronic or mobile business also cope with challenges as inferior-quality commodities, payment security, provision of inefficient and insufficient logistics facilities [7, 8, 21].

Same is the case with Pakistani electronic or mobile commerce vegetable marketing system. Vegetable mcommerce, as a new marketing channel for the vegetables [9], is also confronting the same concerns, which has led to the deterioration of customers’ trust in, and therefore, the less motivation of opting vegetable mcommerce. Therefore, there is a dire need to explore the critical factors that affect the consumers’ willingness to adopt mcommerce vegetables is the key to resolve this concern. For this purpose, the technology specific model namely, technology acceptance model (TAM) has been mainly employed to observe customers ‘acceptance of knowledge systems. The behavior of technology usage is checked by the probability to accept technology and the behavior probability is manipulated by the attitude to adopt or employ; two major factors that influence technology adopt attitudes are the perceived usefulness as well as perceived ease of adoption. On the other way around, the theory of planned behavior (TPB) suggests that the true behavior of the customer is observed by the behavioral intention while attitude, subjective norms and perceived behavioral control are the three major factors that describe the consumer’s behavioral intention [13], characteristics of family, vegetable mcommerce cognition [9], quality cognition [23] as well as the subjective norms along with the external forces. [21] analyzed that electronic commerce, or e-commerce, was the practice of purchasing and reselling goods online. [1] discussed that it was apparent that with the improvement of versatile innovation, m-commerce had changed the internet-based business scene of the world. In their study [23] investigated the preferences of consumers while purchasing fresh agricultural products online. Fresh agricultural products were now purchased online through a variety of commerce platforms. Pakistan, which is predominantly driven by the proliferation of mobile gadgets, indicating an increase of use of ICTs [20]. It is observed that the online shopping trend has been increased in Pakistan. Considering such technological advancement, the food stores and marts have begun to utilize online forums to augment its service quality [1]. The crops are grown as well as marketed in the traditional way in the country, yet with innovation in technology and alterations in the consumer preferences, the fashion of prudent, healthy, and nourishing food is enhancing gradually with by employing mcommerce. The primary vegetables are grown in the country viz. potato, capsicum, onion, garlic, carrot, tomato, chilies etc. Though organic production in Pakistan is done on a minor scale as the situation is altering in response to accelerating the significance of the fresh produce as these vegetables are considered better in terms of quality as compared to traditionally grown vegetables as these vegetables are also considered prudent for healthy life, safe and nutritious [10].

Now days, smart technologies are being adopted by the consumers to buy commodities. Basically, consumer’s awareness has been improved due to social media and access to global markets. Consumers have access to various applications for identifying and buying the premium quality vegetables. It is also noticeable that with the advancement of mobile technology, mobile commerce has transformed the online business terrain of the world. To cultivate consumers' consumption habits, enhance the supply chains of fresh agricultural products, meet consumers' demands, and encourage the further development of commerce, it was necessary to comprehend the characteristics of consumers' preferences for online shopping. In this context, it appears logical to understand consumers ‘willingness to consume fresh vegetables. through Mobile Commerce in Punjab, Pakistan.

MATERIALS AND METHODS

The study was processed mainly in two stages. Firstly, consumers were interviewed for their perceptions and experiences of buying fresh vegetables via mcommerce in Pakistan. Then at second stage, consumers awareness’s were studied, and factors were identified which are affecting willingness to consume these vegetables by using mcommerce. Both qualitative and quantitative research techniques were employed for better understanding consumers’ perception and willingness to purchase fresh vegetables vie mcommerce in the selected regions. Data was gained through structured, semi-structured and non-structured in depth-interviews. The purposive sampling method were employed to get sample or data because it is ideal in the cases having small and diverse audience. A sample size of 600 respondents including two metropolitan cities of Punjab viz. Lahore and Multan including 300 from Multan and 300

consumers from Lahore were selected purposively [2].
The detailed explanation of the model is given as; Consumer willingness to pay for fresh vegetables by using mcommerce. The relationship between the selected dependent and independent drivers is given below:

$$WTP = f\ (Xi, Zj) \ \ldots\ldots\ldots\ldots.. (1)$$

where:
WTP = Willingness to pay for the fresh vegetables by using mcommerce (Rs. per kg)
Xi = Vector of quantitative drivers i = 4
Zi = Vector of qualitative drivers j = 7
In more particular way, equation (1) might be written as:

$$WTP = \beta o\, Xi\, \beta i\, Zj\, \beta j\, e\, \mu \ \ldots\ldots\ldots\ldots.. (2)$$

Taking ln on equal sides of the equation then equation (2) might be written as:

$$\ln WTP = \beta o + \beta 1 \ln X1 + \beta 2 \ln X2 + \beta 3 \ln X3 + \beta 4 \ln X4 + \beta 6 \ln Z1 + \beta 7 \ln Z2 + \beta 8 \ln Z3 + \beta 9 \ln Z4 + \beta 10 \ln Z5 + \beta 11 \ln Z6 + \beta 12 \ln Z7 + \mu \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where:
Categorical representation of the data of given independent drivers will be gained by employing five-point Likert scale as Very high=5; high=4; medium=3; low=2; and very low=1 Xs & Zs are the independent variables where:

X1 = age of the consumer
X2 = education of the consumer
X3 = income of the consumer
X4 = distance of vegetable store
Z1 = advertisement of fresh vegetables
Z2 = prices of fresh vegetables
Z3 = taste of organic vegetables
Z4= no synthetic pesticide residue of fresh vegetables
Z5= availability of fresh vegetables
Z6 = information of fresh vegetable
Z7 = useful cognition of mcommerce
βo=intercept; βs = are the elasticities; μ = error error

RESULTS AND DISCUSSIONS

The relationship between dependent variables (Consumer WTP for fresh vegetables using mcommerce) and independent variables (age of the consumer, education of the consumer, income of the consumer, distance of vegetable store, advertisement of fresh vegetables, prices of fresh vegetables, taste of fresh vegetables, no synthetic pesticide residue of fresh vegetables, availability of fresh vegetables, information of fresh vegetables, useful cognition of mcommerce) was estimated by using a regression model.
Collinearity is an unsuitable situation. This situation persists if when the correlations between or among the independent factors are strong with each other. The tolerance is a statistical term employed to check how much these independent factors are linearly correlated with each other (multicollinear).

Table 1. Multicollinearity Statistics of Factors

Factors	Tolerance	Variance Inflation factor (VIF)
Age of the consumer	.379	3.880
Education of the consumer	.342	2.592
Income of the consumer	.207	2.881
Distance of vegetable store	.132	3.663
Advertisement of fresh vegetables	.352	1.456
Prices of fresh vegetables	.751	2.934
Taste of organic vegetables	.367	1.856
No synthetic pesticide residue of fresh vegetables	.786	1.987
Availability of fresh vegetables	.432	1.334
Information of fresh vegetables	.450	2.798
Useful cognition of mcommerce	.789	1.559

Source: Authors' own calculations.

The VIF is the reciprocation of the tolerance test. If VIF rises, so does the differentiation of the variable coefficient, becoming it an unstable estimation. High VIF value indicates the problem of collinearity, i.e., a number higher than 10.00 portrays the issue of collinearity. In our results, all digits or

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numbers regarding VIF are low than 10.00 which depicted that no issue of collinearity presented in the given set of data.

The value of R^2 in our results was 0.59, which stated that all independent factors collectively explained 59% change in the given dependent variable, i.e., willingness to pay for fresh vegetables. This number also stated that few other factors also caused to change in it i.e. 41% variation in the dependent factor, the impact of which could not be described by the taken model and data set. The adjusted R^2 value was 0.61, which is also significant according to results of research. The adjusted R^2 portrays that all taken independent factors described that 61% variation in the taken dependent factor by considering all other variables constant.

The F-value depicts that all independent factors are significant ones/insignificant ones causing fluctuation in the suggested dependent factor. The F-ratio in the results was 17.86 ($p < 0.05$), which was fairly significant and depicted the appropriateness of the given model. According to the results, it might be stated that willingness to pay for fresh vegetables might be rupees five hundred and fifty rupees (550) per maunds without an impact from the independent factors.

Results shown in Table 2 show that a 1 percent rise in age means a rise in consumers' willingness to pay for fresh vegetables by 0.27 percent. There is a positive sign between both variables but it is significant. So, according to our results age does not guarantee or effect on the consumers' buying towards fresh vegetables by using mobile commerce. The value of coefficient of education is described as that for one unit change or increase in the education, there is 0.58 unit increase in consumers' willingness to pay for fresh vegetables by 0.58 percent by adopting mcommerce technology. This factor is significant at 5% percent significance level in the estimated model. Justification behind this effect, education plays an important role in creating awareness and then buying of fresh vegetables by selected consumers.

The value of coefficient of income of consumer is described as that for one unit increase in the income of consumer, there is 0.97 unit increase in consumers' willingness to pay for fresh vegetables by 0.97 percent. This factor is significant at 5% percent significance level in the estimated model.

Table 2. Econometric Analysis (Consumers' Willingness to Pay for Fresh Vegetables by using Mobile Commerce)

Factors	Coefficient	Standard Error	t-stat	*p*-value
Age of the consumer	0.27	0.056	2.348	0.77 NS
Education of the consumer	0.58	0.057	2.991	0.034**
Income of the consumer	0.97	0.091	1.867	0.055**
Distance of vegetable store	-0.25	0.064	- 1.442	0.05**
Advertisement of fresh vegetables	0.19	0.089	1.854	0.003**
Prices of fresh vegetables	-0.59	0.042	- 1.469	0.001*
Taste of fresh vegetables	0.23	0.084	3.444	0.75 NS
No synthetic pesticide residue use on fresh vegetables	0.29	0.098	2.926	0.89 NS
Availability of fresh vegetables	0.18	0.023	1.625	0.89 NS
Information of fresh vegetable	0.55	0.047	1.745	0.042**
Useful cognition of mcommerce	0.37	0.078	1.952	0.054**
(Constant)	5.50	0.771	77.68	0.85
R^2	0.59			
Adjusted R^2	0.61			
F- Value	17.86			

Source: Authors' own calculations.
* = Significant at 95% level of confidence, ** = Significant at 90% level of confidence, and NS = non-Significant

Justification behind this effect, family income and consumer willingness to purchase fresh vegetables by using mobile phone are positively correlated with each other.

The value of coefficient of distance from store is described as that for one unit increase in the distance from store outlet, there is 0.25 unit decrease in consumers' willingness to pay for fresh vegetables by 0.25 percent. This factor is significant at 5% percent significance level in the estimated model. High distance means high delivery charges to pay by the consumer although there is a significant but negative relationship.

The value of coefficient of advertisement of fresh vegetables is explained as that for one unit increase in the advertisement of fresh vegetables, there is 0.19 unit increase in consumers' willingness to pay for fresh vegetables by 0.19 percent. This factor is significant at 5% percent significance level in the estimated model. High advertisement of fresh vegetables means high willingness to purchase fresh vegetables by using m commerce in the study area.

According to the findings, the value of coefficient of prices of fresh vegetables is stated that for one unit decrease in the prices of fresh vegetables, there is 0.59 unit increase in consumers' willingness to pay for fresh vegetables by 0.59 percent. This factor is highly significant at 1% percent significance level in the estimated model. Decrease in prices of fresh vegetables lead the customer to buy more & more vegetable items by employing m commerce in the selected area.

Considering the findings, the value of coefficient of taste of fresh vegetables, it is stated that for one unit increase or improve in the category of taste of fresh vegetables, there is 0.23 times increase in consumers' willingness to pay for fresh vegetables by 0.23 percent. This factor is non significant in the estimated model.

As per findings of our research, the value of coefficient of no synthetic pesticide residue use on fresh vegetables, it is stated that for one unit increase or improve in the category of no synthetic pesticide residue use on fresh vegetables, there is 0.29 times increase in consumers' willingness to pay for fresh vegetables by 0.29 percent by using mcommerce. This factor is non significant in the estimated model.

According to the findings of our research, the value of coefficient of availability of fresh vegetables, it is stated that for one unit increase or improve in the category of availability of fresh vegetables, there is 0.18 times increase in consumers' willingness to pay for fresh vegetables by 0.18 percent by using mcommerce. This factor is non significant in the estimated model.

Considering the findings, the value of coefficient of information of fresh vegetables, it is stated that for one unit increase or improve in the category of taste of fresh vegetables, there is 0.55 times increase in consumers' willingness to pay for fresh vegetables by 0.55 percent. This factor is significant at 5% significance level in the estimated model.

The value of useful cognition of mcommerce of fresh vegetables is explained that for one unit increase or improve in the category of useful cognition of mcommerce of fresh vegetables, there is 0.37 times increase or improve in consumers' willingness to pay for fresh vegetables by 0.37 percent in the study area. This factor is significant at 5% percent significance level in the estimated model. Highly useful cognition of mcommerce for fresh vegetables implies that high willingness to purchase fresh vegetables by employing mcommerce in the study area.

The research was performed to identify the determinants affecting consumers' purchase intentions for the fresh vegetables by employing the technology of mobile commerce. In this way, consumer has gained more bargaining power in context of product quality and rupees. The results showed that was a positive but non significant relationship exist between the age and consumer's buying intentions by using mobile commerce. It might be due to reluctant behavior of usage of novel technologies by the older consumers. This result is supported by the studies of [1, 2, 7].

Generally, improvement in qualification level of the consumers lead towards buying intentions of consumers for the fresh vegetables with the help of mobile applications. In our research work, this theory is also supported as increase in educational status of the consumers direct them to purchase fresh vegetables with the means of smart phone applications. The education creates awareness among the consumer community about the health benefits of using fresh vegetables as well as usage or adoption of smart phone technologies for buying their fast moving consumer goods as well as fresh vegetables and fruits. This result is in line with the studies of [2, 5, 23].

Income or consumer purchasing power is taken as main component of the buying process. The improvement in this variable leads towards improvement or increase in buying behavior of consumers for fresh vegetables by employing cellular phones. According to our findings, this variable is significant with positive sign, which implies that the increase in income of the selected consumers navigate them to buy fresh vegetables by using mobile commerce technologies. This finding is supported by the research work of [2, 7, 8 14, 15, 22].

The distance of outlet also contributes towards buying of fresh vegetables by using mobile phone application. It also saves the time efforts for the consumers as well. So, there is a negative relationship prevail between distance from vegetable store/mart and consumer's intentions towards buying of fresh vegetables. As per findings of our research, it is depicted that there is negative but significant association exist between these two variables. The research result is aligned with the studies of [1, 2, 5, 22, 24].

Advertisement of products now days the use of social media/ICTs advertisement (Instagram, Facebook, What's app, We Chat, Cable TV, and TikTok) has been augmented. Advertisement is directly proportional to consumer's intentions of buying fresh vegetables via mobile commerce. The similar trend was observed in our research, there was a positive and profound relationship was found between the advertisement of fresh vegetables and buying intentions of consumers for fresh vegetables through mobile application. This finding is in line with the studies of [16, 23, 24]. Prices of agricultural commodities also adds towards consumer's buying decision/intentions towards online buying of fresh vegetables by using mobile applications. According to the findings of the study, there was a strong negative and considerable relationship existed between the prices of the fresh vegetables and buying of these vegetables by performing mobile commerce tasks and applications. The result is supported by the studies of [10, 11, 12, 13].

Taste of fresh vegetables also lead towards buying intentions of fresh vegetables by using mobile phone applications. But in our case the value of this coefficient is positive but insignificant. This result is in line the research studies of [2, 3, 14, 15, 18].

No use of synthetic pesticide residue on fresh vegetables also navigate the consumers to buy fresh vegetables by using mobile commerce. Consumers have got more awareness and advantages of organic produce. The educated consumers prefer to buy the vegetables by exploring its traceability. In metropolitan cities of Pakistan, well-established and reputed outlets are dealing with marketing of organic food stuff mainly organic vegetables. The coefficient of this variable is positive but non significant. It is supported by the studies of [2, 3, 8, 9, 10].

The presence of fresh commodities also play an imperative role while the purchasing of the produce. If consumers know the availability of fresh vegetables then the consumer will prefer to buy these fresh vegetables. The similar trend was found in our research, there was a positive and significant relationship between the availability of fresh vegetables and the buying behavior of consumers. The result is in line with the findings of [2, 8, 13, 14, 16]. In actuality, the consumers who have appropriate information about the benefits and importance of fresh vegetables, this information will definitely direct towards consumer's buying intentions of fresh vegetables via mobile commerce. According to our research findings, there was positive and significant relationship existed between the availability of information for fresh vegetables and buying decisions of consumers for fresh vegetables through mobile applications. It is supported by the findings of [11, 17, 19, 20].

The useful cognition of mcommerce technology characteristics as relative advantage, compatibility, observability, complexity, trialability, data security, also enable the consumers to purchase fresh vegetables by using mobile applications. The same trend was followed as positive and significant association prevailed between the cognition of mcommerce and buying intentions of consumers towards fresh vegetables in our research work. The result is in line with the studies of [2, 3, 4, 5, 15, 23, 24].

CONCLUSIONS

In Pakistan, the demand of fresh vegetables are growing rapidly by using the concept of mobile commerce, but a niche market exists, and consumers prefer and are ready to pay premium prices for fresh vegetables. The study investigated the impact of major determinants influencing consumers' willingness to pay for fresh vegetables via mcommerce in Punjab, Pakistan. In this regard, Lahore and Multan were selected purposively. A sample size of 600 fresh vegetable consumers was selected. Regression analysis was used to identify and evaluate the effects of consumers' willingness to purchase for fresh vegetables in the study area. As per findings of research study, income of the consumer, education of the consumer, distance of fresh vegetable from store, advertisement of fresh vegetables, prices of fresh vegetables, availability of fresh vegetables, cognition of mcommerce are significantly influencing consumers' willingness to buy fresh vegetables by using mobile commerce whereas taste of fresh vegetables, age of consumer, no use of synthetic pesticide residue on fresh vegetables, availability of fresh vegetables are influencing non significantly to consumers willingness to buy fresh vegetables in the study area. The results were helpful in developing room for maneuvering of major food super stores or markets regarding market potential of fresh production then ultimately these findings would be beneficial for these stores to cater the need of consumers who have interest to buy these vegetables via mobile commerce. It is a novel business approach that expands the frontiers of the mobile commerce.

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STRATEGIC MANAGEMENT OF SUSTAINABLE RURAL ECONOMY DEVELOPMENT IN VAIDEENI COMMUNITY, VALCEA COUNTY, ROMANIA

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Abstract

The sustainable management of endogenous resources is a complex and current theme of global interest that promotes a territorial diagnosis model to highlight the specificity of the studied area and develop relevant strategic options for the development of the rural economy. The actuality of the research has a counterpart in the requirement of the development of the rural economy by the achievement of the modernization criteria and the preservation of the natural and anthropic heritage, and the complexity is highlighted by the orientation towards innovation in the sense of the adoption and implementation of technologies with low impact on the environment. Specifically, the research aims at the strategic diagnosis of Vaideeni commune in order to identify the endogenous resources and developing relevant strategies for their sustainable exploitation. Vaideeni commune is located in Vâlcea county and represents a remarkable area recently declared a tourist resort of local interest, rich in traditions and customs preserved unaltered. For the strategic diagnosis, the PESTEL model was used, the usefulness of which is recognized, because it allows highlighting the particular aspects of the studied community. The results of the PESTEL model allow the adoption of relevant measures to correct the rural economy and improve its resistance to the increasingly frequent changes occurring in the environment. Next, the SWOT analysis was used, doubled by the realization of a focus group with key local factors and specialists, concerned with the development of the rural economy. The general conclusion derived from the results obtained when applying the PESTEL and SWOT analysis models highlights that the sustainable development of the rural economy is closely related to the territorial specificity and is supported by the community that gives life to and maintains the territory that belongs to it.

Key words**:** *diagnosis, economy, resources, rural, sustainability*

INTRODUCTION

The issue of rural development in Romania has as a benchmark the accession to the European Union (January 1, 2007) and is focused on the development and implementation of relevant measures to adapt the rural economy to the territorial specificity and integration into the internal market of the European Union through the adoption of the Agricultural Policy Commons [23]. In this context, the sustainable development of the countryside is considered a process characterized by complexity and actuality oriented towards the sustainable exploitation of endogenous resources and the active involvement of the community in the elaboration, implementation, and adoption of relevant strategies for the superior exploitation of its potential. The justification for such an approach is underlined by the wealth and diversity of resources, respectively by the need for their sustainable exploitation in the context of awareness of the limited nature of resources and the ever-increasing demand for food in the conditions of environmental protection and climate change. The choice of this research topic is motivated by the interest that the European Union gives to rural areas and the inclusion in the Common Agricultural Policy of numerous levers of development that Romania adopts for implementation through the National Strategic Program. At the same time, the numerous situations of irrational capitalization of resources require the promotion of such research themes [14, 15]. The central element of the choice of this theme is given by the identification of the most effective means of integration of the developed activities and implicitly by stimulating their diversification in favor of the non-agricultural ones, respectively by encouraging the performance in the agricultural domain [19]. The specialized literature highlights numerous factors with relevant influence on sustainable rural development. They are of an internal and external nature with the mention that recently the role of internal factors is emphasized. The present research is subordinated to the new concept of territorial development which states that economic development is mainly determined by endogenous factors [24, 25], and investments in human capital, innovation, and knowledge are relevant supporters. The endogenous forces involved in this process are represented by factors of local responsibility and various resources - natural, human, material, economic, social, cultural, and spiritual [29]. At the same time, the research takes into account the fact that any territory has a number of characteristics that give it individuality, specificity, and authenticity that must be developed and exploited sustainably, in order to keep them unaltered [13].

The work aims to sustainably capitalize on the endogenous resources available at the territorial level, for the achievement of which the following objectives were established: the strategic diagnosis of Vaideeni commune with reference to the endogenous resources and how to capitalize on them; the choice of the case study as a research methodology and the inclusion of relevant methods of strategic analysis; the development of relevant strategic options for the sustainable exploitation of endogenous resources. The research was carried out in the Vaideeni Territorial Administrative Unit (UAT), located at the foot of the Căpățânii Mountains in the northwest of Vâlcea county with geographic coordinates: 45o10′02″ N 23o56′17″E. It has an area of 15,759 ha, of which approximately 10,000 ha are covered with forests [18].

Local responsibility factors and community members show concern for the long-term capitalization of available endogenous resources by carrying out agricultural and non-agricultural activities with concern for the diversification of the latter through relevant entrepreneurial combinations. For a greater applicability of the phenomenon, encouraging measures are needed in the form of relevant strategies, and this paper provides a model for their elaboration, a model that can be replicated for other areas.

Map 1. Location Vaideeni commune
Source: Map carta Vaideeni, https://mapcarta.com/13673614, Accessed 22.05.2024.

MATERIALS AND METHODS

In The research methodology adopted is the case study because it involves the in-depth study of the rural economy, in the natural setting of the Vaideeni commune, from several perspectives [12]. The case study is a method of holistic analysis applied to complex situations and provides a complete illustration of the analyzed phenomenon "integrated into a real way of life and complete with numerous information from various sources (interviews, questionnaires, testimonies, evidence, documents, direct observation, participant observation)" [28]. Specifically, within the research methodology, quantitative and qualitative methods were used "different but complementary" [17], such as: secondary analysis of specialized literature, identification of critical factors and successful initiatives, application of models of PESTEL (political, economic, social, technological, natural, legislative) and SWOT (strengths, weaknesses, opportunities, threats) analysis. To ensure continuity, we proceeded to carry out the SOR analysis (consolidated by focus-group meetings) and create the problem tree and the objective tree to highlight the problems, and the causal relationships and develop solutions to solve them to develop the rural economy sustainably. The application of the mentioned methods was carried out successively according to the structure shown in Figure 1.

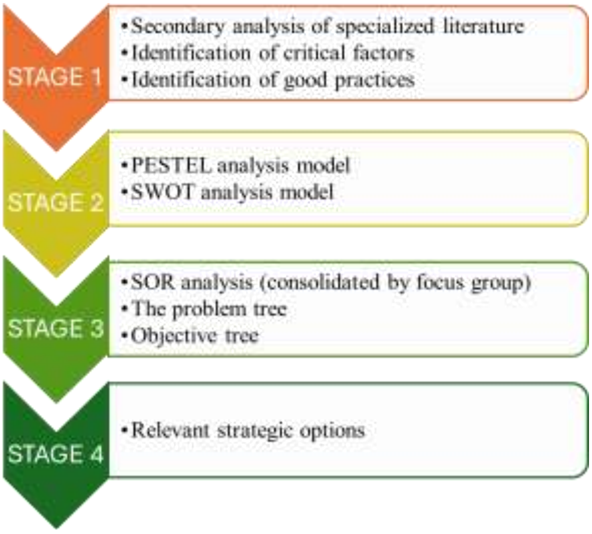

Fig. 1. Schematic structure of the research
Source: Own conception.

From the schematic structure of the research, its development in four stages is highlighted. In stage 1, we proceeded to collect data and information following the purpose of the research using the questionnaire applied at the territorial administrative unit (UAT) level, the secondary analysis of the statistical data and the relevant literature, respectively the observation for the qualitative improvement of the information. The obtained results outlined a realistic picture that also highlights critical factors and good practices. The second stage consisted of carrying out the strategic diagnosis of Vaideeni commune, Vâlcea county with the help of PESTEL and SWOT models [7,16].

RESULTS AND DISCUSSIONS

The materialization of the research consisted of accessing, using, creating, and promoting knowledge, respectively in the realistic highlighting of the level of sustainable development of the community in UAT Vaideeni, Vâlcea county as it results from the detail presented:

I. The study stage of statistical data and specialized literature regarding the development of Vaideeni commune, Vâlcea county highlights an increased interest of specialists for the endogenous potential, respectively the positive results recorded at the level of the 3 pillars of sustainable development (economic, social and ecological). It is also noteworthy the orientation towards the development and diversification of economic activities (non-agricultural), emphasizing the role of agriculture, especially sheep farming, for the development of the community [1, 9, 10, 2]. It was also highlighted that the development of viable solutions for sustainable development is in the attention of specialists, but the expected progress has not yet been achieved.

II. The strategic diagnosis stage using the PESTEL model highlights a series of factors with an impact on this sustainable development, grouped according to the following criteria:

The analysis of the political criterion is centered on the existence of a legislative framework dedicated to the sustainable development of the rural area highlighted at the level of the European Union through the Common Agricultural Policy (CAP) based on the Treaty on the Functioning of the European Union. The purpose of the CAP is to support farmers and guarantee Europe's food security. PAC has evolved with economic development and adapted to the demands and needs expressed over time by consumers. Currently, the 2023-2027 PAC is based on the specific legal framework and the set of detailed specifications in the PAC strategic plans (PS) approved by the European Commission [3]. PS CAPs are intended to make a major contribution to meeting the objectives of the European Green Deal, the Farm to Fork Strategy, and the Biodiversity Strategy (European Green Deal, Farm to Fork Strategy, Biodiversity Strategy) [20, 4, 5, 6]. Thus PAC fulfills multiple functions in society: food production, rural community development, and promotion of sustainable agriculture. For the period 2023-2027, the implementation of the PAC in Romania is carried out through the National Strategic Plan (PNS) which contains measures for the development of a sustainable rural economy. The Local Development Strategy (SDL) ensures the implementation of rural development measures according to the PAC through the PNS at the Vaideeni UAT level, Vâlcea County [26].

The analysis of the economic criterion attests agriculture as the main activity in UAT Vaideeni, Vâlcea county, as well as the development of tourism, Vaideeni commune is a tourist resort. The development of agricultural activities is primarily based on the existing natural resources that mainly favor animal husbandry represented by 2,992 ha of pastures and 1,739 ha of hayfields that provide most of the fodder necessary for raising about 22,000 sheep, 2,820 cattle, 2,100 pigs, and 700 goats. On the 320 ha of arable land, corn, potatoes, and vegetables are mainly grown. Fruit growing occupies about 640 ha where the predominant species are apple and plum. The forest and other forest vegetation is also a renewable resource well represented by the approximately 9,600 ha exploited through various forestry activities [8, 22]. The utilization of endogenous resources available in Vaideeni commune, Vâlcea county is generally carried out at the household level through subsistence agriculture. There is also an appreciable number of enterprises carrying out activities in the following fields: agriculture, hunting, and services (5), forestry (9), food industry (7), wholesale trade (2), retail trade (11), beverage manufacturing (1), wood processing (1), manufacture of chemical substances and products or rubber (1). The workforce numbers around 310 employees (SDL, Vaideeni. Local producers in the categories of vegetables, fruits, jams and jams, bee products, dairy products, and natural juices are promoted in a special section on its website. Also, 13 local producers registered in the National Register of Mountain Products use the mention of mountain product quality, which certifies the mountain origin of the raw materials and feed, the positive influence of their quality on the raw materials of animal origin, and the processing of agri-food products in the mountain area (in our case in UAT Vaideeni, Vâlcea county). Tourist activity at Vaideeni UAT, Vâlcea county is registered on an increasing trend by the tourist resort status, a fact also demonstrated by the tourists visiting the area whose number of arrivals reached a maximum in 2019 (1019 tourists), decreased as a result of the COVID-19 pandemic (617 in 2020) and continued to grow until it reached the number of 748 in 2023 to which 336 arrivals in apartments and rooms are added [21, 27]. At the same time, the positive evolution of the accommodation capacity in tourist structures from 40 places in 2019 to 58 in 2023 (agritourism pensions) is also noted, to which 52 places are added in apartments and rooms for rent [22].

The analysis of the social criterion leads to the highlighting of the phenomenon of depopulation in most mountainous areas in Romania, with the mention that it reaches a minimum in 2022 from where it starts to register a slight increase as can be seen in Figure 2.

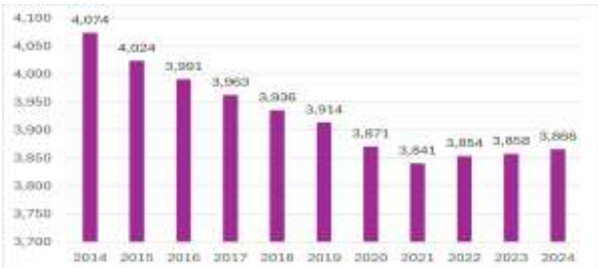

Fig. 2. Population evolution in UAT Vaideeni, Vâlcea county
Source: NIS data Tempo online, 2024, own processing.

This state can also be on the effects of the implementation of policies, programs, and projects included in the local development strategy. The population density is 24 inhabitants/km2. The road infrastructure of UAT Vaideeni, Vâlcea County is good, and the geographical location at the micro-regional, county, and regional levels ensures connectivity with county and national roads. The density of road transport infrastructure corresponds to the current level of development and prospects, its quality requires improvement. The infrastructure of public utilities is well represented by a water supply network with a length of 18,796 m a sewage network with a total length of collecting channels of 3,091 km and a total length of pipelines of 2,463 km. There is also a treatment plant with an installed capacity of 23.58 mc/h and 6.55 l/s and an operating capacity of 4.7 mc/h and 1.3 l/s [8]. All households, institutions, and economic agents are connected to the electricity distribution network. There is no methane gas supply network, thermal energy is provided with stoves and/or individual thermal plants. Waste management is done locally. In Vaideeni UAT, Vâlcea County, the health infrastructure includes two family medical practices and two pharmacies. Social problems are solved with the help of a community nurse and two social workers from the Mayor's specialized apparatus. Education in UAT Vaideeni, Vâlcea county is provided by Luca Solomon Secondary School (Vaideeni village), it has 14 classes, 2 laboratories, an IT office, a library, and a sports field. Each of the neighboring villages has a primary school as follows: Primary School in Atârnati with 3 classes, Primary School in Izvoru Roșu with 3 classes, 1 computer lab, 1 laboratory and library, Primary School in Marița with 2 classes. The number of enrolled children is decreasing and hovers around 380, they are guided by 35 teachers. To these are added 4 kindergartens (about 100 children) and 7 educators.

The analysis of the technological criterion highlights the ability of UAT Vaideeni, Vâlcea county to assimilate sustainable technologies and concerns for increasing the population's access to information and professional training, increasing innovation capacity, and increasing research and development expenses. Also, the location near the town of Horezu creates the conditions for an appreciable level of spending on innovation and the number of enterprises, especially in the field of rural tourism. There is an appreciable number of entrepreneurs who have innovated in products, technological processes, organizational and marketing methods. The main objective of the innovation was to improve the quality of the products, the orientation towards the mention of mountain product quality, and later towards the expansion of the range of products and services. The local administration has numerous projects aimed at innovation and sustainability, as follows: "Purchase of aggregates for snow removal and sanitation in Vaideeni commune, Vâlcea county", through which the purchase of an aggregate for sanitation and snow removal was achieved; DiVA-HUB Digital Innovation HUB Vaideeni an acre project brings together research-development-innovation and tourism; Development of a ski area in the Ursu-Ursuletu holiday village, Vaideeni Commune, Vâlcea County; Development of a ski area in the Transcapatanii Ski - Bear resort, Vaideeni Commune, Vâlcea County; Development of leisure infrastructure in Voineasa tourist resort-Vâlcea County-Adventure Park - Partnership with County Council.

The analysis of the natural criterion highlights a predominantly mountainous area, little anthropically modified with small localities where the density of the stable population is low. Vaideeni commune, Vâlcea county is located at the foot of the Căpățâna mountains, in the north of the Horezu subcarpathian depression and on the upper Luncavațului valley. The geographical coordinates place Vaideeni commune at the intersection of the parallels of 45º10'30" north latitude with the meridian 23º55'30" east longitude. The village of residence is at an altitude of 567 m, the village of Recea at 650 m, and the village of Cerna at 610 m, resulting in an average altitude of 610 m. Climatically, it is on the border between the hill climate II and the specific mountain climate, climate type III. It presents a rich diversity of flora and fauna represented by beech forests, beech with softwoods, and softwood forests (spruce, rarely fir, and pine even yew). Juniper, rose hip, raspberry, blueberry, juniper, and herbaceous vegetation (mosses, lichens), as well as bluebells, rock gorse, mountain lily, bear's grape cornflower (vulnerable species) can be identified next to it. The fauna is rich and diverse, represented by birds (nightingales, warblers, titmouses, etc.) and carnivorous animals (fox, wolf, marten, wild boar, deer, squirrel, deer, Carpathian lynx, black goats, brown bear). The meadows present a qualitative floristic composition that has a positive effect on the quality of the mountain products - an element of identity and development of these areas [26].

The analysis of the legislative criteria attests to the existence of specific laws and regulations for the sustainable development of mountain areas. Public research and executive institutions specialized in rural development, the non-governmental organizations in the field, and the numerous studies, pilot projects, normative acts, and specialists are elements that contribute to the realization of a legislative framework suitable for the sustainable development of rural mountain areas and provide specialists for the application of the EU/EC Resolutions regarding the concept of "mountain product ” product with Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI), etc. This gives a great chance to the mountain economy if the contained government policies are implemented in an integrated manner.

The relevance of the criteria/sub-criteria of the PESTEL model, for the sustainable development of UAT Vaideeni, Vâlcea county:

The strategic diagnosis carried out according to the PESTEL model identified the characterization elements of UAT Vaideeni, Vâlcea county. They are presented centrally about the analysis criteria, highlighting the relevant sub-criteria. (Table 1).

Table 1. Results (criteria and sub-criteria) of using the PESTEL model

POLITICS	ECONOMIC
Adequate legislative framework represented at the level of: • EU of Common Agricultural Policy, European Green Deal, Farm to Farm Strategy, Biodiversity Strategy. • Romania by National Strategic Plan (PNS) • UAT Vaideeni, Vâlcea county of Local Development Strategy (SDL). SDL promotes coherent policies, appropriate social policies, and a friendly business environment	The rural economy is structured by branches Agriculture is the main branch Rural tourism is an economic branch under development Business environment favorable to the development of small businesses and their orientation towards the production of products with the mention of mountain product quality The labor force in a slightly increasing trend
SOCIAL	**TECHNOLOGICAL**
The depopulation characteristic of mountain areas is stabilized at the level of 2022 for UAT Vaideeni The social policies implemented numerically register the population on a slightly increasing trend (2023,2024) The road infrastructure is eco-friendly and ensures connectivity with national roads Public utility infrastructure is well represented. There is a nurse and 2 social workers Education is well-represented	UAT Vaideeni has the capacity for: • Assimilation of sustainable technologies • Increasing the population's access to information and professional training • Increasing innovation capacity and spending on research and development There are many projects that aim for innovation and sustainability
NATURAL	**LEGISLATIVE**
Predominantly mountainous area with little human modification Small towns located at an average altitude of 600 m Rich diversity of flora and fauna The meadows have a qualitative composition that positively affects the quality of mountain products.	Laws and regulations for the development of hilly and mountainous rural areas (PAC, PNS, Mountain Law) normative acts and specialists for the application of EU/EC Resolutions regarding the concept of "mountain product" product with protected

Source: Own information resulting from the PESTEL diagnosis.

The characterization elements were used in the process of assessing the relevance of each sub-criterion selected for the research (Table 2). It was possible to identify 24 sub-categories whose relevance for the research was assessed by organizing a focus group to which local responsibility factors and specialists in the field were invited and participated.

They were asked to appreciate on a scale with 5 levels from 1 to 5 points where 1 represents the very insignificant appreciation and 5 the very significant appreciation, the importance of each sub-criterion for the achievement of the project's purpose. Appreciating the relevance of the criteria and sub-criteria of the PESTEL model for the relevance to the fulfillment of the purpose of the research determined a better orientation of the responsible factors and stakeholders in the process of sustainable rural development.

Table .2. The relevance of the criteria and sub-criteria of the PESTEL model

Diagnostic criteria	Sub-criteria	Impact on future strategy				
		1	2	3	4	5
POLITICS	The corresponding legislative framework at the EU level (CAP)					
	The corresponding legislative framework at the national level (PNS)					
	Appropriate legislative framework at the local level (SDL)					
	Policies to support and encourage local products					
ECONOMIC	Dominance of agricultural activities and small farms					
	Rural tourism is an economic branch under development					
	A business environment favourable to the development of small businesses oriented towards the production of products with the mention of mountain product quality					
	The labor force in a slightly increasing trend					
SOCIAL	The depopulation characteristic of mountain areas is stabilized at the level of 2022					
	Social policies appropriate to population enrollment in a slightly increasing trend (2023,2024)					
	The road infrastructure is eco-friendly					
	Adequate educational system					
TECHOLOGICAL	Ability to assimilate sustainable technologies					
	Population access to information and professional training					
	Increasing innovation capacity and spending on research and development					
	Implementation of projects aimed at innovation and sustainability					
NATURAL	Predominantly mountainous area with little human modification					
	Small towns located at an average altitude of 600 m					
	Rich diversity of flora and fauna					
	Meadows with a qualitative composition that has a positive effect on the quality of mountain products					
LEGISLATIVE	Laws and regulations for the development of hilly and mountainous rural areas (PAC, PNS, Mountain Law)					
	Environmental protection laws and regulations:					
	normative acts for the application of the EU/EC Resolutions regarding the concept of "mountain product"					
	normative acts for the application of EU/EC Resolutions on products with protected designation of origin (PDO) and protected geographical indication (PGI)					

Source: Own information resulting from the PESTEL diagnosis.

III. Results obtained from the implementation of SWOT and SOR models

The matrix arrangement of the elements specific to the studied area in the form of the four quadrants (strengths, weaknesses, opportunities and threats) led to the easy capture of the most advantageous combinations and the identification of strategic options relevant to the purpose of the research. (Table 3). The specific elements were identified through the analysis of the criteria describing the analyzed territorial life framework (PESTEL) and selected within the semi-structured interviews addressed to the responsible factors and stakeholders.

The numerous elements of specificity required the continuation of the research by assessing the relevance of the opportunities and threats on the strong and weak points (SOR analysis) to rank them and take into account the most relevant ones for the research. For this, we organized a focus group meeting attended by 7 people, representing key local factors and specialists concerned with the sustainable development of the rural economy. Some of them also participated in the preliminary phase of the research as interviewees, and are representatives of some institutions with concerns in the field, such as local councils, town halls, APIA, GAL, entrepreneurs, and universities.

Table 3 SWOT matrix

	STRONG POINTS		WEAKNESSES
1	Outstanding natural resources and potential for sustainable development	1	Geographic isolation
2	Ancient traditions well preserved	2	Aging population
3	Attachment to the commune, traditions, and values	3	Unexploited tourist potential
4	Local authorities involved in community life	4	Deficient health system
5	Adequate road infrastructure	5	Lack of public transport in UAT
6	Adequate educational infrastructure	6	Lack of online education (infrastructure and human)
7	Development of traditional local economic activities	7	Poor promotion in the virtual environment
8	Obtaining and promoting local products with the mention of mountain product quality	8	Lack of support measures for the development of the local business environment
9	Annual plan rich in cultural events	9	Lack of digitization at the level of local government
10	The ability to work in partnership (GAL Microregion Horezu)	10	Low capacity of local administration to attract external financing sources
11	the development of joint projects within the LAG	11	Poor development of services
	OPPORTUNITIES		**THREATS**
1	Laws and regulations for the development of rural areas (PAC, PNS, etc)	1	The COVID-19 pandemic crisis
2	Financing period 2021-2027 beneficial to the rural economy	2	The effects of the war in Ukraine
3	Tourist resort status	3	Reduced access to vocational training
4	The possibility of accessing funds for digitization in local public administration	4	Dominance of agricultural activities and small farms
5	Policies to support and encourage local products	5	The predisposition towards an exaggerated consumption of resources
6	The possibility of attracting labor force from outside the locality through telework	6	Low funds for educational and social infrastructure and heritage rehabilitation
7	Increasing attaractivity for local products	7	Promotion and support strategies for local products not adapted to the requirements
8	Increased capacity to assimilate sustainable technologies	8	Increased competition and costs in small holdings as a result of the CAP
9	Business environment favorable to the development of small businesses	9	Weak bargaining power of agricultural producers (low price for products and unmotivated activity)
10	normative acts for the application of EU/EC Resolutions: • regarding the concept of "mountain product"	10	The example of parents (who work abroad) does not motivate young people to continue their studies
11	• regarding products with protected designation of origin (PDO) and • protected geographical indication (PGI)	11	Lack of policies and strategies to attract young people

Source: Own information resulting from the diagnosis.

They noted in the SOR tables (on a scale from 0 – not important to 3 – very important) the relevance of the opportunities and threats on the strengths and weaknesses from the perspective of the project's purpose (Table 4).

The obtained results reveal the most important elements of specificity. These are presented in matrix form in a succinct SWOT matrix (Table 5) whose analysis easily determines rural development measures.

Table 4. SOR analysis

SP/ W	OPPORTUNITIES											THREATS											Total
	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	
SP_1	18	21	18	20	16	15	20	18	19	21	20	18	19	20	16	18	12	18	16	17	16	18	394
SP_2	18	20	16	18	18	16	19	18	19	20	18	18	20	19	15	16	14	16	17	16	16	15	382
SP_3	16	18	15	16	15	16	15	16	17	17	15	19	19	18	16	16	15	14	15	14	15	16	353
SP_4	15	16	16	15	14	15	15	17	17	16	16	17	16	16	14	15	15	12	14	14	15	16	336
SP_5	16	15	15	16	15	15	14	16	16	17	14	16	18	17	15	14	16	14	15	13	16	15	338
SP_6	17	16	14	15	17	16	15	14	13	14	15	14	17	15	17	16	15	14	16	14	15	17	336
SP_7	19	20	18	19	20	19	21	18	20	19	20	18	19	19	17	21	21	20	18	17	17	19	419
SP_8	19	21	19	18	19	20	18	19	21	18	19	18	18	19	20	20	17	18	20	19	17	20	417
SP_9	16	17	16	15	16	15	14	17	17	18	15	16	14	16	16	17	17	19	19	15	15	16	356
SP_{10}	18	20	19	18	19	18	19	17	20	19	18	17	17	19	19	20	17	16	18	18	19	17	402
SP_{11}	19	20	21	18	20	21	18	19	20	17	21	19	19	20	20	21	17	18	18	17	20	18	421
W_1	19	20	18	20	17	15	18	18	19	18	20	17	17	18	17	16	14	18	16	16	17	17	385
W_2	18	19	18	17	17	18	19	19	18	21	18	19	19	20	16	16	15	17	18	17	16	15	390
W_3	19	17	21	18	19	15	19	20	19	20	19	18	18	19	17	17	16	16	17	18	18	17	397
W_4	15	14	15	16	16	17	17	12	15	15	17	18	18	16	17	13	15	14	16	13	15	14	338
W_5	14	15	15	14	14	15	14	16	16	15	16	17	17	18	16	16	15	15	13	13	14	16	334
W_6	15	15	13	12	12	15	15	16	14	14	12	12	15	16	14	12	15	16	13	13	15	14	308
W_7	14	13	13	12	12	16	15	15	12	12	14	13	13	16	14	10	15	21	16	15	13	17	311
W_8	15	16	19	19	21	20	20	21	19	19	20	18	16	17	19	15	20	18	18	17	19	20	406
W_9	16	15	20	17	19	19	17	20	19	19	19	17	17	18	19	19	19	18	19	19	20	19	404
W_{10}	17	19	20	15	18	19	20	15	20	19	18	15	18	18	21	19	20	18	18	19	17	19	402
W_{11}	20	20	21	19	20	20	15	15	18	19	21	17	17	19	20	20	20	19	20	18	18	19	415
TOTAL	373	387	380	367	374	375	377	376	388	387	385	371	381	393	375	367	360	371	370	352	363	374	

Source: Own results obtained from focus group meetings.

Table 5. Summary SWOT matrix

STRONG POINTS		WEAKNESSES	
1	Outstanding natural resources and potential for sustainable development (agriculture, tourism, food industry)	1	Aging population
2	Ancient traditions well preserved	2	Unexploited tourist potential
3	Development of traditional local economic activities	3	Lack of support measures for the development of the local business environment
4	Obtaining and promoting local products with the mention of mountain product quality	4	Lack of digitization at the level of local government, education or health
5	The ability to work in partnership (GAL Microregion Horezu)	5	Low capacity of local administration to attract external financing sources
6	Development of joint projects within the LAG	6	Poor development of services (commercial, banking, etc.)
OPPORTUNITIES		**THREATS**	
1	Financing period 2021-2027 beneficial to the rural economy	1	The consequences of the war in Ukraine
2	Tourist resort status	2	Reduced access to vocational training
3	Increasing the attractiveness of local products	3	Dominance of agricultural activities and small farms
4	Business environment favorable to the development of small businesses oriented towards the production of products with the mention of mountain product quality	4	Promotion and support strategies for local products not adapted to the requirements
5	normative acts and specialists for the application of EU/EC Resolutions:	5	The negative influence of the CAP on small holdings by increasing competition and costs
6	• regarding the concept of "mountain product"	6	Lack of attractive policies and strategies for young people

Source: Own results.

The results obtained from the application of the case study methodology and the included analysis models allow the easy identification of problems and create the prerequisites for identifying the causes of their occurrence. This is done using the problem tree method. To develop the solutions to solve them, we proceeded to use the objective tree method.

Results obtained from the application of problem tree and objective tree methods

The frequent use of the problem tree in the process of strategic planning justifies our option for it in the identification of causal relationships of rural development problems in UAT Vaideeni, Vâlcea county (Fig. 3).

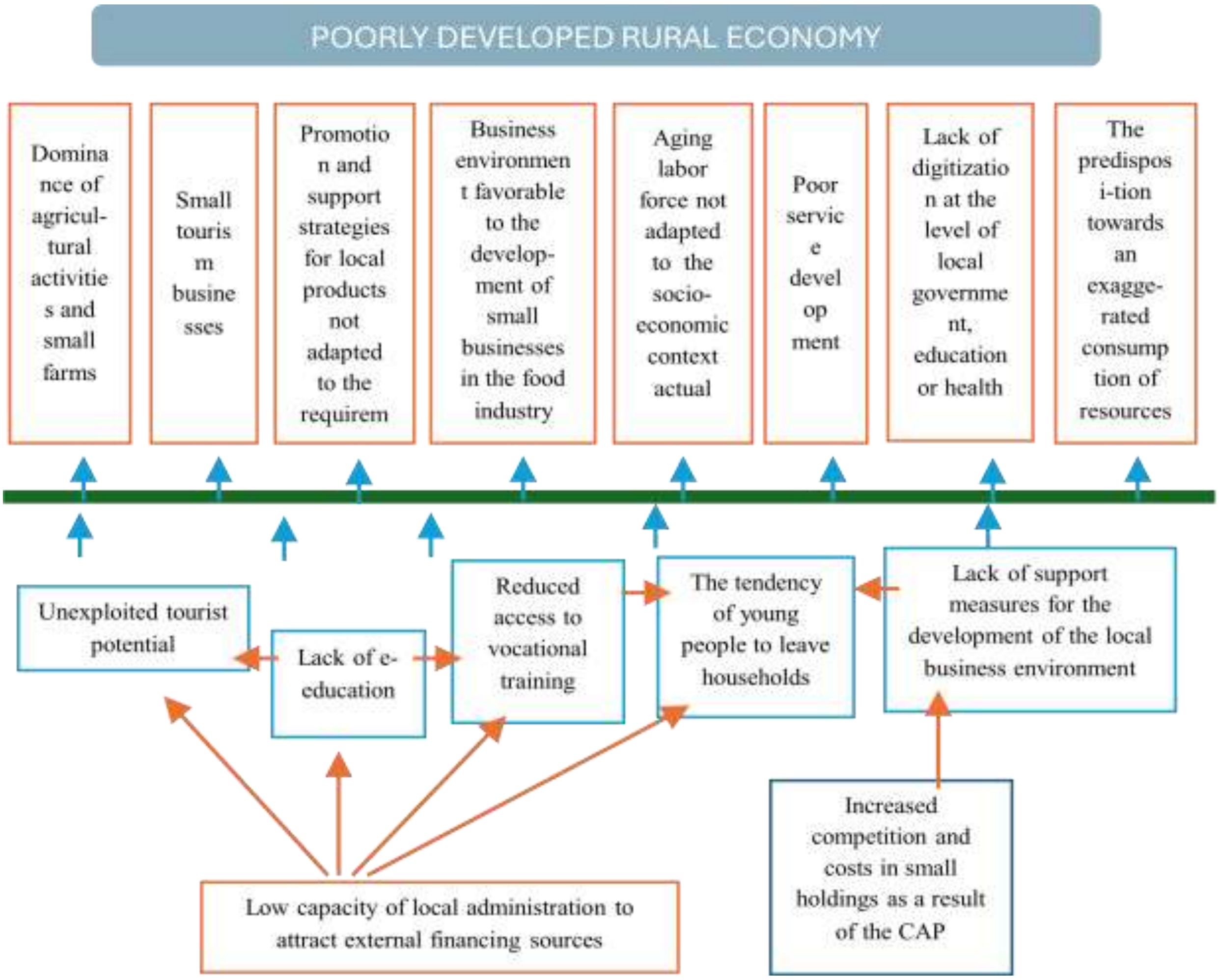

Fig. 3. The problem tree of the sustainable development of the rural economy in UAT Vaideeni, Vâlcea county
Source: own processing.

After identifying the problems and causal relationships, solutions (strategic measures) were developed to replace the problems in the problem tree, obtaining the objective tree (Fig. 4.) with the mention that a problem is solved by several solutions, and one solution can solve several problems.

In the tree of objectives, the strategic options identified with the help of SOR analysis are highlighted, which proves that two different analysis methods (SOR and the problem/objective tree), but correctly carried out, lead to similar results [11, 14].

The integration of the results obtained within the methods used leads to the development of relevant strategic options for the orientation of the rural economy toward sustainable development. They are grouped into two strategic directions, the first for the development of strategic options aimed at preparing the framework necessary for the implementation of sustainable development and the second for the development and implementation of strategic options specific to the achievement of sustainable development.

The first strategic direction highlights the following strategic options:

•Developing the capacity of the local administration to work in partnership (with the Horezu Microregion LAG and other entities);

•Promotion of online education to achieve partnerships and knowledge in the field of accessing funding sources

•Promoting rural entrepreneurship for sustainable exploitation of natural resources and traditions

•Creating a business environment favorable to the development of SMEs and the realization of "mountain product

Within the second strategic direction, the following strategic options were developed:

•Effective capitalization of the post-2020 financing framework favorable for the rural economy;
•Development of joint projects within the LAG
•Effective utilization of the EU/EC Resolutions regarding the concepts of mountain products, products with protected designation of origin (PDO), and products with protected geographical indication (PGI);
•Diversification of social assistance services
•Increasing the quality of life
•Increasing attractiveness for qualified young people

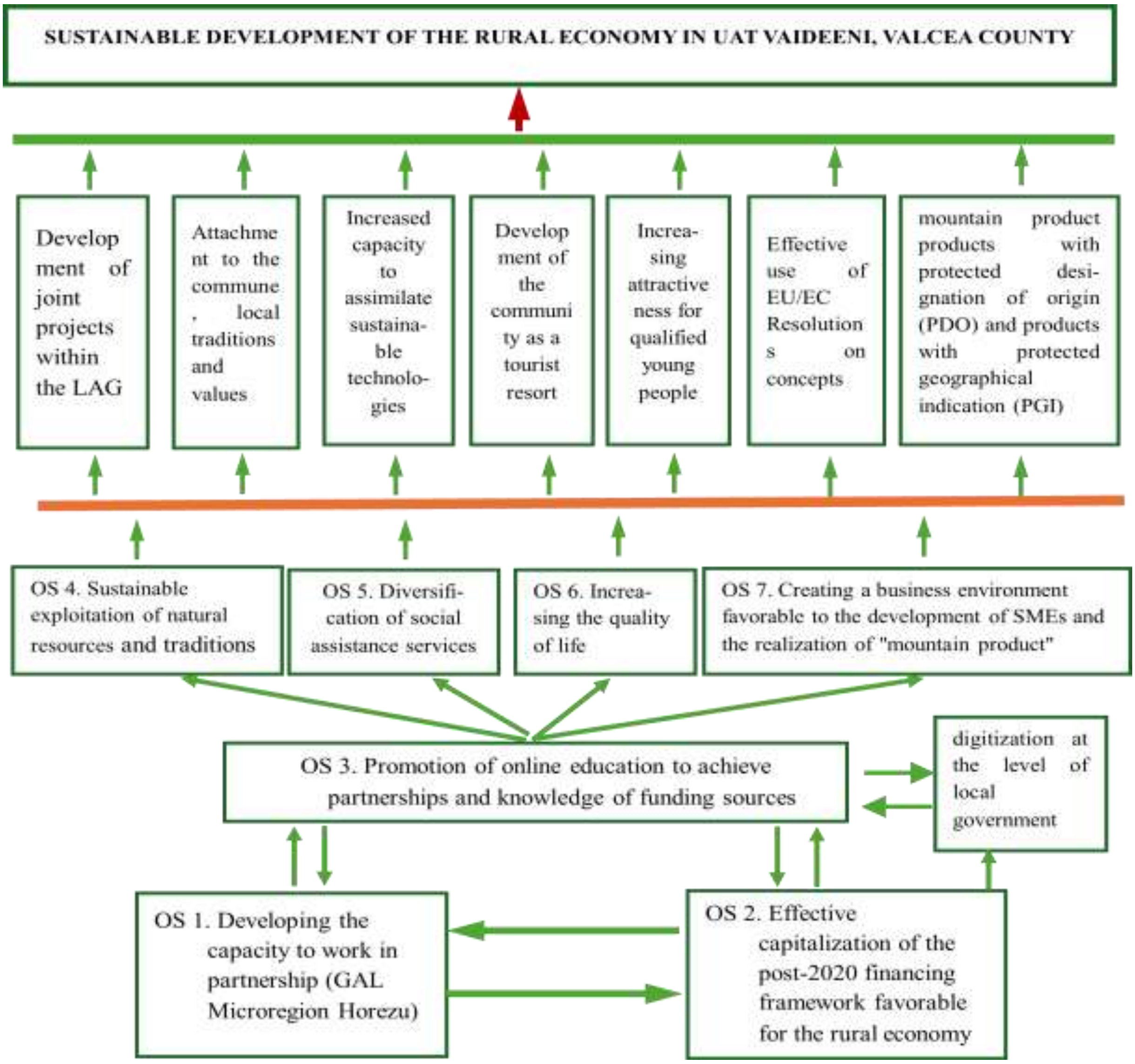

Fig. 4. The objective tree of the sustainable development of the rural economy in UAT Vaideeni, Vâlcea county
Source: own processing.

CONCLUSIONS

The research topic is subscribed to the global concerns in which each country, depending on the experience gained in the community space and the economic and social context, carries out specific activities to develop objectives, strategies, and measures for the sustainable development of the rural economy.

The use of the case study methodology in researching the sustainable development of the rural economy is justified by the positive results obtained in numerous studies and by the ability to integrate quantitative and qualitative methods, respectively to adapt to the research topic.
The research identifies the specific elements of the studied area, highlights the problems of sustainable development elaborates solutions

to overcome them, and frames the rural economy on a trend favorable to the desired achievement according to figures 3 and 4.

The research is completed with the elaboration of strategic options for the sustainable development of the rural economy in the UAT Vaideeni, grouped in two strategic directions for preparing the framework necessary for the implementation of sustainable development and for the elaboration and implementation of strategic options specific to achieving this objective.

The results and discussions highlight the need to continue research in this direction for the evaluation of endogenous resources and the identification of elements specific to the intensity and dynamics of changes in the environment for the elaboration, adoption/adaptation of strategies for the sustainable development of the rural economy.

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RISK MANAGEMENT AT THE LEVEL OF ROMANIAN SMALL AND MEDIUM-SIZED AGRICULTURAL BUSINESS - A SYSTEMATIC LITERATURE REVIEW

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Abstract

The small and medium-sized enterprise (SME) sector plays a crucial role in the economic framework, both at the national and European levels. Small and medium-sized firms (SMEs) are widely regarded as the most risk-averse ventures. Agricultural enterprises are particularly vulnerable to risk due to their strong reliance on climatic conditions. The objective of this study is to present a comprehensive analysis of the existing body of literature about risk management in small and medium-sized firms operating within the agricultural sector in Romania. Through a comprehensive and methodical examination of the specialist literature, following PRISMA 2020 guidelines a total of 16 out of 168 distinct publications found in the databases were deemed relevant and subjected to analysis. The study identified primary categories of risks encountered by these SMEs, including social, economic, environmental, market, production, operational, policy, technological, labor, knowledge, demographic, and resource risks. Additionally, various risk management methods were identified, including accessing public EU subsidies, recruiting skilled workers, offering home delivery services, engaging in risk-sharing mechanisms, implementing crop rotation methods, investing in new technology, and diversifying business operations. The study also highlighted internal factors, such as limited financial and technical resources, resistance to change, and fragmented approaches to risk management, as well as external factors like technological proliferation, regulatory changes, and market dynamics. The lack of comprehensive research in this field suggests a need for further investigation. This study provides a foundation for future research in risk management for agricultural SMEs.

Key words*: *risk management, SMEs, agriculture, climate change, farms

INTRODUCTION

Small and medium-sized enterprises (SMEs) are an essential component of all economies since they are the primary generators of new products and services, social cohesion, and employment [10, 12]. SMEs in the agricultural sector also substantially contribute to economic change in developing nations by addressing a wide array of unemployment, nutrition, income poverty and food security issues. Despite their vital role and contribution to economic development, they have received significant criticism for their poor performance regarding financial risk management [18]. Due to climate change, agricultural hazards associated with weather events, soil conditions, diseases and pests have increased in recent years. These hazards have imposed a financial shock on farmers [19]. Considering this circumstance, entrepreneurs should implement strategies to reduce the risks associated with climate change and maintain agricultural productivity and farm profitability [28].

Taking calculated risks is one of the most important things a company can do to ensure its long-term resilience [35]. Managing risk is a crucial aspect of farming, and EU policy makers include this as one of the main agricultural public policy goals. Risk management should be analyzed as a system in which multiple components interact. These components are organized along three axes: risk sources, farm owners' strategies and government policies. Several crucial issues and ideas must be discussed from all three axes to better comprehend these interactions [23]. Price or market risk (output and input price fluctuations, market shocks), financial risk (loans and credits), production risk (weather-related risk, pests and diseases (biosecurity threats), technology change, (yields), institutional risk (regulations, legal, environment, and tax policy) and human resource risk (physical and mental health) have previously been identified as main sources of risks associated to agricultural business [8]. Nonetheless, numerous empirical studies have disclosed the existence of obstacles impeding the performance of Agri-SMEs and resulting in a low growth rate. These challenges include, but are not limited to: access to finance and a low level of financial inclusion; increased competition; low capacity to deal with new technology; lack of data management; higher transaction costs relative to their size; a lack of entrepreneurial abilities; insufficient business management skills and nevertheless ineffective financial management [10]. Governments have frequently compensated farmers for losses, but there is now a growing demand for farmers to find private-market alternatives [21]. The risk management strategies adopted by farm administrators reflect their risk perceptions [20], specifically, how they evaluate the enterprise's situation and opportunities [29]. In addition, it is evident that when a business operates in an uncertain environment, it must have adequate risk management capabilities [33]. Enterprise risk management (ERM) is a methodology that takes a strategic view of risk management from the point of view of the entire business or organization. It is a top-down business strategy that seeks to identify, assess and prepare for potential losses, dangers, hazards, and other potential risks that may impede an organization's operations and objectives and/or result in losses [6]. Due to the economic downturn, implementing risk management techniques in SMEs is quite a challenging task [17].

Is a fact that the more efficiently Agri-SMEs operate, the more they stimulate economic activities that contribute to the prosperity and development of nations [34]. Risk management should begin at the farm level, where producers should employ multiple strategies to stabilize their incomes. This can be achieved by diversifying production to generate income from multiple activities. In crop farms, the use of various crops, or in livestock farms, the growth of several types/species of animals, or the development of non-agricultural sources of income such as agrotourism, can offset a portion of the losses caused by agricultural activity. In addition to these practices, the farmers can use a variety of risk management techniques that are either privately owned (insurance, mutual funds, and forward/futures contracts that are not subsidized) or publicly available (direct payments, government-guaranteed prices, and other forms of government assistance) [11].

This study aims to evaluate the understanding of risk management in the Romanian agriculture industry, specifically focusing on small and medium-sized businesses. Several keywords and concepts have been established to facilitate the identification of research papers related to enterprise-level risk management strategies in agriculture.

The objective of this study is to assess the risks faced by small and medium-sized firms operating in the agricultural sector of Romania, as well as to examine the strategies employed for their management. To achieve such an objective, several research questions were established:

1. This study aims to investigate the existing knowledge related to the risks faced by Romanian agricultural SMEs, the strategies employed to manage these risks, and the fundamental conceptual frameworks and research areas related to risk management.
2. Secondly the study aims to determine any advantages and disadvantages of risk management strategies implemented by the Romanian agricultural SMEs.

MATERIALS AND METHODS

A comprehensive assessment of the literature was conducted and successfully executed following the guidelines recommended by PRISMA 2020. Prisma 2020 is a handbook that replaces Prisma 2009 and includes revised reporting guidance for systematic reviews that reflect progress in methodologies for identifying, selecting, evaluating, and synthesizing papers, as described by Page et al [26]. A compilation of pertinent publications on risk management in SMEs within the Romanian agriculture sector was conducted

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using Science Direct, the widely-used literature-searching database provided by Elsevier.

The retrieval of database results was achieved by combining distinct sets of keywords (Table 1). To restrict the outcomes, a selection technique was implemented, employing the following filters: exclusively incorporating research and review articles while eliminating all other forms, and exclusively considering papers within the subject field of agricultural and biological sciences. No articles were found in languages other than English, rendering language-based filters unnecessary.

Other studies on risk management in SMEs followed the same PRISMA guidelines are: Small and medium enterprises (SMEs) in a pandemic: A systematic review of pandemic risk impacts, coping strategies and resilience written by Michael Odei Erdiaw-Kwasie et al. [9]. and SMEs in Covid-19 Crisis and Combating Strategies: A Systematic Literature Review (SLR) and A Case from Emerging Economy written by Mohammad Hossain et al. [16].

Table 1. Keywords and applied filters associated with the database.

Keywords	Article type	The field of research	Access type	Results
Risk management in farms AND Romania	review article research article	Agricultural and Biological Sciences	Open access & open archive	164
Agricultural farms risk management AND Romania	review article research article	Agricultural and Biological Sciences	Open access & open archive	142
RM in Romanian farms	review article research article	Agricultural and Biological Sciences	Open access & open archive	7
Risk management in agricultural SMEs AND Romania	review article research article	Agricultural and Biological Sciences	Open access & open archive	3
Agricultural small and medium sized enterprises risk management AND Romania	review article research article	Agricultural and Biological Sciences	Open access & open archive	8
RM in agricultural SME's and Romania	review article research article	Agricultural and Biological Sciences	-	1

Source: Own establishment of search criteria and filters.

The outcomes were integrated into a unified Excel database, and redundant articles were eliminated from the results.

The preliminary investigation yielded 325 entries from the database.

-A total of 157 duplicate records were eliminated, with 61 of them being automatically removed using the "remove duplicates" tool in Excel, while the remaining 96 were manually removed.

-A total of 168 records were subjected to screening, of which 37 were eliminated based on an assessment of the title. These exclusions were made as it was evident from the title that the subject was not related to Romanian agricultural SMEs risk management. Additionally, the abstracts of these records were also reviewed to confirm their lack of relevance.

-A total of 63 complete papers were evaluated. After a thorough examination of the complete articles, it was determined that 47 articles were not relevant to the research subject. In the final review, a total of 16 studies were included in the assessment.

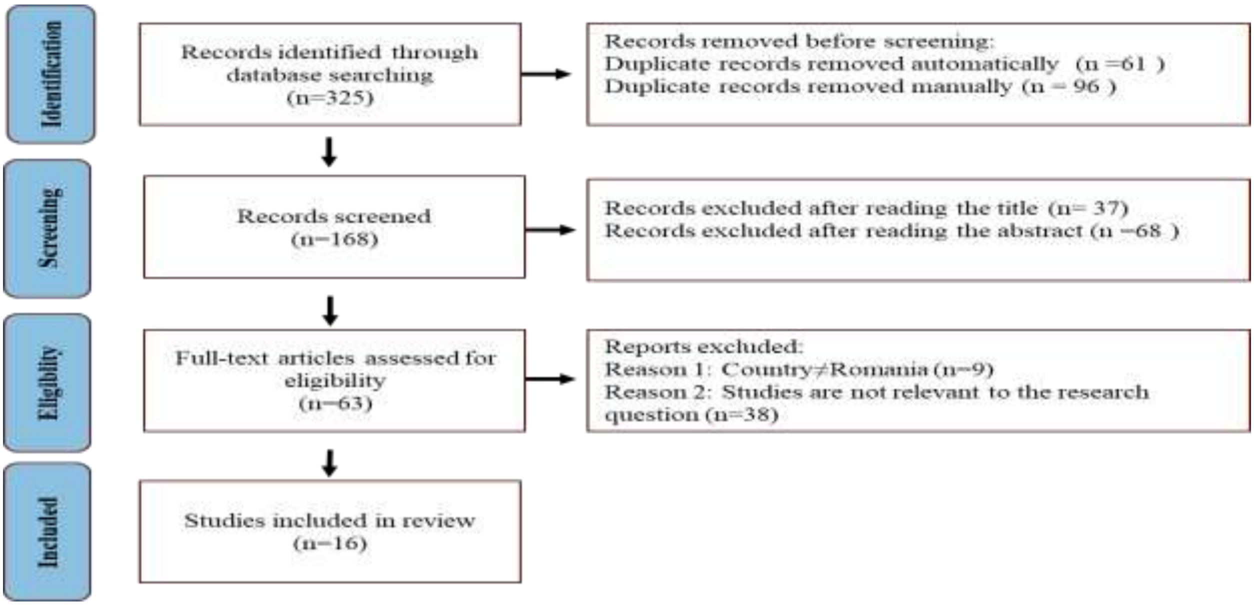

Fig. 1. The PRISMA flow chart methodology used in the study
Source: Author's own creation.

RESULTS AND DISCUSSIONS

The existing literature assessment indicates that there is a scarcity of research on risk management in agricultural SMEs in Romania. Currently, there exist only a small number of studies broadly addressing this topic.

The current investigation has successfully identified the primary categories of risks encountered by small and medium-sized agricultural enterprises in Romania, including social risks, economic risks, environmental risks, market risks, production risks, operational risks, policy risks, technological risks, labor risks, knowledge risks, demographic risks and resource risks (Table 2).

Furthermore, the current study has also identified some risk management methods that have the potential to mitigate the issues encountered by Romanian agricultural SMEs. The recommended strategies presume to access public EU subsidies, recruit young and highly skilled workers, offer home delivery services, employ chemical substances, engage in risk sharing and risk transfer mechanisms, implement crop rotation methods, invest in cutting-edge technologies, and diversify their business operations (Table 2).

Additionally, this inquiry seeks to provide illustrations of the way internal and external factors can exert influence on the capacity of agricultural SMEs to proficiently address risk-developing threats.

Internal factors:

1. Limited financial, personnel, and technical resources pose challenges for SMEs in successfully identifying, assessing, and responding to new hazards. The SMEs may encounter financial constraints that hinder their ability to allocate resources towards the acquisition of risk management software or the recruitment of specialized risk management personnel.

2. Resistance to change: SMEs may exhibit resistance to change, leading to a slow recognition and response to developing hazards. This resistance might stem from a deeply ingrained belief in maintaining traditional practices without considering other approaches. This phenomenon may lead to a diminished capacity for adaptability and prompt decision-making, hence impeding the effectiveness of risk mitigation endeavors.

3. Fragmented approach to Risk Management: SMEs frequently possess constrained risk management capabilities, where in numerous functions about risk management exhibit redundancy or operate in isolation. This fragmented arrangement poses challenges in obtaining a holistic understanding of emerging risks and implementing appropriate responses.

External factors:

1. The proliferation of technology: The emergence of novel technologies, such as automation, might potentially engender new vulnerabilities for small and medium-sized enterprises, with limited access to the necessary resources to acquire technical proficiency in effectively mitigating these risks.

2. Regulations have the potential to undergo rapid and frequent changes. Small and medium-sized enterprises (SMEs) may possess restricted expertise or resources that hinder their ability to effectively adapt to regulatory changes.

3.SMEs frequently face ***susceptibility to market dynamics*** and economic circumstances, such as trade ambiguities or variations in currency values. These factors can exert a substantial influence on their level of risk exposure and their capacity to proficiently handle risk management.

The absence of comprehensive research on risk management in the agricultural sector of Romania, specifically focusing on small and medium-sized firms, excludes the ability to generalize or present a comprehensive picture of their present circumstances. To develop a comprehensive understanding of the present circumstances, it is imperative to undertake further investigation. The present study provides a comprehensive examination of the existing literature on the subject, so establishing a solid basis for subsequent investigations in this field.

Table 2. Studies which reviewed the academic literature on risk management at the level of small and medium-sized enterprises in the agricultural field in Romania

Authors (Year)	Identified risks	Identified risk management strategies
Guarín et al., (2020)[15]	1. Economic vulnerability: even the most successful farm types had a monthly income of approximately 2000 EUR per household, raising concerns about long-term viability and ability to handle unforeseen shocks. 2. Limited access to financial services and training: poorer farm types faced challenges accessing financial services and training, hindering their ability to assume credit risks and invest in labor and innovation. 3. Scarcity of labor: economically disadvantaged peasant farms relied more on hired labor than family labor during critical activities, indicating a scarcity of labor. 4. Difficulty accessing large retail markets: small farms often preferred direct sales to consumers and farmer's markets, as larger retailers favored larger suppliers due to lower costs and predictability. 5. Succession issues: lack of new entrants into farming, reflecting the well-known problem of succession in European small farming, which leads to the underutilization of small farms' potential.	1. Crop insurance: farmers can purchase crop insurance to mitigate the financial impact of crop losses caused by various risks. 2. Diversification: many Romanian farmers practice diversification by growing different crops and raising various livestock. 3. Cooperatives: farmers can form cooperatives to pool resources, share risks, and improve bargaining power. 4. Government support: the Romanian government offers subsidies and financial assistance to farmers.
Agarwal et al., (2021)[1]	1. Aging membership and conflicts among members leading to inactivity of group farms 2. Economic challenges posed by drought and related factors leading to inability of large cooperative associations to survive. 3. Out-migration of youth from rural areas in search of non-farm jobs, resulting in the ability of groups to regenerate inter-generationally 4. Decline in crop cultivation by groups, while livestock breeding remains a sustainable activity for cooperation.	1. Continuously attracting and involving younger people who are willing to take over the farms, modernize them, and ensure their continuity. 2. Diversification of income streams and adoption of climate-adaptive practices to mitigate the impact of drought and other economic challenges. 3. Fostering an attractive environment for young farmers by providing support, incentives, and opportunities in agriculture. 4. Focus on livestock breeding for milk and meat, which requires significant labor and coordination, to sustain and attract farmers for group farming.
Meuwissen et al., (2021)[22]	1. Lower sales of products, specifically lambs for Easter and fresh early spring vegetables. 2. Lower sales in peasant markets due to lack of customers' mobility. 3. Lower sales due to abandoned school programs, such as bread, milk, and apples. 4. Interrupted deliveries of products to restaurants. 5. Lower mobility of commuting workers. 6. Reduced off-farm income if family members lost off-farm jobs. 7. Collapse of agritourism due to cancellations, especially during peak periods like Easter and 1st of May holidays	1. Coping for Agritourism: owners who faced the closing of agritourism activities occasionally began meal deliveries. 2. Coping for Processors: processors reduced buying of milk from farmers due to reduced demand. 3. Compulsory Protection measures for Peasant Markets and Retailers: Established measures to protect sellers and customers. 4. Coping for Government: launched a platform for online sales of vegetables; extended the period for direct payment applications; increased state aid; re-allocated funds from rural development programs; introduced payments for "technical unemployment" for enterprises forced to close or scale down until June 1 (75% of salary paid by the state). 5. Coping for Banks: increased finance opportunities

		for working capital or investments (available for all small and medium-sized enterprises), with 90% guaranteed by the state; postponed credit installments by up to 9 months.
Spiegel et al., (2021)[31]	The potential bias and limitations in perception-based resilience assessments. This means that farmers' perceptions of their resilience capacities may not accurately reflect the actual resilience of their farming systems. The assessments could be influenced by various biases or limitations, such as subjective interpretations, cognitive biases, or limited predictive abilities. As a result, decision-makers and policymakers may rely on inaccurate or biased perceptions when developing interventions or making policy decisions, which can lead to ineffective or suboptimal outcomes.	N/A
Biddoccu et al., (2020)[4]	1. Inadequate erosion rates: The comparison across different wine-growing regions indicates that some soil management practices, such as ACC and TCC, fail to achieve sustainable erosion rates. This suggests a risk of increased soil erosion in these areas if these management practices continue. 2. Soil moisture subfactor: Incorporating the soil moisture subfactor (Sm) into the calibration provides the best soil loss predictions. However, it also highlights the need to carefully consider competition for soil water, especially in drier areas, when implementing certain soil management practices. 3. Differences in predicted erosion rates: The article emphasizes the need to consider differences in climate, topography, soil variability, and the impact of management on ground cover when predicting erosion rates. This suggests that these factors can contribute to variations in erosion rates and may pose a risk if not properly accounted for. 4. Variability of the C factor: The C factor, representing soil cover and management, exhibits significant variability due to its coupling with local climate and specific management practices. This introduces a risk of bias in large-scale studies when extrapolating RUSLE parameters and implies the need for careful consideration of local conditions when using C values. 5. Farm-to-farm variability: The article mentions the importance of considering farm-to-farm variability in C values within the same soil management type, even within the same area. This indicates that different vineyards within a region may have varying erosion risks, necessitating a more nuanced approach to erosion prediction. 6. Erosion: To address the uncertainty of erosion predictions and the statistical significance of differences among areas and vineyard management, the usiage of the probabilistic approach to the distribution of the C factor. This could provide more reliable data and potentially mitigate risks associated with erosion predictions.	N/A
Soriano et al. (2023)[30]	1. Economic long-term pressures: participants in the farming system's focus group in RO-Mixed identified the lack of markets as one of the most important challenges. This suggests a risk of economic instability in the agricultural sector in Romania, particularly related to market uncertainties and low profitability and prices. 2. Environmental shocks: although not explicitly mentioned about Romania, environmental shocks were identified in 7 out of 10 FS' focus groups. This indicates a potential risk of environmental challenges, such as droughts, that could impact the agricultural sector in Romania. 3. Social long-term pressures: the decline in consumer demand for meat was identified as a challenge in the FS' focus group in SE-Poultry. While not directly related to Romania, it suggests a potential risk of changing consumer preferences and demand patterns, which could impact the livestock sector in Romania.	N/A
Rivera-Ferre et al., (2021)[27]	1. Disruptions to the food supply chain due to COVID-19; 2. Interruptions to food trade and distribution; 3. Significant increases in food loss and waste, especially of perishable products; 4. Farmer's high level of exposure and dependence on other actors in the food chain; 5. Reduction in labor force and lack of seasonal workers due to mobility barriers; 6. Impacts on globalized food systems heavily dependent on migrant seasonal workforce; 7. Interruptions and disruptions in food chains resulting in unsold agricultural products; 9. Rapid and unprecedented changes in food habits and consumption patterns.	N/A
Iuliana Dobre and	Risks: 1. Negative impacts on people's health and the environment due to the	N/A

Elena Soare (2015)[7]	use of chemicals in agriculture; 2. Generation of waste and packaging that create issues for people and the environment; 3. Higher costs for producers associated with the use of chemicals; 4. Lack of knowledge about the proper use and allocation of chemicals, affecting resource allocation and economic activities. 6. Information gaps hindering environmental improvements and best management practices in agriculture.	
Paas et al., (2021)[25]	1. Critical thresholds for system function indicators, such as yield per hectare and economic viability, are perceived to be close or beyond in some farming systems. This indicates that the systems are at risk of not meeting the desired levels of food production, economic viability, and natural resources. 2. Variability of markets and climate could lead to a drop in value below the indicated thresholds, which would pose a risk to the system's performance. 3. Some indicator levels in low-performing systems are perceived to be at or beyond the threshold, indicating a need for immediate action in terms of product prices and labor availability. 4. Reaching critical thresholds for soil quality is a concern in some farming systems, requiring continuous adaptation to prevent further degradation. 5. Externally determined thresholds for water quality and greenhouse gas emissions in the BE-Dairy system are perceived to be beyond acceptable levels, leading to disagreement among farmers. 6. Critical thresholds for economic viability differ from farm to farm in some case studies, which may result in the disappearance of economically less competitive farms from the farming system. 7. Interacting thresholds across level and domain were observed, indicating that exceeding critical thresholds in one area can have cascading effects on other areas within the farming system. 8. Decline in performance of system's main function indicators, such as food production, economic viability, and natural resources, is expected when critical thresholds are exceeded. 9. Decline in resilience attributes, such as profitability, support of rural life, and self-organization, is also expected when critical thresholds are exceeded.	N/A
Toma et al.,, (2021)[32]	1. Over-complexity and lack of farm advisory support - The pilot agri-environment-climate measure introduced in Romania in 2014-2020 failed due to its over-complexity and lack of farm advisory support, despite being a fundamentally important measure for supporting the continued contribution of small farms to FNS. 2. Lack of support for small farmers - The comprehensive policy analysis on CAP and small farms conducted by Davidova et al. (2013) found that the recommendations for supporting small farms have not been sufficiently addressed during the 2014-2020 CAP programming period to prevent the decline of small farms. This threatens the continued contribution of CEE small farmers to FNS. 3. Land consolidation - The trend of land consolidation affecting otherwise fragmented CEE countries is natural and likely to continue, which can threaten the viability of small farms and their unique social and environmental assets that contribute to regional food systems.	N/A
Bertolozzi-Caredio et al., (2021)[3]	1. Lack of knowledge and expertise in RM tools and strategies, especially for smaller and less diversified farms. 2. Limited availability and accessibility of financial and policy instruments tailored to farmers' specific needs. 3. Inadequate cooperation and coordination between actors in the value chain, affecting the implementation of effective RM strategies. 4. Insufficient public awareness and societal understanding of the functions and values of farming, especially related to livestock systems and mixed farms. 5. Inflexibility of farms to change, leading to challenges in adapting to changing farming conditions and implementing effective RM strategies. 6. Dependence on CAP aid, which influences farm business and decision-making, and poses a challenge in designing effective RM strategies to promote long-term sustainability.	1. On-farm risk management strategies: learning processes, knowledge exchange, and information and data access to promote risk understanding and effective decision making. 2. Risk-sharing strategies: horizontal cooperation between farmers, vertical cooperation between farmers, supply chain actors, and other cooperatives. 3. Risk transfer strategies: financial and policy instruments like insurance, credit, futures, and policy aids to mitigate risk exposure and share risk. 4. Extension services and provision of training programs to farmers and other value chain actors. 5. Integration of different insurance types to cope with multiple shocks and long-term threats. 6. Creation of financial consultancy services to support farmers in business planning and use of risk management tools and strategies. 7. Development of public and private collaboration schemes to increase accessibility and use of financial and policy instruments. 8. More decentralized, locally-based and bottom-up approaches to cope with regional-specific issues.
Arnalte-Mur		N/A

et al., (2020) [2]	1. Limited access to technology and knowledge on farm management - small farms may face constraints in accessing the necessary resources, information, and knowledge to adopt on-farm productive and managerial changes. This can hinder their ability to respond and adapt to future challenges. 2. Lack of awareness and recognition from consumers - the role of small farms in regional food systems can be heavily influenced by consumers' values and habits. If consumers are not aware of the health and environmental implications of their diets or do not recognize the importance of small-scale and local farming, it can impact the demand and market opportunities for small farms. 3. Insufficient public budget and expenditure - the capacity and willingness of the state to allocate public resources towards small farmers' needs can significantly affect their ability to thrive. This includes financial support programs and targeted investments in public infrastructures that can support small farms. 4. Limited integration into non-conventional value chains - small farms' integration into food systems through alternative market channels, such as short food supply chains (direct selling	
Ortiz-Miranda et al., (2022)[24]	1. Decline in the number of small farms. 2. Difficulties in responding to market demands. 3. Lack of societal awareness of regional small farms. 4. Low public support for small farms. 5. Financial constraints hindering research and development for small farms. 6. Lack of investment in small farms. 7. Impact of climate change on agricultural production.	1. Collective action and cooperation. 2. Increased public expenditure in favor of small farms. 3. Access to technology and knowledge. 4. Differentiation of produce through quality. 5. Search for urban niche markets. 6. Specialization in agro-tourism. 7. Revival of short food supply chains and local trade.
Karolina Furtak and Agnieszka Wolińska (2023)[14]	1. Complexity of the soil environment and difficulty in understanding the interdependencies and impacts of different factors on the ecosystem. 2. Difficulty in determining the distribution of water in the soil and assessing microbial activity and biogeochemical processes. 3. Technical difficulties in analyzing dry soil due to low concentrations of certain compounds and distinguishing between viable microbial biomass and inactive forms. 4. Incomplete research focusing on individual elements rather than complex relationships in the soil environment. 5. Lack of collaboration between different specialists in studying soil ecosystems in stress conditions. 6. Climate change and extreme weather events posing challenges to agriculture and the economy. 7. Uncertainty regarding the development of effective biopreparations and transgenic drought-tolerant plants.	N/A
Dumitru-Florin Frone and Simona Frone (2015)[13]	1. Lack of investment in water infrastructure and irrigation systems in the rural areas of Romania may lead to water scarcity, affecting the sustainable development of the agri-food sector and rural areas. The dependency on weather conditions for agricultural production may cause non-performance in annual agricultural production. The vulnerability of agriculture to climate change may also significantly limit food production. 2. Poor water supply and sanitation systems in rural areas may cause environmental pollution, affecting soil and water resources, and negatively impacting human health. The low access of the rural population to these public infrastructure services may contribute to severe rural poverty areas. 3. Lack of water security may create significant barriers to growth in Romania, particularly in the agriculture and food sector, which can affect the country's food security. 4. The increasing pollution of water resources, over-abstraction of groundwater, and the significant issues created by climate change may lead to severe water shortages in the future, impacting the sustainable economic growth and fighting poverty in the country.	N/A
Chen et al., (2022)[5]	1. High usage of herbicides, insecticides, and synthetic fungicides has potential negative impacts on the environment and public health. 3. Attitudes and beliefs of winegrowers focused on quantity-oriented production rather than quality-oriented production. 4. Lack of implementation of agri-environmental schemes to support pesticide reduction and vegetation cover in Romanian viticulture.	Adapting inter-row management and pesticide use in response to changing weather patterns, and investing in research on how climate change may affect viticultural landscapes.

Source: The author's own structuring of the results identified through the prism of the search.

The agriculture industry holds considerable importance within the Romanian economy, with small and medium-sized firms (SMEs) serving as a vital constituent. Nevertheless, due to the susceptibility of the agricultural sector to various hazards, the implementation of efficient risk management strategies becomes imperative for SMEs operating in the agricultural industry in Romania. The objective of this study was to conduct a comprehensive examination of the primary concerns related to risk management within SMEs operating in the agricultural sector in Romania. Furthermore, the research aimed to identify potential barriers that could hinder the successful application of efficient risk management strategies. The systematic review yielded numerous significant findings. The findings of the studies indicate a notable deficiency in the level of awareness among SMEs on the necessity of implementing risk management strategies. SMEs in the agriculture sector have historically demonstrated a lack of awareness regarding the extent of risks present in their industry. Consequently, they have neglected to acknowledge the importance of implementing risk management strategies to mitigate the potential severity of these risks. Furthermore, a significant number of SMEs had constraints in terms of resources, leading to a lack of proficiency in the field of risk management. Consequently, this posed difficulties in effectively addressing and controlling risks promptly. Insufficient knowledge and skills within the industry may result in suboptimal or insufficient risk management strategies among SMEs. In addition, the assessment underscored the significance of enhanced governmental assistance and cooperation in fostering customized and efficient risk management approaches. Effective risk management practices require collaborative efforts among researchers, policymakers, and SMEs to establish policies and strategies aimed at their development and implementation. The presence of predominantly qualitative research in the study may pose a constraint on the extent to which the findings can be generalized. Moreover, the research papers predominantly concentrated on risk perceptions rather than delving into risk management measures.

The study's results suggest that it would be beneficial for policymakers and stakeholders in the agriculture industry in Romania to actively promote and provide assistance in the development of enhanced risk management policies, strategies, and practices that are specifically designed to address the distinct requirements of SMEs. To enhance the preparation and resilience of SMEs, it was imperative to offer pertinent resources and support to enhance their understanding and proficiency in risk management. Notwithstanding these constraints, the present study offers significant contributions by shedding light on the difficulties encountered by SMEs operating in the agricultural sector in Romania. Moreover, it suggests areas that necessitate additional investigation to enhance comprehension and advocate for the implementation of proficient risk management strategies.

Implications

There are several implications of the literature assessment for policy and practice pertaining to risk management among SMEs in the agricultural sector in Romania. The primary purpose of the evaluation is to provide policymakers with an understanding of the existing risk management procedures inside SMEs. Additionally, it aims to identify any deficiencies in knowledge and draw attention to specific areas that want further consideration. This information can be utilized by policymakers to formulate pertinent and efficacious policies aimed at enhancing risk management methods within the agricultural industry. Moreover, this research emphasizes the necessity of enhanced cooperation among stakeholders and the implementation of a customized risk management strategy within the agriculture industry. Policymakers have the opportunity to collaborate with researchers and SMEs to customize policies and strategies that will facilitate the advancement and adoption of efficient risk management techniques within the agricultural sector.

Also, this analysis serves as a valuable source of information for farmers, small company owners and management personnel of small and medium-sized enterprises (SMEs) operating within the agriculture sector, elucidating the significance of implementing effective risk management strategies. The review can enhance awareness regarding contemporary risk management approaches, as well as the legal and regulatory obligations associated with risk management and the potential dangers particular to various industries. The heightened level of consciousness can facilitate SMEs in comprehending the significance of risk management and motivate them to embrace more effective risk management methodologies.

Ultimately, this study serves as a foundation for future research endeavors concerning risk management approaches, with the potential to enhance the performance, productivity, and profitability of SMEs operating within the agricultural sector. The evaluation has indicated prospective avenues for further research, which encompass exploring the influence of various risk factors on the performance of SMEs, as well as assessing the efficacy of distinct risk management strategies in mitigating different types of hazards. Furthermore, it is imperative to investigate the various determinants that impact the successful execution of risk management strategies. Additionally, conducting scholarly inquiries into the optimal methods for SMEs to actively participate and cooperate with other pertinent stakeholders in the realm of risk management, such as government agencies, insurance firms and financial institutions, is of utmost importance.

Overall, this systematic review has significant implications for policy and practice related to risk management among SMEs in the agricultural sector in Romania. Policymakers, researchers, and stakeholders can use these findings to identify the critical barriers to effective risk management implementation and develop strategies to overcome those barriers.

In summary, this systematic research holds substantial implications for policy and practice concerning risk management within SMEs operating in the agricultural sector in Romania. These findings can be utilized by policymakers, researchers, and stakeholders to identify the key obstacles in implementing risk management effectively and to formulate strategies for overcoming these obstacles.

CONCLUSIONS

The agricultural industry in Romania holds considerable significance as a contributor to the nation's economy, with SMEs playing a pivotal role in fostering its growth and ensuring long-term viability. Nevertheless, the agricultural industry possesses inherent risks that are beyond the control of SMEs, including climate change, catastrophic weather occurrences, and market price volatility, among other reasons. Therefore, the implementation of risk management strategies is of utmost importance SMEs that are engaged in the agricultural sector in Romania. This is necessary to effectively minimize potential risks and ensure the continuity of their business activities. The implementation of effective risk management strategies can assist SMEs in the identification of possible risks and hazards, as well as in the development of plans to address and mitigate crises. Consequently, these practices can contribute to a reduction in the probability and magnitude of losses experienced by SMEs.

Furthermore, the implementation of efficient risk management methods can confer a competitive edge on SMEs through the augmentation of their standing and the fortification of their associations with key stakeholders, including customers, suppliers, and financiers. SMEs operating within the agricultural sector encounter a multitude of obstacles when it comes to the adoption and implementation of efficient risk management strategies. The absence of sufficient resources and knowledge might impede their capacity to discern and handle hazards, whilst a lack of interaction with policymakers can restrict their access to pertinent support systems and resources.

Hence, policymakers must assist SMEs operating in the agriculture industry in Romania, intending to facilitate the adoption of efficient risk management strategies. This form of assistance can encompass various incentives, such as grants or subsidies for training and risk management software, which have the potential to augment the ability of SMEs to proficiently handle hazards. Policymakers have the potential to collaborate with SMEs to recognize and tackle obstacles that hinder the achievement of efficient risk management. These barriers may include the need to comply with regulatory requirements, difficulties in accessing markets, and challenges related to supply chain operations.

To facilitate the development of effective risk management strategies, a comprehensive approach to risk management is needed that includes the involvement of SMEs in policy development and implementation. This approach would encourage information and resource sharing between SMEs and relevant stakeholders, promote collaboration and knowledge exchange between SMEs, and create a supportive environment for SMEs to learn and adopt best practices. Finally, further empirical research into the factors that influence the effectiveness of risk management in SMEs in Romania is needed to better understand the unique challenges and opportunities facing these businesses and to develop evidence-based strategies for improving risk management practices in the agricultural sector.

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HARNESSING URBAN AGRICULTURE TO TACKLE INEQUALITY: 10 LESSONS FROM THE EDIBLE CITIES NETWORK FOR ROMANIA

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Abstract

In recent decades, the pursuit of sustainable solutions to address the challenges of feeding a rapidly growing global population has been a central focus of international programs and mechanisms. Romania, in alignment with these global efforts, has been progressively advancing toward a self-sustainable economy, with significant investments in sustainable and green agriculture. This ongoing commitment to sustainability supports our decision to analyse the outcomes of the Edible Cities Network project, part of Horizon2020 initiative. Our objective is to explore how the principles and practices promoted by this initiative and the outcome of individual projects can be effectively implemented in Romania, contributing to the achievement of the nation's sustainability goals and enhancing food security, in a conscious effort to fight inequality in large urban centres.

Key words*: *urban agriculture, EdiCitNet, sustainable food systems, inequality

INTRODUCTION

As the world population continues to grow, the need to ensure food accessibility, affordability, security, and sustainability becomes more and more pressing. The Department of Economic and Social Affairs (DESA) from the United Nations predicts that by 2050, the world population will increase by 25% surpassing 10 billion people, with more than 68% living in urban areas (10% more than today) [36]. Romania's perspectives are no different than the ones we identified globally. Romania currently finds itself in an increasing urbanization process, like most of Europe [16]. The same UN-DESA data places the urban population in Romania at 54.49%, with the prospect of reaching 66.7% by 2050. This increased level of urban-living citizens results in numerous challenges related to food accessibility, availability and affordability.

It is safe to say that such a change in demographics and living conditions will significantly challenge traditional food chains, increasing the need to find innovative approaches to food production [30]. While traditional agriculture has long been the pillar of food supply chains everywhere, providing the majority of the world's food and accounting for more than 80% of the world's food production, urban agriculture has emerged as a complementary solution that can help meet the growing demand for food in cities. The necessity to bring food production in an urban setting arose especially as urbanization accelerates, leading to the availability of labour resources in rural areas becoming scarce [15], and to a surge in consumption needs within densely populated urban centres due to rising populations. In response to the limitations of traditional agriculture and the challenges posed by increasing urbanization, urban and peri-urban agriculture gained momentum as viable solutions to improving food security and sustainability in cities [24]. According to the European Commission, Urban Agriculture, also shortened as UA in the current research paper, represents "the practice of cultivating, processing, and distributing food in or around urban areas" [13]. As an alternative to traditional agriculture, urban agriculture involves the cultivation of crops and rearing of animals within or around cities, utilizing available spaces such as vacant lots, rooftops, balconies, and community gardens, providing a complementary approach by bringing food production closer to consumers, reducing the need for long-distance transportation, and lowering the carbon footprint associated with food distribution. It is estimated that UA can provide between 15-20% of the world's food necessary involving more than 800 million people in the sector [18], the sector being led by cities like Singapore which has become self-reliant on meat and could provide up to 35% of its fruits and vegetables, solely through urban agriculture, Berlin where more than 60,000 people are involved in UA projects [10] or Rotterdam which has fully integrated urban agriculture in its core [6].

Despite their complementary roles, both urban and traditional agriculture face challenges that must be addressed to ensure a sustainable food future. Traditional agriculture, while productive, often struggles with sustainability issues, and large-scale monoculture farming frequently depletes soil nutrients, requires significant water usage, and contributes to greenhouse gas emissions. Also, traditional farms are often located far from urban centres, making food supply chains vulnerable to disruptions, generating higher costs and a higher carbon footprint. On the other hand, UA challenges related to scalability, profitability, production resources access, and local policy support. Often, urban farms tend to be smaller in scale, which can limit their ability to produce large quantities of food, and due to their innovative nature, more often than not they are met with resistance in their respective communities.

Recognizing the paramount importance of finding long-term sustainable solutions for feeding the world and seeing urban agriculture as a worthwhile pursuit, the EU developed several projects under the Horizon 2020 program and subsequently in Horizon Europe focused on UA initiatives, recognizing the potential they hold for addressing national challenges such as food inequality, urban sustainability, and social inclusion. Several projects directly focused on UA, such as:

- Edible Cities Network (EdiCitNet/ECN) [11] – which focuses on creating "edible cities" where food production is seamlessly integrated into urban spaces—ranging from community gardens and rooftop farms to edible landscapes in public areas. The project aims not only to increase local food production but also to foster social inclusion by involving diverse community groups in urban farming activities.
- URBAN GreenUP [33] - a project designed to re-nature cities through innovative green infrastructure, including urban agriculture. The project focuses on integrating nature-based solutions into urban planning, with a strong emphasis on sustainability and climate resilience by transforming underutilized urban spaces into productive green areas.
- CITYFOOD and Aquaponic [5] - focuses on aquaponics—a sustainable system that combines aquaculture (raising fish) with hydroponics (growing plants in water) in urban settings.
- SUPURBFOOD [32] - focuses on short food supply chains and urban-rural linkages. It aims to strengthen local food systems by promoting urban agriculture and connecting urban consumers directly with local farmers.
- ReGreeneration [29] – whose main purpose is to bring again green spaces in large cities and deliver greener communal spaces to communities.

While Romania's participation in this type of project is still emerging, the country has begun to leverage the opportunities provided by EU-funded initiatives to adapt and implement urban agriculture strategies suited to its unique context.

We have chosen to focus the current paper on the lessons provided by the Edible Cities Network because although Romania was not a primary partner in the project, Romanian cities and research institutions have shown interest in the best practices and innovations developed by EdiCitNet. These include initiatives related to community gardens, urban farms, and the transformation of public spaces into edible landscapes bringing valuable information on how they have succeeded and made viable long-term UA projects.

MATERIALS AND METHODS

To explore our research topic, we’ve chosen to dissect case studies from cities that are part of the Edible Cities Network, that have successfully implemented in the past years urban agriculture projects, offering a wide range of experiences that could be implemented in Romania's larger cities. Our research will focus on understanding how these initiatives were implemented and the subsequent results.

By analysing both the advantages and the challenges faced by these cities, we aim to extract practical insights for future Romanian projects providing insights that could be instrumental in developing local economies and strategies for modernizing Romania by considering the economic implications of sustainability, biophilia theory, built-environment cognitive processes, as well as of general urban growth. We are using publicly available data from both the EdiCitNet website and the cities' own reports.

RESULTS AND DISCUSSIONS

While Romania's percentage of land used for agriculture (55%) is fairly above the European average of 39.1% (Fig.1), the country still imports more than half of its food products.

There is however a concerning trend regarding the decrease of the percentage of land destined for agricultural production in Romania, especially in the context of growing urbanization. Statistics from the World Bank show that in the past 34 years, the share of land used for agriculture in Romania dropped by almost 12% [35]. This massive shift occurred on the premises of large societal changes in land ownership, urbanization, or deforestation [26]. Shall this trend continue, Romanian food production will dramatically decrease, forcing the country to focus on different production technologies like smart farming technologies, controlled environment agriculture, aquaponics, or vertical farming, all options fit to urban and peri-urban agriculture [25].

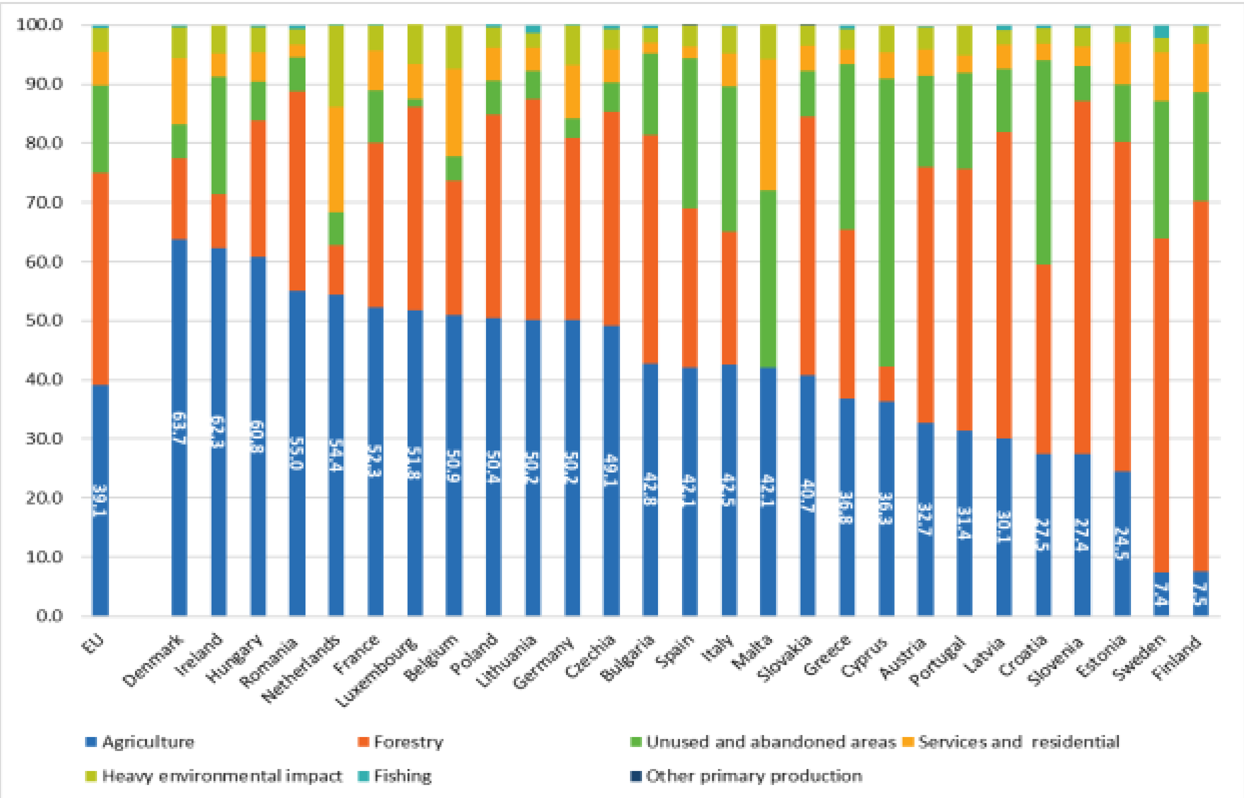

Fig. 1. Destination of land usage, percentages, 2018 (% of total area)
Source: Eurostat [12].

According to long-term strategies developed by Romanian authorities [21, 22] there is a high interest in transitioning the Romanian cities towards more sustainable and green communities. We have noticed that even if the urbanization degree of Romania has increased, so have the green spaces for each county. Overall, there was a growth of over

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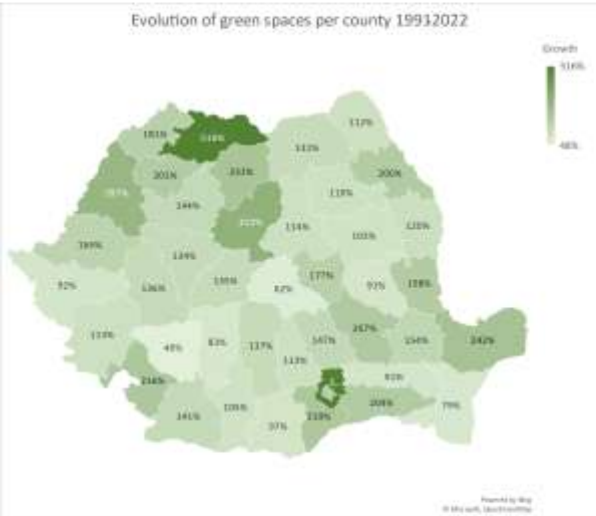
more than 45%, the counties with the largest developments being Bihor, Bistrița-Năsăud, Buzău, Călărași, Giurgiu, Iași, Ilfov, Mehedinți, Mureș, Sălaj or Tulcea who doubled, tripled or more the entire urban green area. On the opposite spectrum, Brașov, Constanța, Gorj, and Vâlcea dramatically decreased the urban green area in the county with more than 20% decrease (Map 1).

Developing urban agriculture spaces within the cities would simultaneously hit two goals in the long-term development of Romania because they would both positively impact food security and accessibility, and they would help reduce pollution and decrease the temperature in large urban concentrations.



Map 1. Evolution of green spaces per county 1991-2022.
Source: INSSE [23].

Currently, Romania has several attempts at urban gardening and implementing UA projects, but most of them are local, small initiatives that are not translated into communal initiatives applicable on a larger scale. Our country is not an official partner of the EdiCitNet project and does not have any candidate cities. However, there are some UA projects currently running, mostly in the largest urban centres in the country.

A local initiative has been acknowledged by the EdiCitNet program, being rewarded for the “Most Innovative Individual Action”. CUIB from Iași County won this award at the Edible Cities Network Awards in 2023, for holistically including in its business model sustainable-produced ingredients [28]. They focus on providing meat-free meals to reduce the businesses’ overall carbon footprint, they reduce the plastic waste they produce by using glass recipients for drinks, not having one-time use cutlery and choosing en-gros ingredients with minimal packaging, they choose locally sourced ingredients and when not possible they select Fair Trade suppliers [8]. Also, they try to spread their philosophy to their entire community by involving them in charity projects aimed at increasing food access to underprivileged individuals and they reward using non-polluting means of transport such as bikes.

Other local UA initiatives include projects like UrbanCultor [34] which is working towards developing and implementing UA solutions for both private and public companies, AcademiadeCompost focuses on finding ways to redirect organic waste toward composting [1], ClimatoSfera focuses on using UA and waste management to improve the living environment [3], Ultragreens [20] who started implementing micro greenhouses in large hypermarkets and recently launched the first Vertical Agriculture Green Hub in Romania, and Gradinescu project [14] that started 9 urban gardens by partnering with the local authorities and involving the local community.

However, while all these small projects are gaining traction in their respective communities, it is still insufficient, and it is important to look towards other successful projects and try to learn from their experience.

The EdiCitNet program aims to tackle inequality by creating the necessary framework for introducing green, edible landscapes into current urban environments. By aligning these initiatives with city planning projects, the program promotes community-led agriculture, creating opportunities for local food production, enhancing access to nutritious food, and fostering social cohesion improving urban sustainability, empowering marginalized communities by offering them both economic opportunities and a stake in their urban spaces, and subsequently resulting in the reduction of socio-economic inequalities [11].

Several scientific papers map the results for the Edible Cities Network, providing insight into the viability and the benefits provided by integrating such projects in our current urban setting. The full ECN consists of 53 solutions, 66 initiatives, and 5 communities spread all around the world (Map 2).

The Edible Cities defined in the project are Andernach and Berlin in Germany, Oslo in Norway, and Rotterdam in the Netherlands. These cities act as sources of inspiration and serve as "Living Labs" where nature-based solutions are put into practice, offering a model for other cities to adopt and adapt within their own communities.

Map 2. Map of The European Edible Cities Network (Locations not shown on map: USA, Ecuador, Jordan, and Somalia)
Source: Source: Edible Cities Network [11].

The EdiCitNet is an integrated ecosystem of its own, providing through its platform a meeting place for experts and interested parties to share knowledge, best practices, and resources among cities, researchers, practitioners, and policymakers, fostering collaboration on edible city solutions, allowing cities to learn from each other and co-create urban agriculture strategies tailored to their local contexts.

For us to be able to adopt lessons from the ECN into Romania’s long-term strategy for tackling inequality by developing urban agriculture systems, it is essential to consider Romania's specific socio-economic, political, and environmental contexts, and figure out which approach is the best. Urban agriculture can be a tool playing a significant role in addressing socio-economic inequalities by enabling access to affordable, healthy food, creating new job opportunities, and fostering community cohesion.

Lesson 1 – The power of multistakeholder partnerships

Developing a sustainable UA project is not feasible for only one entity because creating a circular economy approach for this type of endeavour requires expertise and input from multiple stakeholders. Obtaining the support and engagement of key players like local authorities, experts on different levels for each part of the project, and ultimately the destination community who will directly benefit from the produce is essential for the success of the project. The city of Andernach [31] (Germany) is the best example for this lesson, demonstrating that involving collaboration between local government, community groups, and private stakeholders helped transform public spaces into edible landscapes accessible to all citizens, regardless of socio-economic status. From kindergarten to young teens to adults, all members of the community from all social contexts are involved in sustaining the 11 projects from Andernach. By using a similar approach, Romania could involve representatives from marginalized communities, such as low-income neighbourhoods, minorities, and unemployed youth to help directly plan and implement urban agriculture initiatives that are inclusive and address the needs of those most affected by socio-economic inequalities. By focusing on public spaces in underdeveloped areas of the large cities, Romania can create inclusive urban gardens that provide both food and social cohesion creating a sense of responsibility and belonging.

Lesson 2 – Relevance within context

Not every neighbourhood is suitable for such a project, not every part of the city will ultimately be involved in UA developments. It is imperative to correctly asses the suitability of the physical locations and to identify the areas with the highest levels of socioeconomic disadvantage to provide accessible, affordable food options and foster economic opportunities through local food production. The Urban Gardens in Tempelhof [2] are a fit example for this lesson, because through fostering the local garden they have created a space for learning, socializing and multicultural exchanges while simultaneously helping residents of the poorer district of Neukolln to participate in the project and benefit from the results of the garden. Similarly, Romania can conduct local assessments to identify unused urban spaces, like abandoned lots or rooftops, in disadvantaged neighbourhoods and convert them into community gardens where engaging residents in planning and managing these gardens ensures that the initiatives meet the community's specific needs and help the less fortunate members of the community.

Lesson 3 – Building policies for growth

Implementing measures that help start and sustain urban agriculture projects that are community-oriented can help the inquisitive minds that have the ideas but do not have the proper support for them. For example, creating subsidies or financial incentives for urban agriculture projects in targeted areas, or implementing policies that prioritize the allocation of urban farming plots could help those interested in developing such UA projects. Also, ensuring that urban agriculture is incorporated into city planning in a way that prioritizes access for all residents, no matter their social status can help the citizens get more involved with the urban gardens and have more awareness of their benefits. The best example in this case is the city of Rotterdam, which is one of the first cities to create a complex food strategy [6, 7] and has created the Food Council, a body consisting of representatives from various sectors, including local government, NGOs, and businesses, who help promote sustainable food policies and urban agriculture focusing on creating inclusive, participatory governance structures. By encouraging and developing similar councils or governance frameworks, Romania can ensure that urban agriculture policies are inclusive and promote equitable access to resources and opportunities, particularly, but not exclusively, for marginalized communities.

Lesson 4 – Cultivating minds not only the land

What vulnerable groups suffer the most from, especially in large cities, is a lack of access to education and tools to elevate their status quo. Developing educational programs that focus on teaching urban agriculture skills to low-income residents, particularly in areas with high unemployment could mean a step forward toward building their independence, their self-confidence and self-worth. These programs can empower individuals by providing them with new skills, fostering self-sufficiency, and opening up new economic opportunities, therefore creating opportunities for a better life. Launching community-based initiatives that encourage collective action and community building through urban agriculture can also raise awareness in the area about the social inequities in the community and help different social groups better co-exist by understanding the challenges and difficulties the less fortunate experience. Such programs can help bridge social divides, build social capital, and strengthen community resilience against socio-economic challenges. The Linderud Community Garden in Oslo [17] is designed to engage the local community in sustainable food practices and environmental stewardship by offering workshops, training sessions, and educational programs for all age groups, particularly targeting schools, families, and marginalized communities to foster a hands-on learning environment. Romania can draw inspiration from Linderud by developing community gardens that serve as educational hubs, offering practical training in urban farming techniques and sustainability practices, making these gardens centres for community events, fostering social cohesion while teaching valuable skills that can improve food security and environmental awareness among local residents, especially in underprivileged areas.

Lesson 5 – Food for all

Direct actions towards measures that enhance food security in low-income neighbourhoods by supporting community gardens, urban farms, and food cooperatives can provide affordable, healthy food options and reduce dependence on expensive, processed foods, thereby addressing food insecurity and improving public health. Encouraging sustainable farming practices that are accessible and affordable for low-income communities by promoting methods such as composting, rainwater harvesting, and permaculture as parts of urban agriculture can help communities reduce costs and build resilience against economic and environmental shocks. Losæter Urban Farm from Oslo, Norway [19] for example, integrates sustainable practices like composting and permaculture and serves as a community hub for learning and food production, particularly supporting local low-income residents. Locally, in Romania the authorities could help develop urban farms in disadvantaged neighbourhoods, focusing on sustainable practices that reduce costs and build resilience, thereby enhancing food security for vulnerable groups.

Lesson 6 – Overcoming challenges in urban farming

Creating financial mechanisms such as microloans, grants, and subsidies to support low-income individuals and community groups in starting and maintaining urban agriculture projects combined with simplifying regulatory processes to make it easier for disadvantaged groups to access land and resources for urban farming can help sustain UA projects long term. Additionally, by offering targeted training and technical support to low-income communities to help them overcome barriers to entry into urban agriculture (this could include skills training, access to farming equipment, and ongoing mentorship to ensure long-term success) the chances of UA projects to succeed increase. DakAkker rooftop farm [9] portraits this attitude by becoming an example in using alternative spaces for urban agriculture. The farm was the first of its kind, and the largest rooftop farm in Europe. Over 1,000 m^2 of rooftop is used to grow vegetables, raise bees and chickens, providing local products to restaurants and stores. The farm is also a learning hub for children of all ages and has become a sought-after tourist spot. Romania could introduce a similar program to ease land access for urban agriculture in underserved areas, offering microloans or grants to community groups and simplifying bureaucratic processes of obtaining proper paperwork, to encourage participation in the urban agriculture projects.

Lesson 7 – Plan, Do, Monitor, Evaluate, Adapt, Repeat

Just starting an urban agriculture hub is not enough. By **c**reating frameworks to monitor and evaluate the impact of these projects on reducing socio-economic inequalities and using data to assess whether initiatives are effectively reaching and benefiting disadvantaged groups, stakeholders can adapt their strategies as needed to ensure equity and sustainability are achieved long-term. Brighton & Hove Food Partnership [4] in Brighton, UK closely monitors all its urban agriculture initiatives to assess their impact on food security and social cohesion, using this data to refine and adapt strategies. Romania can use this example to develop monitoring frameworks for evaluating the impact of urban agriculture on reducing socio-economic inequalities, using data-driven approaches to adapt and improve programs over time.

Lesson 8 – Going digital

In a digital era, any urban agriculture initiative must remain connected to virtual communities, taking advantage of its easy reach and possibilities of growth. An inclusive digital hub that provides resources and tools specifically tailored for vulnerable communities and marginalized groups interested in urban agriculture could offer free training materials, access to micro-loans, and a directory of easily accessible support services. By using digital tools to connect low-income urban farmers and community groups with potential mentors, funders, and technical experts the hub could provide the support and resources needed to sustain and grow urban agriculture initiatives. In this case, the EdiCitNet Platform [11] is the best example, because it serves as a digital hub for sharing resources, best practices, and connecting urban agriculture practitioners globally, fostering collaboration and knowledge exchange. Romania has the advantage of being an IT-friendly country, and could easily find partners to develop a similar digital hub specifically focused on local specificities, providing resources and tools tailored to local needs, particularly those of vulnerable communities, encouraging widespread participation and innovation.

Lesson 9 – Access to funding

The most common problem when developing a project, no matter how large or small, is the funding aspect. When planning for funding urban agriculture initiatives the authorities should prioritize grants and investments that target underserved communities, while being well aware of the fact that the monetary return of investment might be negative. Accessing EU funding opportunities and finding private sector partners to secure resources that specifically support urban agriculture projects aimed at reducing socio-economic inequalities is the best option to reduce the burden of financing the projects on private investors or local authorities. By fostering partnerships with private companies that have a strong commitment to social impact and corporate social responsibility the projects can find funding, resources, and expertise to support urban agriculture initiatives that benefit vulnerable communities. Prinzessinnengarten, in Berlin, Germany [27] is a community garden that has successfully secured diverse funding sources to support its operations and growth by utilizing a mix of public funding, private sponsorships, crowdfunding campaigns, and revenue from selling produce and hosting events. Romania can explore diverse funding avenues, prioritizing grants and investments targeting underserved communities, and establishing public-private partnerships to support initiatives aimed at reducing socio-economic disparities, having the added benefit of being part of the EU and having access to funds through initiatives like Horizon Europe.

Lesson 10 – Integrating urban agriculture with national and European goals.

Romania needs to ensure that its urban agriculture strategy is on the same wavelength with broader national and EU goals for social equity, food security, and sustainability, by taking advantage of more complex frameworks like the European Green Deal and the Farm to Fork Strategy to support initiatives that aim to reduce socio-economic disparities. By accessing the EU's social funding mechanisms that support projects addressing poverty and social inclusion, Romania's cities could obtain resources to develop and scale urban agriculture initiatives that empower disadvantaged communities.

The Edible Cities Network has been a European-funded initiative, successfully reaching 18 countries and receiving an overwhelmingly positive response in every city it touched. This success is evident in the ongoing operation of these urban farms, which continue to thrive even after the project's completion, largely maintained by the local communities and the local authorities.

CONCLUSIONS

Romania's long-term strategy on environment and climate sustainability has as a focal point increasing food and nutrition security. A goal, achievable through integrating various methods but including urban agriculture and peri-urban agriculture. While this topic is not currently properly developed, the local government with help and support from the EU is planning on increasing access to food and reasonable pricing by supporting urban agriculture endeavours.

The current paper underlines the transformative potential of urban agriculture as a key strategy for reducing inequality, enhancing sustainability, food security, and community well-being in urban environments by fostering collaboration across sectors and communities. Cities can develop adaptive, sustainable urban agriculture solutions that effectively address local needs and contexts, and strengthening policy support, education, and innovation is essential to building resilient, inclusive, and sustainable urban food systems that can adapt to future challenges. As Romania's cities continue to explore, understand, and implement the lessons learned from the Edible Cities Network, they pave the way for a more sustainable and equitable urban future, where nature-based solutions play a central role in reducing inequalities and shaping urban resilience and sustainability. To meet the challenges of feeding a growing urban population, both traditional and urban agriculture must continue to innovate, to enhance productivity and reduce environmental impacts while maximizing food production by navigating the limited availability of resources.

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IMPACT OF GLOBAL FOOD SECURITY INDEX ADJUSTMENTS IN THE CONTEXT OF MAJOR INTERNATIONAL CHALLENGES

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Abstract

Food security relies on interconnected social, economic, and biophysical systems to meet human nutritional requirements. Addressing risks is crucial for building resilience in food systems and ensuring long-term food security. Some major challenges include climate change, financial risks, and political instability. Resilience, the ability to bounce back from shocks, is increasingly important. To enhance long-term food security, we must build better food systems that can absorb and adapt to climate change and other risks. The proposed study aims to evaluate adjustments to the Global Food Security Index, providing recommendations for improving global food security policies. Identifying gaps in the Index and accurately reflecting the complexity of the global food system are essential outcomes. Access to affordable food is foundational for social well-being and stability. Higher-income households can better cope with temporary price increases, while low-income households require safety nets. The FAO Food Price Index reached an all-time high in March 2022, impacting developing countries facing challenges like the COVID-19 pandemic and resource inadequacy. Rising food prices before Russia's invasion of Ukraine exacerbated the situation. Financial risks, currency depreciation, conflict, and political instability threaten food access. The Global Food Security Index revealed trends, including a decline in food affordability between 2019 and 2022. Additionally, agriculture's expansion, particularly in developing countries, faces challenges due to degraded land. Soil health plays a critical role in food system resilience by retaining moisture and minimizing erosion and nutrient loss. Sustainable agricultural practices and natural resource protection are vital for long-term food security .

Key words**:** *food security, resilience, climate change, financial risks, Global Food Security Index*

INTRODUCTION

Food security relies on the ability of interconnected social, economic and biophysical systems to meet human nutritional requirements, and understanding and addressing these risks is essential to build resilience of food systems, ensuring at the same time long-term food security [13]. As consequence climate change, financial risks but also political uncertainty represent the key challenges we face in this regard. Resilience, the ability to bounce back and better overcome a shock or disaster, is becoming increasingly important in the current context [18], so building better food systems that can absorb and adapt to climate change and other risks is key to ensuring long-term food security [19]. The proposed study aims to evaluate and critically analyse adjustments to the Global Food Security Index (GFSI) to better understand how they influence the assessment and approach to food security in the context of food accessibility and other global risks, providing recommendations for improving global food security policies and programs. Expected outcomes include identifying gaps in the Index and proposing improvements to more accurately reflect the complexity of the global food system and to contribute to the development of more effective policies and programmes to ensure long-term food security in diverse contexts and places. Food security is directly related to the health of the world's productive land, necessary freshwater and wide oceans – essential elements in enhancing food productivity needed for the growing global population expected to reach 9.10 billion by 2050. However, pressures on these essential resources are increasing due to population growth, urbanisation and changing consumption patterns [22]. Agriculture covers a significant proportion of the global land area, and its expansion, particularly in developing countries, is faced with degraded land, which adds further pressure on existing resources, and the quality and quantity of land is critical to global food production capacity [8]. The amount of land suitable for agriculture is finite and soil depletion due to intensification of agricultural practices is a major concern, thus soil health contributes to the resilience of food systems by retaining moisture and minimizing erosion and nutrient loss. Competition for agricultural land, feed and fuel [21] will continue to intensify as populations and incomes grow, putting additional pressure on the quality and quantity of land available for food production, and there is a need to adopt sustainable agricultural practices and protect natural resources to ensure long-term food security in the face of these challenges [1]. Factors contributing to food price increases include weather conditions and wider economic factors, such as fluctuations in oil prices and agricultural policy, and dependence on imports for supplies can exacerbate the impact of these price increases, particularly in lower-income countries. With regard to food security nets, it is essential to diversify methods of support, including cash transfers, vouchers and physical provision of food, so these programmes need to be sensitive to the needs and livelihoods of beneficiaries, with a particular focus on the inclusion of women in decision-making processes, and investment in food security programmes is not only a safeguard against food insecurity but also a way to promote community resilience and stimulate sustainable economic development.

The Covid-19 pandemic affected greatly the consumers` perceptions of food security, safety and hygiene which led to changes in their purchasing behaviour and the need to understand the stakeholders` awareness and knowledge on food safety indicators in their online shopping experience [2]. Climate change, characterized by changes in long-term weather patterns, is emerging as a complex and pervasive threat to global food security. The diverse effects of climate change, including severe weather occurrences, alterations in rainfall patterns, increasing temperatures, and shifts in the frequency and severity of climate-related disasters, present considerable obstacles to global agricultural practices and food production [14].

The impact of food waste is far-reaching. In addition to inefficient use of resources, it results in increased greenhouse gas emissions, greater pressure on water and land resources, reduced overall productivity, and negative impacts on local and global economies. Addressing this challenge is critical not only to alleviate hunger, but also to reduce the environmental footprint of food production, a high priority within the framework of the circular economy model [15].

The workpaper’s originality lies in its detailed examination of the multifaceted and interconnected factors affecting global food security. It uniquely combines economic, geopolitical, environmental, and systemic perspectives to highlight how issues such as income disparity, conflict, climate change, and infrastructure vulnerabilities collectively influence food accessibility and affordability. The necessity of addressing this theme is emphasized by the urgent need for globally coordinated strategies to mitigate these risks, promote equitable food distribution, and strengthen the resilience of the food system against future shocks. This comprehensive analysis is essential to address the urgent and complex challenges that threaten food security worldwide.

MATERIALS AND METHODS

The Global Food Security Index indicators measuring risk and resilience, provide a general overview regarding each country state concerning food security. Identifying vulnerabilities for selected countries and the resilience of their food systems is essential for developing effective policies, investments and interventions, so recognising the unique characteristics of each country and collaboration between governments, the private sector and the non-governmental sector are vital to building resilience and ensuring long-term food security. The

proposed methodology for assessing the impact of adjustments to the Global Food Security Index on the assessment and approach to food security includes:
(a)collecting and reviewing relevant GFSI data on food security and identifying and selecting indicators and sub-indicators used in the GFSI to assess multiple dimensions of food security.
(b)comparing the 2022 edition of the GFSI with previous editions to identify and assess changes and adjustments made by analysing the evolution of indicators and sub-indicators over time and identifying relevant trends in food security.
(c)assessing how the new GFSI adjustments influence the perception and management of food security in the specific context by identifying similarities and differences between how different countries interpret and use the Global Food Security Index.
The paper aimes at assessing the impact of adjustments to the Global Food Security Index on the approach each country adopt for food security, of the extent to which the new indicators and sub-indicators introduced in the GFSI [9] are effective in measuring food security in relation to food affordability and other global risks and the degree to which the adjustments to the GFSI reflect the diversity and complexity of the global food system [10].
The database used in the study includes sources such as Food and Agriculture Organization (FAO), Food Price Index 2022, International Fund for Agricultural Development (IFAD), United Nations International Children's Emergency Fund (UNICEF), World Food Programme (WFP) and World Health Organization (WHO) 2021and Global Food Security Index 2018-2022.

RESULTS AND DISCUSSIONS

Food security is essential for social well-being and stability, and access to affordable food is the foundation of this food security. Households with higher incomes and that allocate a lower proportion of their expenditure to food are more likely to cope with temporary price increases, whereas low-income households require short-term safety nets to ensure that food remains affordable, especially in the face of food price shocks (Fig. 1).

Fig.1. FAO Annual food price indices
Source: World Food Situation- FAO Food Price Index [5].

The FAO Food Price Index [5] reached an all-time high in March 2022 and, although it subsequently declined, remained significantly above the level recorded in the previous year, these shocks come in a context where emerging countries confronts with various problems, like viral outbreaks, insufficient resources and increasing social disparities [20]. Food costs is the most important challenge next to food affordability, both

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inducing undernourishment or malnutrition for a part of the world population. The COVID-19 pandemic has driven up food prices, direction continued by the war caused by Russia.

The war has led to large price increases, with regional supply shortfalls through disrupted supplies, stock shortages and sometimes even the creation of stocks that could not follow the delivery route and were blocked. Globally, rising fuel and other basic agricultural inputs costs have resulted in additional transportation costs and sometimes in the inability to get products to their destination [17], with shortages of some commodities contributing to food price increases that have exceeded all expectations.

Financial risks limit access to food for low-income families, and military conflicts and political instability negatively affect agricultural production due to unreliable transportation routes with various logistical limitations. In general, ensuring food security requires complex and coordinated global approaches that address risks and require that food resources distribution to be equitable and sustainable.

Even developed countries are vulnerable to these categories of risks and that is why they must manage their capabilities in a balanced way and outline clear strategies and contingency plans in order to increase accessibility to food and natural resources even in the case of situations of crisis. After registering a relative decrease, the general index of food security indicated a return as a result of the decrease of instability and the realization of agreements between countries on common protection measures.

This improvement has been underpinned by advances in infrastructure, along with increased production capacity and relatively stable food prices, however, these advances are threatened by various risks, both environmental and socio-economic (Fig. 2).

Fig. 2. Global Food Security Index for 2018-2022 within the top ranked countries
Source: Global Food Security Index 2022 report [11].

Singapore ranks first in the 2018 GFSI rankings for the first time, this performance is largely attributed to its status as a high-income economy, thus rising GDP per capita and low household spending on food contribute to this high score [11], in addition, low import tariffs on agricultural products reduce food import costs, strengthening Singapore's position in the rankings. Food security in Singapore is, however, exposed to challenges regarding climate change and variability in access to natural resources. This fact is caused by the country's high dependence on food imports (90% of the food consumed comes from imports), the country being exposed to food security risks caused by various natural, military or climatic threats.

In recent years, the United States (US) has seen a decline in its food security ranking, dropping from first place between 2012 and 2016 to second place in 2017, and now tied for third place with the United Kingdom (UK), basically this change reflects a slower improvement compared to other countries rather than a deterioration in score, however, the relatively modest progress the US has made is threatened by a polarised political environment and growing protectionist sentiment.

Whithin the Global Food Security Index there were identified more obvious changes and directions. Food affordability decreased by 4% in 2022 compared to the reference year 2019, the determining factors being represented by the phenomenon of COVID-19 and Russia's military aggression in Ukraine which increased food costs and affected people's ability to afford food, in addition, social and political barriers reduced food availability, and armed conflict and political instability contributed to a decrease in scores in these areas. Increasing reliance on food aid has also been a concern, with an 8% decline in scores for this indicator between 2019 and 2022, however, there are also positives such as rising scores for agricultural inputs such as farmer empowerment commitments and food security strategies, which have seen significant increases, also policy commitments to adaptation and agricultural sustainability have increased, reflecting greater attention to these issues globally, however, there are still challenges such as low soil organic content and poor irrigation infrastructure.

In terms of performance by country, the top of the Global Food Security Index for 2022 is dominated by high-income countries in Europe, with Finland, Ireland and Norway at the top, in contrast, the worst performing countries are concentrated in the Middle East, North Africa and Latin America, with Syria, Haiti and Yemen at the bottom. The inequalities within the worldwide food system indicate that common strategies are needed to reduce disparities and differences in access to food (Fig. 3).

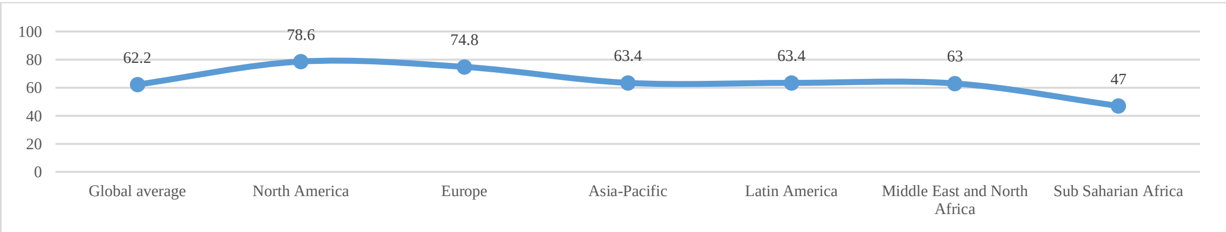

Fig. 3. Global Food Security Index by Region in 2022
Source: own calculations based on GFSI 2022 Report [11].

It is clear that concerted global efforts are needed to strengthen the resilience of food systems and address systemic issues affecting food security. This involves investment in technology, infrastructure, services for farmers and the implementation of effective policies at national and global levels, only by addressing these issues and increasing resilience can we hope to successfully address the long-term challenges within food security, ensuring as equal as possible accessibility to food. Food affordability is one of the most important indicators that participates in creating the Global Food Security Index. The highest increase in this aspect, over the analyzed period (10 years), was in Tanzania (from 34.7 in 2012 to 48 in 2022) as can be seen in Figure 4.

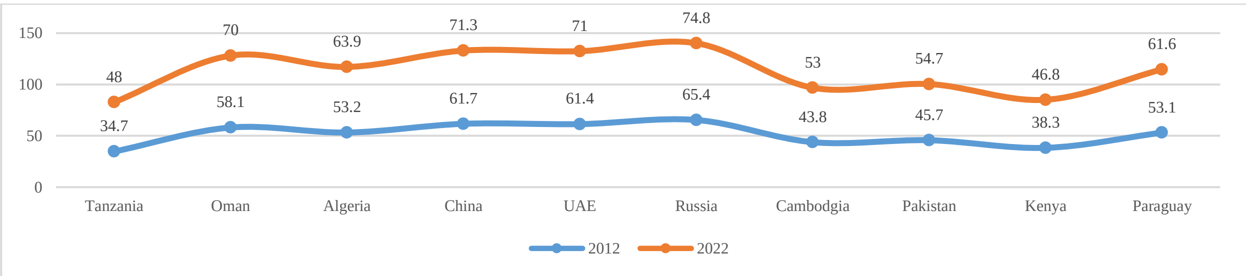

Fig. 4. Countries recording the highest increase in food security (2012-2022)
Source: own calculations using GFSI 2022 Report data [11].

The Global Food Security Index for 2022 exposes visible disparities between different countries (Fig.5). For food security in 2022, the countries from Europe, the North American continent and Australia obtained a score of over 70 points, while at the opposite pole, the vast majority of countries on the African continent recorded less than 55 points [7].

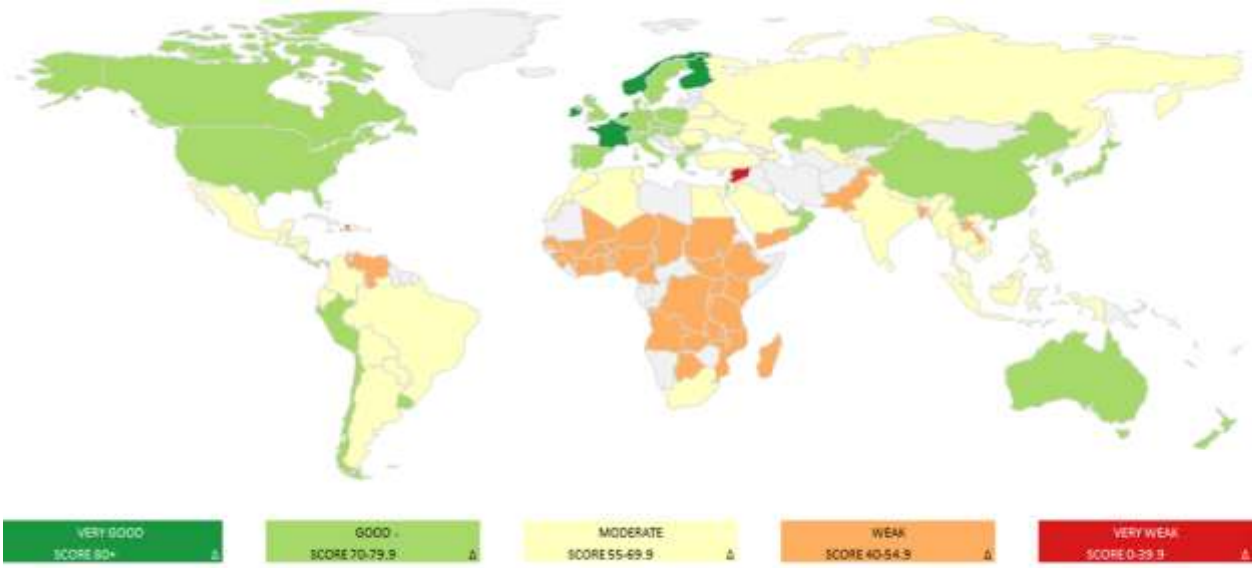

Fig.5. 2022 Country score map regarding food security environment (scores are normalized 0-100, where 100=best conditions).
Source: Own calculations based on GFSI 2022 Report [11].

In terms of food affordability, eight of the ten nations benefited most from the opportunity to reduce food prices, while for Oman and Cambodia, the launch of a safety net was key, and for the first six nations, improving market access was key to increasing food affordability. The United Arab Emirates, Algeria and Niger saw the biggest increase in food availability, thanks to tackling volatile food production and a commitment to food security policies, with many of these nations scoring better by strengthening infrastructure and investing in agricultural research and development. Increased food availability is associated with significant decreases in hunger in countries such as Bolivia, Ethiopia and Angola, which realised significant improvements regarding poverty reduction and farmer productivity, while Sudan, recorded great progress in the implementation of nutritional standards [12]. The global food system fragility was underlined by the pandemic [6] or the climate changes which generated food security gaps, manifestations that continues to appear along [16] with droughts and floods [4]. The Index values for 2022 resulted from the analysis of the global food security environment shows, the progresses in food security made by Romania [7] even if further attention is required (Fig.6). The country ranks well in affordability and quality and safety but needs improvement in both sustainability and adaptation needing security measures as part of a general risk strategy. As shown in the 2022 GFSI data food affordability decreased by 4% as related to the same indicator value in 2019.The increase in food prices is worrying given that the world is now facing the third global food price crisis in the last 15 years (Fig. 7).

The ability of the countries to face disrupting events is questioned and tested as the leader have to prepare efficient strategies in order to ensure sufficient food supplies. Vulnerabilities in the system are becoming particularly evident in the availability of and access to food, as well as the sustainability of the environment that supports this availability, so it is increasingly clear that a holistic approach to the food system is required, taking into account both the consumer side, with a focus on accessibility and quality, and the complexities of food production impact on the entire food system (Fig. 8).

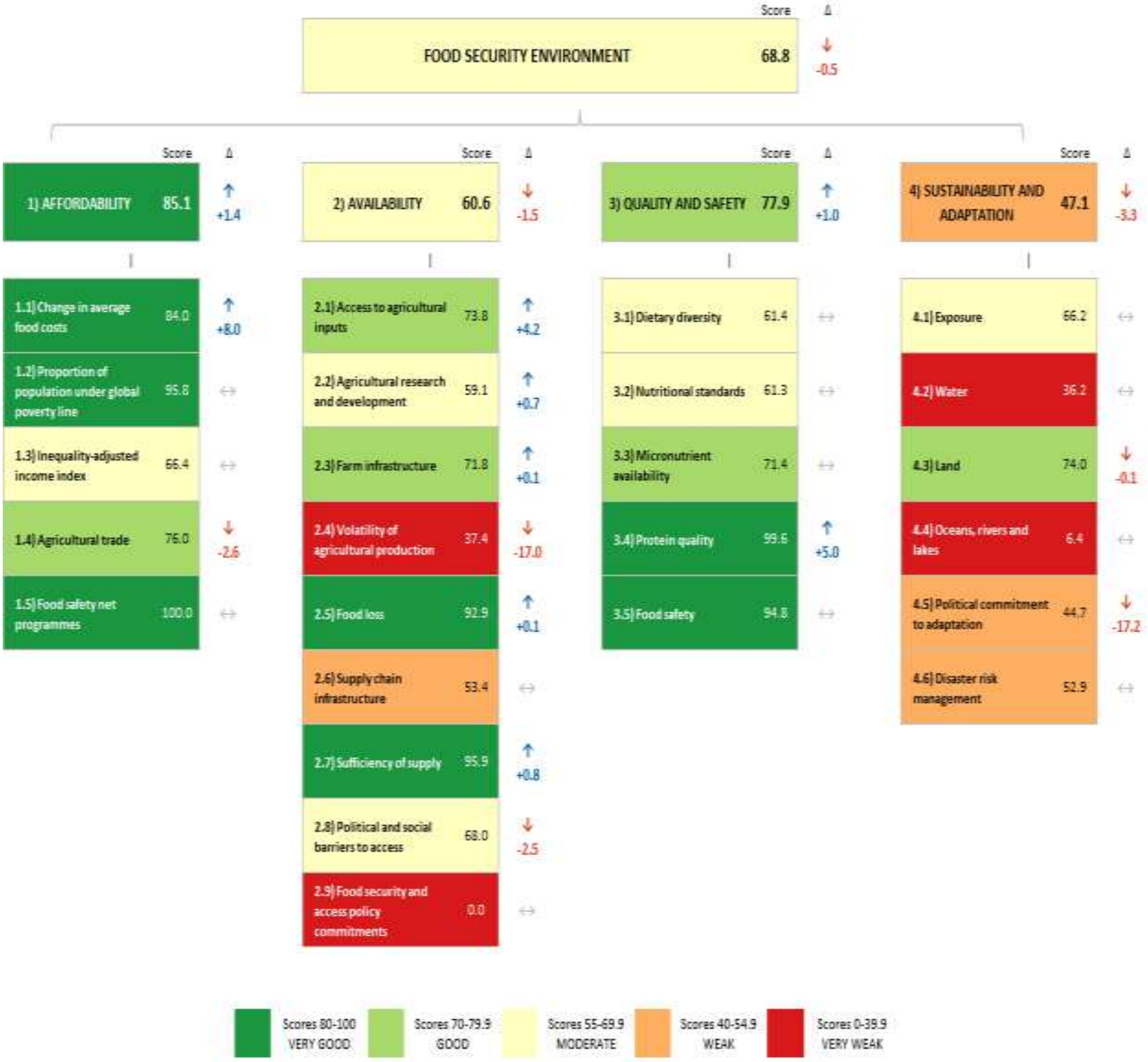

Fig.6. Romania - score regarding food security environment (scores are normalized 0-100, where 100=best conditions).
Source: Own calculations based on GFSI 2022 Report [11].

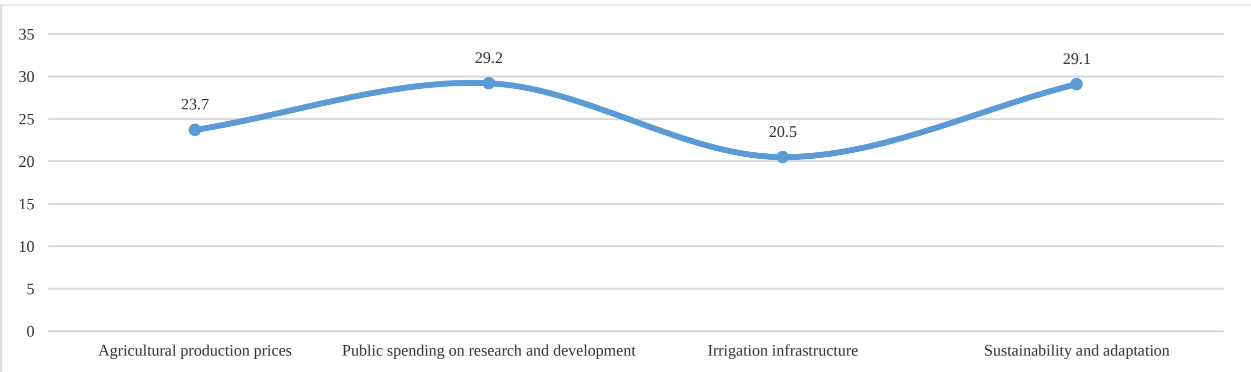

Fig.7. Indicators with the lowest score from GFSI 2022 (%)
Source: own calculations based on GFSI 2022 Report [11].

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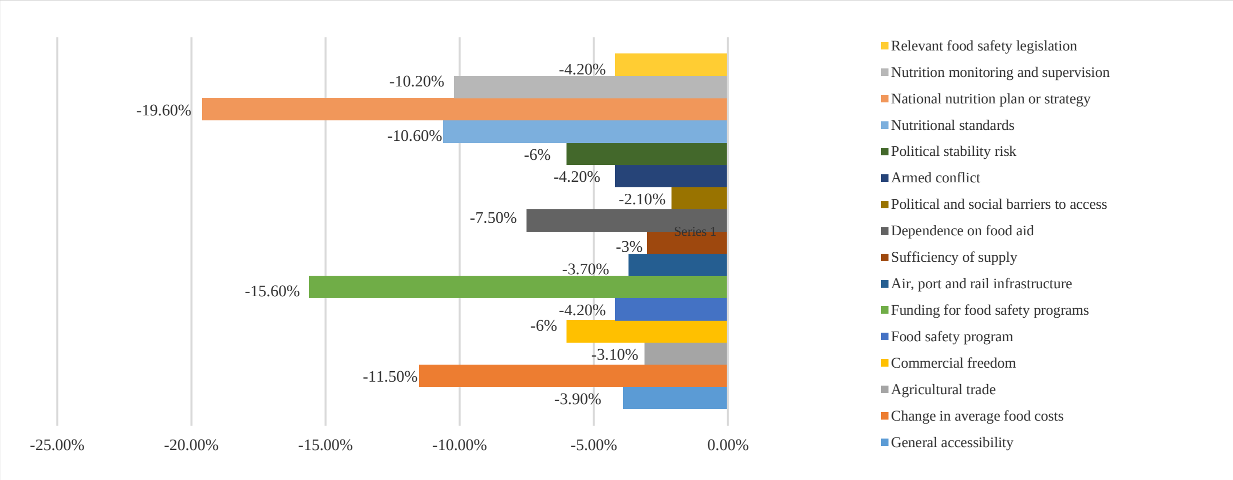

Fig. 8. Global Food Security Indices with the largest percentage decrease in scores in the year 2022 (%)
Source: own calculations based on GFSI 2022 Report [11].

Strengthening the resilience of the global food system necessitates an integrated and collaborative strategy that addresses the complex interplay of social, political, and environmental challenges. To achieve this objective by implementing timely policies that address social inequalities, climate change and environmental degradation, ensuring access to food resources is vital. These main efforts can make a difference in this area and consist in reducing the waste of resources, a collaborative approach and active participation (especially of local communities). All these efforts can lead to a healthy global food security (Fig. 9).

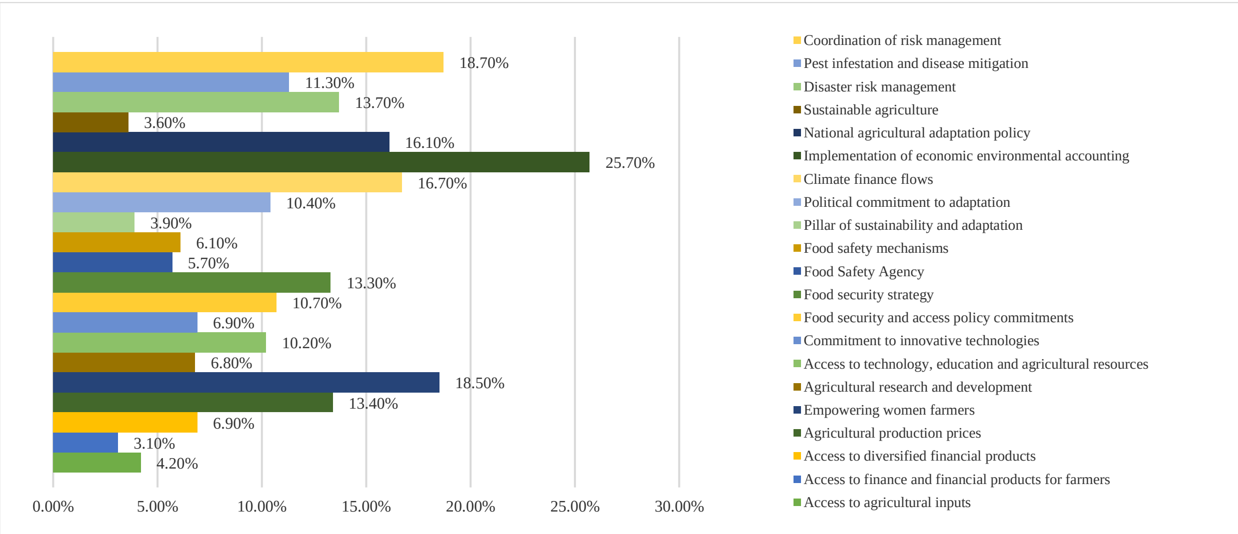

Fig. 9. GFSI indicators with the highest percentage increase in scores in the year 2022 (%)
Source: own calculations based on GFSI 2022 Report [11].

Reducing food costs requires trade freedom, support for farmers and financing facilities for large food-importing countries [23], so imposing trade or export restrictions should be avoided, and price volatility should be minimized, and building long-term systemic resilience must also be a priority and will require an approach tailored to context and specific needs [3]. The emphasis should be placed on supporting the food supply and the environment that supports it, with improvements in land management, increasing the organic carbon content in the soil, adopting sustainable sources and reducing food pollution and waste, so adapting to a changing climate and promoting resilience in agriculture will ensure sustainable and nutritious food production. It is essential that there is a renewed commitment and action from all actors in the food supply system - governments, consumers and NGOs - to strengthen a sustainable food system and improve its ability to withstand shocks.

CONCLUSIONS

The research highlights the critical importance of addressing food security through comprehensive and scientifically informed approaches. The FAO Food Price Index reaching an all-time high in March 2022, followed by persistently elevated levels, highlights the volatility of global food prices and the need for resilient strategies to mitigate these impacts. The complex interplay of factors such as the COVID-19 pandemic, geopolitical conflicts like the Russia-Ukraine war, and systemic issues within the food system contribute to this volatility, underscoring the necessity for globally coordinated policies that can adapt to and manage such multifaceted challenges.

While high-income countries are generally more resilient, significant declines in food security are observed when adjusted for natural resource and climate risks. This indicates that wealth alone does not shield nations from food security threats and emphasizes the necessity for all countries to invest in climate adaptation and natural resource management to ensure long-term food security. Environmental and socio-economic risks are identified as the most important threats, which can only be prevented and stopped through continuous joint efforts and concrete strategies. Strategic investments can enhance the performance of countries reflected in the IGFSI indicators, with current research highlighting that ensuring food security requires an integrated approach, both in the short and long term. Promoting trade freedom, supporting farmers, and ensuring financing facilities for large food-importing countries are essential strategies. Additionally, avoiding trade restrictions and minimizing price volatility are crucial for maintaining food affordability. Building systemic resilience through sustainable land management, increasing soil organic carbon, adopting sustainable sources, and reducing food pollution and waste are vital for adapting to climate change and promoting agricultural resilience.

The findings highlight the necessity for renewed commitments and coordinated actions from all actors in the food supply system—governments, consumers, and NGOs—to create a sustainable, resilient food system capable of withstanding future shocks. This scientific approach is essential for developing effective policies and practices that ensure global food security and promote equitable and sustainable food production for all.

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STUDY ON THE INFLUENCE OF ORGANIC MANURE ON SOIL FERTILITY

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Abstract

Fertility and soil balance cannot be maintained without the presence of organic matter and the addition of new quantities of plant residues or chemical and organic fertilizers, as plants extract significant amounts of nutrients from the soil each year. Therefore, the application of manure can be considered a good source for increasing the potential fertility of the soil. This study addresses on the fertilization with manure derived from cattle and sheep farming activities on the typical chernozem soil from the Romanian Plain. The effects of using these organic fertilizers are mainly observed in the behavior of nitrogen (N) and phosphorus (P) in the soil, as they are the main nutrients that influence agricultural crop yields. Potassium (K) has a secondary role, but along with pH and other macronutrients, it improves the physical and biological properties of the soil, as evidenced by the appearance and formation of a positive humus balance and an improvement in the NPK content of the soil. Following the application of manure over a period of more than five years, changes in the physical-chemical indicators are observed, such as the bulk density of soil which decreases from 1.28 g/cm^3 to 1.17 g/cm^3, or the humus that increases from 2.07 % to 2.57 %, after five years of manure action.

Key words: *fertilization, manure, soil, humus, typical chernozem, increase in production*

INTRODUCTION

Agriculture has a major impact on soil nutrients worldwide. In some regions, soil nutrients are depleted due to the low initial soil fertility or excessive nutrient removal through intensive land use compared to nutrient additions [14].
Soil organic matter is an essential component with multifunctional roles in soil quality and is linked to many physical and biological properties of the soil [19].
As a complex property of retaining, transforming, and providing mineral substances and water to plants, fertility is related to the soil's openness to the external energy flow. Kleinhempel advanced the idea that fertility is the variation of entropy over time as an inherent property of the soil [10].
The consumption of mineral substances from the soil (N, P, K, Ca, Mg, etc.) and organic matter with each harvest, needs to be replenished to the soil through the application of organic fertilizers (manure, compost) and the incorporation of plant residues (straw, corn stalks, sunflower, rapeseed, etc.), complemented by chemical fertilizers [20, 18].
The balanced application of organic fertilizers greatly influences the accumulation of organic matter in the soil and the microbial activities in the soil. The benefits of balanced fertilization using crop residues, organic manure, and green manure in maintaining soil organic matter levels are well known [9].

Manure is a byproduct of animal farming activities and is considered an organic fertilizer with high agrochemical and agronomic value. Studies conducted by researchers have shown that the application of manure led to changes in soil elements, with soil organic carbon reaching 17.7%, available nitrogen at 16.0%, available phosphorus at 66.2%, and available potassium at 19.1% [16], [12], [7] and [5].

The continuous application of organic manure alone or in combination with NP fertilizer for 10 years led to a decrease in soil pH from 8.1 to 7.69 due to the formation of organic acids during the decomposition of organic matter [1].

Other studies on poultry manure have shown that annual application of 10 tons of poultry manure significantly increased the available phosphorus and potassium content for plants, inhibited alkaline phosphatase activity, and resulted in the accumulation of a high level of available phosphorus for plants [11].

The object of study is the typical chernozem soil [8], used for the application of manure and the observation of changes in its properties compared to the same soil where this fertilizer is not applied.

MATERIALS AND METHODS

The soil used in this exeperiment is located in the Burnașului Plain, a subdivision of the Romanian Plain, situated in southern Romania, where an arid climate is encountered, with average annual precipitation of P = 400 - 450 mm and average annual temperatures above 12^{o}C.

The texture of this soil type is loamy-clayey, with a humus content ranging from 1.95% to 2.36%, available phosphorus content of 1.56 - 1.82 mg/100g soil, exchangeable potassium of 16.1-16.9 mg/100g soil, and a slightly alkaline reaction with a pH of 7.9 – 8.2, being included in the III class of quality with 72 points of bonitation out of a maximum of 100. [3]. The parent rock is represented by loess and loessoid deposits.

The manure applied to this type of soil comes from cattle and the soil is tested with a dose of 40 t/ha every two - five years for agricultural crops. The applied agronomic practices include autumn plowing to a depth of 18-20 cm with the incorporation of manure, then sowing after disc harrowing at a depth of 12 cm, and maintenance work during the growing season.

RESULTS AND DISCUSSIONS

The soil cover is one of the most important natural resources and the main means of production in agriculture, so it is crucial to exploit this resource rationally, as it is constantly subject to degradation due to the export of nutrients by plants.

This degradation of soils occurs due to the consumption and depletion of nutrients, degradation of soil structure, acidification, and suboptimal addition of organic and chemical fertilizers to the soil. Such adverse soil conditions can lead to poor soil quality and crop yields [15].

Therefore, long-term addition of organic matter, such as manure, improves crop yield, water retention capacity, total porosity, and reduces bulk density and surface crusting [17].

Manure is a byproduct of cattle and other animal farming, considered an organic fertilizer that provides significant contributions to the soil and falls into the category of environmentally friendly organic products [2].

The chemical composition of manure depends on the maintenance practices of animals, resulting in manure with bedding or without bedding, which significantly differs in terms of nutrient content and physico-mechanical properties.

Manure from animals with bedding has a lower nitrogen content by 33.3% in cattle (5.7 kg/t) compared to sheep where it is 9.4 kg/t. Bedded cattle manure contains 3.8 kg/t of N, while non-bedded cattle manure contains 2.9 kg/t of N, which is significantly lower than sheep manure.

The P_2O_5 content also decreases in non-bedded cattle manure where it is 2.9 kg/t, compared to bedded cattle manure where it is 4.1 kg/t. The K_2O content in manure decreases by approximately 48% when bedding is used in animal housing compared to manure from non-bedded housing. In cattle manure, it decreases from 10.2 kg/t to 4.5 kg/t, while in sheep manure, there is a difference of 6.7 kg/t in K_2O content in manure (Table 1).

Table 1. Analysis of nutrient content in organic manure, kg/t

The type of manure	N (kg/t)	P_2O_5 (kg/t)	K_2O (kg/t)
Cattle manure with bedding	5.7	4.1	10.2
Cattle manure without bedding	3.8	2.9	4.5
Sheep manure with bedding	9.4	4.4	17.8
Sheep manure without bedding	9.1	3.7	11.1

Source: Own determination.

From the research, it was found that organic fertilization with manure contributed to the improvement of soil supply with humus, mobile phosphorus, and exchangeable potassium (Table 2).
After the first year of applying a quantity of 40 t/ha of manure, the soil's humus content increased only slightly from 2.07% to 2.10%. However, its effect was noticeable after three years of action when the humus content increased by 0.33% compared to the control group from the year 2017, and after five years of fertilization, it increased by 0.50%.

Table 2. Dynamics of humus content, mobile phosphorus (P), and exchangeable potasium (K) in the soil under the influence of organic manure

Fertilization type	Humus content (%)	Increase (%)	Mobile phosphorus (P) (mg/100g sol)	Increase (mg/100g sol)	exchangeable potassium (K) (mg/100g sol)	Increase (mg/100g sol)
The year 2017						
Unfertilized soil (control)	2.07	-	1.85	-	16.5	-
Manure (40 t/ha)	2.10	-	1.53	-	16.2	-
The year 2019						
Unfertilized soil (control)	1.95	- 0.13	1.96	0.11	16.8	0.3
Manure (40 t/ha)	2.40	0.33	2.54	1.04	20.2	3.7
The year 2021						
Unfertilized soil (control)	2.19	0.11	2.00	0.15	16.9	0.4
Manure (40 t/ha)	2.57	0.50	3.56	1.71	22.2	5.7

Source: Own determination.

Fertilization with manure at doses of 40 t/ha and at different intervals led to an increase in mobile phosphorus ranging from 0.11 to 1.71 mg/100g of soil over the five years of fertilization, compared to the initial content in 2017, which was 1.85 mg/100g mobile phosphorus (P) of soil. The mobile phosphorus content increased from 1.85 mg/100g of soil in the unfertilized soil to 3.56 mg/100g of soil after five years of fertilization with manure.
The values of exchangeable potassium (K) increased in the fifth year of application, in 2021, by 5.7 mg/100g of soil, rising from 16.5 mg/100g of soil in 2017 to 22.2 mg/100g of soil in 2021.
Fertilization with manure of the typical chernozem, contributes to the formation of structural elements with agronomic value. Applying manure at a rate of 40 t/ha leads to a reduction in the coarse fraction (>10 mm) while increasing the structural formations by over 10% in fractions with a diameter below 0.25 mm [13].
The content of fine clay, as well as physical clay, remains constant when fertilizing with manure. The loamy-sandy texture can be considered very favorable as it provides

normal conditions for the growth of cultivated plants. However, the low hydrostability of structural aggregates formed by soil work, weak resistance to secondary compaction, and high erosion risk are considered negative aspects of this loamy-sandy structure.

The highest increase in humus, phosphorus, and potassium compared to the unfertilized control, is observed after 5 years of manure application, with a 0.50% increase in humus, 1.71 mg/100g of soil increase in phosphorus, and 5.7 mg/100g of soil increase in potassium.

Table 3. The influence of manure on the physical indicators of the typical chernozem

Fertilization type	Bulk density (g/cm^3)	Total porosity (%)	Penetration resistance (PR) at depth 0–30 cm (kgf/cm^3)
Unfertilized soil (control)	1.28	52.4	23.2
Manure applied at 3 years (40 t/ha)	1.20	53.6	19.9
Manure applied at 5 years (40 t/ha)	1.17	55.4	13.5

Source: Own determination.

The increase in organic matter content in the variants fertilized with manure leads to a decrease in the bulk density of soil from 1.28 g/cm^3 to 1.17 g/cm^3 after 5 years of applying this fertilizer (Table 3). These changes have resulted in an increase in pore space of up to 55.4%.

The value of soil penetration resistance (PR) decreased by 9.7 kgF/cm^3, from values of 23.2 kgf/cm^3 to values of 13.5 kgf/cm^3, and the total soil porosity (TP) improved by 3 percentage points, increasing from 52.4% to 55.4% after five years.

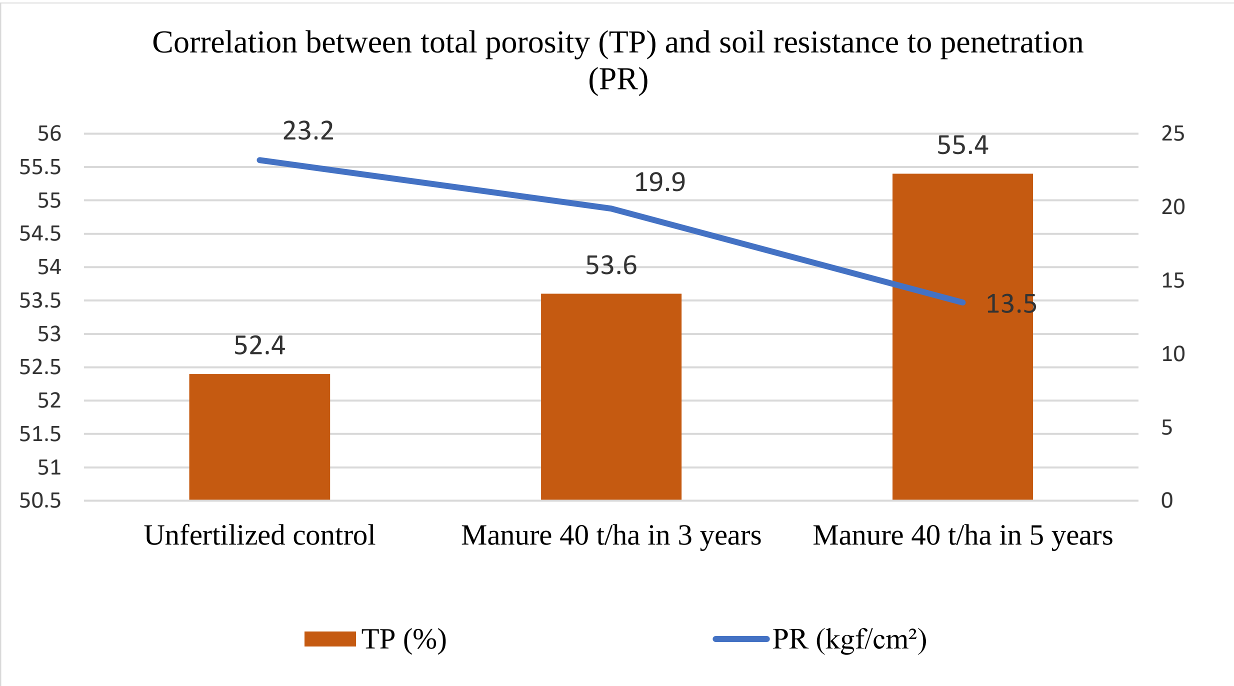

Fig. 1. Correlation between total porosity (%) and soil resistance to penetration (kgf/cm^3)
Source: Own determination.

The influence of manure fertilization has demonstrated that it has a high fertilizing effect on the soil, especially on its physical and chemical properties.

As observed in Figure 1, penetration resistance is inversely proportional to total porosity. At total porosity values of 52.4%, the penetration resistance increases to moderate values of 23.2 kgf/cm^3. As the total porosity increases to values of 55.4% after 5 years of manure application, the penetration resistance decreases by 41.8%, reaching values of 13.5 kgf/cm^3, which are considered low in this zone. This indicates a considerable improvement in the physical properties of the soil [6].

Since organic materials in the soil have a low apparent density and high porosity, adding organic matter to the soil through the incorporation of manure improves the physical properties of the soil [4].

Table 4. Analysis of the influence of manure on production

Variant	Productions without fertilization (kg/ha)		
	Corn	Wheat	Peas
Unfertilized soil (control)	3,583.2	1,383.5	6,375.9
Fertilization type	Increase in production (kg/ha)		
Manure applied at 3 years (40 t/ha), increase in production	1,361.3	626.4	2,038.2
Manure applied at 5 years (40 t/ha), increase in production	1,220.9	543.6	1,901.7

Source: Own determination.

The average productions increase significantly, following the application of manure, for the corn crop it increases by 1,361.2 kg/ha, for wheat by 626.4 kg/ha and for peas it increases by 2,038.2 kg/ha when it is applied after 3 years (Table 4).
In the variants fertilized with manure with a dose of 40 t/ha at 3 and 5 years, significantly higher production increases were obtained.

Table 5. The increase in production under the conditions of application of 40 t/ha of manure

Fertilization type	Increase in production (%)		
	Corn	Wheat	Peas
Manure applied at 3 years (40 t/ha)	37.99	45.27	31.96
Manure applied at 5 years (40 t/ha)	34.07	39.29	29.82

Source: Own determination.

The biggest increase in production was recorded when fertilizing with 40 t/ha of manure once every two to three years, in the pea crop, the increase being 31.96%. In the wheat crop we have a significant increase of 45.27% and in the corn crop the production increase is 37.99% (Table 5).

CONCLUSIONS

Manure is the most important and widespread source of organic matter and nutrients for restoring soil fertility in chernozem soils and increasing agricultural crop productivity.
Applying manure for 5 years led to a positive balance of humus in the chernozem soil and an increase in the content of mobile forms of phosphorus and potassium. The humus content increased by 0.50% over the five years analyzed, the mobile phosphorus content increased by 1.71 mg/100 g of soil, and the exchangeable potassium content increased by more than 5.7 mg/100 g of soil.
The value of penetration resistance decreased by 48%, and total porosity significantly improved, reaching values of 55.4%, increasing by 3%.
It is recommended to apply manure on chernozem soils used for annual field crops at a rate of 40 t/ha, at least once every 2 years, but the greater effect is observed after at least 2 applications, after 3 years.
The increase in production after the application of manure 40 t/ha, is between 31.96% for wheat and 45.27% for wheat, which makes the best use of this fertilization.

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CLIMATE CHANGE AND LAND TEMPERATURES AND THEIR IMPACT ON AGRICULTURE AND SOCIETY: A GLOBAL INVESTIGATION

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Abstract

This article examines how climate change influences Earth's temperatures and affects communities worldwide. As temperatures continue to rise, so do economic challenges, making it critical to understand these shifts and create effective strategies for adaptation and mitigation. We highlight global and local initiatives addressing these issues, emphasizing their environmental and social benefits while underlining the need for cooperation between communities, governments, and international organizations. To support our analysis, we incorporate data from FAOSTAT and use advanced tools to present clear visualizations. We also rely on trusted sources, including specialized websites, to ensure our insights are accurate and current. By exploring the complex connections between climate, society, and the environment, this review calls for collaborative and integrated action to meet sustainability goals and build a more resilient future.

Key words: *climate change, land temperatures, climate indicators, climate variations, global impact*

INTRODUCTION

Climate change stands out as a defining challenge of our time, reshaping life on Earth in profound ways. Its effects are evident everywhere, from shrinking glaciers and rising oceans to the increasing frequency of extreme weather events, leaving no region untouched.

Against this backdrop, understanding and analyzing global temperature change becomes essential to develop effective adaptation and mitigation strategies.

In recent years, scientists have drawn particular attention to the climate crisis and global warming, presenting the need for climate change mitigation as imperative. The effects of climate change, society's vulnerability, and the urgent need for adaptation are gaining increased attention in both scientific research and media discussions [7].

Statistics from 2023 reveal notable temperature increases worldwide, with the Americas experiencing the highest rise at 4.17°C. These changes bring unique challenges, such as intense heatwaves in the Americas and Africa and disrupted agriculture in Europe and Asia, showing the need for local, tailored solutions.

Climate change isn’t just about the environment-it’s affecting economies, public health, and food security. In Europe and Asia, rising temperatures are lowering crop yields and putting pressure on water resources, while urban areas in the Americas and Africa face extreme heat stress.

Agriculture in drought-prone regions like Dobrogea, Romania, has been particularly hard hit. Between 2016 and 2023, Dobrogea saw annual average temperatures above 11°C and rainfall between 351–450 mm [5, 6, 9, 13]. Similar issues affect Ukraine and Slovakia [4, 10]. Modern tools, like advanced information systems, can help farmers plan better despite these challenges [11, 12].

Across the EU, extreme weather over the past decade has reduced crop yields, increased costs, and hurt grain quality [7]. Romania has also faced rising temperatures, less rainfall, and worsening soil water deficits over the past 35 years [4].

Addressing these problems requires international cooperation, renewable energy adoption, ecosystem restoration, and raising public awareness [2]. The need for action is urgent to protect both people and the planet and ensure a sustainable future.

This article aims to examine how climate change affects global land temperatures, highlight key indicators, and propose sustainable strategies for adaptation and mitigation to protect the environment and secure a sustainable future worldwide.

MATERIALS AND METHODS

In order to carry out a detailed and comprehensive analysis of climate change and its impact on terrestrial temperatures, we used statistical data provided by FAOSTAT and various visualization tools. In this section, we detail the methods and materials used to collect, analyze and present the data, thus providing a solid basis for our conclusions and recommendations.

Data Sources

The statistical data used in this article comes from FAOSTAT, an internationally recognized database that monitors global climate change and temperature. The data provided cover land-based temperature changes for different regions of the world for the months of January, March, June, September and December of 2023.

Methods of analysis

Data collection: temperature change data were collected for each specified month, covering various geographical regions including Africa, the Americas, Asia, Europe and Oceania. These data were centralized and organized to facilitate comparative analysis and identification of regional and global trends.

Graphical visualization: To illustrate temperature changes and make them easier to understand, we created graphs using Microsoft Excel 365. The graphs shown include average temperature variations for each month and region, highlighting the seasonal and regional impacts of climate change. These graphical visualizations are essential to provide a clear and intuitive view of complex data, making the information accessible and easy to interpret.

Graphs used

To support the analysis, we have created graphs illustrating the variations in mean land-based temperatures in January, March, June, September and December 2023 for different regions of the world. These graphs help visualize the impacts of climate change clearly and concisely, highlighting regional trends and anomalies.

Comments and interpretations

Based on the statistical data collected, we have produced unique and interesting commentaries that highlight regional trends and anomalies in temperature change. These commentaries provide valuable insights into climate impacts in different parts of the world and highlight the need for tailored adaptive strategies.

Conclusions of the methods used

Using a combination of statistical data from FAOSTAT and graphical visualization tools allowed a thorough understanding of global climate change. These methods were essential for identifying trends and anomalies in temperature change and for formulating effective adaptation and mitigation strategies.

By clearly and comprehensively presenting the data and methods used, this article provides a solid basis for further discussion and analysis of climate change and its impact on terrestrial temperatures.

RESULTS AND DISCUSSIONS

The image uses intense colors such as red, orange, and yellow to highlight the areas most affected by rising global temperatures. The blue background of the oceans adds a strong contrast, highlighting the severity of the problem. Natural elements, such as the bright sun and a tranquil landscape with flowing water, symbolize both the beauty of our planet and its fragility in the face of climate change.

This vibrant palette conveys a sense of urgency and hope, suggesting that while the challenges are great, there is still a chance to protect the planet through coordinated and sustainable action.

Fig. 1. The global impact of climate change (a visual look at rising temperatures)
Source: Image built by using the keywords: climate change, global map, rising temperatures, rising sun, natural landscapes, forests, mountains, oceans [8].

Statistical data is essential for understanding how climate change affects land temperatures. In 2023, significant temperature increases were recorded across regions, highlighting the variability and complexity of the global climate system.

Using FAOSTAT data, we identified key seasonal and regional trends in Africa, the Americas, Asia, Europe, and Oceania [3]. These rising temperatures have far-reaching impacts on ecosystems, public health, and economies, stressing the urgent need for coordinated global action.

Graphs and statistics illustrate these changes clearly, emphasizing the importance of continuous monitoring and sustainable strategies. Key findings are summarized below.

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Table 1. Dry temperature changes in various regions of the world (January 2023)

Unit = °C, description = estimated value			
Domain	Area	Element	Value
Temperature change on land	World	Temperature change	1.70
	Africa		0.83
	Americas		2.91
	Asia		1.07
	Europe		1.84
	Oceania		0.24

Source: FAOSTAT/DATA/ET [1].

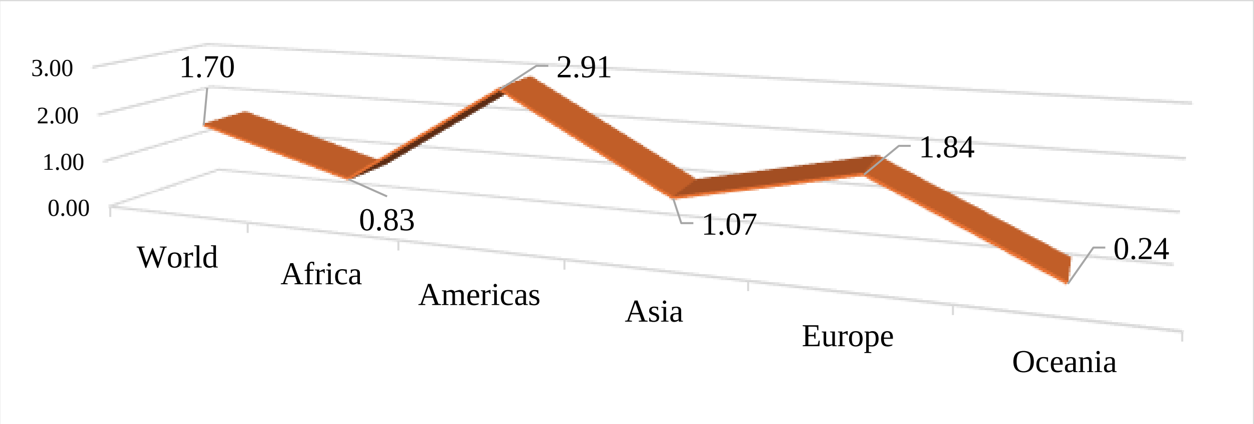

Fig. 2. Dry temperature changes by region (January 2023) (^{0}C)
Source: Own design based on the data from FAOSTAT [1].

The global average temperature rose by 1.70°C, signaling significant warming with potential impacts on ecosystems, agriculture, and human life.
The Americas saw the highest increase, 2.91°C, intensifying extreme weather and affecting water resources and biodiversity.
Europe (+1.84°C) and Asia (+1.07°C) also recorded notable increases, posing challenges for agriculture, public health, and biodiversity.
Africa (+0.83°C) and Oceania (+0.24°C) experienced smaller rises, but their vulnerability to climate change makes even modest increases impactful.
Rising temperatures highlight the need for stronger climate policies, tailored solutions, and efforts to boost community resilience.

Table 2. Dry Temperature changes in various regions of the world (March 2023)

Unit = °C, description = estimated value			
Domain	Area	Element	Value
Temperature change on land	World	Temperature change	2.12
	Africa		1.38
	Americas		1.09
	Asia		3.22
	Europe		4.07
	Oceania		0.91

Source: FAOSTAT/DATA/ET [1].

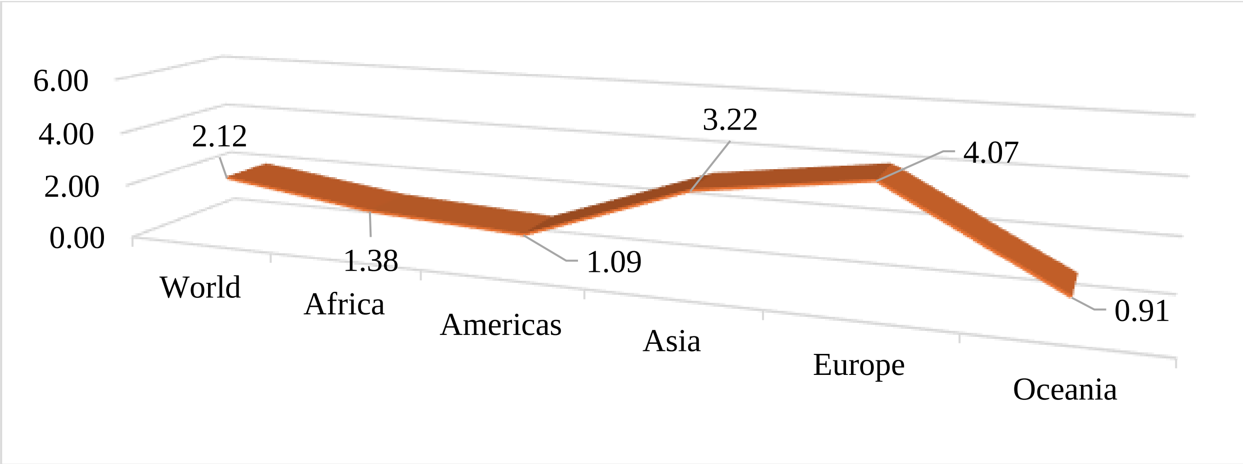

Fig. 3. Dry temperature changes by region (March 2023).
Source: Own design based on the data from FAOSTAT [1].

This table and graph show temperature changes in different regions of the world for March 2023. The table provides exact temperature increase values, while the graph visually represents the data to make it easier to understand trends. The graph highlights how Europe experienced the largest temperature rise (4.07°C), followed by Asia (3.22°C), while Oceania had the smallest increase (0.91°C). The inclusion of the graph helps to quickly see the ascending and descending order of temperature changes across regions.

Table 3. Dry Temperature changes in various regions of the world (June 2023)

Unit = °C, description = estimated value			
Domain	Area	Element	Value
Temperature change on land	World	Temperature change	1.54
	Africa		1.45
	Americas		1.59
	Asia		1.66
	Europe		1.57
	Oceania		1.01

Source: FAOSTAT/DATA/ET [1].

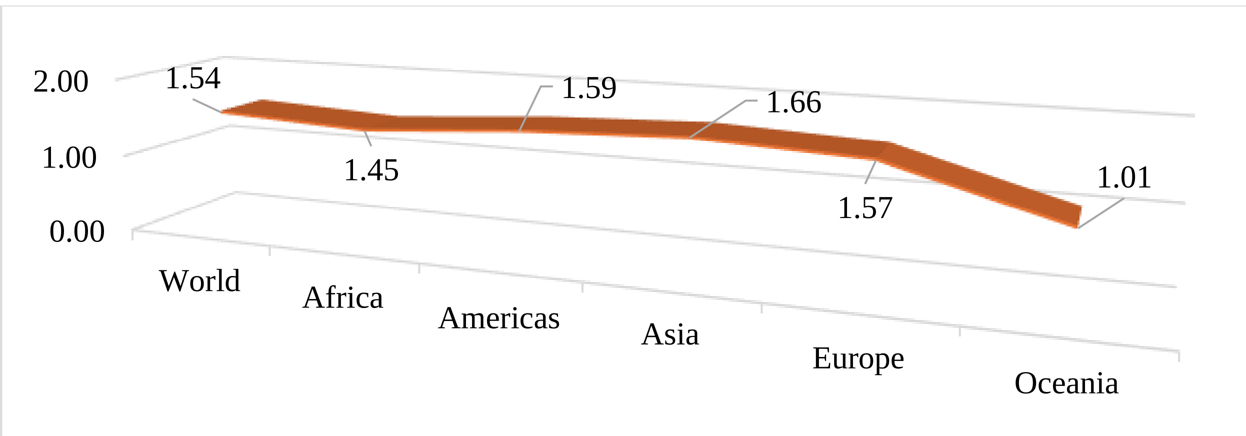

Fig. 4. Dry temperature changes by region (June 2023).
Source: Own design based on the data from FAOSTAT [1].

This table and graph present temperature changes across global regions for June 2023. The table provides exact values, with the global average increase at 1.54°C. Asia recorded the highest rise at 1.66°C, followed closely by Europe (1.57°C) and the Americas (1.59°C). Africa (1.45°C) and Oceania (1.01°C) showed smaller increases.

The graph complements the table by visually showing the slight variations in temperature increases, making it easier to see the trends across regions. Together, they highlight the uneven effects of climate change worldwide.

Table 4. Dry Temperature changes in various regions of the world (September 2023)

Unit = °C, description = estimated value			
Domain	Area	Element	Value
Temperature change on land	World	Temperature change	2.14
	Africa		1.74
	Americas		2.48
	Asia		1.87
	Europe		2.3
	Oceania		2.32

Source: FAOSTAT/DATA/ET [1].

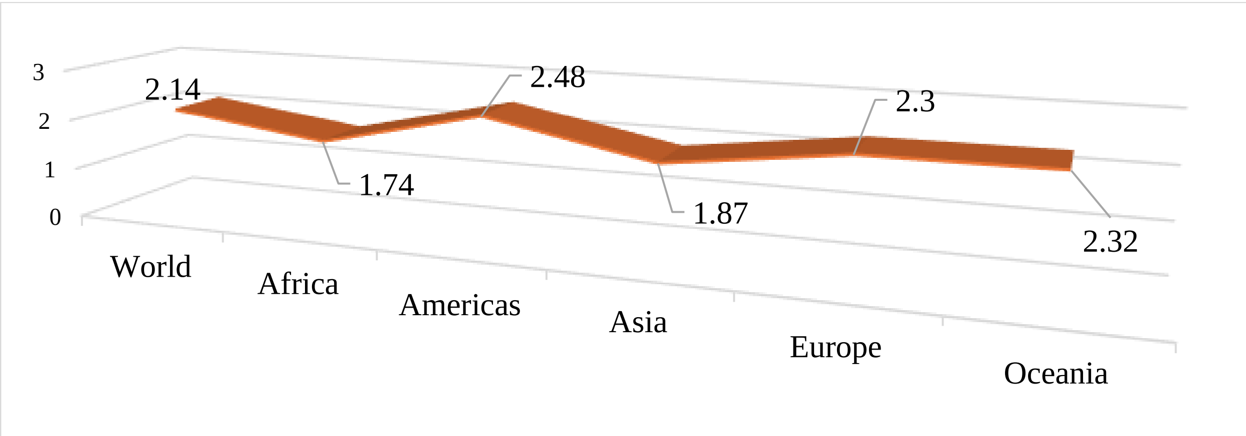

Fig. 5. Dry temperature changes by region (September 2023)
Source: Own design based on the data from FAOSTAT [1].

In September 2023, the global temperature increased by 2.14°C. This marks a return to the higher values observed in the earlier months of the year, emphasizing the seasonal variability of global warming (Table 4, Figure 5).

Africa recorded a temperature increase of 1.74°C, which is higher than in June. This indicates an intensification of the effects of climate change on the continent, which is already experiencing droughts and water shortages.

The Americas saw a 2.48°C increase, the highest on record this year for the region. This increase may contribute to worsening extreme weather events such as hurricanes and wildfires.

Asia saw an increase of 1.87°C, confirming the continuing warming trend. This can affect vital crops and cause extreme events such as floods and heat waves.

Europe has seen an increase of 2.3°C, one of the largest regional increases. This may lead to significant disruptions in agriculture, water resources and public health.

Oceania recorded an increase of 2.32°C, significantly higher than in June. This can affect marine and terrestrial ecosystems, contributing to coral bleaching and other ecological changes.

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September temperature rises coincide with the harvest season in many regions, affecting crop yields and crop quality. Farmers need to adjust their practices to cope with these conditions.

Cities in the most affected regions, such as Europe and the Americas, need to invest in resilient infrastructure to cope with heat waves and ensure the thermal comfort of their residents.

Table 5. Dry Temperature changes in various regions of the world (December 2023)

Unit = °C, description = estimated value			
Domain	Area	Element	Value
Temperature change on land	World	Temperature change	2.44
	Africa		1.49
	Americas		4.17
	Asia		2.02
	Europe		1.09
	Oceania		1.57

Source: FAOSTAT/DATA/ET [1].

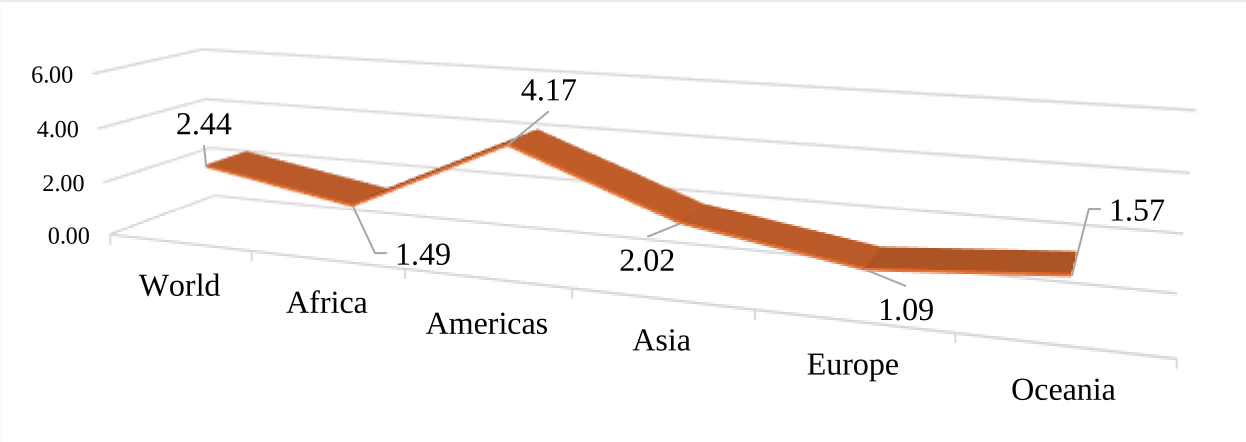

Fig. 6. Dry temperature changes by region (December 2023).
Source: Own design based on the data from FAOSTAT [1].

This table and graph present temperature changes across global regions for December 2023. The table shows the highest global average increase at 2.44°C, with the Americas recording the largest regional rise of 4.17°C. Asia follows with a 2.02°C increase, while Africa (1.49°C), Oceania (1.57°C), and Europe (1.09°C) show smaller but still significant changes.

The graph visually emphasizes the sharp increase in the Americas compared to other regions, making it easier to understand the magnitude and distribution of these changes. Together, they highlight the uneven impacts of climate change and the need for region-specific solutions.

Ways to address temperature changes

The dramatic changes in temperature, highlighted by significant increases in various regions of the world in 2023, call for effective strategies to balance and combat their effects. Here are some unique and innovative strategies:

S*$_1$*). Implement urban green infrastructure

Cities can reduce the urban heat island effect by developing green infrastructure such as green roofs, green walls and extensive urban parks. These solutions not only reduce local temperatures but also improve air quality and provide recreational spaces for residents.

S*$_2$*). Agroforestry and sustainable reforestation

Tree planting and agroforestry development in agricultural areas can help stabilize local microclimates and reduce extreme temperatures. This not only protects soil and conserves water, but also provides shade and habitat for biodiversity.

S_3). Advanced irrigation and water management systems

Implementing smart irrigation systems, which use sensors to monitor soil moisture and optimize water use, can help combat the effects of drought and maintain plant health in high temperatures.

S_4). Promoting renewable energy

The transition to renewable energy sources, such as solar, wind and geothermal, can reduce greenhouse gas emissions and mitigate the human contribution to climate change. Investments in green energy infrastructure are essential for a sustainable future.

S_5). Ecosystem restoration schemes

Restoring degraded ecosystems, such as wetlands and forests, can help absorb carbon dioxide and moderate local temperatures. Ecological restoration projects help make ecosystems more resilient to climate change.

S_6). Climate education and awareness

Educating the public about the impacts of climate change and what they can do to help mitigate it is crucial. Awareness campaigns and educational programs can change behavior and encourage individual and collective action.

S_7). Use of reflective building materials

In urban areas, the use of reflective construction materials for roads and buildings can reduce heat absorption and contribute to lower ambient temperatures. It can also reduce energy needs for cooling in summer.

S_8). Integrated public policies and international collaboration

Governments must adopt integrated public policies that address climate change from multiple perspectives: economic, social and environmental. International collaboration is essential to share knowledge and resources and to coordinate global efforts to tackle climate change.

S_9). Adopting passive cooling technologies

In architecture, the adoption of passive cooling technologies, such as natural ventilation and the use of thermally efficient materials, can help to maintain thermal comfort in buildings without requiring high energy consumption.

S_{10}). Climate monitoring and prediction systems

The development and use of advanced climate monitoring and prediction systems can help to anticipate extreme climatic events and adequately prepare communities. These systems can provide essential data for informed decision-making.

S.W.O.T. Analysis

Table 6. The S.W.O.T. analysis of efforts to balance and combat dramatic temperature changes

Strengths	Weaknesses
Climate change is a global priority, driving policies and action. Technologies like renewable energy and smart irrigation offer real solutions. Partnerships between countries strengthen efforts to combat climate change.	High upfront costs make green solutions less accessible. Many regions, especially developing ones, lack access to sustainable technologies. Unique regional challenges complicate global strategies.
Opportunities	**Threats**
Rising demand for green products creates jobs and drives innovation. Funding for sustainable projects makes green solutions more achievable. Climate monitoring systems can boost resilience to extreme weather.	Extreme weather events increasingly damage communities and infrastructure. Economic issues like poverty limit adoption of sustainable practices. Political instability can weaken long-term climate efforts.

Source: Own determination.

By tackling weaknesses and threats while leveraging strengths and opportunities, we can create effective strategies to fight climate change and build a sustainable future. This S.W.O.T. analysis offers a clear overview of the key challenges and opportunities in global climate action, as summarized in Table 6.

CONCLUSIONS

The 2023 data shows significant temperature increases, such as +4.17°C in the Americas, highlighting the urgent need to address climate change as it disrupts ecosystems, economies, and daily life globally.

Each region faces unique challenges-extreme weather in the Americas or agriculture adaptation in Asia and Europe-requiring local strategies alongside global efforts.

Green infrastructure, renewable energy, ecosystem restoration, and agroforestry are essential for reducing emissions and stabilizing climates.

The data confirms that climate change demands immediate and creative solutions. By acting decisively, we can protect the planet and secure a sustainable future for generations to come.

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COMPARATIVE STUDY OF SEEDS AGRONOMIC ATTRIBUTES AND OF YIELD IN SOME SUNFLOWER GENOTYPES

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Abstract

A collection of 45 sunflower genotypes (Express genotypes, N=21, T1 to T21; Clearfield genotypes, N = 24, T22 to T45) was studied based on the yield and agronomic traits of the seeds. The comparative crops were organized within ARDS Lovrin, in a non-irrigated system. In the case of the Express genotype group (EG), the mean yield value was YmEG = 2,245.56 kg ha^{-1}, the mean value for the hectoliter weight was HWmEG = 40.64 kg hl^{-1}, and the mean value for the weight of 1,000 seeds was TKWmEG = 63.71 g. Trial T8 was highlighted, which presented positive, statistically guaranteed differences for each parameter, ΔY = 989.73 kg ha^{-1}, (***), ΔHW = 1.56 kg hl^{-1} (**), respectively ΔTKW = 7.89 g (***). In the case of the Clearfield genotype group (CG), the mean yield value was YmCG = 2,087.41 kg ha^{-1}, the mean value for the hectoliter weight was HWmCG = 40.10 kg hl^{-1}, and the mean value for the weight of 1,000 seeds was TKWmEG = 56.85 g. The T34 trial was highlighted, which presented positive differences, statistically assured ($p<0.001$, ***), for each parameter (ΔY = 545.64 kg ha^{-1}; ΔHW = 2.90 kg hl^{-1}, and ΔTKW = 8.75 g, respectively). The Express genotype group (EG) presented higher mean values compared to the Clearfield genotype group (CG), under statistical safety conditions for TKW ($p<0.001$). Compared to the mean at the level of the experiment, genotypes with values above the mean were identified, under conditions of statistical safety. In the multivariate analysis, the main components (PC1, PC2) explained 81.966% of variance.

Key words: *multivariate analysis, PCA, seed parameters, sunflower, yield*

INTRODUCTION

The sunflower (*Helianthus annuus* L.), is a crop plant originating from the United States, and was placed in the first five crop plants, within the 13 agricultural crops with major importance and weight for global food security [20].
Sunflower is important for the production of oil and derived products [9]. Within commercial crops, sunflower occupies an important place, with multiple agronomic, economic and ecological values [2, 18].
The sunflower shows preferences for warm climates, and the cultivated areas and the use of sunflowers have registered a significant expansion [18].
[17] communicated the influence of recent climate changes on the sunflower crop, along with other important agricultural crops, under the conditions in Romania. The sunflower is one of the main crop plants in Romania, with an important share on the market of agricultural products in the country, but also on the European and international market [16, 22].
The agronomic traits for cultivated sunflower genotypes are based on the genetic diversity of germplasm collections worldwide (e.g. 2519 accessions within the USDA-ARS, with 53 species, of which 39 are perennial and 14, are annual) [20].
Multivariate analysis was used to classify and separate some groups, according to criteria of interest, in a study on 68 sunflower genotypes [23]. Based on the recorded similarity coefficient values, the authors of the study found a genetically restricted (narrow) base that was the basis of the studied genotypes, and at the same time they considered it necessary to expand the genetic base for future genotypes.
Ten genotypes of sunflower were studied in relation to pollination methods, for the

progress of productivity and yield parameters [1]. The authors of the study selected the genotypes with parameters that presented an essential contribution for increasing yields (e.g. morphological parameters in plants and parameters in seeds).

A collection of 32 sunflower genotypes was studied to evaluate attributes and traits associated with oil production [11]. The authors identified positive correlations of oil yield with different plant and seed attributes. Based on the results of the study, the authors classified the genotypes into eight distinct groups, and identified the differences between the groups, respectively the superior genotypes (with genetic advantages).

The genetic variability was studied in a collection of 33 sunflower genotypes, in order to characterize the respective accessions [10]. Based on the results of the applied tests, the authors found significant differences, which indicated the presence of sufficient variability between the analyzed genotypes. From the comparative analysis of PCV (coefficient of phenotypic variation) against GCV (coefficient of genotypic variation), the authors recorded the differentiated influence of the environment in character expression.

Improving the yield and some quality parameters of the seeds in commercial crops represent current and perspective objectives [2].

From the perspective of the growth of the human population, and the growing requirements for food, increasing the yields of the main crop plants, including sunflowers, are priority objectives for plants breeding programs [3, 15].

The variation of sunflower production was studied in relation to climate and soil conditions, in mixed forest areas in Central Europe [24]. The authors of the study found the log-logistic model that appropriately described the variation in production, under the study conditions.

The high interest in the production of sunflowers associated with the expansion of the cultivated areas requires genotypes with improved traits, with tolerance to stress factors, at the same time with practical agricultural technologies appropriate to the requirements of the genotypes and the environmental conditions [5].

Interactions of the genotype with the plant traits and interactions of the genotype with the environment in the expression of the plant traits were studied in ten sunflower genotypes [21]. The authors recorded the different variation of plant traits, as a result of the genotype x environment interaction. Based on the results, the authors identified genotypes suitable for several regions, as well as genotypes suitable for narrower regions, or only for certain regions.

Based on a study of 20 sunflower genotypes, considerable impact of irrigation treatments on the yield of some agronomic characteristics was recorded [9]. Based on the analyzed parameters, the authors of the study recorded a variable response of the studied genotypes to watering treatments and water stress conditions. The recorded results showed importance both for the agricultural practice and for the breeding program, in the selection of genotypes for the breeding programs.

Stagnant yields, with a certain inconsistency, have been identified as high constraints for agronomic efficiency in sunflower [4]. By cultivating a collection of sunflower genotypes in different ecological conditions, the authors were able to select genotypes of interest for agricultural practice, as well as for breeding programs.

The yield variation was studied in relation to different sunflower genotypes and crop locations [19]. The author of the study communicated different correlations between yield and plant parameters, respectively seed parameters.

Quality indices in sunflower production were analyzed and different positive or negative correlations, as well as different levels of variation, were communicated [14].

The variation of sunflower yield was studied in relation to different technological methods [7, 12, 13]. Based on the recorded results, the authors found the most suitable methods to ensure optimal yields in the study conditions.

In the context of climate change, high importance is given to the precise estimation of crop plant phenotypes, based on genotypes, and the "genotype × environment"

relationship and the way crop yields are formed in relation to biotic and abiotic conditions [8].
Based on the yield and some agronomic parameters of the seeds, the present study made a comparative analysis of 45 genotypes of sunflower, 21 genotypes in the Express group (EG), and 24 genotypes in the Clearfield group (CG).

MATERIALS AND METHODS

The researches were organized within ARDS Lovrin, in order to evaluate the yield and some agronomic parameters of the seeds of 45 sunflower genotypes.
The Express group (EG; genotypes with the gene resistant to Express 75 WG; herbicide for post-emergence control of dicotyledonous weeds) included 21 genotypes (T1 to T21). The Clearfield group (CG; genotypes with better adaptation to environmental conditions and Pulsar herbicide) included 24 genotypes (T22 to 45).
The comparative sunflower crops were in a non-irrigated system, on a chernozem type soil. Sowing was done in the optimal time, the first decade of April. Fertilization was ensured with NPK complex, 1:1:1, in a dose of 300 kg ha^{-1}.
The surface of the crop plot for each genotype was 714 m^2. Harvesting was done mechanized, with a combine, between August 30 and September 1, 2023.
The yield (Y, kg ha^{-1}) was quantified for each genotype. The hectoliter weight (HW, kg hl^{-1}) and the weight of 1,000 seeds (TKW, g) were determined.
Based on the recorded data, the mean values were calculated for the two groups of genotypes and at the level of the experiment, for each parameter.
The comparative analysis between the groups of genotypes was done. Also, each genotype was analyzed against the mean value of the group it belonged to, as well as against the mean of the experiment, in the case of each parameter.
Appropriate mathematical and statistical tests were applied to assess the safety of the differences.
The multivariate analysis was applied to obtain the distribution and correlation of the genotypes with the yield and agronomic parameters of the seeds.
Adequate statistical safety parameters were used to interpret the results. The mathematical analysis and experimental statistical processing was done with dedicated tools in EXCEL, and with dedicated applications [6].

RESULTS AND DISCUSSIONS

Based on the comparative crops of the 45 sunflower genotypes, the yield values (Y, kg ha^{-1}) and the seed parameters were obtained, in the form of hectoliter weight (HW, kg hl^{-1}), and the weight of 1,000 seeds (TKW, g), (Table 1).
The result of each genotype was analyzed in relation to the mean value calculated for each genotype group.
In the case of the group of Express genotype (EG), the mean yield value was YmEG = 2,245.56 kg ha^{-1}, the mean value for the hectoliter weight was HWmEG = 40.64 kg hl^{-1}, and the mean value for the weight of 1,000 seeds was TKWmEG = 63.71 g. The calculated differences for each sunflower genotype from the Express group (EG), in relation to the mean value for each parameter, are presented in Table 2.
In the case of the group of Express genotypes (EG), the T8 trial was highlighted, which presented positive differences, statistically assured, for each parameter (ΔY = 989.73 kg ha^{-1}, ***), ΔHW = 1.56 kg hl^{-1} (**),and ΔTKW = 7.89 g (***) respectively.
In the case of yield, five genotypes were recorded with a positive increase in yield (ΔY) between ΔY = 387.49 kg ha^{-1} (T9), and (ΔY = 989.73 kg ha^{-1} (T8), under statistical safety conditions ($p<0.001$, ***).
In the case of the HW parameter, four genotypes with positive growth (ΔHW) were recorded, between ΔHW = 1.56 kg hl^{-1} (T8; $p<0.01$, **), and ΔHW = 7.76 kg hl^{-1} (T2, $p<0.001$, ***).

Table 1. Values of the yield and some seeds parameters of tested sunflower genotypes

Genotypes group	Company	Trial	Genotype	Y (kg ha^{-1})	HW (kg hl^{-1})	TKW (g)
Express genotypes group (EG)	ALTA SEEDS	T1	Hysun 310	1,848.73	41.20	57.60
		T2	Hysun 189	2,030.81	48.40	50.00
	BASF	T3	Acordis	2,100.84	41.00	53.20
	BAYER	T4	Averon	2,114.84	38.70	61.60
		T5	Hudson	2,044.81	41.20	55.60
	CORTEVA	T6	HE 118	2,352.94	41.20	77.60
		T7	LE 162	2,422.96	42.70	73.60
		T8	LE163	3,235.29	42.20	71.60
		T9	P64LE99	2,633.05	39.40	71.20
		T10	LE25	2,647.05	38.70	70.60
	EXPERT AGRO	T11	Demetera	1,904.76	37.60	53.60
		T12	Soleea	2,058.82	39.20	55.20
		T13	Geea	2,226.89	39.20	55.20
	KWS	T14	Artenes	2,184.87	42.50	66.00
		T15	Suvex	3,011.20	41.20	65.60
	MAISADOUR	T16	MAS83	2,086.83	44.00	62.40
		T17	MAS85SC	2,352.94	38.90	65.40
		T18	MDS5123LS	1,876.75	39.90	64.40
		T19	DT3402TT	2,759.10	39.90	77.60
	NS SEME	T20	NS NSH8002	1,540.61	37.10	66.00
		T21	NS NSH8005	1,722.68	39.20	64.00
Clearfield genotypes group (CG)	ALTA SEEDS	T22	Hysun180it	1,960.78	39.40	60.80
		T23	Hysun232ITHO	2,380.95	38.90	52.80
		T24	Hysun238IT	1,064.42	34.80	48.80
	BASF	T25	Coloris	2,338.93	38.10	45.60
		T26	Insun 200	2,408.96	40.70	54.40
		T27	Dracaris	2,198.87	40.20	60.80
		T28	Insun222	1,750.70	41.70	54.40
		T29	Acordis	2,422.96	40.40	59.60
	CORTEVA	T30	LP170	2,212.88	40.40	76.40
		T31	LP180	2,492.99	38.90	66.00
	KWS	T32	S2201	2,072.82	39.40	61.60
	LIDEA	T33	Oasis CLP	2,591.03	41.00	57.20
		T34	Belfis	2,633.05	43.00	65.60
	MAISADOUR	T35	CL Blade	2,044.81	41.00	58.00
		T36	MAS920	2,002.80	38.10	65.60
	NUSEED	T37	N5LE442	1,540.61	38.10	65.20
		T38	N4L215E	1,456.58	39.40	46.00
		T39	NH4161	1,288.51	40.20	55.60
		T40	N4H471	1,414.56	41.20	54.40
		T41	NHK12M010	2,464.98	40.40	44.40
		T42	X9767	2,240.89	41.00	46.80
	SAATEN UNION	T43	Marquesa	2,170.86	42.20	64.00
		T44	Surimi	2,549.01	40.40	50.40
		T45	Integral	2,394.95	43.50	50.00

Source: Original data.

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Table 2. Differences and significance for parameters determined in sunflower genotypes, Express group (EG)

Trial	ΔY			ΔHW			ΔTKW		
	Differences	Significance	p value	Differences	Significance	p value	Differences	Significance	p value
T1	-396.83	ooo	0.0003	0.56	ns	0.3138	-6.11	oo	0.0026
T2	-214.75	o	0.0303	7.76	***	5.99E-12	-13.71	ooo	1.97E-07
T3	-144.72	ns	0.1319	0.36	ns	0.5133	-10.51	ooo	8.51E-06
T4	-130.72	ns	0.1713	-1.94	oo	0.0019	-2.11	ns	0.2473
T5	-200.75	o	0.0414	0.56	ns	0.3138	-8.11	ooo	0.0002
T6	107.38	ns	0.2575	0.56	ns	0.3138	13.89	***	1.63E-07
T7	177.40	ns	0.0685	2.06	**	0.0011	9.89	***	1.87E-05
T8	989.73	***	9.34E-10	1.56	**	0.0094	7.89	***	0.0002
T9	387.49	***	0.0004	-1.24	o	0.0339	7.49	***	0.0004
T10	401.49	***	0.0003	-1.94	oo	0.0019	6.89	***	0.0009
T11	-340.80	oo	0.0014	-3.04	ooo	1.81E-05	-10.11	ooo	1.40E-05
T12	-186.74	ns	0.0562	-1.44	o	0.0156	-8.51	ooo	0.0001
T13	-18.67	ns	0.8414	-1.44	o	0.0156	-8.51	ooo	0.0001
T14	-60.69	ns	0.5175	1.86	**	0.0027	2.29	ns	0.2123
T15	765.64	***	6.43E-08	0.56	ns	0.3138	1.89	ns	0.3005
T16	-158.73	ns	0.1003	3.36	***	4.87E-06	-1.31	ns	0.4674
T17	107.38	ns	0.2575	-1.74	oo	0.0045	1.69	ns	0.3533
T18	-368.81	ooo	0.0007	-0.74	ns	0.1898	0.69	ns	0.7032
T19	513.54	***	1.86E-05	-0.74	ns	0.1898	13.89	***	1.63E-07
T20	-704.95	ooo	2.30E-07	-3.54	ooo	2.42E-06	2.29	ns	0.2123
T21	-522.88	ooo	1.48E-05	-1.44	o	0.0156	0.29	ns	0.8737

Note: o – the symbol of negative differences; * the symbol of positive differences; ns - non-significant differences
Source: Original data..

In terms of the TKW parameter, six genotypes were recorded that showed a positive increase (ΔTKW), between ΔTKW = 6.89 g (T10, p<0.001, ***), and ΔTKW = 13.89 g (T6, and T19, p<0.001, ***).

In the case of the group of Clearfield genotype (CG), the mean yield value was YmCG = 2,087.41 kg ha^{-1}, the mean value for the hectoliter weight was HWmCG = 40.10 kg hl^{-1}, and the mean value for the weight of 1,000 seeds was TKWmEG = 56.85 g. The calculated differences for each sunflower genotype from the Clearfield group (CG), in relation to the mean value for each parameter, are presented in Table 3. In the case of the Clearfield genotype group (CG), the T34 trial was highlighted, which presented positive, statistically assured differences (p<0.001, ***), for each parameter (ΔY = 545.64 kg ha^{-1}; ΔHW = 2.90 kg hl^{-1}, and ΔTKW = 8.75 g respectively), (Table 3).

In the case of yield, 10 genotypes with positive increase in yield (ΔY) between ΔY = 251.52 kg ha^{-1} (T25, p<0.05, *), and ΔY = 545.64 kg ha^{-1} (T34, p<0.001, ***). In the case of the HW parameter, eight genotypes with positive growth (ΔHW) were recorded, between ΔHW = 0.90 kg hl^{-1} (T33, T35, T42; p<0.05, *), and ΔHW = 3.40 kg hl^{-1} (T45, p<0.001, ***). In the case of the TKW parameter, nine genotypes were recorded that showed a positive increase (ΔTKW), between ΔTKW = 3.95 g (T22, T27; p<0.05, *), and ΔTKW = 19.55 g (T30; p<0.001, ***). The results indicated performing genotypes in each group, for the study conditions.

The comparative analysis was made between the two groups of sunflower genotypes, the Express group (EG; N = 21) and the Clearfield group (CG, N = 24). In the case of the yield, the mean value (Ym) for the genotypes from the Express group (EG) was YmEG = 2,245.56 kg ha^{-1}, and in the case of the genotypes from the Clearfield group (CG), the mean value of the yield was YmCG = 2,087.41 kg ha^{-1}.

Table 3. Differences and significance for parameters analyzed in sunflower genotypes, Clearfield group (CG)

Trial	Y			HW			TKW		
	Differences	Significance	p value	Differences	Significance	p value	Differences	Significance	p value
T22	-126.63	ns	0.1770	-0.70	ns	0.0715	3.95	*	0.0248
T23	293.54	**	0.0037	-1.20	oo	0.0036	-4.05	o	0.0217
T24	-1,022.99	ooo	7.90E-11	-5.30	ooo	6.14E-13	-8.05	ooo	6.04E-05
T25	251.52	*	0.0110	-2.00	ooo	1.75E-05	-11.25	ooo	5.61E-07
T26	321.55	**	0.0018	0.60	ns	0.1190	-2.45	ns	0.1498
T27	111.46	ns	0.2327	0.10	ns	0.7896	3.95	*	0.0248
T28	-336.71	oo	0.0012	1.60	***	0.0003	-2.45	ns	0.1498
T29	335.55	**	0.0012	0.30	ns	0.4264	2.75	ns	0.1080
T30	125.47	ns	0.1809	0.30	ns	0.4264	19.55	***	2.65E-11
T31	405.58	***	0.0002	-1.20	oo	0.0036	9.15	***	1.16E-05
T32	-14.59	ns	0.8739	-0.70	ns	0.0715	4.75	**	0.0083
T33	503.62	***	1.24E-05	0.90	*	0.0233	0.35	ns	0.8333
T34	545.64	***	4.05E-06	2.90	***	6.22E-08	8.75	***	2.11E-05
T35	-42.60	ns	0.6438	0.90	*	0.0233	1.15	ns	0.4913
T36	-84.61	ns	0.3617	-2.00	ooo	1.75E-05	8.75	***	2.11E-05
T37	-546.80	ooo	3.92E-06	-2.00	ooo	1.75E-05	8.35	***	3.84E-05
T38	-630.83	ooo	4.51E-07	-0.70	ns	0.0715	-10.85	ooo	9.85E-07
T39	-798.90	ooo	8.27E-09	0.10	ns	0.7896	-1.25	ns	0.4548
T40	-672.85	ooo	1.59E-07	1.10	**	0.0069	-2.45	ns	0.1498
T41	377.57	***	0.0004	0.30	ns	0.4264	-12.45	ooo	1.09E-07
T42	153.48	ns	0.1049	0.90	*	0.0233	-10.05	ooo	3.10E-06
T43	83.45	ns	0.3683	2.10	***	9.03E-06	7.15	***	0.0002
T44	461.60	***	3.86E-05	0.30	ns	0.4264	-6.45	ooo	0.0007
T45	307.54	**	0.0026	3.40	***	3.76E-09	-6.85	ooo	0.0004

Note: o – the symbol of negative differences; * the symbol of positive differences; ns - non-significant differences
Source: Original data.

According to Two-sample tests, the difference between the mean values (158.15 kg ha^{-1}) did not show statistical certainty (t test, t=1.2174, p = 0.230; Mann-Whitney test, U=229, p = 0.608). In the case of hectoliter weight, the mean value (HWm) was very close, HWmEG = 40.64 kg hl^{-1}, respectively HWmCG = 40.10 kg hl^{-1}.

According to the applied statistical analysis test, the difference did not show statistical certainty (t test, t=0.8350, p = 0.408; Mann-Whitney test, U=236.5, p = 0.732).

In the case of the weight of 1,000 seeds (TKW), the mean value (TKWm) was TKWmEG = 63.71 g (Express group), respectively TKWmCG = 56.85 g (Clearfield group). According to the applied statistical analysis test, the differences showed statistical certainty (t test, t=2.8397, p = 0.0068; Mann-Whitney test, U=137, p = 0.0091).

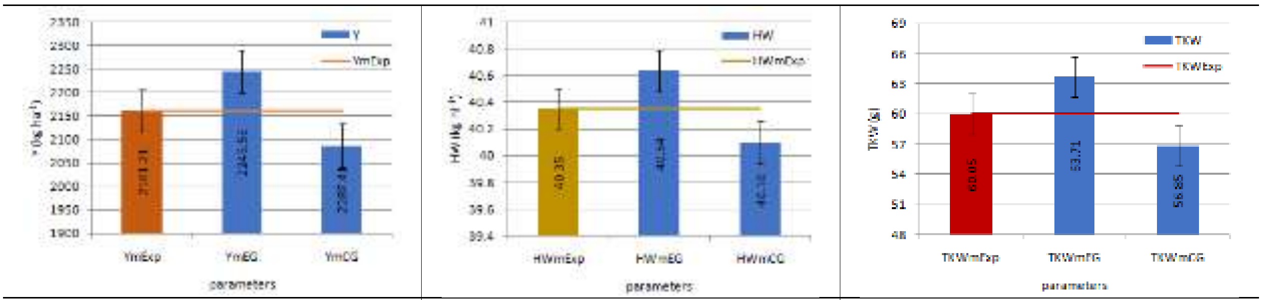
A comparative analysis was made of each group of genotypes, as well as for each genotype, in relation to the mean calculated at the level of the experiment for each parameter (Table 4, Figure 1).

From the analysis of the values obtained, and the graphic representation (Figure 1), it was found that the genotypes from the Express group (EG) presented an average value above the average of the experiment, for each parameter. Also, the individual values of the studied parameters (Y, HW, TKW), recorded by each genotype, are compared to the mean value at the experiment level (Table 4). In the case of yield, compared to the mean per experiment (YmExp = 2,161.21 kg ha^{-1}), 18 genotypes showed a positive increase in production (ΔY), with values between ΔY = 193.73 kg ha^{-1} (T6, T17) and ΔY = 1,074.08 kg ha^{-1} (T8).

Table 4. The results of the analysis of sunflower genotypes compared to the mean value of the experiment

Trial	ΔY			ΔHW			ΔTKW		
	Difference	Significance	p value	Difference	Significance	p value	Difference	Significance	p value
T1	-312.48	ooo	1.89E-05	0.85	*	0.0111	-2.45	ns	0.0656
T2	-130.40	ns	0.0516	8.05	***	9.99E-28	-10.05	ooo	9.6E-10
T3	-60.37	ns	0.3592	0.65	*	0.0489	-6.85	ooo	3.86E-06
T4	-46.37	ns	0.4804	-1.65	ooo	5.79E-06	1.55	ns	0.2402
T5	-116.40	ns	0.0809	0.85	*	0.0111	-4.45	oo	0.0013
T6	191.73	**	0.0052	0.85	*	0.0111	17.55	***	2.95E-17
T7	261.75	***	0.0002	2.35	***	3.74E-09	13.55	***	1.81E-13
T8	1,074.08	***	1.91E-20	1.85	***	7.31E-07	11.55	***	2.22E-11
T9	471.84	***	5.08E-09	-0.95	oo	0.0048	11.15	***	6.02E-11
T10	485.84	***	2.47E-09	-1.65	ooo	5.79E-06	10.55	***	2.73E-10
T11	-256.45	ooo	0.0003	-2.75	ooo	5.88E-11	-6.45	ooo	1.07E-05
T12	-102.39	ns	0.1233	-1.15	ooo	0.0008	-4.85	ooo	0.0005
T13	65.68	ns	0.3190	-1.15	ooo	0.0008	-4.85	ooo	0.0005
T14	23.66	ns	0.7183	2.15	***	3.07E-08	5.95	***	3.84E-05
T15	849.99	***	1.01E-16	0.85	*	0.0111	5.55	***	0.0001
T16	-74.38	ns	0.2598	3.65	***	1.04E-14	2.35	ns	0.0777
T17	191.73	**	0.0052	-1.45	ooo	4.48E-05	5.35	***	0.0002
T18	-284.46	ooo	7.58E-05	-0.45	ns	0.1661	4.35	**	0.0017
T19	597.89	***	8.86E-12	-0.45	ns	0.1661	17.55	***	2.95E-17
T20	-620.60	ooo	2.94E-12	-3.25	ooo	4.24E-13	5.95	***	3.84E-05
T21	-438.53	ooo	2.85E-08	-1.15	ooo	0.0008	3.95	**	0.0040
T22	-200.43	oo	0.0036	-0.95	oo	0.0048	0.75	ns	0.5684
T23	219.74	**	0.0016	-1.45	ooo	4.48E-05	-7.25	ooo	1.38E-06
T24	-1,096.79	ooo	8.6E-21	-5.55	ooo	2.82E-21	-11.25	ooo	4.61E-11
T25	177.72	**	0.0091	-2.25	ooo	1.04E-08	-14.45	ooo	2.25E-14
T26	247.75	***	0.0004	0.35	ns	0.2821	-5.65	ooo	7.92E-05
T27	37.66	ns	0.5663	-0.15	ns	0.6395	0.75	ns	0.5684
T28	-410.51	ooo	1.22E-07	1.35	***	0.0001	-5.65	ooo	7.92E-05
T29	261.75	***	0.0002	0.05	ns	0.8794	-0.45	ns	0.7288
T30	51.67	ns	0.4321	0.05	ns	0.8794	16.35	***	3.56E-16
T31	331.78	***	7.12E-06	-1.45	ooo	4.48E-05	5.95	***	3.84E-05
T32	-88.39	ns	0.1819	-0.95	oo	0.0048	1.55	ns	0.2402
T33	429.82	***	4.48E-08	0.65	*	0.0489	-2.85	o	0.0334
T34	471.84	***	5.08E-09	2.65	***	1.67E-10	5.55	***	0.0001
T35	-116.40	ns	0.0809	0.65	*	0.0489	-2.05	ns	0.1211
T36	-158.41	o	0.0192	-2.25	ooo	1.04E-08	5.55	***	0.0001
T37	-620.60	ooo	2.94E-12	-2.25	ooo	1.04E-08	5.15	***	0.0003
T38	-704.63	ooo	5.67E-14	-0.95	oo	0.0048	-14.05	ooo	5.6E-14
T39	-872.70	ooo	3.99E-17	-0.15	ns	0.6395	-4.45	oo	0.0013
T40	-746.65	ooo	8.52E-15	0.85	*	0.0111	-5.65	ooo	7.92E-05
T41	303.77	***	2.92E-05	0.05	ns	0.8794	-15.65	ooo	1.57E-15
T42	79.68	ns	0.2279	0.65	*	0.0489	-13.25	ooo	3.6E-13
T43	9.65	ns	0.8830	1.85	***	7.31E-07	3.95	**	0.0040
T44	387.80	***	3.98E-07	0.05	ns	0.8794	-9.65	ooo	2.69E-09
T45	233.74	***	0.0008	3.15	***	1.13E-12	-10.05	ooo	9.6E-10

Source: Original data.



(a) (b) (c)

Fig. 1. Graphic representation of the mean values by genotype groups, in relation to the mean of the experiment; (a) yield values; (b) HW values; (c) TKW values
Source: Original data.

Among these genotypes, 8 genotypes were from the Express genotype group (EG) and 10 genotypes were from the Clearfield genotype group (CG). In the case of hectoliter weight (HW), compared to the mean per experiment (HWmExp = 40.35 kg hl^{-1}), a number of 18 genotypes showed positive increase (ΔHW), with values between ΔHW = 8.05 kg hl^{-1} (T3, T33, T35) and ΔHW = 0.65 kg hl^{-1} (T2). Of these, 10 genotypes were from the Express group (EG), and 8 genotypes were from the Clearfield group (CG). In the case of the TKW parameter, compared to the mean value at the experiment level (TKWmExp = 60.05 g), a number of 18 genotypes showed a positive increase, with values between ΔTKW = 3.95 g (T21, T43) and ΔTKW = 17.55 g (T6, T19). Of these, 12 genotypes were from the Express group (EG) and 6 genotypes were from the Clearfield group (CG).

Multivariate analysis (PCA) was applied to obtain the distribution of sunflower genotypes in relation to the considered parameters (Y, HW, TKW). The result was the diagram in figure 2, in which the main components explained 81.966% of variance.

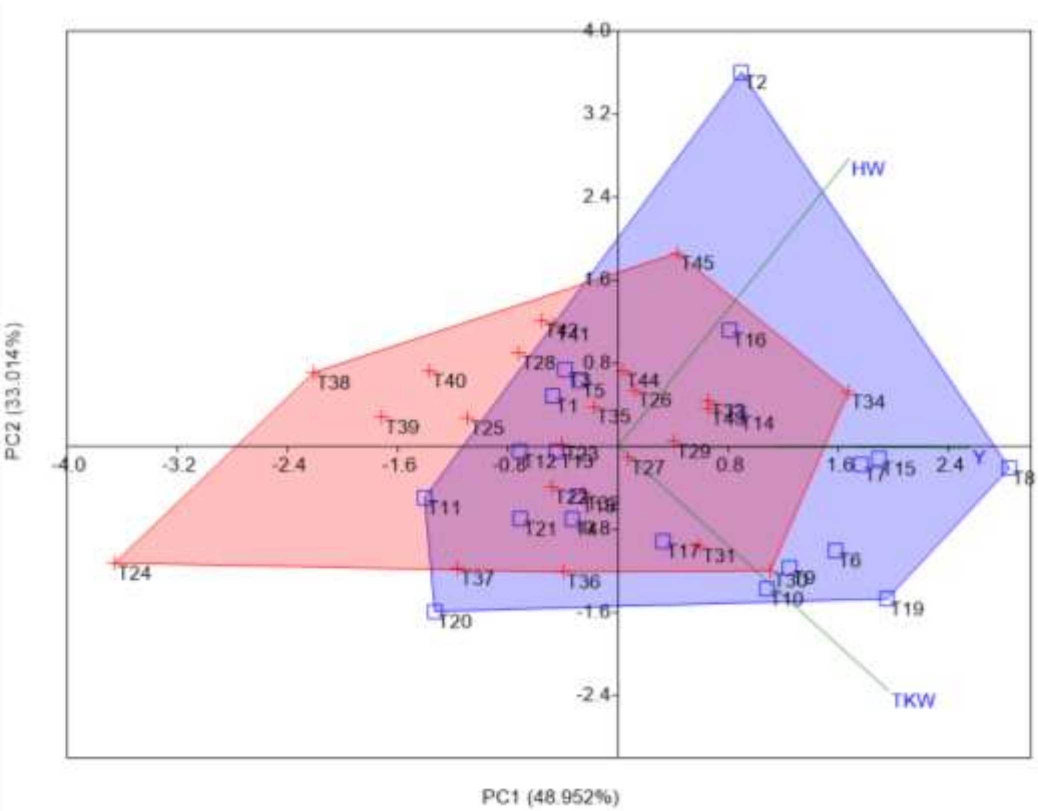


Fig. 2. PCA diagram (blue field – Express genotypes; red field – Clearfield genotypes)
Source: Original figure.

The Express genotype group is represented in blue, and the Clearfield genotype group is represented in red. From the analysis of the two fields (blue - EG, red - CG), an overlapping area was found, which includes genotypes with similar behaviour under the study conditions, as well as independent areas, which includes genotypes with different behaviour. It was also found from the PCA diagram (Figure 2), the orientation/correlation of some genotypes towards the Y parameter (e.g. T8, T15, T17), the correlation of some genotypes with the HW parameter (e.g. T16), and the correlation of some genotypes with the TKW parameter (e.g. T10, T30).

Sunflower seed parameters vary in relation to genotype and environmental and technological conditions, and quality improvement represents an objective of interest for commercial crops [2]. Seed quality is important in ensuring seed yield as well as oil production [1, 11]. Seed mass was considered important for genotypes with improved yield [1]. Correlations were communicated between plant parameters (e.g. height, calathidium diameter), seed parameters (e.g. TKW, HW) and seed yield per surface unit [19].

The description of "genotype × environment" interaction relationships in the formation of yields, associated with climate changes, is considered important in the selection of genotypes with high adaptability for agricultural practice [8].

The results communicated by the present study are integrated into the area of interest for the present and the perspective regarding the efficiency and sustainability of the sunflower crop, with direct applicability for the study area and extension of the approach for other areas, or crop of interest.

CONCLUSIONS

The sunflower genotypes analyzed under similar crop conditions generated differentiated values for agronomic parameters of seed quality (HW, TKW), and yield (Y).

The genotypes from the Express group (EG) presented higher mean values for yield and HW parameters, respectively TKW, compared to the genotypes from the Clearfield group (CG).

Within the group of Express genotypes, the T8 trial was highlighted, which showed positive differences, statistically ensured, for each parameter (ΔY = 989.73 kg ha^{-1}, ***), ΔHW = 1.56 kg hl^{-1} (**), respectively ΔTKW = 7.89 g (***).

In the case of the Clearfield (CG) genotype group, the T34 trial was highlighted, which presented positive, statistically assured differences ($p<0.001$, ***), for each parameter (ΔY = 545.64 kg ha^{-1}; ΔHW = 2.90 kg hl^{-1}, and respectively ΔTKW = 8.75 g).

Compared to the mean values per experiment (YmExp = 2,161.21 kg ha^{-1}; HWmExp = 40.35 kg hl^{-1}; TKWmExp = 60.05 g) genotypes were identified that presented values above the mean, within each group of genotypes (EG, CG).

Multivariate analysis (PCA) facilitated the distribution, correlation and association of genotypes in relation to the values generated for the parameters considered in the analysis..

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STUDY ON THE RE-ASSESSMENT OF TOURIST POTENTIAL AND ACTIVITIES FROM A BOARDING HOUSE IN THE PONOARELE AREA - MEHEDINȚI, ROMANIA, IN THE PERIOD 2018 – 2022

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Abstract

The present study addresses a theme of topicality and continues to be new because it tries to re-invent and update the data regarding the natural and anthropic tourism potential of the Ponoarele area in Mehedinți county, Romania. Although there are numerous data regarding the Mehedinți area, during the pandemic and after it, the tourist activity at the level of the region and implicitly at the national and even international level was subjected to new challenges, trials and realities, which made it fall back, reconsider and quickly adapt to new conditions. In the first phase, the work aims at an inventory of all the natural and human resources of the area, and in the second phase, the case study presents the reality of the tourist activity in the Pensiunea and in the town of Ponoare, during the studied period, based on which a plan of measures and directions that will contribute essentially to the popularization of the advantages of practicing tourism in smaller structures that can adapt quickly and that can obtain secure incomes in the new realities of tourism.

Key words: *natural and anthropic tourism potential, management, sustainable tourism, Ponoare, Mehedinti, Romania*

INTRODUCTION

The area under study is part of the Mehedinți Plateau, which has numerous and valuable tourist resources, both natural and human, as well as an old tradition in terms of ethnography, an asset that can include tourism in the future among the basic branches of the economy, this being also a great chance in terms of the economic market, for the development of the rural area of this plateau.
The tourist activity in this area is supported by a series of tourist resources, which can be the basis for the creation of diversified tourist offers and implicitly the establishment of the tourist potential of the region, the area has long been an attraction and for scientific research aimed at determining the tourist fund biogeographical and speleological. Unfortunately, today the area is faced with serious problems such as: the continuous deterioration of the standard of living, the aging of the population, the exodus of the young population to the city, the irrational exploitation of natural resources, the lack of an infrastructure, etc. precisely for that reason, it was necessary to include this area on the list of protected areas [9].
Regarding the existing tourist accommodation capacity in the Mehedinți Plateau, at the level of 2020 there were 721 places in accommodation units that are not evenly distributed, with important differences from one administrative unit to another. From the data in the specialized literature and from the study, it was observed that two localities (Bala and Baia de Aramă), hold over 60% of the entire accommodation capacity. Ponoarele and Gura Văii communes together own over 31% of the total number of accommodation places in the studied area. Ponoarelehas the largest number of accommodation structures, but with a small number of accommodation places, on average 6-7, which makes its weight in the total number of places to be reduced, below 13%.
From the research carried out by us and other Romanian and even foreign researchers, it was found that the activity of rural tourism in general and that of agritourism in particular is practiced in Romania and in Eastern countries, more in units of the type of

agritourism households and less in agritourism farms, specific to western countries [1,13]. Also from these researches, it was found that although peasant households are multiplying, most of them have a precarious existence, not having the necessary equipment specific to modern farms and no corporate organizations found in Western Europe to protect their interests [11, 12, 26].

The progress and extent of agricultural industrialization in Western Europe in the second half of the 20th century led not only to the spectacular increase in agricultural production, but also to the drastic decrease in the number of peasant households, unable to face the competition of large farms. The progress also had very serious negative consequences on the environment, a fact that brought back to the attention of the public and European officials the status of the peasant household, its ability to conserve the environment and provide the population with natural products. The great diversity of peasant households in the Union, generated by the work specific to the traditional household, and the effects of agricultural intensification, led to the idea of rehabilitating the traditional peasant household, to become complementary to the large agricultural farms (which cannot be abandoned), and to contribute to protecting concrete environment, offering natural products to the consumer society [7, 15, 19].

A form specific to the studied area of the household is that of temporary dwellings, known as "mansions", which extend in the immediate vicinity of the village, up to distances of more than 10–15 km and which benefit from climatic shelter, favorable exposure, density sea of springs, numerous pastures and hayfields. The demographic and economic consistency of the phenomenon was noted from the second half of the 19th century to the first half of the 20th century [11]. The frequency of their establishment is in the Piedmont plateau, where the mansions form a real mosaic. Here there are hilltops and parcelled slopes, each parcel having hay, arable land cultivated with cereals but also vegetable plants necessary for daily food, alongside even small vine plantations, in the terraced areas, as well as fruit tree crops. From the research carried out in the area, today a phenomenon of an accelerated decrease in the use of these manors can be seen, in direct connection with the aging of the population and the abandonment of occupations related to animal husbandry, especially the progressive decrease of shepherding, once this was the standard for the economic existence of the communities from the area [3].

The present paper wants to present in a scientific and academic manner the current situation and the degree of capitalization of the very rich tourist potential of the Ponoarele area in Mehedinți county, by inventorying and analyzing all existing natural and anthropogenic tourist resources and objectives and by reconsidering the use in the activity of tourism, of the traditional forms of household organization, such as "plai" mansions, which can give a unique character to the tourist offer in the area. In Romanian, the word "plai" means "a mountain or a hilly region almost flat or slightly inclined covered by grasslands".

MATERIALS AND METHODS

The research methodology is the classic one combined with the case study method, applied on a smaller scale, namely at the level of Ponoare commune in Mehedinți county. At the beginning, the principle of observing the tourist phenomenon at a general level was used, within the delimited area to be studied, in which the level of implementation of rural tourism in the area was followed, as an integrated part of sustainable tourism based on ecological principles [4, 5]. After that, we went on to describe all the more important aspects that define as a whole the type of tourism mainly practiced in the area of Ponoare and the effective way of applying them. The subsequent stage included the inventory and analysis of all existing natural and anthropogenic tourist resources and objectives and the reconsideration of the use in tourism activity of traditional forms of household organization, such as plai mansions, which can give a unique character to the tourist offer in the area. The case study concerned a boarding house in Ponoarele commune where the first phase was to inventory and count all the natural resources with very valuable tourist potential, which represent a real asset for the practiced tourism activity [4, 6].

Also, the totality of the existing anthropic tourism resources was studied, being represented in particular by the multitude of monuments of monumental architecture and art, religious and cultural edifices of unique beauty. After identifying all the assets that can positively favor the tourism activity practiced at the Boarding house, the main economic indicators were also studied on the basis of which the tourism activity and the quality level of the management practiced were characterized and diagnosed. These indicators mainly concerned the tourist offer of the boarding house, tourist traffic, the utilization index and the degree of occupancy, indicators on the basis of which a series of conclusions could also be formulated regarding the level of competence of the staff working and especially on the quality and the efficiency of management activities, from the "Conacu Boierului" boarding house.

RESULTS AND DISCUSSIONS

The study was carried out in Ponoare commune in Mehedinți county, which according to the census carried out in 2021, has a population of 2,249 inhabitants, down from 2011, when 2,425 inhabitants were registered. Accessibility in the area is ensured by the main road, which is the European Road E70, which connects Bucharest and Timișoara. It ensures good connectivity between the county and the rest of the country and other national and county roads that serve different localities in the county. Mehedinți County has a few railway lines, but rail accessibility can be limited compared to other means of transport. The county does not have its own airport, but the nearest airport is Craiova International Airport, located approximately 150 kilometres north of the county [23].

Inventory and analysis of the specific tourist potential of the Ponoarele area

In the present study, the research was oriented especially towards the touristic objectives and attractions specific to the studied area, and the general touristic potential of Mehedinți County, which is very well known, was no longer insisted upon. They were insisted on because only through them, the studied area can develop a unique, attractive and personalized offer, totally different from other mountainous areas in our country. One of the most famous and popular tourist attractions of the Ponoarele area is the Bridge of God, which represents a real emblem of the places, being the most famous natural monument in the entire land. It is found right in the centre of Ponoarele, at a distance of only 100 m from Conacu' Boierului, being a huge stone arch. It is one of three existing natural bridges in the world and the second largest in Europe. It is also called God's Bridge, because according to a legend, a battle between the Devil and God took place here, and also, over the years, several cars ran out of brakes, but also a cyclist fell off it and they escaped without injury [8, 9, 27].

There are many legends about the Bridge of God, the most widespread among them is the one that talks about the formation of the bridge through the intervention of divine power. The bridge was formed by the collapse of the upper wall of the cave. Residents prayed to God to banish evil from the territory of the commune, and he helped them, descended to the ground and the Devil entered the cave. God pressed the ceiling of the cave with his hand to catch the Devil, but he slipped through the cave and came out through the other side of the cave, but still he was banished from this area [23, 20, 28].

Another representative objective located in the immediate vicinity of the God's Bridge is the Ponoarele Cave, which is 734 m long and is located just below the hill that bears its name, representing the only connection between Lake Zătonul Mare and Lake Zătonul Mic, made at the level underground. It is a complex, multi-storied cave with two openings. The stalactites, but especially the present stalagmites, have sculptural shapes, similar to statues, some representing people, others animals or flowers, and some formations have changing colors between white - reddish - yellowish. Numerous bats of the Myotis, Miniopterus and Rinolophus species roost in the cave [2, 28].

The church under Stei is another beautiful and interesting tourist attraction, which is located at the foot of Steiul Ponorii. The church has the appearance of a wooden house with a porch, supported by four pillars that have bent as if under the weight of the weather. Here, the monk Nicodim (founder of the Tismana Monastery), in the century XIV, he wanted to build a monastery. The only evidence remained the small oak church in front of which you can still see some stones covered with earth that marked the crosses from the old cemetery [16, 20].

Moara Crăcucenilor, that is, the mill of the inhabitants of the village of Cracu Muntelui, is the only mill that has remained intact and functional, on this water course. In the past, there were eight wooden mills lined up on Valea Morilor, used for the traditional grinding of wheat and corn. These bore names depending on the village and the villagers who used them, being private or belonging to the community, as follows: Andrei's Mill, Răiculeștilor Mill, Crăcucenilor Mill, Nebunilor Mill, Martineștilor Mill, Tihoilor Mill, two mills of the Băluceni [16, 23, 20].

The Field with Lapies, known in the literature as "Lapiezul de la Ponoarele", this is the most impressive karst phenomenon of this kind in Romania. The slates represent special karst forms that the water has encrusted in the limestone. They have the shape of channels, being real wrinkles furrowed by time on the calcareous surfaces [17, 24].

Lake Zăton, located beyond Dealul Peșterii, on the opposite side of the Bridge of God, just 15-20 minutes on foot from Conacu' Boierului, it presents special features, being the largest karst lake in Romania. In rainy springs, immediately after the snow melts, it can reach impressive dimensions: 2.5 km long, an area of 2 km^2 and more than 20 m deep, at the maximum point at the level of the sorb, during dry summers it can dry up completely, therefore it is also called Phantom Lake. After it dries, the landscape becomes arid, the mud on the bottom of the lake cracks, having the appearance of a lunar landscape [24, 25].

On the opposite side of the lake, behind the Boarding house, also due to the accumulation of water, the Zătonul Mic Lake was formed. The karst lakes Zătonul Mare and Zătonul Mic, also called "Ghost Lakes", appear and disappear depending on the amount of precipitation: rain and snow melt. Cheile Băluței, connects Ponoarele with the spa resort of Bala. On their route, impressive landscapes are encountered, being crossed by a winding road with a special appearance. In 1967, sequences were filmed here for the Romanian film "Dacii" (The Dacians) [20].

The Ponoare Lilac Forest, a natural wonder, is a botanical reserve located 3 km from Conacu' Boierului. The reserve covers an area of 20 ha, at an altitude of 500 m and is the only Lilac Forest in the country preserved due to the mild climate, with sub-Mediterranean influences. It is declared a protected area of the Mehedinți Plateau Geopark.

Peștera Bulba, the cave is classified in category A, which includes caves of exceptional value which, through their scientific interest or the uniqueness of their resources, are representative of the national and international speleological heritage [8, 14].

Steiul Ponorii is a massive cornet, having the appearance of a dinosaur's spine, bordered by a rocky slope and is 597 m. At the foot of the Steiul there are 2 smaller caves, to which various legends are related: Peştera Soimului where it is said that people descended on times to catch this bird, used for falconry and the Cave of Elijah the Thief, which is linked to legends of outlaws and treasures. Also, from the base of the rock springs the Ponorii (Morilor) River.

Other important events that represent real attractions for tourists in the studied area are The Bat Festival which takes place every year on the first Sunday of May, during the period when the bat is in bloom. The venue is the well-known "Lilac Forest", located in the Prislop Valley, a unique reserve in the country with an area of approximately 20 hectares. It is a celebration dedicated to spring, when nature dresses up in festive clothes and to the flowering of the Lilac, symbol of this locality. It is said that such parties were held here since ancient times. The Bat Festival became famous both for the special setting in which it took place, but especially because of the folk music performances. The lilac forest, as well as the festival itself, brings many tourists who discover the landscapes and sights of the area. Likewise, folklore, the popular music so loved both in the world of the village and in the city, resonates with great affection in our valleys, in Ponoarele [8, 10, 20].

Another significant event is the National Folklore Festival "PonoarePonoare", which takes place every year on the first weekend of August, in a superb natural amphitheatre in the immediate vicinity of the Bridge of God. It is a welcome opportunity for the inhabitants of the 16 villages of the commune to meet again and spend time together, listening to traditional music or eating outdoors. Every year, thousands of people come to this Festival, turning the quite common below the foothills into an anthill of happy people. The contest has grown year by year and has always maintained a superior quality among contests of its kind [20].

An event dedicated to cycling lovers is the competition called Ponoarele MTB Race, which is addressed to all lovers of sports and movement in nature. The main organizer is the Association for Tourism "Mehedintiul under the mountain", a non-governmental organization that aims to develop tourism in the northern area of Mehedinți county by promoting natural beauty, preserving local traditions, but also by encouraging the practice of sports in nature, in any season and at any age. This competition proposes two routes designed in such a way as to be attractive to as many cyclists as possible, regardless of age category, level of physical training or competitive experience [8, 23].

Ethnographic and folklore values. The area is distinguished by its wealth of ethnographic and folkloric values, which are an important part of the region's cultural identity. These values reflect the traditions, customs and creativity of local communities and include aspects such as traditional architecture, folk installations and techniques, folk costumes, musical, choreographic and literary folklore, folk celebrations, festivals, village traditions and rituals. Wooden houses in the villages of the area you can still see traditional wooden houses with hipped roofs, which preserve the architecture specific to the area. Pottery: An important part of the Mehedinți tradition and the ceramics of the area is known for its traditional designs and for the vessels and decorative objects made by hand [22].

Hand weaving was a widespread activity in the past. Traditional textiles such as bark, woollen fabrics and embroidery are preserved as significant elements of local culture. The popular port of Mehedinți reflects influences of local and regional traditions, using specific materials and patterns. Folk costume is traditionally worn at cultural and festive events. Traditional Music - the area has a rich tradition in folk music, with instruments such as the flute, bagpipes and violin. The repertoire includes folk songs, ballads and Mehedițean hora (a traditional folk dance). Traditional Dances - such as boy dance and girl dance, are present at the celebration events. Traditional Holidays. Events such as Christmas, Easter and Christmas are marked by a series of customs and traditions involving songs, dances and specific dishes [22].

These ethnographic and folkloric values contribute to the preservation and transmission of local traditions, as well as to the promotion of the cultural identity of the area. They offer a rich and varied picture of the cultural heritage of this region and make a significant contribution to Romania's cultural diversity. The huge treasure in the rural area of Mehedinți is highlighted through events related to various religious or secular events, which bring generations together in exceptional events.

Study on the tourist activity at the Boarding house

The case study was carried out in Ponoarele commune, Mehedinți county, at the Conacu' Boierului farm boarding house, which has 14 rooms, as follows: 4 twin rooms, 5 rooms with double bed (180 x 200) and 5 suites (double bed + sofa bed). Each room is decorated differently, with hand-painted traditional motifs from all areas of the

country. This is how the cameras were born: Oltenia, Moldova, Banat, Dobrogea, Ponoarele, Muntenia, Maramureş, Mureş, Flori de Liliac, Bucovina, Crișana, Vatra Dornei, Clisura Dunării and Transilvania [20].
Conacu' Boierului is located just 150 meters from Ponoarele Cave and God's Bridge, Târgu Jiu City is 50 km away, Băile Herculane resort is 69 km away and Drobeta-Turnu Severin is 61 km away. The agrotourism boarding house has an accommodation capacity of 34 places, with equipment corresponding to the comfort category, for which it received classification.

Table 1. Evolution of tourist circulation indicators from the Boarding house, in the period 2018-2022

Years	Number of arrived tourists	Number overnight stays	Average number of tourists arriving per day	Average duration of stay (days)
2018	731	1,584	2	2.1
2019	1,021	2,390	2.8	2.3
2020	483	1,000	1.3	2
2021	695	1,521	1.9	2.1
2022	987	2,245	2.7	2.2

Source: processing from field and NIS data[18].

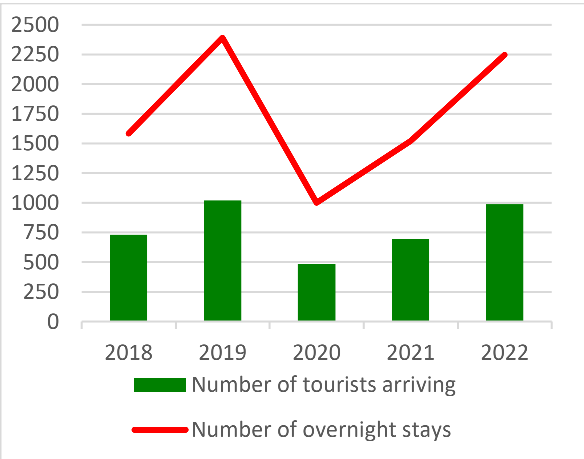

Fig. 1. Number of tourists arriving and overnight stays at the Boarding house, in the period 2018-2020
Source: processing from field and NIS data[18].

From Table 1 and Figure 1, it can be seen that in the first year of the study, the Boarding house received 731 visitors and recorded over 1,584 overnight stays. In 2019, the number increased significantly to 1,021 tourists and 2,390 overnight stays. However, travel restrictions imposed by the COVID-19 pandemic resulted in a significant drop in 2020 to just 483 tourists and 1,000 overnight stays [21]. Tourism activity revived after 2021, with the number of tourists and overnight stays increasing significantly, a fact also observed in 2022, when the values of these indices were the highest.
Table 1 and Figure 2 highlight the fact that the number of tourists arriving per day was the highest in the second year of the study, of 2.8 tourists, a phenomenon that was also observed in the other analyzed indicator, the average length of stay, which reached the maximum value of 2.3 days. Also, from here you can see a drastic drop in the values of the two indicators in figure 2, in the year most affected by the pandemic 2020, to only 1.3 tourists, even if the average length of stay remained at an average value of over 2, 0 days.
Following the data recorded during the studied period, entered in table 2, it was found that tourist activity in the Ponoarele area began a slow but sure process of recovery, thanks to the drastic but effective measures aimed at its revival and re-adaptation to the new realities of economic life and everyday life of the locality. This process is highlighted by the fact that the values of the two indices (arrivals and average length of stay) began in 2022 to be close to those of the second year of study 2019 (2.7 and 2.2).

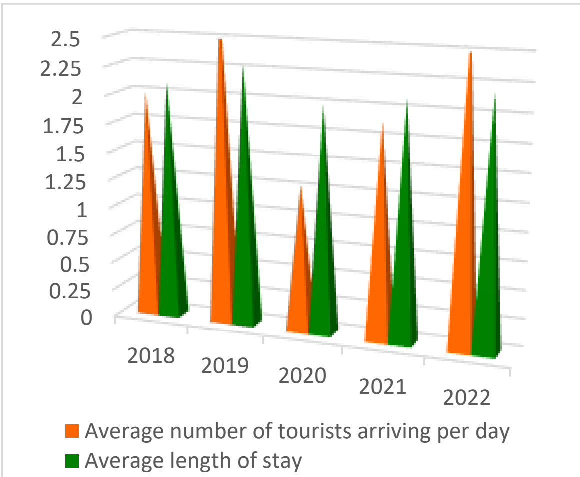

Fig. 2. Number of tourists arriving per day and the duration average stay at the Boarding house.
Source:
processing from field and NIS data [18].

Regarding the tourist demand in Table 2, it can be seen that the number of tourists arriving at boarding houses showed large

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fluctuations, especially in terms of the difference between normal years and 2020, the peak of the pandemic. Comparing the values recorded at the 3 daisies boarding house and those of the 4 daisies boarding house taken into the study, it can be very easily observed that the differences between them are significant, a fact that was primarily due to the services and quality management practiced at this boarding house.

Table 2. Tourist demand at rural tourist boarding houses in the locality, in the period 2018-2022

Specification	Number of arrived tourists at Boarding house				
	2018	2019	2020	2021	2022
Boarding house of 4 daisy	731	1,021	483	695	987
Boarding house of 3 stars/daisy	567	820	323	529	745

Source: processing from field and NIS data[18].

Table 3. Number of days tourists stayed at boarding house, in the period 2018-2022

Years	Number of arrived tourists	Number nights	Total number tourist days (t)
2018	731	1,584	1,157,904
2019	1,021	2,390	2,440,190
2020	483	1,000	483,000
2021	695	1,521	1,057,095
2022	987	2,245	2,215,815

Source: processing from field and NIS data [18].

Analyzing the data in Table 3, it can be seen that in 2018, the boarding house received 731 tourists, with 1,584 overnight stays and which led to the registration of 1,157,904 days of accommodation. In 2019, this number increased significantly, reaching 1,021 tourist arrivals, 2,390 overnight stays and 2,440,190 day-tourists. The severe restrictions in 2020 made the total number of travel days only 483,000, a fact that strongly affected the economic efficiency of the tourism activity carried out in this guesthouse. In the following years, thanks to some very good and efficient management measures taken by the owner, the values of this indicator, listed in table 3, increased constantly and continuously reaching in 2021, a total of 1,057,095 days of accommodation, and in the year 2022 to over 2,215,815 tourist days. The large number of accommodation days also reflects the permanent and sustained concern of the owner and the staff of the guesthouse to offer very good quality services, which will attract new and loyal customers.

Table 4. Accommodation capacity in operation (places-days) in the Boarding house, in the period 2018-2022

Years	Number of days of operation	Number of places of accommodation	The capacity of accommodation in operation
2018	355	34	12,070
2019	340	34	11,560
2020	251	34	8,534
2021	334	34	11,356
2022	345	34	11,730

Source: processing from field and NIS data[18].

Table 4 shows the data related to the accommodation capacity in operation (places-days) of boarding houses in the period 2018-2022. In 2018, the boarding house had 12,410 bed-days and operated for 355 days. In 2019, the boarding house had 11,560 bed-days and operated for 340 days. In 2020, the hostel had 7,324 bed-days and operated for 251 days, possibly due to travel restrictions imposed by the COVID-19 pandemic. In 2021, the boarding house had 9,520 bed-days and operated for 334 days. For the year 2022, an operational accommodation capacity of 9,980 place-days and an operation of 345 days are estimated.

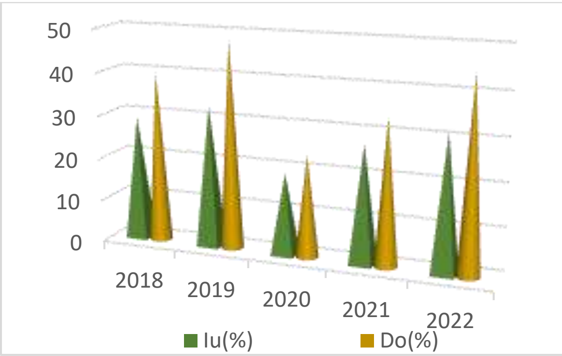

Fig. 3. Graph of the variation of the utilization index Iu (%) and the degree of occupancy Do (%), in the period 2018-2022.
Source: processing from field and NIS data [18].

As can be seen from Figure 3, in 2018, the Iu utilization index was 28.9%. It increased significantly in 2019, reaching 32.8%. However, in 2020, the usage index dropped to only 28.9%, in 2021, the usage index increased again, and in 2022 it reached again, close to the maximum value of 32%. From the same figure, it can also be seen that in 2018, the occupancy rate was 39.9%, it increased significantly in 2019, reaching 48.5%. However, in 2020, the degree of occupancy decreased significantly, following that later after the removal of all restrictions on the movement of tourists, it will steadily recover, reaching in 2022, a percentage of over 44.8. The high values of the main indicators regarding tourist supply and demand from the boarding house were, in our opinion, also due to the relatively good price of accommodation and quality services, practiced at the boarding house under study, leading to a favourable quality/price ratio. The rates are differentiated according to the quality of the accommodation conditions in each room. The loyalty of tourists has also led to an increase in demand and the values of the main indicators of tourist traffic, because in addition to the offer of accommodation, the management of the boarding house was also oriented towards the diversification of food and leisure services, the Boarding house offering breakfast, half board, full board, gastronomy, traditional recipes, cure of natural products made in the household or farm, etc.

The restaurant has a number of 35 places where you can serve the specialties of the manor, soups, snacks on the run, for those who are hungry, fish, borrowed from the city, snacks, dessert and picnic basket, as well as traditional Gorjenese food: Tismana trout with garlic sauce, sprinkled with wine from our own production, sarmaluțe with polenta, peasant stew, chicken soup, bean soup with smoked bone, sausage, dairy and meat products obtained from farm animals, compotes (stewed fruit), home-made juices [20].

Private events can be held in the Pension's restaurant on the major Christian holidays (Easter, Christmas, New Year's Eve, etc.) or upon request, the reservation can be made before the arrival time, with a time interval greater than 5 hours. A terrace with over 50 seats can also be provided on request, and the conference room, which is equipped with all the necessary technical equipment, can also be requested.

Leisure services in the Boarding house were also an important factor in attracting tourists and positively influencing the analyzed tourist indices. These consisted of walking, sports, hiking, horseback riding, fishing and hunting, cultural, religious, spa, congress and conference tourism, cycling, table tennis, billiards, children's playground, game room and others.

CONCLUSIONS

As found in this study, the researched area is part of the area of Mehedinți county, which has a significant potential for the development of agritourism and rural tourism, having a series of natural and cultural characteristics that can attract tourists willing to explore the countryside and enjoy of authentic experiences. The area enjoys an impressive variety of landforms, including canyons, caves, mountainous areas, dense forests and areas with Mediterranean influences. This diversity of landscapes creates the right setting for various tourist activities, from easy hiking to extreme sports in the natural environment. The cultural and historical heritage has a rich heritage of archaeological remains, monasteries, castles and tourist attractions related to the history of the place. These can be included in tourist itineraries to give a wider perspective on the region. Also, agricultural activities and traditional crafts provide opportunities for tourists to engage in traditional agricultural activities, and traditional crafts such as pottery and weaving can be introduced into leisure activities and tourist itineraries.

A benefit of agritourism in Ponoarele commune is its contribution to the sustainable development of the community, by promoting traditional agriculture and local production, not only representing an economic opportunity, but also an effective means of preserving traditions, promoting sustainability and improving the quality of life for the residents of the community, creating lasting connections between the local community and those who come to discover the charm of Ponoarele village. Holiday homes or agritourism boarding houses can offer tourists a comfortable and authentic stay, giving them the chance to experience the rural lifestyle and especially a revival of the authentic way of living in this area, such as plai mansions, which have a strong local specificity and authenticity.

From the analysis of the main indicators of tourist activity, it was found that the priority of agritourism in Ponoarele and Pension is focused on economic development, by increasing incomes, thus causing significant changes in the structure of expenses, increasing investments, expanding economic activities through the emergence of new branches related to agritourism (a real local industry). Along with the development of this activity, there is also a constant increase in commercial activities, to which both tourists and the local population turn. Households that practice agritourism reinvest the income obtained in improving their own homes, upgrading tourist facilities, repairing and purchasing household and household equipment. All this leading to the provision of decent living conditions in Ponoare, as well as to the diversification of employment options, especially for the young population, who are often the most vulnerable and who most frequently want to leave the area.

A very relevant aspect to emphasize is that agritourism in Ponoarele can totally influence the behaviour of local authorities, in the sense of remodelling, modernizing and streamlining the general infrastructure in the locality, restoring all the tourist attractions and heritage buildings and preserving the authentic way of life in the plai mansions, specific to the area.

Their behaviours were also influenced by the fact that agritourism has demonstrated that it has the ability to preserve and promote local traditions, thus, local artisans have a platform to exhibit and pass on their traditional crafts to future generations. This process of preserving cultural identity is vital to maintain a balance between modernization and respect for cultural roots.

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ON THE EVALUATION OF FORAGE MANAGEMENT PRACTICES APPLIED BY RUMINANT RAISERSUSING REGRESSION MODEL

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Abstract

The main aim of this research article is to evaluate the forage management practices of ruminant raisers in the Municipality of Jaro, Leyte, Philippines. The study also predicted the statistically significant factors of forage management practices and described their implications. A validated developed questionnaire was used to gather primary data for selected ruminant raisers in the Municipality of Jaro. Descriptive measures were calculated to provide the necessary information to describe the collected data and summarize it in statistical tables. Additionally, regression models were constructed to determine the significant predictors of forage management practices. The results depicted that, on average, ruminant raisers are not implementing forage management practices regarding planting, care and management, harvesting, and feeding procedures. This means that ruminant raisers are not implementing agricultural technologies that might improve their productivity and profitability. The regression analysis revealed that male ruminant raisers are implementing forage management as opposed to female raisers. In addition, the regression model showed that ruminant raisers are observing forage management if they have more number of ruminant animals. Moreover, it is depicted that ruminant raisers are more likely to practice forage management to increase their income. Hence, to encourage the ruminant farmers to implement forage management, the local government must conduct a seminar and educational training to introduce to them the new existing technologies and their advantages in the production process.

Key words*: *forage management, ruminant raisers, predictors, regression modeling

INTRODUCTION

Ruminant farming is considered one of the sources of income as well as a source of food for many Filipinos [12], [14]. In fact, ruminant farming in the country Philippines is one of the production business that earns significant profits that contributes to the national income [3]. In [7], it is stated that forage serves as a main source of food for ruminant animals which comprises various plant species that supply their dietary needs. In that case, forage management practices are crucial in ruminant raising to optimize the production process and provide enough food for the animals. It is worth noting that ruminant animals extract essential substances from forages that are essential to their growth with the help of their unique digestive system. In other words, the dependency of ruminant animals on forages is significant for them in regard to their health and development [16]. Apparently, the selection of the right forages for ruminant production results in nutritional and wellness implications.

In the country Philippines, raisers feed their ruminant animals with forages from their own grazing lands, however, farmers often lack an of understanding the impact of forages on their livestock's wellness. In [21], it is mentioned that innovation in processing new feed forages is important to help ruminant animals adjust to the changes in global temperatures and climate change which is a vital part of their growth. Hence, enhancing forage management practices among ruminant raisers is necessary as it promotes awareness and the effective optimization and utilization of livestock resources [3]. In fact, over the years, there are changes have taken place in ruminant raising production which is driven by advancements in modern technology, management strategies, growth enhancers, and financial incentives [17], [22].The positive results of this initiative are more marked in developed regions, where the animal production of food has increased and involves larger farms [7], [12], [14]. With that, it is important to acknowledge and resolve the hunger and poverty that exist worldwide. Perhaps, there remains a widespread deficiency of knowledge regarding the forage management and sustainable production of meat and poultry worldwide [4].

On the face of it, the investigation of forage management practices will lead to sustainable ruminant production and may increase the farmer's income. Although there are studies that deal with forage management, the evaluation of the factors is scarcely mentioned. With that research gap, this study exists. In general, the study aims to assess the awareness of forage management practices among ruminant raisers in Jaro, Leyte as the basis for designing a sustainable forage production and investigate the factors affecting its implementation. This study is significant because it aims to improve forage management practices among ruminant raisers, enhancing animal health and wellness, as well as the production process. By promoting sustainable forage production, the study seeks to boost resource efficiency, reduce environmental impact, and ensure long-term agricultural viability. The findings hope to provide a foundation for designing effective, eco-friendly forage systems, benefiting both ruminant raisers, animal consumers, the economy, and the ecosystem.

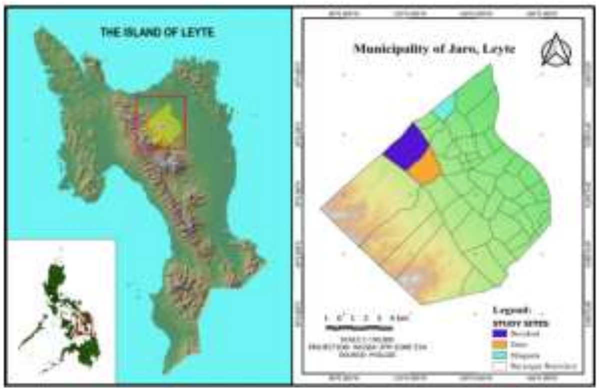
MATERIALS AND METHODS

Research Design

The goal of this investigation study is to elucidate the level of forage management practices and their determinants, hence, the research design employed in this article is descriptive-correlational which uses statistical measures and inferences. The study engaged a one-time survey for the data collection and involved primary information needed for the research design. The target of the design is to determine the cause and effect of the dependent and independent variables in the study. Moreover, the design made use of statistical inference to extract conclusions that may be used for future information about forage management practices to improve its current condition.

Research Locale, Respondents, Sampling, and Ethics

This survey study is restricted only to ruminant raisers in the three chosen barangays of Jaro, Leyte, Philippines such as(1) Burabod, (2) Hiagsam, and (3) Daro. These three barangays were selected since they have the highest number of ruminant raisers in the municipality of Jaro, Leyte. In addition, the said barangays have substantial grazing lands and water resources which makes them suitable for ruminant farming. Map 1 shows the picture of the three barangays in the municipality of Jaro, Leyte, Philippines that are involved in the study.



Map 1. Municipality of Jaro, Leyte, Philippines.
Source: [15].

As the first step of the research survey, an ethical process was done by sending a formal consent letter to the Municipal Agriculture Office (MAO) of Jaro, Leyte indicating the purpose and its significance to ruminant farming. After approval to conduct the study, the list of all registered ruminant raisers was asked through their MAO secretary. In that case, there are 103 ruminant raisers on the list and the researchers decided to employ complete enumeration to collect accurate results considering that the population is manageable. Table 1 presents the distribution of respondents per barangay.

Table 1. Distribution of respondents

1. Barangay	2. No. of Ruminant Raisers
3. Burabod	4. 39
5. Hiagsam	6. 35
7. Daro	8. 29
9. Total	10. 103

Source: Authors' guide (2024).

Additionally, a second formal consent was constructed for the chairmen of the said three Barangays involved in the survey informing them to inquire for permission to conduct the survey research and interview. Fortunately, the three chairmen per barangay were all positive and supportive of the research study. Hence, the survey took place from February to March 2024 focusing on evaluating the existing forage management practices by ruminant raisers. Furthermore, the ruminant raisers who participated in the study were informed that their cooperation was voluntary and the data collected from them were treated confidential.

Survey Instrument and Data Collection

In regard to the survey instrument, the study used a researcher-made questionnaire constructed in English language and translated into the local dialect (Leyte-Samaron) for the sake of ruminant raisers who are not fluent in English language. The research questionnaire has two parts namely (1) socio-demographic profile and (2) current forage management practices among ruminant raisers. For socio-demographic profile, the ruminant farmers were asked on their (i) age (in years), (ii) sex (male or female), (iii) civil status, (iv) educational attainment, (v) household size (count), (vi) monthly income (Philippine peso (PHP)) in ruminant raising, (vii) number of years in ruminant raising, (viii) number of current ruminant animal/s raise, and (ix) tenurial status. As for the forage management practices, respondents were asked a structured questionnaire involving a 3-point scaling on the following: (a) planting practices (3 questions), (b) care and management (9 questions), (c) harvesting (4 questions), and (d) feeding (5 questions). Table 2 depicts the possible forage management practices perception score, and corresponding response and interpretation.

Table 2. Forage management practice perception score

Perception score	Response	Interpretation[a]
1.00-1.67	Disagree	Not practice
1.68-2.34	Neutral	Moderately practice
2.35-3.00	Agree	Practice often

Source: Authors' guide (2024).

The research instrument has undergone a validity test by some experts in social science holding at least a master's degree and found that it is valid to use for the survey. Additionally, using a Cronbach alpha [23] as a reliability test, it is found that the set questions for forage management practices are reliable as shown in Table 3.

Table 3. Reliability test forage management practices research instrument

Questions	Items	Alpha	Interpretation [23]
Planting practices	3	0.55	Poor but acceptable
Care and management	9	0.76	Fair
Harvesting	4	0.55	Poor but acceptable
Feeding	5	0.51	Poor but acceptable

Source: Authors' guide (2024).

Data Analysis and Statistical Model

To get robust and clear results, the data gathered has undergone quality control by clearing the missing responses and outliers. Qualitative responses were then coded to quantitative responses for statistical calculation using Microsoft Excel and formatted to fit into the statistical software called STATA. To provide a meaningful description of the data gathered, descriptive statistical metrics were computed such as Mean, standard deviation (SD), minimum (Min) value, and maximum value (Max). Descriptive results were then presented in a statistical table and interpreted accordingly. Moreover, forage management practices perception scores for each category question were summed up and considered as a continuous variable so that parametric statistics could be applied [8]. In predicting the determinants of forage management practices as the dependent variable, ordinary least square regression was used. In that case, the study has the empirical statistical model as follows:

$$FMPractice_i = c_0 + c_1Age_i + c_2Male_i + c_3Married_i + c_4Educ_i + c_5HHsize_i + c_6log(income_i + 1) + c_7Nyears_i + c_8Nruminant_i + c_9Owner_i + \varepsilon_j \quad (1)$$

This study has four statistical models since forage management practices have four categories namely: planting practices (Model 1), care and management (Model 2), harvesting (Model 3), and feeding (Model 4). Hence, $FMPractice_i$ refers to the perception score for each category mentioned above. Moreover, *i*refers to the *i*thruminant raisers ($i \in \{1, 2, \ldots, 103\}$), c_k($k \in \{1, 2, \ldots, 9\}$) refers to the models' parameters to be calculated by approximation, Age_i refers the age of ruminant farmers in years, $Male_i$refers to a dummy variable that indicates a male ruminant raisers (0-female, 1-male), $Married_j$ refers to a dummy variable that captures a ruminant raisers who is officially married (0-non married, 1-married), $Educ_j$ refers to the ruminant raisers' educational attainment in the form of scoring (1-elementary level, 2-elementary graduate, 3-high school level, 4-high school graduate, 5-college level, 6-college graduate), $HHsize_i$ refers to the number of family members in the household, $log(income_i + 1)$ refers to the normalized (taking logarithm based 10) monthly income of ruminant raisers, $Nyears_i$ refers to the number of years in raising ruminant animals, $Nruminant_i$ refers to the current number of ruminant animals being raise during the survey, $Owner_i$ refers to a dummy variable that indicates a ruminant raisers who own farm land, andε_i refers to the remaining random errors in OLS regression model (1).To obtain statistically sound results, diagnostic tests for regression analysis were performed [2, 9, 20]. In this case, the null hypothesis (H_o) is that the forage management practices have no significant influence on the socio-demographic profile of ruminant raisers, and the alternative hypothesis (H_a) is the otherwise scenario. Furthermore, statistical computations in the regression analysis were subjected to the likelihood of rejecting H_o with the standard level of significance (1%, 5%, or 10%), and all calculations were aided with STATA software.

RESULTS AND DISCUSSIONS

Socio-demographic Profile

It is revealed in Table 4 that the age of the ruminant raisers in Jaro, Leyte, Philippines is close to 52.26 (SD=12.58) years old. The youngest of them is 23 years old and the oldest is 79 years old. This average age is consistent with the findings in [11] which found that farmers are relatively old. About 57% of the ruminant raisers are male and 43% of them are female. Most (75%) of them are married and about 25% of them are non-married (single, widower, etc). In regard to their mean educational attainment score, it is close to 2.79 (SD=1.65) which can be interpreted as high school level. Additionally, Table 3 shows that there is a ruminant raiser who is elementary level and the highest educational attainment is college graduate. Approximately, their household size is close to 2 (SD=0.77).

The monthly income of ruminant raisers is close to PHP 7,121.36 (SD=5,391.29) where the lowest is PHP 3,000 and the highest is 40,000.

Table 4. Ruminant raisers' profile (n=103)

Profile variable	Mean	SD	Min	Max
Age	52.26	12.58	23	79
Male[a]	0.57	0.49	0	1
Married[a]	0.75	0.44	0	1
Educational attainment	2.79	1.65	1	6
Household size	2.02	0.77	1	5
Income in ruminant raising[b]	7,121.36	5,391.29	3,000	40,000
Number of years in ruminant raising	23.19	18.12	1	63
Number of ruminant animals	2.83	1.49	1	8
Owner[a]	0.65	0.48	0	1

Note: a - dummy (indicator) variable; b - Philippine peso (PHP).
Source: Original computation (2024).

On average, the number of years in ruminant raising is close to 23.19 (SD=18.12) where the minimum is 1 year and the maximum is 63 years.

The number of ruminant animals raised is close to 3 (SD=1.49) where the minimum number is 1 and the maximum number is 8. About 65% of the ruminant raisers own their farmland for raising the animals and 35% of them do not own a land for ruminant raising. In [19], it is stated that owning land is very crucial due to competition for resources particularly in grazing.

Forage Management Practices

Table 5 depicted that ruminant raisers are not exercising *"Planting Practices"* (Mean=1.02, SD=0.11) such as testing soil fertility, seedbed preparation, proper seeding rates, and appropriate planting depth, and even rotating forage crops with other crops for ruminant raising. In [5], it is depicted that planting practices are one of the activities that increase production and yield. Secondly, ruminant raisers are not practicing any *"Care and Management"*(Mean=1.53, SD=0.19) in their forage fields such as monitoring signs of pests, diseases, nutrient deficiencies, and maturity to optimize harvest timing and Implementing appropriate weed control. In addition, they are not practicing a regular assessment of forage quality, utilizing rotational grazing, implementing strategies to prevent soil compaction, and soil fertility management.After planting, care and management must be observed to produce a good quality of forage and the desired amount must be obtained [13].Thirdly, ruminant raisers are not also practicing *"Harvesting"* (Mean=1.18, SD=0.07) management for their forage such as appropriate harvesting schedule, equipment and techniques, storing harvested forages properly, utilization of additives, weather monitoring, and regrowth management for right recovery. It is mentioned in [18] that high-quality of forage can positively influence the profitability of ruminant animals, hence, optimizing forage harvest is highly suggested. Lastly, ruminant raisers are not exercising any *"Feeding"*(Mean=1.50, SD=0.15) management such as incorporating harvested forages into the ruminants' diets, prioritizing rotational grazing, balancing forage-based diets, regular assessment of ruminants' body condition, seasonal adjustments in feeding strategies, and assessment of forage quality. It is mentioned in [6] that the right amount and feeding values must be observed to optimize the growth of the ruminant animals.

Overall, the ruminant raisers are not practicing (Mean=1.31, SD=0.22)forage management and new technology that might improve their productivity and profitability. This shows that these ruminant raisers need to be introduced to the new agricultural activities suitable to their production process through educational training and seminars. With the new agricultural technologies, farmers can progress their production activities and will have a resilient attitude towards the environment and climate change [1].

Table 5. Ruminant raisers' forage management practices

Practices	Mean	SD	Interpretation
Planting practices	1.02	0.11	Not practice
Care and management	1.53	0.19	Not practice
Harvesting	1.18	0.07	Not practice
Feeding	1.50	0.15	Not practice
Total	**1.31**	**0.22**	**Not practice**

Note: a-Scale 1 to 3.
Source: Original computation (2024).

Regression model

Table 6 presents the diagnostic tests for the four (4) regression models to measure the consistency and validity of the results [9, 20]. These four models have the same possible independent variables and they showed no multicollinearity (mean VIF=1.36) problem [2]. The dependent variable for Model 1 is the ruminant raisers' perception score on *"Planting Practices"*. The diagnostic tests showed that Model 1 is Heteroscedastic (X^2=108.31; p-value<0.001), no omitted variable bias (F=1.37; p-value=0.256), and residuals are not normally distributed (Z=108.31; p-value<0.001). Model 2 dependent variable is the "C*are and Management"* perception score; diagnostic tests showed that it is not Heteroscedastic (X^2=0.55; p-value=0.459), no omitted variable bias (F=2.52; p-value=0.063), and residuals are not normally distributed (Z=2.261; p-value=0.011). Additionally, Model 3 dependent variable is *the "Harvesting"*perception score and the diagnostic tests depicted that the model is Heteroscedastic (X^2=65.89; p-value<0.001), has omitted variable bias (F=4.40; p-value=0.006), and residuals are not normally distributed (Z=3.563; p-value=0.034). Furthermore, Model 4 dependent variable is *the "Feeding"*perception score and it is found that the model is Heteroscedastic (X^2=10.32; p-value=0.001), has no omitted variable bias (F=2.59; p-value=0.058), and residuals are not normally distributed (Z=5.26; p-value<0.001). In that case, models are adjusted by robust options in the STATA program to get statistically sound results [9].

Table 6. Diagnostic tests for regression models

Test Statistic		p-value	Interpretation
Model 1: The dependent variable is the Planting practices score			
Breusch-Pagan test	χ^2=108.31	<0.001	Heteroscedastic
Ramsey RESET test	F=1.37	0.256	No omitted variable bias
Variance inflation factor (VIF)	Mean VIF=1.36	-	No Multicollinearity
Shapiro-Wilk test	Z=9.059	<0.001	Residuals are not normal
Model 2: The dependent variable is the Care and management score			
Breusch-Pagan test	χ^2=0.55	0.459	Not heteroscedastic
Ramsey RESET test	F=2.52	0.063	No omitted variable bias
Variance inflation factor (VIF)	Mean VIF=1.36	-	No Multicollinearity
Shapiro-Wilk test	Z=2.261	0.011	Residuals are not normal
Model 3: The dependent variable is the Harvesting score			
Breusch-Pagan test	χ^2=65.89	<0.001	Heteroscedasticity
Ramsey RESET test	F=4.40	0.006	Has omitted variable/s bias
Variance inflation factor (VIF)	Mean VIF=1.36	-	No Multicollinearity
Shapiro-Wilk test	Z=3.563	0.034	Residuals are not normal
Model 4: The dependent variable is the Feeding score			
Breusch-Pagan test	χ^2=10.32	0.001	Heteroscedastic
Ramsey RESET test	F=2.59	0.058	No omitted variable bias
Variance inflation factor (VIF)	Mean VIF=1.36	-	No Multicollinearity
Shapiro-Wilk test	Z=5.260	<0.001	Residuals are not normal

Source: Own calculation based on data gathered (2024).

Fig. 1, 2, 3, and 4 presented the Kernel density estimate and normal density for the residuals of Models 1, 2, 3, and 4, respectively, which indicates that the residuals are far from normality. This implies that the response variables of the four models are skewed.

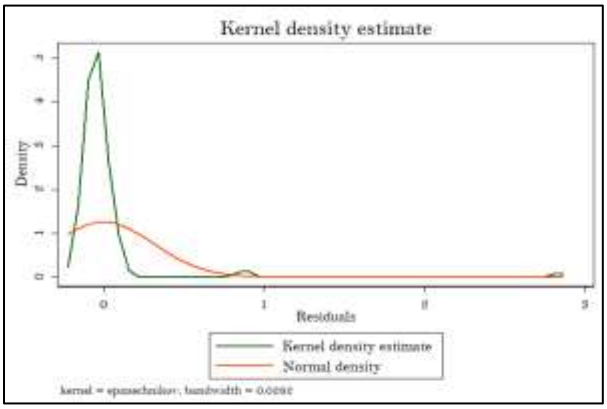


Fig. 1. Kernel density estimate and normal density for residuals of regression model 1.
Source: Original construction (2024).

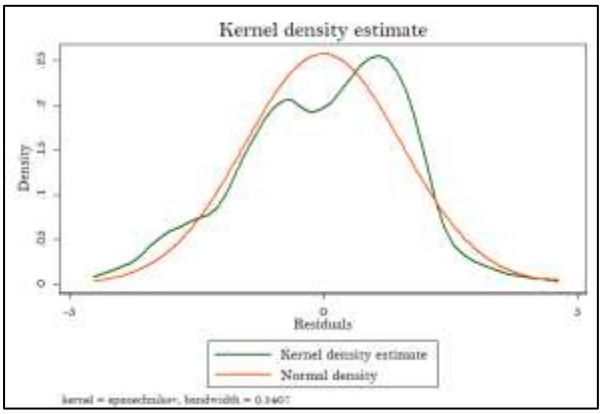


Fig. 2. Kernel density estimate and normal density for residuals of regression model 2.
Source: Original construction (2024).

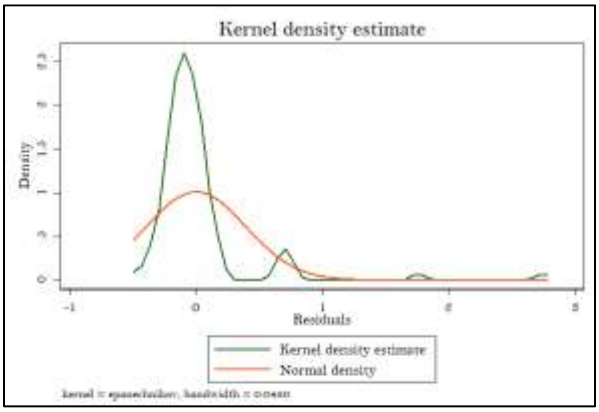


Fig. 3. Kernel density estimate and normal density for residuals of regression model 3.
Source: Original construction (2024).

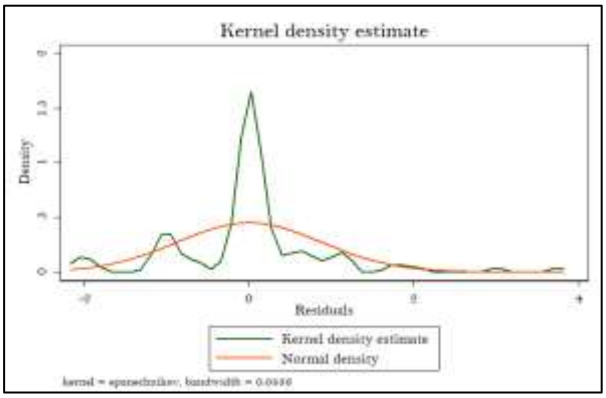


Fig. 4. Kernel density estimate and normal density for residuals of regression model 4.
Source: Original construction (2024).

Table 7 presented the regression models 1 and 2 with the *"Planting practices"* and *"Care and management"* perception scores as dependent variables, respectively. The two models are both not significant (Model 1: F=0.35, p-value=0.95; Model 2: F=0.48, p-value=0.88) and revealed a very little coefficient of determination (Model 1: R^2=0.05; Model 2: R^2=0.04). However, the individual T-test for independent variables showed some significant predictors. In Model 1, it is shown that age (p-value=0.407), civil status (p-value=0.738), educational attainment (p-value=0.985), household size (p-value=0.340), income (p-value=0.959), number of years in ruminant raising (p-value=0.291), number of ruminant animals (p-value=0.286), and tenurial status (p-value=0.811) are not significant predictors of *"Planting practices"*. The only significant independent variable in Model 1 is sex (p-value=0.099) at a 10% level and the positive coefficient indicates that male ruminant raisers are the ones who observed *"Planting practices"*. In [10] and [11], males are more capable in farming activities and they are more efficient because most of the tasks are masculine in nature. Meanwhile, Table 5 showed that the variables such as age (p-value=0.942), civil status (p-value=0.634), educational attainment (p-value=0.598), household size (p-value=0.915), number of years in ruminant raising (p-value=0.693), number of ruminant animals (p-value=0.923), and tenurial status (p-value=0.452) are not significant predictors of *"Care and management"* in Model 2. The significant independent variables in Model 2 are sex (p-value=0.091) and income (p-value=0.092) both at a 10% level. These results imply that male (positive coefficient) ruminant raisers are observing *"Care and management"* than females which is consistent with the results in [11]. Moreover, findings indicated that ruminant raisers with lower income (negative coefficient) are more observing *"Care and management"* as opposed to raisers with higher income.

Table 7. Regression (OLS) models 1 and 2.

Independent variables	Model 1		Model 2	
	Coeff.	Std. Error	Coeff.	Std. Error
Age	0.003^{ns} (0.407)	0.004	-0.001^{ns} (0.942)	0.016
Sex[a]	0.081* (0.099)	0.054	0.450* (0.091)	0.338
Civil status[a]	0.013^{ns} (0.738)	0.039	0.186^{ns} (0.634)	0.389
Educational attainment	0.001^{ns} (0.985)	0.030	0.065^{ns} (0.598)	0.124
Household size	0.027^{ns} (0.340)	0.028	0.024^{ns} (0.915)	0.229
log (income[b]+1)	0.007^{ns} (0.959)	0.142	-1.559* (0.092)	1.041
Number of years in ruminant raising	-0.003^{ns} (0.291)	0.003	-0.004^{ns} (0.693)	0.011
Number of ruminant animals	0.026^{ns} (0.286)	0.024	-0.011^{ns} (0.923)	0.123
Tenurial status[a]	0.018^{ns} (0.811)	0.076	0.278^{ns} (0.452)	0.368
No. of observation	103		103	
F-test computed	0.35		0.48	
p-value	0.95		0.88	
R^2	0.05		0.04	

Note: a - dummy (indicator) variable; b - Philippine peso (PHP); p-values are enclosed with parenthesis.
Source: Original computation(2024).

It is worth noting that making the right and optimal decisions in organizing and operating a farm leads to maximizing production and profitability [10], [14].

Table 8 shows the regression models 3 and 4 with the *"Harvesting"* and *"Feeding"* perception scores as dependent variables, respectively. Again, the models are not significant (Model 3: F=1.07, p-value=0.39; Model 4: F=0.47, p-value=0.88) and revealed a very little goodness of fit (Model 3: R^2=0.11; Model 4: R^2=0.04). The same with models 1 and 2, the individual T-test for independent variables showed some significant predictors for models 3 and 4.

Model 3 revealed that age (*p*-value=0.538), civil status (*p*-value=0.748), educational attainment (*p*-value=0.921), household size (*p*-value=0.172), income (*p*-value=0.460), number of years in ruminant raising (*p*-value=0.739), and tenurial status (*p*-value=0.285) are not significant predictors of *"Harvesting"*.

Table 8. Regression (OLS) models 3 and 4

Independent variables	Model 3		Model 4	
	Coeff.	Std. Error	Coeff.	Std. Error
Age	0.003^{ns} (0.538)	0.004	0.002^{ns} (0.822)	0.008
Sex^{a}	0.157** (0.032)	0.072	-0.059^{ns} (0.750)	0.187
Civil status^{a}	0.023^{ns} (0.748)	0.073	0.194^{ns} (0.350)	0.207
Educational attainment	-0.004^{ns} (0.921)	0.038	-0.003^{ns} (0.953)	0.060
Household size	0.074^{ns} (0.172)	0.054	0.059^{ns} (0.610)	0.116
log (income^{b}+1)	-0.145^{ns} (0.460)	0.196	-0.668^{ns} (0.274)	0.607
Number of years in ruminant raising	-0.001^{ns} (0.739)	0.003	0.003^{ns} (0.612)	0.006
Number of ruminant animals	0.045* (0.096)	0.029	-0.047^{ns} (0.378)	0.053
Tenurial status^{a}	0.086^{ns} (0.285)	0.080	0.027^{ns} (0.901)	0.219
No. of observation	103		103	
F-test computed	1.07		0.47	
p-value	0.39		0.88	
R^2	0.11		0.04	

Note: a - dummy (indicator) variable; b - Philippine peso (PHP); p-values are enclosed with parenthesis; *-significant at 10% level; **-significant at 5% level.
Source: Original computation (2024).

The significant independent variable for Model 3 is sex (*p*-value=0.032) at a 5% level and number of ruminant animals (*p*-value=0.096) at a 10% level. The results showed that male (positive coefficient) ruminant raisers are practicing forage management in terms of harvesting compared to females. Again, this result is parallel to the discoveries in [10] and [11]. Additionally, a raiser with a higher number of ruminant animals (positive coefficient) is more likely to observe forage management in *"Harvesting"* as opposed to raisers with a lower number of ruminant animals. In [18], it is portrayed that management in harvesting forage is crucial in maximizing limited resources and optimizing the production activities in raising ruminant animals. However, Model 4 revealed that variables such as age (*p*-value=0.822), sex (*p*-value=0.750), civil status (*p*-value=0.350), educational attainment (*p*-value=0.953), household size (*p*-value=0.610), number of years in ruminant raising (*p*-value=0.612), number of ruminant animals (*p*-value=0.378), and tenurial status (*p*-value=0.901) are not significantly affecting the *"Feeding"* management of ruminant raisers. This implies that ruminant farmers do not have enough understanding in regard to the importance of managing the feeding activities and strategies of ruminant animals which can influence the health and wellness as well as the growth process [22].

CONCLUSIONS

The study concluded that ruminant raisers do not implement forage management practices in terms of right planting practices, care, and management for forage, harvesting, and as well as feeding procedures. This implies that ruminant raisers face challenges in practicing forage management, particularly in understanding and implementing suitable practices that involve new technology. Results have found that male ruminant raisers are more likely to practice forage management compared to female raisers indicating that farming is more suitable for male workers. It is also found that ruminant raisers practice forage management if they have more ruminant animals to optimize their resources. Moreover, ruminant raisers are encouraged to practice forage management to increase their productivity and profitability. Hence, the study suggests that to enhance forage management practices among ruminant raisers, education and outreach efforts should be intensified to raise awareness and promote the adoption of modern technologies alongside traditional knowledge, thus improving overall productivity and sustainability. Moreover, ruminant raisers require support to enhance planting and care practices, while ensuring a strong emphasis on forage quality and sustainable grazing methods. The study's limitation is that it only deals with socio-demographic profiles as predictors of forage management practices, hence, the study strongly recommends incorporating the variables such as access to credit and economic behavior like resilience in the regression model as future research.

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BIOFUELS AND ABSOLUTE COUPLING. POTENTIAL AND CHALLENGES FOR A SUSTAINABLE FUTURE

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Abstract

Absolute decoupling is an economic and sustainability concept that refers to the complete separation of economic growth from natural resource use and environmental impact. This form of decoupling is observed when an economy sustains its growth while the consumption of resources and greenhouse gas emissions decline, signifying an enhancement in resource efficiency and a reduction in environmental impact. Absolute decoupling is considered essential to achieving sustainable development goals, as it offers a solution to developing economies without exacerbating ecological problems such as climate change, biodiversity loss and soil degradation. In this context, biofuels have a significant role, because their utilization can aid in reducing carbon dioxide emissions, thereby facilitating the decoupling of greenhouse gas emissions from economic growth. However, their positive effects depend on several factors, such as cultivation methods, the types of biomass used and the efficiency of the production process, so that the negative ecological impact of their use does not counteract the benefits offered by reducing CO_2 emissions. Another relevant aspect of the relationship between biofuels and absolute decoupling is their potential to encourage innovation in the energy sector. By investing in and developing second- or third-generation bioenergy technologies that use organic waste and residues, biofuels can become more sustainable, this approach contributes to reducing natural resource consumption and minimizing ecosystem impact. The current study undertook a bibliographic analysis focused on the objective of absolute decoupling and the role of biofuels in achieving this goal, and on the other hand from the collection, processing and interpretation of statistical data regarding energy consumption, CO_2 emissions, production and the consumption of biofuels. The findings revealed a steady rise in these factors, suggesting a direct correlation between economic expansion and its environmental impact. The growth in biofuel production and consumption illustrates the effort regarding the transition to more sustainable energy sources. However, CO_2 emissions continue to have an upward trend, which requires the intensification of efforts to increase the share of renewable energy and reduce the intensity of emissions, so that economic growth is sustainable and with minimal effects on climate change.

Key words: *absolute decoupling, biofuels, climate change, efficiency*

INTRODUCTION

Climate change and the need to reduce greenhouse gases are topics that have long concerned political factors, as well as specialists and non-specialists, worried about the impact they will have on the future of humanity. Conversely, some researchers advocate for a balanced strategy that emphasizes adaptation and the advancement of low-emission technologies, rather than an overly aggressive push for rapid emission reductions, which could adversely impact global well-being. In this context, the challenges related to the need to obtain reliable and cheap energy, especially in developing countries, and the global objectives of reducing emissions must be met. Forecasts indicate that fossil energy sources will continue to dominate until 2050, particularly in developing nations, raising concerns about meeting the 'Net Zero' target of limiting global warming to below 1.5°C relative to pre-industrial levels [27].

In this context, in the 2000s, another concept was brought into discussion, that of absolute decoupling, which supports the objectives of the Paris Agreement, as it promotes the transition to cleaner energy sources and provides a theoretical and practical framework for reducing emissions and consumption of natural resources, while economies continue to grow [8]. By means of the OECD report from 2002, entitled "Indicators to Measure Decoupling of Environmental Pressure from Economic Growth", absolute decoupling was defined and analyzed in detail, with indicators and evaluation methods being proposed of how economic growth can continue without intensifying the impact on environment [17, 26].

Therefore, absolute decoupling implies the adoption of clean energy solutions, but studies show that these solutions are expensive and resource-consuming [3], and therefore there is a need to focus on the adaptation and development of low-emission technologies, instead of a pressure exaggerated for rapid reductions in emissions, which could have negative effects on global well-being [2].

Alongside various strategies encompassing renewable energy, carbon capture and storage, sustainable agriculture, enhanced energy efficiency, and energy demand management, bioenergy and biofuels serve as crucial resources that can be further advanced to bolster decarbonization initiatives without hindering economic growth or global welfare [4, 13]. For instance, bioenergy with carbon capture and storage (BECCS) merges bioenergy with carbon capture technologies, leveraging plants to sequester CO_2 while capturing and storing emissions produced during biomass combustion. On the other hand, biofuels, which could be obtained from plant biomass, agricultural and industrial waste or vegetable oils, can reduce the impact on agricultural land, given that the world's growing population already puts a high pressure on obtaining food and other necessary resources, thus gaining popularity due to their ecological advantages [11, 15].

Over time, there have been several generations of biofuels: the first generation, obtained from food crops (corn, sugar cane, etc.); the second generation obtained from agricultural and forestry waste that contributes to the implementation of the circular economy and to the reduction of pollution through the efficient use of resources (biogas, cellulosic bioethanol); the third generation obtained from microalgae and other aquatic sources. These advanced generation biofuels have a much smaller impact on land use and do not compete with food production, while also having, according to studies, the potential to reduce greenhouse gas emissions by up to 85% [12]. Fourth-generation biofuels are more advanced than third-generation ones, and their production is based on the metabolic engineering of algae with the advantage of absorbing CO_2 and having a high production rate [18]. However, there are certain economic and feasibility challenges, as the production technology is still in the research and development stage, and the conversion of raw materials into final biofuel requires new technologies [19, 20].

Thus, although biofuels are considered essential in the transition to a low-carbon economy, it is found that there are significant challenges in their widespread adoption, namely: competition for resources between biofuel production and food production, considering the fact that in many regions, the allocation of agricultural land for biofuel crops may drive up food prices and limit access to essential food resources; furthermore, the intensive cultivation of biofuel feedstocks can result in deforestation, soil degradation, and a decline in biodiversity; although biofuel production technologies are continually advancing, their costs remain elevated in comparison to conventional fuels; moreover, the infrastructure required for biofuel production, transport, and distribution demands significant investment; in many countries, the regulations are not yet clear or favorable enough to stimulate the transition to biofuels, and coordinated international policies are needed to support investments in technologies for the production and use of biofuels, which can at the same time guarantee compliance with the standards of environment and social [1, 9, 16, 21, 24].

Biofuels therefore have an important role to play in the relationship between absolute decoupling and large and rapid emission reductions, providing a lower carbon alternative to fossil fuels. They can be incorporated into existing fuel infrastructures, supporting the transition toward a more sustainable economy without hindering economic growth [10]. In the context of absolute decoupling, biofuels allow the reduction of economic dependence on fossil resources and allow the continuation of economic development without a proportional increase in greenhouse gas emissions [25].

To support large and rapid emission reductions, biofuels can be used especially in hard-to-electrify sectors such as aviation, shipping and heavy industry, where the transition to electricity is complex and expensive. By using biofuels, these sectors can substantially reduce carbon emissions, thus contributing to the objective of absolute decoupling [14].

Thus, biofuels can be part of an absolute decoupling strategy that pursues sustainable economic growth with low environmental impact, while simultaneously supporting short- and long-term climate goals.

Moreover, absolute decoupling and large and rapid reductions in emissions are complementary concepts, essential for effectively addressing the climate crisis [28].

Factors that have a direct and indirect influence on natural resources and greenhouse gas emissions are represented by demography, economic development and energy use.

In this context, the aim of this research was to examine how absolute decoupling may impact the relationship between energy intensity, greenhouse gas emissions and the use of biofuels in order to evaluate how the impact on the environment can be reduced, in the conditions of maintaining growth economic.

MATERIALS AND METHODS

The analysis was carried out for the period 2000-2023, taking into account the estimates for the time horizon 2030 and 2050. To carry out the research, data taken from world and European statistics were used, which were processed and analyzed, but the purpose of formulating the research results, which they were the basis for formulating conclusions regarding the importance of this extremely present and necessary subject for ensuring the future of generations to come.

RESULTS AND DISCUSSIONS

Significant population growth means greater demand for resources and energy to support the population, which will intensify the pressure on the environment, making it more difficult to achieve absolute decoupling. In this sense, absolute decoupling implies the need for solutions that will have the effect of maintaining the consumption of resources and emissions, at a low level per inhabitant, even in the conditions of population growth.

According to estimates, the world population will exceed 8.5 billion inhabitants in 2020, will reach over 9.70 billion inhabitants in 2050 and over 11 billion inhabitants in the year 2100 (Figure 1).

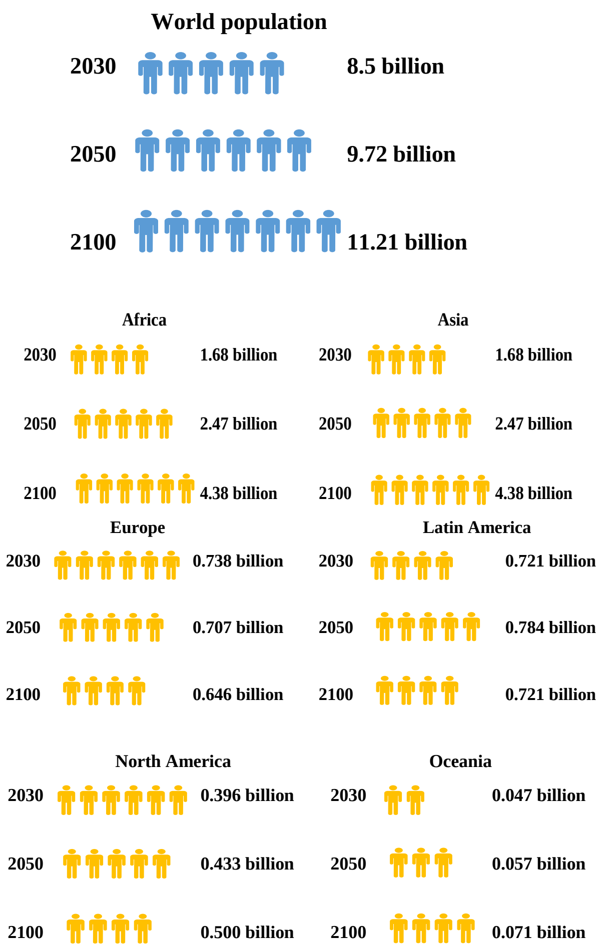

Fig. 1. Population evolution in the period 2030-2100
Source: [7].

Africa and Asia are the engines of population growth, given that at this currently the largest countries in the world are Nigeria, Bangladesh, China, India, Indonesia, Pakistan. To these are added Brazil, Mexico, the USA and Russia. Europe and North America are regions expected to experience population

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declines, with reductions projected to reach up to 15% in certain countries, including Romania.

Therefore, as the population grows, so does the global demand for energy. That is why, especially in emerging economies, where demographic growth is faster, biofuels offer an affordable solution to cover energy needs, especially in the transport and agriculture sectors. However, in order to meet a large and growing demand, biofuels must be produced efficiently and sustainably, given that the production of biofuels involves the use of energy crops (such as corn, soy or sugar cane) that require extensive areas of agricultural land. Thus, as the population grows, agricultural land will be in greater demand for food production, which may create competition between the use of land for biofuels and land for food production. This can lead to increased food prices and deforestation to create new agricultural land, negatively impacting the environment. In this context, second-generation biofuels, which use residues and waste instead of food crops, are a greener and more sustainable alternative.

In densely populated regions and expanding cities, biofuels can play a major role in supporting a sustainable energy transition by reducing greenhouse gas emissions in congested urban areas. At the same time, biofuels from urban waste can be a sustainable solution that reduces dependence on energy crops and contributes to waste management in large urban agglomerations. Furthermore, in regions with accelerated population growth, there is greater pressure on governments to provide affordable energy and stimulate local economies, therefore biofuel production can create jobs in rural areas and contribute to local economic development. However, policies must balance the need for biofuels with the impact on food security and the environment to ensure sustainable development.

Therefore, the analysis must be completed with information about the relationship between energy consumption and population growth.

Thus, it is found that worldwide, energy consumption has continuously increased, so compared to the years 2000, when the consumption was 397 TWh, according to the estimated data, it will be doubled by 2030, which is due to both economic growth, but especially urbanization. The reduction in consumption in 2019 and 2020 is the consequence of the cessation of industrial activity due to the emergence of the Covid-19 pandemic. It is observed that the impact of the economic crisis from 2007-2009 had a direct impact on energy consumption (Figure 2).

The increase in this consumption in the following period highlights a growing demand for energy resources and, implicitly, the increase in pressure on the global energy infrastructure.

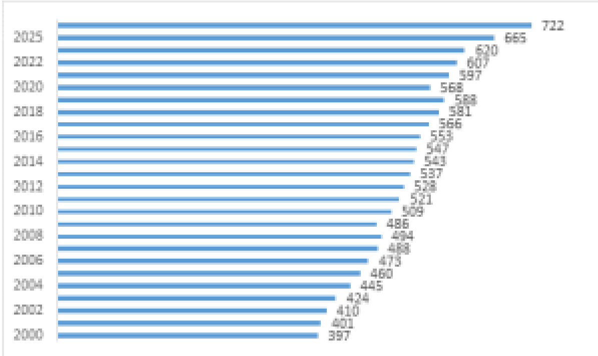

Fig. 2. The evolution of energy consumption, worldwide
Source: own processing based on the data from [22].

Global global energy consumption faced significant differences between OECD and Non-OECD regions. If in the case of OECD countries there is a moderate increase, from 282 TWh in 2020 to 309 TWh in 2030, reflecting both energy efficiency and the transition to green energy, it is found that Non-OECD regions, especially in Asia and Africa, there is an increase in consumption during the analyzed period, from 332TWh to 413 TWH, which is due to economic growth and urbanization. North America and Europe, which are two mature energy markets, are experiencing slow growth due to stability and adaptation to environmental regulations. Asia is an emerging region, whose growth is determined by the development of the economies of countries such as China and India. Thus, in this region, consumption growth will go from 173 TWH in 2020 to 224

TWh in 2030, thus becoming a driver of global energy demand.

The Middle East and Africa have moderate increases reflecting industrial development and economic growth.

The particularity of these regions is represented by a consumption/capita that remains low compared to the other regions, but also the fact that the energy sources are represented by resources that lead to increased pollution (wood, plant residues, etc.), so it is immoral to asks the residents to keep their energy consumption so low (Table 1). Therefore, the elimination of energy poverty in these regions requires the development of reliable energy sources, but also with affordable costs, and these sources can only be represented by fossil fuels.

Moreover, once the population increases, there will also be an increase in CO_2 emissions.

Table 1. The evolution of energy consumption, by region, in the period 2020-2030

Region	2020	2025	2030
OECD	282	295	309
North America	148	157	166
Europe	89	91	95
Asia	44	46	48
Non-OECD	332	371	413
Europe and Eurasia	69	74	79
Asia	173	197	224
Middle East	31	34	38
Africa	22	24	27
Central and South America	37	41	46
Total World	613	665	722

Source: own processing based on the data from [5].

That's why we decided to continue to analyze the data related to CO_2 emissions recorded worldwide.

Thus, there is an increase in CO_2 emissions from 25.5 billion metric tons in 2000 to 37.55 billion metric tons in 2023, with some fluctuations in the analyzed period (Figure 3). Annual growth is relatively constant, as a consequence of intensified global industrial and economic activities, with notable declines in 2009 and 2020 due to the global financial crisis and the COVID-19 pandemic, respectively. After 2020, emissions resume their upward trend, reaching 37.55 billion metric tons in 2023, which shows the need to take measures to reduce emissions and transition to more ecological energy sources, such as biofuels.

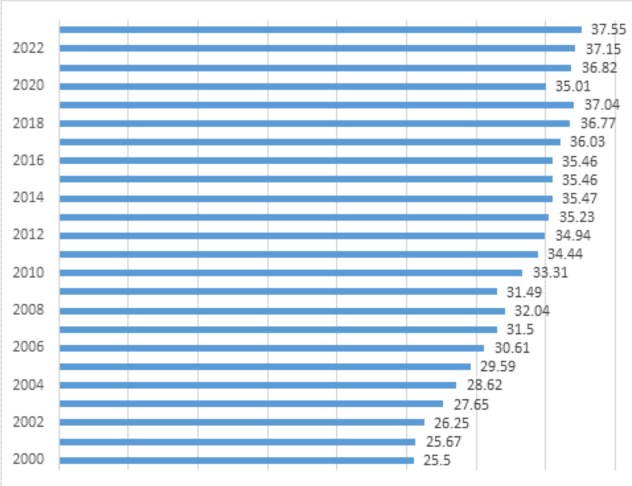

Fig. 3. Evolution of CO_2 emissions, worldwide
Source: own processing based on the data from [23].

Biofuel production has increased over the years, from 315 Mb/d in 2000 to 2,810 Mb/d in 2022, driven by increased demand for renewable energy sources.

The main contributors are ethanol and biomass-based diesel.

Ethanol increased from 299 Mb/d in 2000 to 1,828 Mb/d in 2022, while biomass diesel saw higher growth, from 16 Mb/d in 2000 to 983 Mb/d in 2022.

Although total production declined in 2020 due to disruptions caused by the COVID-19 pandemic, it has since recovered, highlighting the importance of biofuels in the global decarbonisation and green energy transition strategy (Table 2).

Biofuel consumption has increased from 300 Mb/d in 2000 to 2,778 Mb/d in 2022, along with increasing demand for renewable energy sources. Ethanol and biomass-based diesel contributed to this growth.

Thus, ethanol consumption increased from 285 Mb/d in 2000 to 1,834 Mb/d in 2022, while biomass diesel consumption rose from 14 Mb/d in 2000 to 943 Mb/d in 2022 (Table 3).

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Table 2. The evolution of biofuel production, worldwide, in the period 2000-2022

Year	Production (Mb/d)	Fuel ethanol (Mb/d)	Biomass - based diesel (Mb/d)
2000	315	299	16
2001	345	324	21
2002	405	378	27
2003	498	465	33
2004	553	511	42
2005	650	585	65
2006	786	682	104
2007	1,035	866	169
2008	1,420	1,158	262
2009	1,564	1,251	313
2010	1,814	1,459	355
2011	188	1,446	442
2012	1,894	1,422	572
2013	2,040	1,513	527
2014	2,205	1,611	594
2015	2,219	1,673	546
2016	2,300	1,686	614
2017	2,387	1,729	658
2018	2,601	1,846	755
2019	2,778	1,932	847
2020	2,586	1,738	848
2021	2,650	1,735	914
2022	2,810	1,828	983

Source: own processing based on the data from [5].

Table 3. The evolution of biofuel consumption, worldwide, in the period 2000-2022

Year	Consumption (Mb/d)	Fuel ethanol (Mb/d)	Biomass - based diesel (Mb/d)
2000	300	285	14
2001	283	265	18
2002	336	314	22
2003	387	359	28
2004	484	446	38
2005	565	500	65
2006	764	651	113
2007	984	811	173
2008	1,326	1,092	234
2009	1,555	1,280	274
2010	1,751	1,414	336
2011	1,832	1,394	438
2012	1,831	1,374	457
2013	1,978	1,480	498
2014	2,120	1,563	557
2015	2,217	1,687	530
2016	2,274	1,676	599
2017	2,315	1,685	631
2018	2,502	1,794	708
2019	2,669	1,883	787
2020	2,498	1,677	822
2021	2,660	1,777	883
2022	2,778	1,834	943

Source: own processing based on the data from [6].

Although consumption dipped temporarily in 2020, it quickly recovered and continued to increase starting the following year.

This evolution demonstrates the importance of biofuels in the global energy mix and its contribution to reducing carbon emissions.

These data demonstrate the existence of increased pressure on energy resources, which requires the formulation of sustainable policies, adapted to regional specificities, which balance economic development, concomitant with environmental protection measures.

CONCLUSIONS

In the context of globalization and rising global energy demand, biofuels have emerged as a promising alternative to conventional energy sources. They provide an effective solution for reducing dependence on fossil fuels and lowering greenhouse gas emissions, a core objective in international climate change mitigation efforts. However, their necessity and associated challenges require a detailed analysis of their impact on the economy, environment and society as a whole.

Although they are necessary to reduce the negative impact of fossil fuels on the environment and promote a sustainable economy, the challenges they pose cannot be ignored. Investments in research and development, the adoption of coherent policies and responsible management of resources are essential to maximize the benefits of biofuels and minimize their associated risks in the context of a globalized and interconnected economy.

Maintaining this balance is essential for fully leveraging the potential of biofuels as a clean, renewable energy source, supporting a sustainable future and advancing global climate objectives.

Absolute decoupling through the use of biofuels is not a simple solution, but a complex one, which involves balancing the climate advantages with the impact on natural resources and biodiversity. Only well-designed policies and sustainable agricultural practices can ensure that biofuels support absolute decoupling, playing an important role in reducing fossil fuel dependence and combating climate change.

As developing countries experience growing energy demand, biofuels can serve a pivotal role in providing dependable, clean energy and in mitigating energy poverty.

In conclusion, although biofuels have the potential to support absolute decoupling, reducing dependence on fossil fuels and contributing to lower CO_2 emissions, their production involves challenges, such as competition for agricultural resources and their impact on biodiversity. For biofuels to be a sustainable solution, it is necessary to adopt ecological production practices and integrate them into a wider energy transition strategy, alongside renewable sources.

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THE SUNFLOWER OIL MARKET IN ROMANIA: TRENDS AND PERSPECTIVES FROM THE PROCESSING INDUSTRY

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Abstract

The paper provides an analysis of Romania's sunflower oil market from the perspective of sunflower seed agricultural production and oil processors. Romania is a key player in the European sunflower market, covering approximately 29% of the European Union's production and playing a significant role in seed exports. However, a substantial share of the agricultural output is exported as raw material, leading to considerable economic losses for the national economy. The oil processing sector generates a turnover of approximately €1.7 billion and employs over 2,500 people. The industry is dominated by a few major players, with a high market concentration that limits the entry of new competitors. Reduced processing capacities and a lack of diversification in value-added products are the main challenges facing the sector. To capitalize on the country's agricultural potential, it is essential to expand processing capacities, adopt modern technologies, and promote exports of finished products. Integration into European value chains and effective management of economic and geopolitical risks could enhance competitiveness on the international market. Furthermore, increasing the area of organic cultivation and meeting consumer demand for sustainable products represent crucial opportunities for the sector's growth.

Key words: *Romania, sunflower, oil, market*

INTRODUCTION

Sunflower (*Helianthus annuus*), a plant native to North America from the Asteraceae (Compositae) family, was initially cultivated in Europe as an ornamental plant starting in the 16th century. Later, it became an essential agricultural crop used for oil production. Today, sunflower crops are found on nearly all continents and rank as the second most important technical plant globally for oil production. In the last ten years, the worldwide area dedicated to sunflower cultivation has expanded at an average yearly rate of 2.7% [1].

In Romania, the first sunflower crops were established in the 19th century for ornamental purposes and oil production. The cultivated areas expanded significantly due to the increasing demand for vegetable oil. During the interwar period, Romania emerged as an important sunflower producer in Europe. Under the communist regime, sunflower cultivation was incorporated into national economic development plans, with substantial growth in cultivated areas and output. Agricultural research, primarily conducted at the Fundulea Institute, led to the development of plant varieties adapted to local conditions and the implementation of modern cultivation technologies [1].

Sunflower seeds are highly nutritious, containing 8.6% dietary fiber, 21.0% protein, and 47.5% crude fat. They are also rich in minerals, B vitamins, essential amino acids, and antioxidants, making them a valuable food ingredient. Recent research has highlighted sunflower seeds as one of the most valuable sources of plant-based protein and micronutrients, which may reduce the risk of certain cancers. Additionally, sunflower seeds are well-received by consumers for their sensory qualities and can be processed into various culinary products [22].

Processing sunflower seeds produces sunflower oil, widely consumed globally, and protein-rich meal, effectively used as animal feed. Commercial sunflower oil features a high caloric value (884 kcal/100 mL), low saturated fat content (10%), high unsaturated fat content (90%), and no cholesterol. It also contains vitamins E (41 mg), K (5.4 µg), and B8 (0.2 mg), as well as iron (0.03 mg/100 mL). The high unsaturated fat content, supplying omega-6 fatty acids, is vital for metabolism regulation, LDL cholesterol reduction, and promoting heart, skin, hair, and bone health [11].

The high energy value and digestibility of sunflower oil, comparable to butter, and its longer shelf life make it a staple in human nutrition. Being of plant origin, sunflower oil attracts a wider range of consumers than butter or lard. Within the food industry, it is utilized as a key ingredient in margarine production and various canned products. Additionally, specific types of sunflower oil are well-suited for soap manufacturing. The increasing global demand for sunflower oil further underscores its versatility and significance [7].

The increasing of global demand for sunflower oil and the industrial potential of sunflower seeds have driven an increasing number of Romanian farmers to focus on this crop [19]. A study by Soare and Chiurciu (2023) indicates that enhancing the competitiveness of the domestic sunflower seed production and marketing sector requires expanding cultivated areas, increasing yields per hectare, developing processing and marketing capacities, attracting investments, and accessing European funds for production and industrialization [20].

Research made by Brumă et al. (2021) highlights organic sunflower oil production. Sunflower remains one of the most valuable oilseeds globally, with Romania being a European leader in both production and cultivated area. In organic agriculture, the national sunflower crop area grew by 37.8% between 2017 and 2019, with Tulcea County accounting for approximately 30% of Romania’s total organic sunflower crops, ranking first nationally [4].

Pânzaru et al. (2023) report that, from 2007 to 2019, Romania cultivated an average of 3.81% of the global sunflower area and 5.39% of the European total, amounting to 966,840 hectares. During this period, Romania's sunflower production contributed 4.62% to the global output and 6.79% to the European total. Additionally, the country's exports represented 22.52% of the global sunflower trade volume and 26.97% of the European market.. Despite relatively low imports (3.96% of the global total), Romania does not hold a dominant position in this market. Effectively leveraging its natural potential for sunflower production, increasing oil processing capacity, and exporting finished products could generate significant revenue for Romania, helping to reduce the external trade balance deficit [16].

In this context, the paper analyzed Romania's sunflower oil market from the perspective of sunflower seed agricultural production and oil processors.

MATERIALS AND METHODS

Clarivate, Google Scholar, and ResearchGate databases were utilized for sourcing references. Additionally, the research documentation incorporated articles from specialized journals available in online media. Data obtained from the Ministry of Agriculture and Rural Development, the National Institute of Statistics, and TopFirme.com were analysed. The gathered information was subsequently processed, visually represented, and interpreted. The collected information underwent processing, graphical representation, and interpretation.

To evaluate market concentration, the Gini-Struck Index method was applied. To ensure validity, the findings were cross-referenced with insights from relevant specialized literature.

RESULTS AND DISCUSSIONS

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Sunflower seed production in Romania

Romania benefits from favorable natural conditions for sunflower cultivation, a specialized workforce, and a geographic location that facilitates the export of agricultural products.

Figure 1 illustrates the evolution of agricultural land cultivated with sunflower (thousand hectares) and the corresponding production (thousand tons) from 1990 to 2023.

According to data provided by the National Institute of Statistics (2024), the cultivated area has consistently increased, from approximately 400,000 hectares in 1990 to over 1,200,000 hectares during its peak (around 2017-2018).

Following this period of sustained growth, a relative stabilization of cultivated areas can be observed, with a slight decrease noted after 2020.

The increase in cultivated areas may indicate that local farmers are adapting to trends observed on the domestic or European markets, likely influenced by the rising demand for vegetable oil and other derivative products [17].

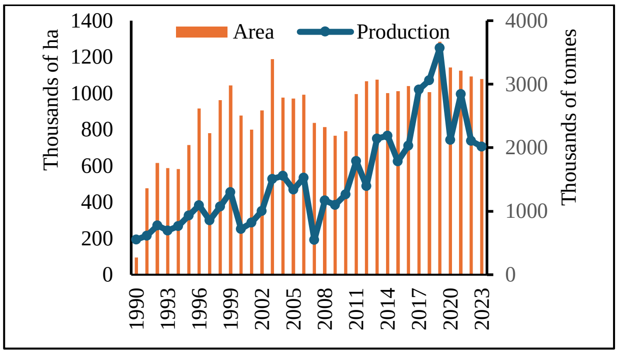

Fig. 1. Area cultivated and sunflower production in Romania, 1990–2023
Source: Authors' design using the data from [13].

The quantity of sunflower harvested from these cultivated areas shows annual fluctuations, influenced by climatic factors, technology, or productivity levels.

Until approximately 2014, the growth in domestic production was based on an extensive cultivation system. After this period, production exhibited significant fluctuations, despite cultivated areas remaining relatively high (Figure 1).

Following a production peak in 2018, output dropped considerably by 2023. This decline can likely be attributed to the effects of drought and climate change (exacerbated by the lack of irrigation systems), as well as other constraints such as reduced yields or logistical challenges.

Unlike other crops, sunflower cultivation in Romania has not been subject to European production quotas.

This lack of restrictions has provided significant opportunities, allowing Romania to become one of the leading sunflower producers in the European Union.

Figure 2 presents the trend in the average purchase price of sunflower seeds (RON/kg) in Romania from 2015 to 2023.

This graph, derived from the latest data provided by the Ministry of Agriculture and Rural Development, highlights price dynamics over the period. Between 2015 and 2020, sunflower seed prices in Romania showed relative stability with minor fluctuations.

However, beginning in 2021, prices experienced an upward trend driven by decreased production levels.

In 2022, prices increased significantly, by over 44% compared to the previous year. Potential factors behind this sharp rise include adverse weather conditions (drought and extreme climate events that impacted production in key producing countries, reducing available market supply), the conflict in Ukraine (Russia's aggression against the neighbouring country disrupted supply chains and sunflower seed exports as Ukraine ranks among the world's leading sunflower producers, the situation was further compounded by increasing production costs associated with the COVID-19 pandemic (higher prices for energy, fuel, and agricultural inputs increased farmers' costs, which were reflected in the final seed price), and increased global demand (the easing of pandemic restrictions led to a rise in demand for vegetable oils, including sunflower oil, further pressuring raw material prices).

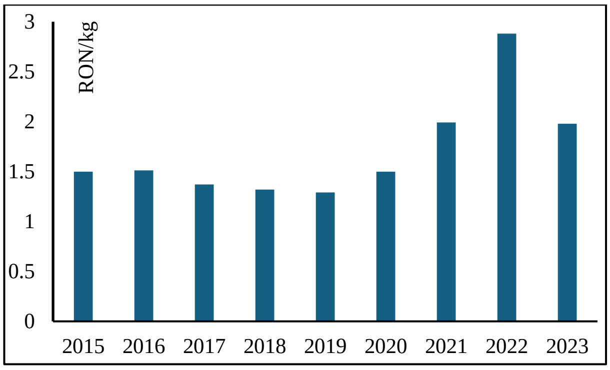

Fig. 2. Sunflower seeds price in Romania
Source: Authors' design using the data from [12].

The combined effect of these factors contributed to the spike in sunflower seed prices in 2022, affecting both producers and consumers [2].

In 2023, prices dropped compared to 2022 but remained higher than pre-pandemic levels. Influencing factors include oversupply and large stockpiles (in 2023, high harvests were recorded in major producing countries, leading to a surplus on the market and lower prices), significant imports from Ukraine until the situation stabilized (the availability of a large volume of lower-priced sunflower seeds from Ukraine directly influenced domestic prices), falling prices for other vegetable oils as alternatives to sunflower oil (soybean and palm oil prices declined globally, negatively affecting sunflower oil and seed prices), and favourable weather conditions contributing to high yields and lower prices. A similar situation was reported in the Republic of Moldova [3].

Against the backdrop of a reduced agricultural harvest caused by severe drought this year, by October 2024, sunflower seed prices reached 2.8 RON/kg (approximately 560 EUR/ton), one of the highest levels in recent years. Local processors bid up to $525/ton for sunflower seeds, with offers in Bulgarian ports reaching around $550/ton. Although by October harvesting was nearly complete in Ukraine, high transaction prices in the neighbouring country ($500-$530/ton) led domestic farmers to hold off selling their crops [10]. Price differences can be attributed to factors such as logistical costs, product quality, and local economic conditions. This increase is further influenced by growing demand on the international market and the tendency of farmers to delay sales in anticipation of further price developments.

Romania remains an important player in the European sunflower market, but price volatility highlights the need for a strategy to manage economic and geopolitical risks to ensure the stability of local producers and competitiveness on the international market.

Sunflower oil market in Romania

The estimated European sunflower oil production for 2024 is 10.9 million tons, representing approximately 20% of global production. The EU is the third-largest global producer, following Russia, with an estimated production of 17.0 million tons (31% of the total), and Ukraine, with 14.7 million tons (27% of global production). Romania, with an estimated production of 3.161 million tons, accounts for about 29% of EU production.

Other positions in the global Top 10 are occupied by Argentina (3.8 million tons), Turkey (1.675 million tons), China (1.6 million tons), Kazakhstan (1.3 million tons), Moldova (0.9 million tons), Serbia (0.75 million tons), and the United States (0.736 million tons) [9].

Between 1991 and 2023, Romania's trade balance in international transactions involving "Animal or vegetable fats" (III.15 according to CN sections and chapters) showed a positive evolution. Currently, Romania records a trade surplus in this category of goods (Figure 3). Until 2006, Romania's imports of edible fats significantly exceeded exports, highlighting a major dependency on external suppliers. Transaction volumes were low, and the trade balance was negative.

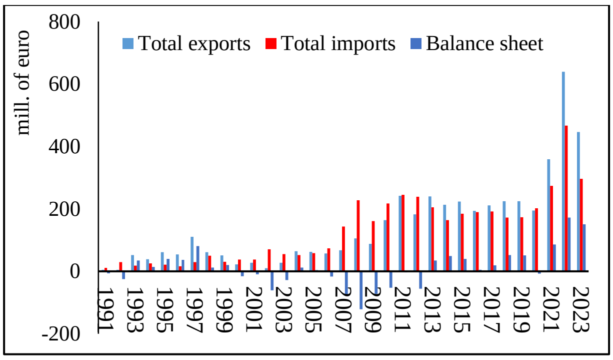

Fig. 3. Total Romanian trade in edible fats CN III.15 (1991-2023)
Source: Authors' design using the data from [14].

After Romania's accession to the EU, external trade transactions increased, although imports remained dominant. Exports began to grow due to increased sunflower seed production and likely efforts to modernize the local industry through foreign capital investments.

Between 2017 and 2023, exports saw a significant rise, peaking in the 2020-2022 period, driven by high demand in external markets and geopolitical context. During this time, the domestic sector became a net exporter, marking a significant improvement in the trade balance. Romania has thus evolved from a net importer to a competitive exporter in the edible fats sector, maintaining a stable trade surplus since 2017. This performance underscores the growing competitiveness of Romania's food fats industry, primarily sunflower oil, in the European market. Most transactions occurred with EU member states, except in 2022, when imports from Ukraine increased significantly due to the war initiated by Russia. More than 50% of Romania's fat exports were directed to EU member states. Figure 4 illustrates the evolution of Romania's trade transactions with the European Union in the edible fats sector, including exports, imports, and the trade balance, over the period 1991-2023.Romania's accession to the EU improved access for domestic products to European markets, positively impacting the trade balance through increased exports. Foreign investments in processing facilities and the growth in domestic production of raw materials supported this upward trend in exports.

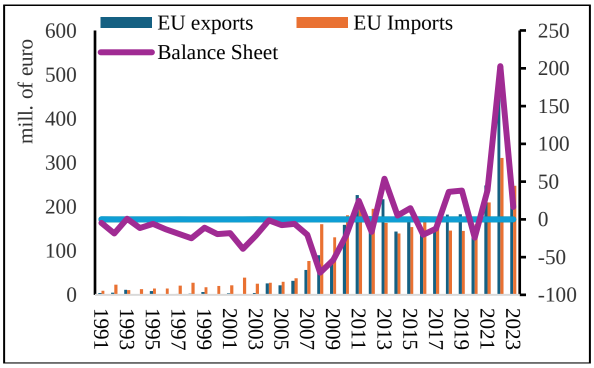

Fig. 4. Romania's Trade with EU in edible fats CN III.15 (1991-2023)
Source: Authors' design using the data from [14].

From a geopolitical perspective, the outbreak of the war in Ukraine created commercial opportunities for local companies, as traditional global trade flows for sunflower and sunflower oil were disrupted.

Figure 5 shows the evolution of sunflower oil production in Romania between 2009 and 2023, expressed in thousands of tons. The data was collected from the consultancy firm ReportLinker Consulting [18]. The domestic production of sunflower oil exhibits a relatively linear growth, with a positive trend throughout the analysed period.

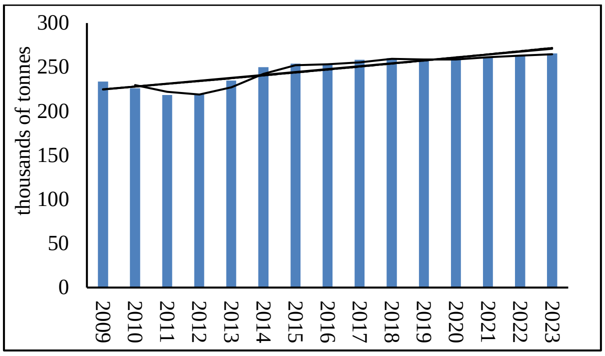

Fig. 5. Sunflower oil production in Romania, 2009-2023
Source: Authors' design using the data from [18].

Romania's domestic sunflower oil production showed gradual growth between 2009 and 2015, driven by improvements in the competitiveness of processing capacities and the availability of raw materials (sunflower seeds). From 2016 onwards, production levels stabilized between 250,000 and 270,000 tons annually. This stabilization can be attributed to factors such as the optimization of existing industrial capacities and consistent demand on both the domestic and European markets.

The stability of Romania's sunflower oil production reflects its strong position in the regional vegetable oil market, particularly amidst growing demand within the European Union. Approximately 30% of the sunflower oil consumed in the EU originates from Romanian factories. Constant production levels suggest a balance between increased cultivation areas and advancements in processing technologies. However, Romania continues to export significant amounts of raw materials, namely sunflower seeds. Between 2016 and 2020, Romania was the EU's largest exporter of sunflower seeds, with around 60% of domestic production allocated for export.

In 2020, Romanian sunflower seed exports totaled 1.544 million tons, valued at €606 million, while domestic consumption was estimated at 750,000 tons [6], [15]. Following the onset of Russia's aggression in Ukraine, Romania became the leading European importer of sunflower seeds from its neighboring country [8]. Figure 6 illustrates the evolution of Romania's sunflower oil market, according to ReportLinker Consulting [18]. Between 2010 and 2014, the sunflower oil market in Romania consistently retained a significant value, estimated at around €400 million per year.

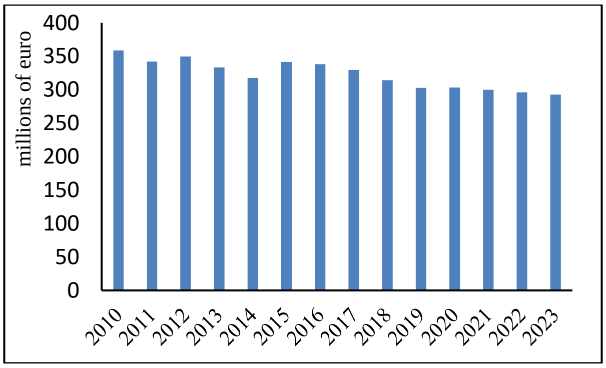

Fig. 6. Sunflower oil market size value in Romania, 2010–2023
Source: Authors' design using the data from [18].

Starting in 2015, the value of Romania's domestic sunflower oil market began to decline, reaching approximately €300 million in 2023. According to the cited report, this reduction may be linked to relatively stable domestic demand combined with increased competitive pressure from other European producers.

Additionally, the volatility of sunflower oil prices on the international market directly impacted the value of the domestic market.

The presented data suggests that Romania's sunflower oil market has reached a state of maturity, characterized by a period of growth until 2014, followed by a gradual decline and stabilization in recent years.

Producers of Oils and Fats in Romania (CAEN Code 1041)

An analysis of processing units operating under CAEN Code 1041 (Manufacture of Oils and Fats), conducted using data from the TopFirme.com platform [21], reveals several noteworthy insights. This sector includes 138 active companies, representing approximately 0.01% of all economic operators in the country. The cumulative turnover of these operators reaches 7.4 billion RON (approximately 1.7 billion EUR), equivalent to 0.30% of the national turnover. The sector employs 2,615 people, representing 0.06% of Romania's total workforce. The net profit reported by companies in this domain amounts to 76.4 million RON (around 17.4 million EUR), which is 0.02% of the total national net profit. The leading market players are: BUNGE ROMANIA SRL, Buzău (turnover of 3.1 billion RON/705.1 million EUR, 570 employees), EXPUR SA, Slobozia, Ialomița (turnover of 1.8 billion RON/417.8 million EUR, 462 employees), PRUTUL SA, Galați (turnover of 1 billion RON/235.8 million EUR, 488 employees).

The next four companies are significantly smaller, with turnovers between 100 and 400 million RON: Global Grain International SA, Bucharest (439.6 million RON), Ardealul SA, Satu Mare (427.8 million RON), Argus Constanța SA (246.6 million RON), Sarapac Impex SRL, Slobozia (105.8 million RON).

The distribution of key companies in the sector across counties is shown in Figure 7. Ten counties account for 72 companies, representing approximately 52% of the total firms in the sector.

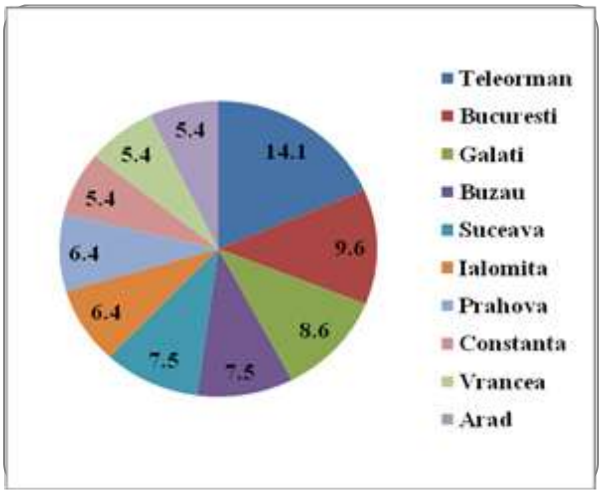

Fig. 7. Sunflower oil market size value in Romania, 2010–2023 (%)
Source: Authors' design using the data from [18].

This geographic distribution, concentrated in a few counties, likely reflects favorable economic and logistical factors in these regions. The most important agricultural areas for sunflower cultivation are located in the south (Teleorman, Ialomița, Buzău, Călărași, and Giurgiu), southeast (Brăila, Galați, Tulcea, and Constanța), and east (Vaslui and Iași). In counties with extensive sunflower cultivation, the main production units (Bunge, Expur, Prutul) are situated, suggesting a correlation between the availability of raw materials and the location of processors. The presence of well-developed logistical structures further supports the localization of processors in these regions, aiming to minimize logistical costs and optimize access to raw materials.

The top three companies generate 79.73% of the sector's turnover and employ 58.13% of the total workforce in the industry. To assess market concentration among oil and fat producers (CAEN 1041), the Gini-Struck Index is a suitable tool. This indicator evaluates economic concentration by analysing the share of total market turnover attributed to each company. The authors have previously utilized this method in other specialized studies [22]. The calculated Gini-Struck Index (GSI) for Romania’s oils and fats production market is 0.50, indicating a high level of market concentration. This value reflects the fact that the majority of the market's turnover is generated by a small number of companies, particularly the top three firms (BUNGE, EXPUR, and PRUTUL).

The high degree of market concentration can have significant implications for competitiveness and create barriers to entry for new players in the industry.

CONCLUSIONS

Romania possesses significant agricultural potential in sunflower production, being the leader in the European Union in terms of cultivated area and output.

However, the sector's performance is constrained by the predominant export of raw materials, resulting in substantial economic losses.

The fluctuations in Romania's sunflower production, even amidst an increase in cultivated areas, indicate variability in agricultural yields influenced by factors such as weather conditions, agricultural technology, and soil fertilization. The decline in sunflower production after 2028 is likely linked to adverse climatic conditions, with the period marked by frequent droughts in Romania. The absence of a national irrigation system has exacerbated the effects of insufficient rainfall.

The development of the local processing industry is crucial to fully capitalize on domestic production potential. Currently, the sunflower oil processing market in Romania is dominated by a few major players, reflecting a high degree of market concentration that limits the entry of new competitors.

Expanding processing capacities, promoting value-added products, and diversifying the product portfolio are essential strategies to reduce the trade deficit and enhance competitiveness.

Adopting modern technologies, expanding organic farming, and aligning with global sustainability trends are necessary steps to meet international market demands and strengthen Romania's position in the global vegetable oil market.

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THE SUGAR MARKET IN ROMANIA: ANALYSIS AND PERSPECTIVES

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Abstract

The paper analyzes the sugar market in Romania, focusing on production, trade, and consumption trends from 1990 to 2023. The study highlights the significant decline in domestic sugar beet production, which has led to increased dependency on imports, primarily from the European Union. Despite Romania's favorable conditions for sugar beet cultivation, internal production meets only 10% of national demand. The findings underscore the challenges faced by local producers, including high production costs and limited processing capacity. The paper also examines market concentration, revealing an oligopolistic structure dominated by a few key players. Recommendations include enhancing local production capacities, promoting modern technologies, and supporting consumer education to balance market dependency on imports.

Key words: *sugar beet production, sugar market, imports, trade deficit, local producers, oligopoly, Romania*

INTRODUCTION

Sugar production, trade, and consumption are crucial to both the national and global economies. Governments have implemented several measures to reduce sugar consumption, yet public demand has remained relatively constant over the past 30 years. The introduction of a sugar tax in Romania in 2023 aimed to improve public health while generating additional state revenue. Changes in consumer preferences and public authority initiatives may influence demand for sugar and sugar-rich foods, with a trend toward replacing sugar with healthier alternatives [16].

Sugar production in Romania has undergone significant transformations in recent decades, influenced by economic factors, post-accession EU regulations, and strong pressure from importers. During the communist regime, Romania produced enough sugar to meet domestic demand and had surplus for export. After joining the European Union (EU), local factories faced financial difficulties due to a lack of competitiveness within the common economic market, rising manufacturing costs, and reduced domestic sugar beet production. Romania's sugar beet production sharply declined between 1990 and 2023, leading to increased dependency on sugar imports and minimal domestic production capacities, with internal prices now largely controlled by importers [14].

As an EU Member State, Romania had to adopt the Common Agricultural Policy (CAP) for sugar production, adhering to strict rules and production quotas designed to stabilize the EU internal market [8]. Initially, the allocated quotas offered relative protection to Romanian producers, but high production costs compared to other European producers reduced their market presence. Globally, around 50% of total sugar beet production comes from the EU. The EU's global leadership is supported by large sugar beet yields, traditionally cultivated in northern France, Germany, the Netherlands, Belgium, and Poland. European producers also supply significant quantities of sugar refined from imported raw cane sugar [9]. Currently, the European sugar market is dominated by France and Germany. Romania imports significant amounts of sugar from Germany, whose production is primarily oriented toward the EU market. Among European consumers of German sugar, Romania ranks second after Italy. In the broader European context, Romania is mid-ranked, with leading positions held by countries hosting major chocolate producers. For the 2023/2024 production season, with two active sugar refineries, Romania ranked 12th in Europe, after Italy (two refineries) and Hungary (one refinery). In comparison, Poland, with 17 refineries, ranked fourth, while Germany led the rankings [4].

The abolition of EU sugar production quotas in 2017 resulted in increased sugar price volatility. Romanian producers were strongly affected by competition with more efficient and modern European companies with longstanding traditions in sugar production. Local Romanian producers, characterized by high production costs and outdated infrastructure, could not withstand the competition, leading to the closure of most domestic production units and a significant reduction in national sugar processing capacity. The case of the Luduș Sugar Factory, acquired by the French group Tereos and put up for sale in 2022 due to market profitability challenges, serves as an example. The Romanian government expressed intentions to intervene to avoid total dependence on imports [10], but the factory was eventually acquired by Romanian investors, who also own the Bod Sugar Factory [6].

Currently, only about 10% of Romania's domestic sugar consumption is covered by local production, leaving the internal market highly dependent on imports. Domestic sugar consumption is estimated at approximately 400,000 tons, with a significant portion used in food industry sectors where sugar is a key ingredient. Romania's sugar imports amounted to approximately 360 million euros last year, double the amount in 2019. Amid the war in Ukraine, sugar exports from the neighboring country to the EU reached 237,733 tons between October 2023 and February 2024, a 21.7% increase compared to the same period the previous year. About 20% of these imports were sold in Romania, with non-quota imports and lower prices posing significant competition to domestic production [7].

The decline in domestic sugar beet production is unjustified, given Romania’s agricultural tradition, favorable natural conditions, particularly in the northern region and the Transylvanian Plateau, and the potential income for farmers. By employing modern agricultural technologies, sugar beet cultivation could become a significant source of revenue for farmers [15].

These aspects highlight the importance of a detailed analysis of Romania’s sugar sector to understand current challenges and anticipate possible future developments.

In this context, the paper analyzes the sugar market in Romania, focusing on production, trade, and consumption trends from 1990 to 2023.

MATERIALS AND METHODS

Open-access sources from Clarivate, Google Scholar, and Research Gate databases were utilized for references.

The documentation was completed with articles published online.

Official information presented by the Ministry of Agriculture and Rural Development, National Institute of Statistics, TopFirme.com were used for research.

The data have been processed and graphically presented and then interpreted.

Fior validation, teh results have been compared with other relevant information from the literature.

RESULTS AND DISCUSSIONS

Domestic Sugar Beet Production

During the communist era, domestic sugar beet production held a significant share of agricultural output. Romania was a major regional producer of sugar beet, supported by an extensive network of processing factories. Cultivated areas frequently exceeded 100,000 hectares, with sugar beet production meeting

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both domestic demand and export needs. After Romania's accession to the European Union (2007), following the liberalization of the EU sugar market and the elimination of production quotas (2017), Romanian producers faced direct competition with Western European countries [2]. By 2023, cultivated areas had dropped below 10,000 hectares, with total sugar beet production falling to under 200,000 tons, far below domestic demand (Fig. 1). Transition to a market economy affected the agricultural sector and also the sugar industry who experienced a significant decline due to the privatization of agricultural land and the lack of investments.

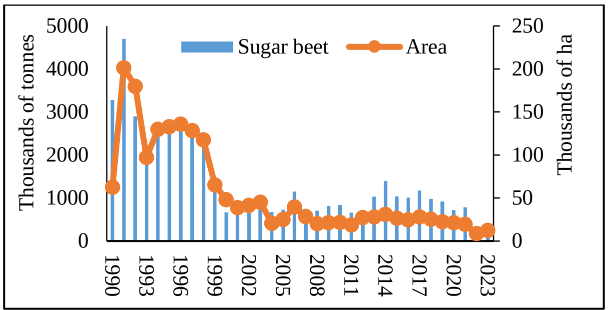

Fig. 1. Area Cultivated and Sugar Beet Production in Romania, 1990–2023
Source: Authors' design using the data from [13].

In 1990, Romania produced approximately 1.4 million tons of sugar beet. The historical peak of sugar beet production and yields was recorded in 1991, following a positive trend driven by centralized agricultural policies. However, the cultivated area and production saw steep declines during the 1990–2000 period.

After this consistent decrease, the 2000–2010 period marked a stabilization of cultivated areas and production, albeit at much lower levels compared to 1990, as the sugar beet sector adapted to new economic and market realities. The sector has faced sharp decline in recent decades due to factors such as the liberalization of the EU sugar market, decreased processing capacity, and the reduction of cultivated areas.

Since 2010, there have been slight variations in cultivated areas and production, likely influenced by weather conditions, global developments in the sugar market, and the EU Common Agricultural Policy (CAP), which Romania adopted upon joining the EU in 2007. The reduction in sugar beet production and national sugar output can be correlated with the decreasing amount of land allocated to this crop.

The price of sugar beet has remained low at processors, driven by the presence of only one processing plant in Romania, owned by the Austrian company Agrana (Fig. 2). By 2022, the price of sugar beet remained relatively stable, with low values ranging between 200-300 lei/ton (approximately 40-60 euros/ton). In 2023, a dramatic increase was observed, exceeding 1,000 lei/ton (equivalent to approximately 200 euros/ton), driven by rising demand and the opening of a second processing unit in Luduş.

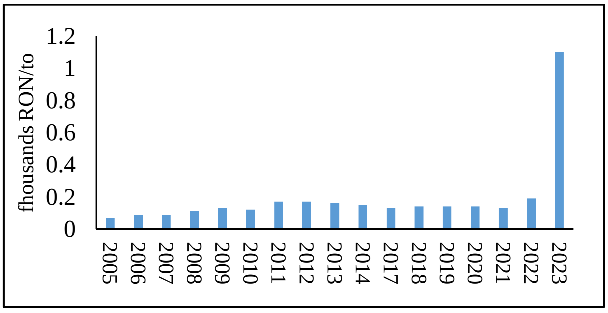

Fig. 2. Sugar beet price in Romania
Source: Authors's design using the data from [11].

In 2017, four sugar beet producer groups were recognized by the Ministry of Agriculture and Rural Development (MADR) under specific legislation. However, by 2023, only two associations remained active in the market [11].

Romania’s Sugar Trade

To meet consumption needs, Romania imports significant amounts of sugar derived from beet or cane, primarily from the EU market (Germany) and, more recently, from Ukraine. The data presented in Figure 3 illustrates Romania's international trade in cane or beet sugar and pure sucrose between 2004 and 2022, including imports, exports, and trade balance expressed in thousand tons. Sugar imports far exceed exports, highlighting a high dependency of the domestic market on trade with other countries.

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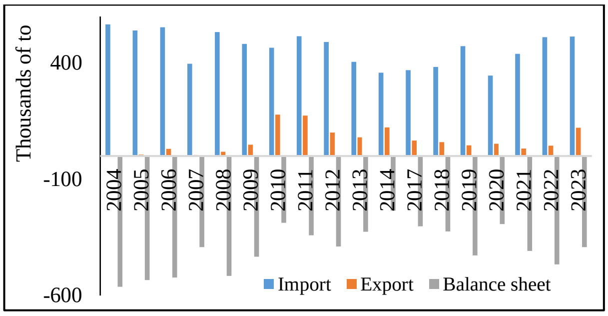

Fig. 3. Romanian intra and extra cane or beet sugar and pure sucrose trade
Source: Authors' design using the data from [11].

The volume of sugar imported has remained relatively constant, ranging between 400,000 and 600,000 tons annually. Exports have varied between 50,000 and 100,000 tons per year, reflecting Romania's low production capacity for exports. The trade balance has been negative throughout the period, with significant trade deficits reaching up to 800,000–900,000 tons annually. Despite minor variations, the ratio between imports, exports, and the trade deficit has remained consistent, indicating a lack of significant changes in domestic production or consumption. Figure 4 illustrates the value of Romania's international sugar trade between 2004 and 2023, expressed in millions of euros, including imports, exports, and the trade balance.

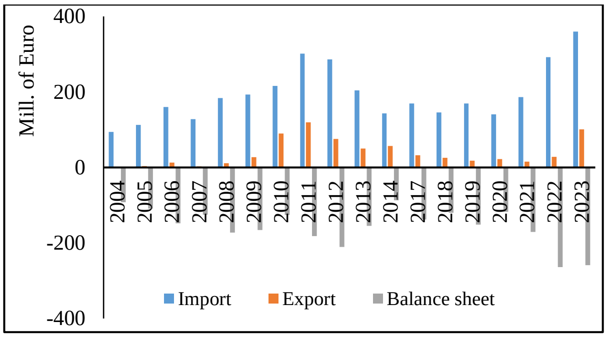

Fig. 4. Romania's Sugar Trade Balance, 2004-2023
Source: Authors' design using the data from [11].

Sugar imports in Romania have remained relatively constant, with values significantly higher than exports throughout the analyzed period. After 2020, the value of imports increased substantially, surpassing 300 million euros in 2023 due to rising international prices. Romanian sugar exports have remained modest compared to imports, varying between 20 and 80 million euros annually, reflecting limited export availability. Over the analyzed period, the trade balance has been consistently negative, with the deficit worsening in recent years, exceeding 200 million euros in 2023.

Romania is a net sugar importer, with a growing trade deficit. This situation highlights a significant challenge for the local sugar production sector, necessitating measures to reduce dependency on imports, either by increasing domestic production or through policies supporting exports.

Market Analysis from the Perspective of Economic Operators

Based on data from the TopFirme platform for CAEN code 1081 – "Sugar Manufacturing" – several observations can be made about Romania's sugar market [18].

According to the cited source, there are 13 active economic operators in the sugar manufacturing sector in Romania. Considering that approximately 1 million companies are registered on the platform, sugar industry operators represent 0.0013% of the total number of economic operators nationwide.

In 2023, the sugar industry employed a total of 555 people, accounting for 0.01% of the national workforce. The combined turnover of these companies amounts to 1.3 billion lei (approximately 298.5 million euros), constituting 0.05% of Romania's total turnover.

The net profit achieved by these firms is 97.8 million lei (around 22.2 million euros), representing 0.02% of the total national net profit. Key players in the market include:

AGRANA ROMANIA S.R.L., headquartered in Bucharest, with a turnover of 1.2 billion lei (279.3 million euros) and 366 employees in 2023. AGRANA is an international industrial company headquartered in Vienna, Austria, specializing in the production of sugar, starch, and fruit preparations. Founded in 1988, AGRANA has evolved from a holding company for the Austrian sugar and starch industries into a global player with approximately 50 production facilities in countries such as Austria, Germany, Romania, Hungary, Poland, Ukraine, France, Morocco, South Africa, China, South Korea, Argentina, Brazil, Mexico, Australia, and the United States. AGRANA produces sugar from beet and cane, serving both the food industry and final consumers.

AGRANA began operations in Romania in 1998 by acquiring several sugar and starch factories. Currently, the company operates sugar factories in Roman (producing sugar from sugar beet and serving as a key partner for local sugar beet growers), Buzău (operating exclusively as a raw sugar refinery), and a starch factory in Țăndărei (producing native and modified starch, glucose, and maltose syrups, with a processing capacity of approximately 100 tons of corn per day). In 2023, AGRANA Romania recorded a record turnover of 1.23 billion lei (approximately 247 million euros), 46% higher than in 2022. However, the company reported losses of 9.3 million lei (approximately 2 million euros), mainly due to supply chain disruptions and significant economic impacts. In July 2024, AGRANA announced the indefinite suspension of the sugar refining line at its Buzău factory due to supply chain challenges [3]. Other operations, such as packaging, storage, and logistics, continue at both the Buzău and Roman sites [12].

Sugar Plant Premium Luduș S.A., . (Fabrica de Zahăr Premium Luduș S.A.), located in Luduș, Mureș County, has a long history of sugar production from sugar beet, established in the 1960s. The factory operated continuously until 2021, when it was on the verge of closure.

As of now, based on platform data, the company has a turnover of 47.4 million lei (10.8 million euros) and 114 employees. After being acquired by Romanian investors, the factory resumed operations, increasing production in 2023 to 24,000 tons of sugar, processing sugar beet from approximately 3,500 hectares [17]. For 2024, the company announced production of around 65,000 tons of sugar, with contracted production from 8,800 hectares and agreements with over 500 farmers in Transylvania. The company markets the Bod brand of sugar, 100% Romanian. Future plans include investments of approximately 128.8 million lei over the next three years, aiming to increase the sugar beet cutting capacity from 3,200 tons per day to 4,000 tons per day and introducing new packaging lines and products such as vanilla sugar and sugar sachets. These investments benefit from state aid of 62.5 million lei through the Investalim Program.

EUROPLANT INTERNATIONAL S.R.L., based in Jilava, Ilfov County, specializes in producing fruit syrups based on sugar. In 2023, the company had a turnover of 21 million lei (4.8 million euros) and 29 employees.

Other companies specializing in sugar beet processing have ceased operations [5]. For example, Antrepriza Zahăr Bod, located in Brașov County, faced financial and operational difficulties in recent years, leading to the suspension of activities. Similarly, Tereos Romania, based in Luduș, Mureș County, saw its factory closed in 2021 by its French parent company, Tereos, citing economic and market challenges. The factory was later acquired by Romanian investors.

Geographic distribution: The three main producers are distributed as follows: Bucharest (the leading economic operator in sugar manufacturing, with a turnover of 1.2 billion lei and 366 employees), Mureș County (one economic operator with a turnover of 47.4 million lei and 114 employees), Ilfov County (one economic operator with a turnover of 21 million lei and 29 employees).

From this perspective, the sugar manufacturing market in Romania is concentrated, with a small number of active companies. AGRANA ROMANIA S.R.L. [1] dominates the market, holding a significant share in turnover and employment. The geographic distribution indicates notable activity in Bucharest and the counties of Mureș and Ilfov. The sector’s contribution to the national economy, in terms of turnover and profit, is modest. The Romanian sugar market is not a monopoly but exhibits oligopolistic characteristics, being dominated by two major players, AGRANA Romania and Fabrica de Zahăr Premium Luduș, which control a large part of production and distribution. However, the market is not exclusive, as competition comes from substantial sugar imports, which constitute a significant proportion of domestic consumption. Imports mainly originate from the European Union, where sugar is produced at lower costs due to subsidies. The current oligopoly is characterized by a small number of large factories and a relatively high volume of imports, balancing local production and international supply.

CONCLUSIONS

Sugar beet production and processing in Romania have undergone significant transformations, transitioning from a well-represented industry to a limited one dominated by imports.

While the sugar market is not a monopoly, the high dependency on imports underscores the vulnerability of the domestic sector. In this context, measures are necessary to reduce the trade deficit and stimulate domestic production.

The adoption of modern technologies could significantly improve productivity and reduce costs, giving Romanian farmers a chance to become more competitive. Additionally, product diversification, including the development of premium or organic lines, could represent an opportunity for both the domestic and export markets. Consumer education plays an essential role, and awareness campaigns highlighting the benefits of consuming local products could increase demand for Romanian-produced sugar.

Furthermore, government support, through direct subsidies, investments in infrastructure modernization, and facilitating market access, is critical for revitalizing the sector. Another recommendation involves strengthening agricultural cooperatives in the sugar beet production sector, which could enhance the bargaining power of small producers and facilitate their access to processing and distribution networks.

Integrating these measures into a national strategy could contribute to the sustainable growth of Romania's sugar sector and reduce its reliance on imports.

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EFFECT OF USAID MARKET II PROGRAMME ON THE FOOD SECURITY STATUS OF BENEFICIARY FARMERS IN AKWA IBOM STATE SOUTH-SOUTH, NIGERIA

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Abstract

Over the years, various agricultural programmes and policies that are both public and private sector driven has been developed, focusing more on increasing farm production with little or no emphasis on the food security status of farmers. The study determined the effect of USAID/MARKETS II Programme on the food security status of farmers in Akwa Ibom State, south-south Nigeria and was analyzed 2020. Specifically the determined the food security status, index and compared the differences in the food security status of programme beneficiary and non-beneficiary farmers. It adopted both purposive and multi-stage random sampling procedures to select one hundred and eighty (180) respondents made up of 90 programme beneficiary and 90 non-beneficiary farmers). The study made use of structured questionnaire to collect data and were subjected to analysis using food security index and Z-test analyses).Food security status result showed that the mean per capita household expenditure per month for programme beneficiary farmers was ₦21,120.46(69.02USD)as against the non-programme beneficiary farmers with ₦5,474.41(17.89 USD). More so, the food security index, showed that a moderate proportion of programme beneficiary farmers were food secured (43.33%) than non-programme beneficiary farmers (33.33%).The study concluded that the programme has impacted on the beneficiary farmers by increasing their food security status. Policies aimed at replicating the programme in other rural communities and encouraging farmers to engage in foreign sponsored programmes is thereby advocated in order to guarantee household food security.

Key words: *effect, USAID MARKET II, programme, food security, beneficiary, farmers*

INTRODUCTION

The Federal Government of Nigeria has undertaken series of measures and policies over the years to use agriculture as a strategy to alleviate poverty and attain food security among rural households. Food security is an essential determinant for any population to be healthy and well -nourished [8]. In Nigeria, more than 82.9 million of its population lived below poverty line of ₦137,430 per year, whereas 40.1 per cent of the country's populations live in abject poverty as affirmed by National Bureau of Statistics, (NBS) [10], [1]. Food security is said to manifest when people always have both physical and economic access to sufficient, safe and nutritious food to meet their dietary needs for a healthy life [7], [4]. It also referred to as the availability and affordability of food which is an indication of effective agricultural development policy in most developing countries. Though Nigeria claims to be the largest economy in Africa, the food insecurity rate in the country is worrisome, as not less than 70% of the populations are food insecure surviving on less than a dollar per day [18].

The World Bank, International Fund for Agricultural Development (IFAD), United States Agency for International Development (USAID), International Institute of Tropical Agriculture (IITA), National FADAMA Development Project (NFDP) and among others are foreign agencies and international organizations are development collaborators with the Federal and State governments of Nigeria with the mandate to ensuring rural households were food secure through their promoted programmes. This intervention resulted to engagement of stakeholders in their projects targeted towards having significant impact on the food security and livelihoods of the country's population [13][12]. [6] reported that household food security is comprehensive as it integrates food stability, access and availability of adequate food for the populace to utilize judiciously. Studies has shown that most of the World food insecure countries are in Africa which is characterized by the prevalence of poverty, hunger, malnutrition, famine and high population growth rate [19], [9].

In order to ameliorate food insecurity among rural households in Nigeria, The Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites (MARKETS II) USAID/Nigeria's flagship project under their Feed the Future (FTF) Agricultural Transformation Program (ATP) was introduced to enhance the performance, incomes, nutrition and food security of poor rural farmers or smallholders in an environmentally appropriate manner through proven private sector demand-driven market interventions and programme support services; This initiative has helped about 3.6 million beneficiary farmers to gain access to new technologies of which Akwa Ibom State benefited [18].

In view of the above assertion, it is not certain whether the programme has increased the food security of its beneficiaries. It is against this backdrop that this study was undertaken to determine the food security status of beneficiary and non-beneficiary farmers of the programme in Akwa Ibom State, south-south Nigeria.

Specifically this research:

(i) analyzed the food security statues of programme beneficiary and non- beneficiary farmers

(ii) ascertained the food security index of programme beneficiary and non-beneficiary farmers; and

(iii) compared the differences between the food security statuses of programme beneficiary and non-beneficiary farmers in the study area.

MATERIALS AND METHODS

Area of Study

The area of study is Akwa-Ibom State, Nigeria south-south Nigeria. The State lies between Latitude $4^0$33N', $5^0$35N' of the Equator and Longitude $7^0$35E', $8^0$25E' of the Greenwich Meridian. It shares border on the east by Cross Rivers State, the west by Rivers State as against Abia State, and the south by the Atlantic Ocean. Akwa Ibom State occupies a total landmass of 7,246 square kilometers, and is blessed with natural resources abound in agriculture, forestry, solid minerals, crude oil and gas. It has a population of 5,482,200 people and 3.5% annual population growth rate of 191,877 people [11]. The climate is tropical rain forest marked by two distinct seasons, the dry (November, April) and the wet (May–October) seasons. It has an average annual rainfall of 2,500mm-3,000mmm and temperature of between 20^0C to 30^0C with mean Relative Humidity of 80.0%. The soil found in the area is generally fertile sandy loam which favours the cultivation of many arable and cash crops such as maize, cassava, oil palm, rubber and cocoa [2].

Sample Size and Data Analysis

The study adopted purposive and multistage random sampling procedures. Purposively, one Local Government Area/programme area each were randomly selected from the agricultural zones of the State namely; Uyo, Eket, Oron, Ikot Ekpene, Etinan and Abak, because the intensity of their engagement in the programme activities. Randomly, multistage sampling procedure was used to select two (2) communities each from the six (6) Local Government Areas; **Uyo**, Effat Offot and Aka Offot were selected; **Eket**–Afaha Eketand Okon Eket; **Oron** – Eyo Abasi District and Uya Oro District; **Ikot Ekpene** – Ikot Abia Idem and –Ikot Osura; **Etinan** – Ekpene Obom and Ikot Ekan and **Abak**–Utu Edem Urua and Oku Abak, which gave a total of twelve (12) participating communities. In the second stage two (2) farmer groups were randomly selected to give a total of twenty four (24) farmer groups. In the third stage, four (4) beneficiary farmers of the programme each were randomly selected to which gave a sample size of ninety six (96) programme beneficiary farmers.

The non-programme beneficiary farmers were also selected from the areas where the participating farmers were selected and this gave a grand sample size of one and ninety two (192) farmers (96 for programme beneficiary and 96 for non-beneficiary farmers). A total of 192 questionnaires were administered but 180 were returned, making the grand sample size of 180 (90 programme beneficiary farmers and 90 non-programme beneficiary farmers) that was finally used for the study.

Map 1. Map Showing the Local Government Areas of Akwa-Ibom State, Nigeria
Source. Google (2020). Akwa Ibom State, Nigeria [Google Maps}. www.akwaibomstate.org,ng [20].

Measurement of Variable

The food security index model was used to determine the food security status of programme beneficiary and non-programme beneficiary farmers.The food security index was employed to classify the households that were food secure and food insecure which is expressed thus:

$$Fi = \frac{per\ capital\ food\ expenditure\ for\ ith\ household}{\frac{2}{3} mean\ per\ capital\ food\ expenditure\ of\ all\ households} \quad \text{.............................. ....(1)}$$

As implied, Fi = Food security index.
If Fi > 1= Food secure i^{th} household
if< 1= Food insecure i^{th} household.

The model infers that households whose per capita monthly food expenditure are above or is equal to two thirds of the mean per capita are food secure and otherwise, food insecure. The headcount ratio (H) of food security was calculated based on the percentage of the population of households that are food secure/insecure. The headcount index formula is given by:

Headcount index (H) = M/N ....(2)

where:
M = number of food secure/insecure households
N = the number of households in the sample

Model Specification

The Z-test analysis was adopted to compare the mean differences between food security status of programme beneficiary and non-beneficiary farmers

The model is specified thus:

$$Z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$n_1 + n_2$ - 2 degrees of freedom

Where,
Z = Z Statistic
$\bar{X}_1$ = sample mean of programme beneficiary farmers' food security status
$\bar{X}_2$ = sample mean of non-programme beneficiary farmers' food security status
$\sigma^2{}_1$ = non-programme beneficiary farmers' standard deviation
$\sigma^2{}_2$ = non-programme beneficiary farmers' standard deviation
n_1 = programme beneficiary farmers' sample size
n_2 = non – programme beneficiary farmers' sample size

RESULTS AND DISCUSSIONS

Food Security Status of Programme Beneficiary and Non- Beneficiary Farmers

The result showed the food security status of programme of both farmer groups (Table 1).

The result indicates that the mean income for programme beneficiary farmers was ₦233,855.60 (764.23 USD), non-programme beneficiary farmers (₦192,986.70 630.67USD), expenditure ₦193,555.60(632.53USD) (programme beneficiary farmers) and ₦38,923.33 (127.20USD) (non-programme beneficiary) with household sizes of 6.54 and 5.87 persons for programme beneficiary and non-programme beneficiary farmers respectively. Using two-third of the mean per capita household expenditure following [17], the study estimated ₦21,120.46(69.02USD)and ₦5,474.41 (17.89USD) as a food security line (bench mark) for programme beneficiary and non-beneficiary farmers respectively.

The study revealed that a good proportion (56.67%) and most (66.67%) of the programme beneficiary and non-beneficiary farmers as food insecure respectively while a moderate (43.33%) of beneficiary and 33.33% of non-beneficiary farmers were food secure. The result implied that the mean per capita household expenditure per month for programme beneficiary farmers was ₦21,120.46, (69.02 USD) which was higher than the non-beneficiary farmers (₦5,474.41(17.89USD) amounting to an equivalent of₦704.02 (2.30USD) and ₦182.48,(60 cents) daily expenditure respectively.

The result is corroborates with the previous studies of [5], as they observed ₦7,967.57 (26.03USD) as monthly mean capita expenditure which translate to ₦265.57 (87 cents) per day while [16], [17] estimated ₦75.71, (25 cents) as daily mean capita expenditure for rural households in Ogun State, Nigeria.

Table 1. Frequency distribution of food security statues of programme beneficiary and non-beneficiary farmers

Farmers	Beneficiary farmers			Non-beneficiary farmers		
Variables	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
Income	233,855.60	77,000	400,000	192,986.70	39,000	850,000
Expenditure	193,555.60	70,000	350,000	38,923.33	10,000	170,000
Household size	6.5	3	10	5.8	1	13
Food security	21,120.46	6,533	46,66.67	5,474.41	666.67	33,333.33

Source: Author's estimated based on Field Survey, 2020.
Note 1. United States Dollar exchanged for 306 Nigerian Naira (NGN) during the research.

Food Security Index of Programme Beneficiary and Non- Beneficiary Farmers

The result of food security index of beneficiary and non-beneficiary is shown in Table 2. There was a lower percentage of food secured farmers for both farmers in the study area as compared to greater percentage of those that were food insecure. There was more percentage of food secure farmers for programme beneficiaries than that of the non-programme farmers. This is an indication of effect of USAID programme in improving the livelihood of the farmers particularly on increased expenditure. This result further portrays that the USAID farmers were moderately food insecure since the number of food insecure (56.67%) were slightly greater than food secure (43.33%) compared to non-programme beneficiary farmers that were likely food insecure (66.67%) with greater percentage than food secure (33.33%). This finding is consistent with that of [14], [15] as they reported that two third of farming rural households in Nigeria were not food secure.

Table 2. Frequency distribution of food security index of programme beneficiary and non-beneficiary farmers

	Beneficiary Farmers		Non- beneficiary farmers	
Food security index	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Food secure	51	56.67	60	66.67
Food insecure	39	43.33	30	33.33

Source: Field Survey Data, 2020.

Comparison between Food Security Statues of Progarmme Beneficiary and Non-Beneficiary Farmers

The result of comparison of the differences between food security index for programme beneficiary and non-beneficiary farmers is presented in Table 3. The result revealed that mean food security index for both farmer groups were 21,120.46 (programme beneficiary farmers)and 5,474.441 (non-beneficiary farmers). The difference in mean between the two groups of farmers was 15,646.02 with a standard deviation of 13,665.68. The result shows that the calculated “Z” was 16.42, which is higher than the tabulated “Z” of 2.58 was highly significant at 1.0% level of probability.

Table 3. Z-test comparison of the differences between food security statues of beneficiary and non- beneficiary farmers in the study area

Variables	Mean	Standard Deviation	F-calculated	F-tabulated
Beneficiary farmers	21,120.46	7,474.4920		
Non-beneficiary farmers	5474.441	5083.9030		
Combined	13297.45	10107.93		
Difference	15,646.02	13,765.68	16.42***	2.58

Source: Field survey, 2020
***p≤ 0.01
Note: 1. United States Dollar exchanged for 306 Nigerian Naira (NGN) during the research.

This finding is in consonance with the findings of [10], [3] as they found that there was an increased availability and access to food in rural areas of Nigeria which was as a result of the intervention of rural development programme.

CONCLUSIONS

The study concluded that the programme has effect on the food security status beneficiary farmers. It is therefore recommended that the programme should be replicated in other rural communities and policies aimed at encouraging farmers to engage in foreign and donor sponsored programmes is advocated for increased household food security.

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A PROPOSED AGRICULTURAL EXTENSION MODEL FOR ROMANIA: LEVERAGING UNIVERSITIES' RESOURCES TO CREATE A COST-EFFICIENT AND IMPACTFUL KNOWLEDGE TRANSFER SYSTEM INSPIRED BY THE U.S. MODEL

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Abstract

This study proposes an university-based agricultural extension model, inspired by the U.S. agricultural extension system, to address systemic challenges in Romania's agriculture. By integrating research, education, and community engagement, the model aims to bridge the gap between academia and rural communities while promoting sustainable rural development. The model was developed through the Fulbright-RAF Scholar Award program, where Romanian scholars collaborated with U.S. extension experts at the University of Georgia. Romanian scholars acquired valuable expertise through field visits, stakeholder engagement, and institutional analysis, which formed the foundation for adapting the U.S. system to Romania's unique agricultural context. The model proposes the establishment of extension hubs within Romanian agronomic universities, leveraging existing resources and involving students at all academic levels in extension activities. Key initiatives include tailored advisory services, a centralized knowledge platform, and community engagement programs such as workshops, online resources, and farmer interactions on social media groups. The proposed model fosters innovation and ecological practices by aligning academic activities with regional needs and ensuring effective knowledge transfer.
This phased, cost-effective system empowers farmers to overcome systemic challenges, strengthens rural communities, and positions universities as leaders in agricultural modernization and rural development. Through the integrating collaboration and optimizing resources, the model provides a transformative framework for a sustainable agricultural future in Romania.

Key words: *agricultural extension model, financial viability and scalability, knowledge gap, research transfer, rural development*

INTRODUCTION

Romania's rural regions host a vibrant and diverse agricultural sector, which remains a cornerstone of both the national economy and the country's cultural heritage [20]. Over 45% of the population resides in rural areas, where agriculture provides the primary source of income for many families. Despite its significance, the sector faces persistent challenges that have slowed its modernization and limited its economic potential [11].

Many farms in Romania are small and family-run, relying on traditional practices with little access to modern technology, advanced equipment, or research-based methods. This reliance on outdated approaches leads to low productivity, diminished competitiveness, and a limited ability to adapt to environmental and economic challenges [17]. Furthermore, fragmented land ownership and a lack of organizational infrastructure exacerbate these difficulties. Most farmers work on plots smaller than five hectares, which restricts their ability to invest in new technologies or achieve the economies of scale needed for significant improvements in production and profitability [1, 12]. Access to financial resources is another critical hurdle. Rural communities often face challenges in obtaining credit, navigating EU funding programs, and accessing subsidies that could help alleviate financial constraints [16]. These financial barriers are compounded by a shortage of labour in rural areas, driven largely by migration to urban centres or abroad in search of better economic opportunities [3].

A significant obstacle to progress lies in the knowledge gap between modern agricultural practices and the traditional methods still widely used in rural Romania [23]. Although the country boasts several respected agronomic universities with robust research capabilities, the transfer of this knowledge to local farmers remains limited. As a result, many farmers lack the necessary guidance to adopt green, productive, and market-oriented practices that could enhance their livelihoods and competitiveness [8].

Addressing these challenges requires a more structured and accessible support system to bridge the divide between academic research and practical farming needs. A cooperative agricultural extension system, inspired by proven international models, could provide Romanian farmers with the technical support, training, and resources they need to succeed. Such a system would offer tailored knowledge and solutions to meet the specific needs of different regions, helping farmers improve yields, manage resources withprudency, and adapt to evolving market demands [7].

The U.S. agricultural extension system, established over a century ago, offers a valuable example of how universities can play a central role in supporting farmers and rural communities [2]. This model emphasizes collaboration between universities, local governments, and agricultural producers to deliver practical, research-based solutions [4]. Recognizing the potential of this approach, a group of Romanian scholars participated in the Fulbright-RAF Scholar Award in Agricultural Extension Services. During their semester-long residency at the University of Georgia (UGA), these scholars studied the operational frameworks, community engagement strategies, and adaptability of the U.S. extension system across diverse agricultural contexts.

As part of their residency, the scholars engaged in hands-on learning through visits to research centres, community-based extension programs, and rural areas facing significant challenges. Scholars observed how extension agents provide tailored support to farmers and participated in discussions with administrators, policymakers, and agribusiness representatives to understand the funding mechanisms and institutional structures sustaining the U.S. model. These experiences allowed them to conceptualize a Romanian adaptation of the system, tailored to the specific realities of the country's agricultural sector [10].

This study proposes a university-based agricultural extension model for Romania, with a focus on regional specificity. Each agronomic university would act as a hub of knowledge and support for the rural areas surrounding it. The proposed system ensures the use of existing resources and reallocating personnel, the model aims to deliver cost-effective, accessible assistance to address the unique challenges of Romania's rural communities. The following sections detail the methodology and key components identified by the scholars, outlining the foundation for a feasible extension system capable of driving agricultural and rural development in Romania.

MATERIALS AND METHODS

The methodology of this study is based on the direct experiences of the authors, who participated as scholars in the Fulbright-RAF scholar award in agricultural extension services. This program selected five

Romanian academics from agronomic universities and the Polytechnic University of Bucharest to complete a semester-long residency at the University of Georgia (UGA), College of Agricultural and Environmental Sciences (CAES), during the 2024-2025 academic year, building upon an exchange initiated the previous year.

During their residency, the scholars engaged in a variety of field-based learning activities, gaining a thorough understanding of the U.S. agricultural extension system, from its operational frameworks to its impact on agricultural and rural environments.

Field-based learning across diverse agricultural contexts

A major part of the methodology involved field visits to multiple counties in Georgia, providing scholars with comprehensions into a wide range of agricultural extension activities. These visits included tours of UGA research centers and local extension offices, where the scholars observed extension agents working with farmers, agribusiness owners, and rural communities. These activities demonstrated how extension services are adapted to different farm sizes—from small family-owned operations to large commercial enterprises—showcasing the flexibility of the U.S. model.

Each scholar was paired with an experienced extension specialist who acted as a mentor throughout the program. This mentorship enabled scholars to actively participate in activities such as consultations with farmers, community workshops, and on-site advisory services. Scholars attended courses at UGA, where they observed the integration of extension activities into research and teaching. Additionally, the scholars shared their reflections with faculty and students at the College of Agricultural and Environmental Sciences (CAES).

Engagement with extension leaders and stakeholders

The scholars interacted with leaders of the extension system, including deans, department heads, and key personnel involved in the management of extension services. These discussions provided importantinformation into the institutional frameworks and strategies required to sustain an effective extension system. A visit to Washington, D.C., included meetings with officials from the Romanian Embassy, the American Farm Bureau Federation, and the United States Department of Agriculture (USDA), offering a broader understanding of the policies supporting the U.S. system. These engagements informed the scholars about the governmental involvement needed to establish a similar system in Romania.

Collaboration with authorities and underserved communities

The scholars also engaged with central, regional, and local government authorities, highlighting the importance of multi-level support for sustaining extension services. Visits to underserved communities and a correctional facility showcased the social impact of extension programs, such as initiatives to reintegrate inmates and support disadvantaged populations.

Interactions with farmers and agribusinesses

Throughout their residency, the scholars engaged with a diverse range of stakeholders, including farmers, agribusiness owners, and program leaders. These interactions provided practical understandings into the challenges faced by agricultural practitioners. Observing volunteer-driven programs like the Master Gardener initiative offered inspiration for community engagement strategies that could be adapted to Romania.

Designing a cost-effective extension model

Informed by their observations, the scholars developed a model tailored to Romania's budget constraints. The proposed system involves establishing extension offices at agronomic universities by leveraging existing resources and infrastructure. The model incorporates doctoral, master's, and undergraduate students into research and community outreach activities, while potential revenue streams, such as consultancy services and certifications, ensure financial efficiency.

Limitations of the study

The study identifies several limitations. Unlike the U.S., where extension systems are supported by federal and state funding, Romania's system must focus on cost-effective strategies, which may restrict scalability. Additionally, cultural and institutional differences could pose challenges in adapting volunteer-driven and community-focused practices. The limited duration of the scholars' residency in the U.S. also means that long-term operational insights might not have been fully captured.

Adapting knowledge transfer to local contexts

Mentorship from UGA specialists was essential in understanding how knowledge transfer works between universities and rural communities. Scholars participated in training sessions, field visits, and community programs that illustrated how academic research can be transformed into actionable advice. To gain broader experience and insights, scholars also visited extension systems at other institutions, such as Virginia Tech, North Carolina State University, and agricultural colleges like Fort Valley State University and North Carolina Agricultural and Technical State University. These visits provided a diverse perspective on operational models, outreach strategies, and innovative practices in agricultural extension.

Based on these findings, the scholars proposed creating extension hubs within Romanian agronomic universities. These hubs would act as knowledge centers for workshops, advisory services, and regional solutions tailored to the specific needs of local farmers. Through the incorporation of best practices observed across multiple extension systems and aligning them with Romania's unique agricultural challenges, the proposed system prioritizes resource efficiency, financial conscientiousness, and practical solutions for long-term development.

RESULTS AND DISCUSSIONS

The suggested model for a university-based agricultural extension system in Romania offers a comprehensive strategy to establish agronomic universities as central hubs for agricultural expertise, rural development, and community involvement. Grounded in the extensive experience of Romanian scholars within the extension system at the University of Georgia (UGA), this initiative focuses on practical and regionally tailored solutions, aiming to utilize current resources more effectively, reorganize staff responsibilities, and capitalize on the academic strengths of these institutions. The system is designed to meet the specific agricultural requirements of various regions in Romania while fostering innovation and experiential learning opportunities.

With a structured implementation over four years, this model envisions a fully operational extension network involving all major agronomic universities. Each institution would act as a regional anchor, offering advisory services, facilitating the exchange of knowledge, and aligning research efforts with the realities of local agriculture. This phased approach supports gradual expansion, allows for ongoing improvement, and strengthens collaborations with farmers, local governments, and agribusinesses.

Regional allocation and collaborative framework

To optimize operations, the responsibilities for extension services are divided among Romania's primary agronomic universities. Each university will provide support to counties in its vicinity, reducing travel costs and strengthening local ties by building on its familiarity with the region's agricultural practices.

Map 1. Universities regional allocation possibility
Source: Own conception.

The allocation presented in Map 1 considers the number of students and faculty resources available at each institution, ensuring that capacity aligns with regional demand. For instance, USAMV-Bucharest can handle the southern and southeastern regions, the University of Life Sciences in Iași can cover the northeast, USAMV Cluj can oversee the central and northwestern areas, and the University of Life Sciences in Timișoara can manage the western and southwestern regions.

Moreover, the model proposes partnerships with other Romanian universities, including those specializing in technical fields like polytechnic institutions, as well as faculties focusing on food science, agricultural economics, and rural development.

Objectives and strategic goals of the proposed project

The main aim of this project is to integrate agronomic universities more closely with the surrounding rural communities by customizing their research, education, and outreach activities to address local needs. By aligning academic objectives with the challenges of the agricultural sector, universities can play a pivotal role in modernizing agriculture and promoting sustainable development.

Key objectives include:

1.**Strengthening community connections and building trust**

Universities will focus on developing strong relationships with farmers, cooperatives, producer associations, and other regional stakeholders. Initial efforts will involve actively bringing knowledge on farmers social media groups, participating in local agricultural events, and conducting consultations to better understand the unique needs of the area [9].

2.**Aligning academic research with community needs**

Academic research will be closely aligned with the priorities of the regions served. Doctoral, master's, and undergraduate students will focus on relevant topics identified through consultations with farmers, agribusinesses, and local authorities.

3.**Establishing extension offices as community hubs**

Each university will establish an extension office to act as a center for knowledge exchange, training, and advisory services. These hubs will serve both farmers and students, offering workshops, consultations, and practical advice on topics like crop management and pest control. Over time, they will become trusted community resources.

4.**Developing a centralized knowledge platform**

A digital platform will be created to consolidate data, research findings, and educational materials. Organized by region and topic, this platform will enable collaboration across disciplines and institutions, fostering efficient sharing of information and resources.

5.**Creating financially sustainable revenue streams**

Extension offices will offer consultancy services to help farmers secure EU funding and implement green practices. A success-based fee model will minimize risk for farmers while generating revenue to support extension activities.

6.**Attracting students and increasing university visibility**

By actively engaging in rural development and addressing real-world agricultural challenges, universities will attract a larger pool of students. High school students interested in agriculture will view these universities as practical and impactful, while higher-level students will appreciate the opportunities for hands-on learning and meaningful research [6].

Building an ecosystem for knowledge transfer and extension services

By embedding these community-oriented initiatives within the extension system, universities will establish themselves as key resources for agricultural education and rural development. These programs not only address local challenges but also create a dynamic flow of knowledge among farmers, students, and agricultural professionals [19].

The concept presented in Figure 1 emphasizes the interconnected nature of a university's core missions: research, education, and community engagement. It highlights how these elements are not standalone functions but rather work together to create a synergistic system that amplifies the university's impact.

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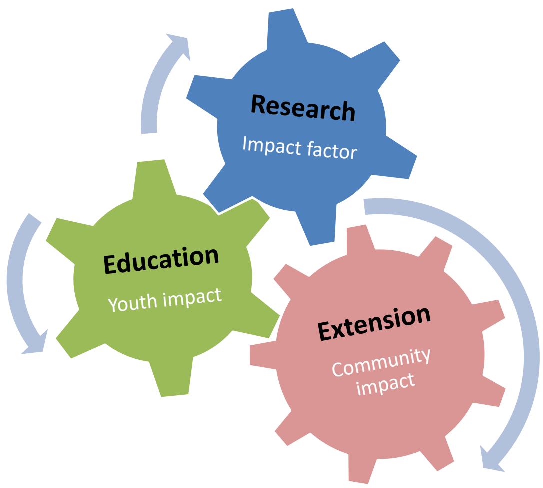

Fig. 1. Knowledge transfer ecosystem
Source: Own conception.

Research drives innovation and generates knowledge that informs both teaching and practical solutions [15]. Education translates this knowledge into meaningful learning experiences, empowering students to address societal challenges and contribute as skilled professionals. Extension serves as the bridge between academia and society, ensuring that the knowledge generated and taught is applied in real-world contexts to benefit communities [17]. This interconnected approach fosters a continuous cycle of improvement, where feedback from extension activities informs research priorities and educational practices, while education develops future leaders who can advance both research and community development [21]. By aligning these functions, the model demonstrates how universities can become central to addressing societal challenges and fostering feasible growth, creating a ripple effect that benefits both individuals and communities at multiple levels.

The result is a cohesive network where academic research informs practical application, and real-world needs guide university activities. This ecosystem will empower rural communities, strengthen the agricultural workforce, and position Romanian universities as leaders in innovation and public service.

Multilevel Framework for Romania's Agricultural Extension Strategy

The pyramid framework presented in figure 2 can align academic research efforts with practical agricultural needs across Romania, focusing on research made in the Management in Agriculture and Rural Development domain.

This approach ensures targeted data collection and analysis at multiple administrative levels, creating the foundation for a robust agricultural extension strategy and identifying future research topics in other fields.

Fig. 2. Proposed multilevel framework for agricultural extension strategy
Source: Own conception.

1.Top Level: Strategy Formation: University administrators integrate findings from all research levels—doctoral, master's, and undergraduate—into a cohesive extension strategy tailored to Romania's agricultural landscape. Insights from this research will also generate new topics for other domains, such as agronomy, horticulture, animal science, and food product engineering.

2.Regional Level: Doctoral Theses (4): Four doctoral theses, one for each macro-region of Romania, will focus on systemic agricultural challenges, such as regional policy design, resource management, or rural economic development. These theses consolidate regional data, addressing broad-scale issues and guiding the national strategy.

3.County Level: Master's Dissertations (41): Each county in Romania will be the subject of a master's dissertation. These studies will analyze specific agricultural challenges and opportunities within the county, offering practical recommendations and creating a bridge between regional insights and local implementation.

4.UAT Level: Undergraduate Diploma Projects (3,181): Each UAT (administrative-territorial unit) in Romania will be studied through an undergraduate diploma project. These projects will gather granular data from specific communities or agribusinesses, providing importantinformation into the agricultural practices, needs, and potential of each UAT.

5.*Undergraduate Class Projects*: In addition to diploma projects, undergraduate students will engage in class projects that involve direct interactions with local farmers and producers. These projects will complement the larger research efforts, ensuring continuous community involvement and practical learning.

Phased development approach through a four-year progression

The proposed agricultural extension system in Romania presented in table 1 focuses on creating a self-sustaining, cost-effective model by strategically leveraging the existing resources of agronomic universities and establishing a well-organized research framework across all academic levels. This systematic approach ensures that each university contributes to a layered body of research, addressing local and regional agricultural needs to form a comprehensive understanding of challenges and opportunities.

Each university will oversee a designated region, with doctoral theses addressing broad, systemic issues, master's dissertations focusing on county-level challenges, and undergraduate projects delving into specific localities or agribusinesses.

This hierarchical approach guarantees a thorough analysis of agricultural practices at various scales while aligning academic activities with practical extension objectives. While much of this research already takes place in individual universities, this proposed model consolidates these efforts into a cohesive framework, enabling better coordination and practical application.

Year 1: Foundation and resource allocation

The first year will focus on laying the groundwork for the extension system. This involves setting up dedicated extension offices and launching pilot programs that heavily involve doctoral students and faculty. Key activities include:

•**Establishing extension offices**: Each university will set up an extension office as a central hub for coordinating extension activities, managing resources, and fostering partnerships with local stakeholders. Minimal new infrastructure is needed, as these offices will utilize existing university spaces and equipment.

•**Doctoral student pilot program:** Research scholarships will be offered to doctoral students who align their research themes with the specific challenges of their assigned regions. These students will play a central role in the extension system by integrating their academic work with real-world agricultural needs. The program will primarily rely on doctoral students with scholarships in the field of Engineering and Management in Agriculture and Rural Development, who can develop theses focused on agricultural extension.

•**Data collection and stakeholder analysis**: Doctoral students will receive training and begin gathering data on local agricultural issues through surveys, community consultations, and online farmer forums.

•**Community engagement and networking**: Students will attend agricultural events, initiate conversations with farmers, and connect with agribusiness representatives to build relationships and identify the region's most pressing needs. This initial engagement will help establish trust and visibility for the extension program.

Year 2: Fieldwork and expansion of extension activities

In the second year, the system will shift toward applying understandings gained from the initial data collection and community interactions. Extension activities will begin to provide tangible support to farmers both online and in person.

•**On-the-ground support**: Doctoral students will actively respond to inquiries from farmers on digital platforms, offering practical advice and sharing research findings. When necessary, students will consult with faculty to ensure the accuracy of their recommendations.

•**Field visits and advisory services**: Regular visits to farms will allow students to gather updated data and offer direct support to farmers in areas such as pest control, crop management, and green farming practices.

•**Research themes for undergraduate and master's students**: Findings from doctoral research will guide the development of research projects for students at all levels, ensuring academic work is aligned with real-world agricultural challenges.

•**Mentorship**: Doctoral students in their second year can mentor undergraduate and master's students, fostering a collaborative learning environment and ensuring continuity in the extension work.

Table 1. Proposed timeline for implementing a university-based agricultural extension model

Extension model timeline	**Year 1** Foundation and resource allocation	**Year 2** Fieldwork and expansion:	**Year 3** Advanced research and thesis development:	**Year 4** Finalization and system institutionalization:	**Year 5** **Functional extension system**
Administrators	Establish extension offices at each university as coordination hubs. Providing resources for the digital platform for data collection and knowledge sharing.	Identify new research topics and developing strategy. Expand collaboration with agribusiness and technical partners for additional resources	Developing the university extension strategy. Assess and adapt resource allocation, faculty involvement, and program goals based on feedback from extension activities.	The finalization of the extension strategy based on research findings. Universities can consider hiring graduates as extension agents or extension specialists to sustain outreach activities.	Establishing and coordinating the extension offices at, regional level and local branches.
Extension specialists and Fulbright-RAF alumnus	Disseminating the principles of university extension among their peers. Help at launching a pilot program with PhD candidates focusing on regional agricultural challenges. Development of pilot projects for disseminating information online: podcasts, online workshops, presentation videos.	Begin aligning undergraduate and master's research projects with regional priorities. The launch of a large online campaign to promote extension. on all major social media and streaming platforms. Extension advisory services and fostering the pilot projects.	Establish ongoing mentorship for involved master and undergraduate students to support continuity. Identify new research topics for graduate and undergraduate students and maintain communication with them. Extension advisory services, knowledge transfer and fostering the pilot projects. Working on the centralized digital platform.	Encourage collaboration among students at different levels to promote a coherent, integrated approach to data collection and problem-solving. Extension advisory services, knowledge transfer and fostering the pilot projects. Finalizing the centralized digital platform.	Identify new research topics for new PhD thesis and graduate and undergraduate students and maintain communication with them. Extension advisory services and knowledge transfer fostering the pilot projects.
PhD candidates	Initial data collection and stakeholder analysis through surveys, interviews, and community events. Gathering information and provide advice on farmers' social media groups.	Doctoral candidates start provide advisory services online and attend community events and continue data collection. Participate in the online campaign to promote extension. on all major social media and streaming platforms.	Concentrate on thesis work addressing comprehensive regional issues and conduct regular field visits and offer targeted support face to face and online. They identify new research topics for graduate and undergraduate students and maintain communication with them. Extension advisory services under extension specialist supervision.	PhD candidates defend their theses and provide recommendations for extension model scaling Introducing research findings on the centralized digital platform. Extension advisory services under extension specialist supervision.	Extension advisory services . Disseminating research findings in journals and online: podcasts, online workshops, presentation videos on university websites, and on major social media and streaming platforms. Actively participate in following discussions in online farmer groups
Graduate and undergraduate students	The allocation of research topics based on the principle of university extension begins. Gathering information on farmers' social media groups.	Collecting data in specific communities or individual agribusinesses, gathering granular data. Start to actively participate in following discussions in online farmer groups and provide advice to farmers under supervision.	They begin presenting the results of the research conducted, actively participate in following discussions in online farmer groups, and provide advice to farmers. Consolidating data at the county level, knowledge transfer	Disseminating information online: podcasts, online workshops, presentation videos on university websites, and on major social media and streaming platforms. knowledge transfer Introducing research findings on the centralized digital platform.	Introducing research findings on the centralized digital platform. Disseminating information online: podcasts, online workshops, presentation videos on university websites, and on major social media and streaming platforms. knowledge transfer

Source: Own results based on proposed model.

Year 3: Advanced research and thesis development

The third year will focus on deepening research efforts and preparing doctoral theses that will serve as feasibility studies for the long-term implementation of the extension system.

•**Region-specific research**: Graduate students will conduct detailed studies on issues such as soil health, water management, and economic conditions within their regions. These findings will guide future research and extension activities at all academic levels.

•**Collaboration and mentorship**: Senior doctoral students will continue mentoring younger peers, sharing data, and building on previous years' work. This collaboration ensures that research efforts remain consistent and comprehensive.

Year 4: Finalization and establishment of the extension system

The fourth and final year will culminate in the establishment of a permanent extension system. Doctoral students will defend their theses and provide actionable recommendations for scaling the program.

•**Comprehensive feasibility studies**: Doctoral theses will offer in-depth analyses of regional agricultural challenges, providing a detailed roadmap for a fully operational extension system.

•**Recruitment of extension agents**: Graduates from the program will be well-prepared to take on roles as extension agents, equipped with the knowledge and experience necessary to address local agricultural needs.

•**Establishing regional and local offices**: Based on the research findings, universities will determine the required number and specialization of local extension offices to ensure responsive and efficient service delivery.

Collaborative and interdisciplinary partnerships

The extension system will collaborate with a wide range of institutions and stakeholders to maximize its reach and impact:

•**Technical universities and research centers**: These institutions will provide expertise in precision agriculture, digital farming, and innovative technologies to support modernization efforts.

•**Progressive farmers and pilot farms**: Model farms will serve as practical examples of best practices, offering example and techniques that can be shared with the broader farming community.

•**Private sector collaborations**: Agribusiness companies and technology providers will contribute technical support, sponsorships, and access to cutting-edge tools and equipment. These partnerships will also create opportunities for direct farmer engagement and education.

By integrating these partnerships and leveraging the expertise of diverse stakeholders, the extension system will foster innovation and ensure its feasibility, benefiting Romania's agricultural sector for years to come.

Financial sustainability through consultancy services

To secure the long-term viability of the agricultural extension system, university-based extension offices will provide consultancy services aimed at assisting farmers in accessing European Union funding, particularly CAP grants. Using a success-based fee structure, commissions will be charged only on successful applications, reducing financial risk for farmers while maintaining accessibility.

•**Accessible support**: Farmers can access expert advice without upfront costs, encouraging participation and fostering trust in the system.

•**Revenue generation**: Success fees will ensure a consistent income stream to cover operational expenses, support outreach programs, and advance research.

•**Building credibility**: Fair and transparent consultancy practices will position universities as trusted partners, strengthening relationships with the agricultural community.

State partnership and funding

Animportant aspect of this proposal is securing long-term support from the Romanian government. Inspired by the American model, the system suggests that local, regional, and central authorities should commit funding to the agricultural extension system once its effectiveness is demonstrated through pilot programs. This financial backing would enable universities to establish anefficient extension network, directly benefiting rural communities and agriculture nationwide [18].

•**Ensuring continuity and expansion**: State funding would allow universities to expand their services, hire specialized extension agents, and implement targeted programs tailored to regional needs.

Institutionalization and scaling of the extension model

As the pilot programs evolve, each university's extension office will transition into a formalized, institutionally supported center, funded through a mix of government resources, EU grants, and revenue from consultancy services.

1.**Regular evaluation and adaptation**: Extension offices will continuously assess their programs' effectiveness, responding to community feedback and emerging agricultural challenges.

2.**Nationwide network**: Once fully established, the system can be scaled to include all major agricultural regions, creating a coordinated national framework for extension services.

3.**Centralized knowledge repository**: A digital platform will house all research, data, and program materials, ensuring easy access and promoting collaboration among stakeholders.

By institutionalizing the extension model, Romanian universities will create a lasting impact on agriculture, education, and rural development, ensuring the system's relevance and effectiveness for years to come.

The integrated knowledge platform

To promote effective information sharing, the proposal includes the development of a centralized digital platform. This platform will serve as a repository for data, research findings, and educational resources, ensuring they are easily accessible to students, faculty, and extension staff. The main features of the platform include:

•**Regionally organized data**: Information gathered from various counties will be structured and mapped geographically, making it easier to manage data and encouraging interdisciplinary collaboration [5].

•**Resource and activity coordination**: Acting as a central hub, the platform will streamline the management of extension activities, ensuring that students and staff can efficiently plan, coordinate, and execute programs.

•**Long-term strategic planning**: By consolidating resources, the platform will aid in identifying future research opportunities, refining extension initiatives, and optimizing resource allocation to better align with regional needs.

Development of community-focused programs

The proposed extension model incorporates community-focused initiatives, drawing inspiration from successful U.S. programs like 4-H, Master Gardener, Farm-to-table, beginning farmer and rancher program, Family and consumer sciences, etc.. These programs aim to engage youth, promote green practices, encourage agricultural innovation, and foster active community participation. Volunteer involvement is integral, providing opportunities for knowledge sharing, skill development, and strengthening social ties [13].

Additionally, some of these programs may generate revenue through certification opportunities, appealing to those seeking formal recognition of their skills. However, the model ensures these programs remain free for students and disadvantaged groups to maintain equitable access to agricultural education and resources [14].

(1)**4-H youth development program**

A program modeled on 4-H would focus on engaging young people in agriculture, STEM, and leadership activities. It would encourage rural youth to consider careers in agriculture while fostering skills such as critical thinking and collaboration. University students and alumni could act as mentors, enriching the program with their expertise and experiences.

(2)**Master gardener program**

This program would train community volunteers in sustainable gardening techniques and plant health. Certification as a master gardener could provide a revenue stream for

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universities while offering participants practical expertise. University students would access this training for free, gaining credentials alongside their academic studies.

(3)**Farm-to-table initiatives**

Programs connecting local farmers with consumers and institutions such as schools or hospitals would support rural economies while promoting fresh, local produce. Volunteers would play a key role in building these market connections and educating consumers about the benefits of local agriculture.

(4)**Beginning farmer and rancher program**

Designed for new and aspiring farmers, this initiative would provide training in areas like financial management, marketing, and modern farming practices. Experienced farmers and agribusiness professionals could volunteer as mentors, sharing practical advice and insights.

(5)**Family and consumer sciences (FCS) program**

A program addressing life skills like nutrition, financial literacy, and food safety would improve the quality of life for rural families. Volunteers, including students from relevant disciplines, would extend the program's reach. While disadvantaged groups would access these resources for free, fee-based workshops could be offered to other participants, providing an income stream for universities.

(6)**Small farm program**

Aimed at supporting small-scale farmers, this program would focus on sustainable farming practices, product marketing, and market access. Volunteers from universities and the agricultural sector would share their knowledge and facilitate networking opportunities.

(7)**Nutrition education programs**

Inspired by SNAP-Ed and EFNEP in the U.S., these programs would promote healthy eating and food safety among vulnerable groups. Volunteers from nutrition, health sciences, and related fields would provide outreach and education, creating a practical learning experience for students.

Expanding volunteer involvement and certifications

Volunteer participation is a cornerstone of these community programs. It provides students with hands-on experience and fosters a sense of community involvement. Students from diverse fields—agriculture, economics, engineering—could contribute to initiatives that align with or broaden their academic interests.

To enhance the system's sustainability, certain programs may offer fee-based certifications. For example, individuals seeking advanced credentials such as master gardener or beginning farmer certification could pay for these courses, generating revenue to support extension activities. University students, however, would access these programs free of charge, enriching their educational experience without additional financial burdens.

Balancing time, budget, and quality: a triple constraints analysis of Romania's proposed agricultural extension system

The proposed agricultural extension model is assessed using the triple constraints framework, focusing on time, budget, and quality. By positioning agronomic universities as key regional centers for knowledge and community engagement, the project aims to foster rural economic development and address the specific needs of Romanian agriculture. The phased four-year implementation seeks to establish a fully functional and self-sustaining network that balances these three important factors.

Time

The proposed timeline spans four years, providing a structured and gradual implementation process. The initial stages focus on foundational steps such as setting up extension offices, engaging with local agricultural stakeholders, and defining research priorities tailored to regional needs. Later phases will introduce advanced components, including the centralized digital platform and tailored consultancy services.

This step-by-step approach prevents rushed development, allowing each stage to build on the previous one while incorporating feedback and adjustments. However, efficient time management will be critical. Delays in any phase could create bottlenecks, potentially jeopardizing the overall schedule for full implementation.

Budget

The project is designed to be cost-effective, primarily by leveraging existing university infrastructure and human resources. Extension offices will use current university facilities, while faculty and students at all academic levels will contribute to research, outreach, and data collection.

Financial sustainability is further bolstered by introducing revenue-generating activities, such as offering consultancy services on a success-fee basis to help farmers secure EU funding. Certifications, such as those for master gardener or beginning farmer programs, will also provide an additional income stream. Careful financial oversight will be necessary to ensure these initiatives generate sufficient revenue to cover operational expenses and allow for scaling the system.

Quality

Maintaining high standards is a central objective of the model. Each extension office will act as a knowledge hub, combining academic research with practical outreach tailored to local agricultural challenges. The system emphasizes interdisciplinary collaboration among faculties, including agronomy, engineering, and economics, to develop well-rounded solutions.

Community-focused programs, such as 4-H youth initiatives and master gardener training, will enhance quality by encouraging active engagement, fostering practical skills, and supporting green practices [22]. Regular evaluations will ensure that each office adapts its programs to meet local needs effectively.

Integrated analysis

The proposed extension model strategically balances time, budget, and quality to maximize impact and success. By leveraging existing resources, implementing a phased approach, and emphasizing tailored, high-quality programs, the model provides a realistic path for enhancing Romanian agriculture. However, careful monitoring and adaptation will be needed to address challenges as they arise, ensuring the system's relevance and success.

CONCLUSIONS

The proposed university-based agricultural extension system represents a transformative opportunity for Romania to address the persistent challenges in its rural and agricultural sectors. By leveraging lessons from the U.S. extension model and tailoring them to Romania's unique needs, the system provides a framework for modernizing agricultural practices, fostering rural development, and bridging the gap between academic research and practical farming needs.

The model's strength lies in its multi-level approach, which integrates the efforts of doctoral, master's, and undergraduate students to collect data and address challenges at regional, county, and local levels. This hierarchical structure ensures a comprehensive analysis of agricultural needs while aligning academic objectives with real-world challenges. The incorporation of community-focused programs, such as 4-H youth initiatives and master gardener training, reinforces the system's impact by directly engaging local communities and promoting green agricultural practices.

The phased implementation timeline enhances the model's feasibility, allowing for gradual development, flexibility, and scalability. By utilizing existing university infrastructure and integrating revenue-generating activities, such as consultancy services and certification programs, the model addresses financial constraints while ensuring long-term sustainability. Partnerships with government entities, EU funding bodies, and private sector stakeholders will further enhance the system's reach and effectiveness.

Despite potential obstacles, including cultural differences and budget limitations, the model demonstrates how Romanian universities can play a central role in driving innovation, education, and rural development. It highlights the importance of continuous evaluation and refinement to adapt to emerging challenges and ensure the system's relevance.

Ultimately, this extension system not only addresses the immediate needs of Romanian farmers but also fosters a skilled workforce equipped to lead future agricultural and rural development initiatives. With proper oversight, collaboration, and commitment from all stakeholders, the proposed system has the potential to significantly enhance the resilience and efficiency of Romania's agricultural sector, contributing to broader economic and social progress.

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THE ROLE OF FOREIGN DIRECT INVESTMENTS IN ROMANIA'S ECONOMIC DEVELOPMENT: ANALYSIS 2013-2023

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Abstract

The paper aimed to emphasize the importance of foreign direct investments in fostering the sustainable development of the Romanian economy, as well as their influence on economic growth and the evolution of the business environment. Statistical data on foreign direct investments (FDI) provided by the National Bank of Romania formed the basis of the research. The study presents the dynamics, structure, and volume of foreign direct investments in Romania during the 2013–2023 period. A simple linear regression econometric model was employed to analyze the impact of foreign direct investments on economic growth. The findings revealed a rising trend in foreign direct investments in Romania. Additionally, there was a strong and statistically significant correlation between FDI and the gross domestic product (GDP). The overall conclusion highlights that FDI serves as a vital instrument for narrowing the economic disparity between developed and developing nations, promoting sustainable economic growth, and tackling structural challenges in Romania.

Key words: *Foreign direct investment (FDI), Romania, economic growth, GDP correlation, investment trends*

INTRODUCTION

According to the definition given by UNCTAD Foreign direct investment (FDI) is defined as an investment reflecting a lasting interest and control by a foreign direct investor, resident in one economy, in an enterprise located in another economy (foreign affiliate) [21].

Foreign direct investment (FDI) is a robust foundation for fostering economic growth, even during periods when economic stability and growth are under pressure, because [12]:

• FDI complements public financing sources and provides essential capital for economic development;

• FDI generates employment not only within the invested companies but also by stimulating growth in upstream and downstream enterprises;

• FDI brings more than capital, introducing technology, knowledge, and organizational practices that drive economic growth. Foreign investors implement efficient work methods and innovative technologies that enhance employee productivity and company competitiveness. These advantages cascade across the supply chain, compelling businesses to adapt and remain competitive in the market;

• FDI offers long-term stability, as it is defined by the sustained interest of the investor in the company. Investors who establish new companies are unlikely to abandon their investments easily, even in times of economic turbulence.

FDI inflows include capital supplied by a foreign direct investor to a foreign affiliate or received by a foreign direct investor from a foreign affiliate. In contrast, FDI outflows describe these transactions from the perspective of the foreign affiliate's home economy. FDI flows are measured on a net basis, calculated as credits minus debits, allowing for negative values in cases of reverse investment or disinvestment. FDI stock represents the aggregate value of capital and reserves held by a non-resident parent enterprise, plus the net debt of foreign affiliates owed to the parent enterprise. (UNCTAD, 2020) [22].

Adam Hayes define foreign direct investment (FDI) as a type of cross-border investment where an investor from one economy acquires a lasting interest in and significant control over a business in another economy [22]. A significant investment relationship is indicated by owning at least 10% of the voting power in a company based in another country. Foreign Direct Investment (FDI) plays a crucial role in fostering international economic integration by establishing stable, long-term connections between economies. It serves as a vital means for transferring technology across borders, enhancing global trade by providing access to new markets, and acting as a powerful driver of economic development. Key metrics used to analyze FDI include inward and outward stocks, flows, and income, broken down by industry, partner countries, and measures of FDI restrictiveness [18].

The attracted investments must be directed to those economic sectors that contribute to sustainable economic growth - agriculture, tourism, manufacturing industry - and not to speculative sectors, such as the real estate or retail sector [13].

Foreign direct investments have positive effects both at the macroeconomic and microeconomic levels, expressed through economic growth, through the creation of new jobs, new production capacities and also through the increase of contributions to the state budget, as a result of taxes and taxes paid by new taxpayers. From a macroeconomic perspective, foreign direct investment (FDI) drives economic growth by establishing new production facilities and creating additional jobs, particularly through greenfield investments. It also stimulates domestic investment by encouraging local producers to enhance the quality of their goods and services and to boost operational efficiency in response to newly introduced foreign competition. Furthermore, FDI facilitates access to valuable knowledge and resources, enabling local businesses to collaborate more effectively with foreign investors and adapt to global market demands.

Foreign direct investments also have a positive effect on national producers who will invest in their turn, out of the desire to make the activity more efficient, but also to have the opportunity to become suppliers of the foreign business partner [2].

The high interest in the field of foreign direct investments is justified by the fact that they represent a factor for stimulating economic growth and GDP[3], do not generate external debt, being complementary to domestic investments [15].

Foreign direct investment is regarded as the most promising solution for narrowing the competitiveness that separate the economies of developed countries from the economies of developing countries. It is recognized that foreign direct investments represent an important source of jobs for host countries, thus more and more emphasis is placed on their role in the creation or reallocation of jobs. Also, they could be a way to reduction social exclusion from the rural areas [10].

Investors focus their attention on the implications of expanding the production activity internationally.

Foreign direct investments (FDI) are typically drawn to countries with stable political and economic environments. Experience demonstrates that developed nations, as the primary recipients of FDI, reap considerably greater benefits compared to developing countries. Key advantages include fostering economic growth, stimulating domestic investments, facilitating restructuring and privatization efforts, and enhancing state budget revenues through increased tax contributions. However, FDI can also produce negative impacts, both at the macroeconomic and sectoral levels. These adverse effects, often short-term in nature, are closely tied to how well the investment is implemented and its overall efficiency.

In this context, the paper aimed to highlight the role of foreign direct investment in supporting the sustainable development of the Romanian economy and their influence on economic improvement and the business climate enhancement.

MATERIALS AND METHODS

The structural analysis of foreign direct investments recorded in Romania in the period 2013-2023 was carried out based on

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the information supplied by the statistical study on foreign direct investments (FDI) conducted by the National Bank of Romania in collaboration with the National Institute of Statistics, as well as data provided by the official database of the European Commission [16].

The comparison method involves analyzing similarities and differences between two or more phenomena to identify patterns, trends, or disparities. This method is foundational in empirical research and is applied across disciplines like economics, sociology, and natural sciences [19], [4].

The index method involves creating indices, which are numerical measures used to summarize and compare changes in data relative to a base period or value. Indices can be simple or complex and are frequently used in economics and finance [18], [9].

The correlation method examines the relationship between two variables to determine if they are associated. It measures the strength and direction of their linear relationship [20], [9].

The regression method explores the relationship between dependent and independent variables to model and predict outcomes. It extends correlation by quantifying the impact of one or more independent variables on a dependent variable [11], [5].

RESULTS AND DISCUSSIONS

GDP is an important economic indicator used to assess the health of a nation's economy, as well as to compare the economic performance of different countries. Romania's GDP is structured on three large sectors: agriculture, manufacturing industry and construction, and the service sector.

Over the years, the services sector has had the largest share in GDP, especially due to the development of the IT and telecommunications, trade and tourism sectors [17].

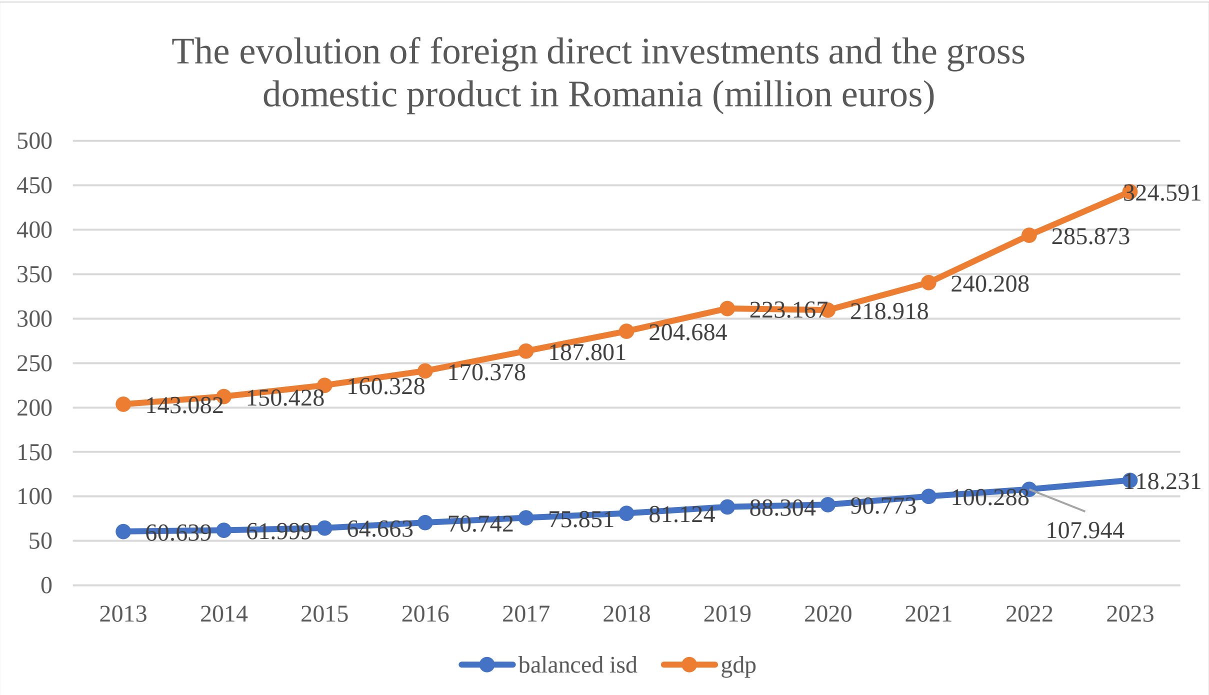

Fig. 1. The evolution of the GDP and the total FDI (ISD) in Romania (million euro) in the period 2013-2023
Source: National Bank of Romania, 2024, Annual Report 2023 [14].

Analyzing the evolution of GDP in Romania, a constant increase is found in the analyzed period, with the exception of 2020 compared to 2019, when a decrease of 2% is recorded, according to Figure 1.

This decrease is due to the restrictions imposed to limit the spread of the virus, which directly affected economic activities, especially in the tourism, trade and transport sectors.

The government has implemented measures to support the economy, including financial aid for firms and incentives for consumers, but the global impact of the crisis has been significant.

The GDP growth in 2023 compared to 2013 was 125.7%. In 2023, compared to 2022, an increase of 13.5% was registered, while in 2022 compared to 2021, the increase was 19% (Figure 1).

GDP growth is due to economic reforms, increased foreign direct investment and integration into the single European market. But the positive effect from the IT sector, which experienced a rapid expansion, should not be omitted either, Romania is one of the main destinations for the outsourcing of IT and software services in Europe [7].

Despite steady economic growth in recent decades, Romania faces a number of challenges that can influence its GDP in the long term, such as insufficient infrastructure, which can limit productivity growth and attract new investment [15]. Shortage of skilled workers, especially in technical and specialized fields, which can limit the development of some key sectors. [9] An aging population and the migration of young people to other EU countries is a major challenge for the long-term sustainability of the economy and GDP [15]. Energy effects, inflation and external economic turbulences that can contribute negatively to the gross domestic product must also be taken into account [14].

Foreign Direct Investment (FDI) is the funds or capital that a company or investor from one country places directly in another country, usually by purchasing assets, opening branches or establishing subsidiaries, or buying shares in a local company.

According to graph 1, foreign direct investments in Romania are trending upward, with constant increases recorded.

The balance of foreign direct investments in Romania increased in 2023 by 94.9% compared to 2013. In 2023 compared to 2022 the increase was 9.5%, in 2021 compared to 2020 an increase of 10 .5%.

A series of both internal and external factors influence these increases.

Tax regulations, investment incentives, subsidies and trade policies have a direct impact on attracting FDI. The government can create a favorable environment through tax reductions, facilities for foreign investors or by providing subsidies. Foreign investors are looking for a stable environment with a clear legal framework and respect for property rights [20].

As a member state of the European Union, Romania enjoys unrestricted access to the European single market, which can serve as a motivation for foreign investors to establish their operations in Romania [6].

Multinationals, which come with technology, know-how and capital, are the main investors in Romania. They are attracted by lower production costs, a well-trained workforce and access to the European market [16].

Investment funds, pension funds and other international financial institutions play an important role in foreign direct investment, especially in sectors such as technology, infrastructure and energy [8].

Production relocation trends from China or Asian regions may bring more FDI to Eastern Europe [1].

Bilateral or regional trade agreements, such as those between the European Union and other states, can stimulate FDI flows to Romania [6]. To analyze the impact of foreign direct investments on the economic growth in Romania in the period 2013-2023, the method of econometric modeling was used, with the help of the computer software Excel, the Data Analysis module, and the results obtained are presented in Table 1.

The linear regression model is the following one:

$GDPt = \beta0+\beta1\cdot ISDt+\beta2\cdot X1+\beta3\cdot X2+\cdots+\epsilon t$ ....(1)

where:

• PIB_t is GDP in year t.
• FDI_t is the value of foreign direct investment in year t.
• X_1, X_2, ... are the control variables (eg inflation, government spending, etc.).

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• β_0, β_1, β_2,... are the coefficients of the model.
• ε_t is the prediction error (error term).

Analyzing, according to Table 1, the correlation between the dependent variable, respectively the Gross Domestic Product and the independent variable, respectively the balance of Foreign Direct Investments, a very strong relationship between variables is observed due to the value of 0.987, a value very close to 1.

The coefficient of determination (R^2) indicates the percentage of the variation in the dependent variable (Y) that is accounted for by the regression model.

An R^2 of 0.973 reveals that 97.32% of the variation in the dependent variable is explained by your model. It is a very good model because a value close to 1 indicates an excellent fit.

Table 1. The results of the regression function

Regression Statistics	
Multiple R	0.986508669
R Square	0.973199355
Adjusted R Square	0.969849274
Standard Error	9,636.564859
Observations	10

ANOVA

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	1	26976838000	26976838000	290.500274	0.00000014
Residual	8	742907058.3	92863382.29		
Total	9	27719745058			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-35,272.43	15,090.80	-2.33	0.0476	-70,071.90	-472.97	-70,071.90	-472.97
FDI	2.929	0.17	17.04	1.426E-07	2.5331	3.3258	2.53	3.32

Source: own calculations.

Adjusted R^2 corrects the R^2 value for the number of predictors in the model, given that it is very close to R^2, it suggests that the model is adequate and not overfitting.

The F statistic is used to test the overall significance of the regression model. The F-value of 290.5 is extremely high, suggesting that the model is statistically significant.

The Significance F (p-value) is extremely small at 0.00000014 (well below 0.05), which means that there is very strong statistical significance. The model explains a significant proportion of the variation in the dependent variable.

Regression equation reflecting the value of GDP (Y) depending on FDI (X) is given below:

Y= -35,272.43+ 2.929 FDI

According to the results in Table 1, for each unit of increase in the balance of foreign direct investments by 1 million Euro, the gross domestic product will grow by 2.2929 Million Euro. This coefficient is significant, having an extremely small p-value (1.43E-07), much lower than 0.05.

CONCLUSIONS

The analysis highlights that foreign direct investments (FDI) have played a crucial role in Romania's economic growth from 2013 to 2023. The econometric analysis using regression models demonstrates a strong correlation between FDI and GDP growth, with an adjusted R^2R^2R^2 of 0.973, indicating that 97.3% of GDP variance is explained by changes in FDI inflows.

FDI positively impacts both macroeconomic and microeconomic levels by creating jobs, enhancing production capacities, and increasing state budget contributions through taxes. Investments in sustainable sectors such as agriculture, manufacturing, and tourism were emphasized as drivers of sustainable growth, in contrast to speculative sectors like real estate and retail.

Foreign investments bring advanced technology, knowledge, and organizational practices to local industries, improving efficiency and competitiveness across the value chain.

There was a consistent increase in FDI during the studied period, with a 94.9% rise in FDI stock from 2013 to 2023. Economic reforms, EU integration, and competitive production costs contributed significantly to this growth.

The paper suggests that government measures such as tax incentives, infrastructure improvement, and clear legislative frameworks are critical for attracting FDI. Strengthening these areas will help mitigate challenges like an aging population, labor shortages, and external economic volatility.

Despite the positive impacts, FDI can have short-term negative implications, such as market dominance by foreign entities and dependency on foreign capital. Policies must balance the benefits of FDI with potential risks to national industries.

The overall conclusion highlights that FDI serves as a vital instrument for narrowing the economic disparity between developed and developing nations, promoting sustainable economic growth, and tackling structural challenges in Romania.

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ACCOUNTING AND INFORMATIONAL VALUES OF THE REVENUE AND EXPENDITURE BUDGET IN PUBLIC INSTITUTIONS. CASE STUDY

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Abstract

The transformations that took place in accounting over the last ten years have been profound, the Romanian accounting system being subject to an extensive and serious reform process, in order to adapt it to the new economic, political, legal and, social conditions. In the public sector, the changes made aimed at optimizing the budget execution so that they reflect, in a real way, the way in which public money is spent in order to achieve the objectives of general interest of the community. The current state of this paper, with a case study in a locality in Călărași county, resides in the fact that, being an accounting of commitments, public entities are obliged to organize and conduct accounting according to the approved income and expenditure budget, and its effective management, has direct implications on the development of the rural community, on all levels. As research methods, documentation, information and analysis were used, used in several stages undertaken in the research, as well as the method of comparative analysis and graphic representation. We observe that the total revenues (collected) of the local budget of the analyzed commune increased in the period of 2022 compared to 2021, after the restrictions imposed by the Covid-19 pandemic prevented the development of economic activities bringing income to the local budget, by 21.10 %, so that then, in 2023, we see a slight decrease in them by 0.04%. The total expenses of the commune budget have in the analyzed period the same trajectory as the budget revenues, in which they were totally incorporated. Investments are required in the education sector, because the training of human capital is the most important in a community. At the same time, we appreciate the fact that the representatives of the local public authority are concerned with attracting European funds to the community and implemented projects with European funding, which came to support the community, the socio-economic development of rural communities also depends on these funds.

Key words: *budget, expenditure, rural community, public institution, revenue*

INTRODUCTION

The foundation and drawing up of an income and expenditure budget is not only a complex process of resources forecasts, where legislative regulations must be respected, first of all, but simply both the needs and the problems f the community in question must be taken into account [4, 9].
The optimal management of resources within a budget remans a rather complex problem that requires special attention, but which, accordint to the current legislation, still presents some ambiguities and gaps [6, 13].
Many times legislation is implemented by governments without impact studies, aiming in particular to attract the electorate and not necessarily the real needs of the entty, respectively the costs generated. Regulations thus become inoperative and ineffective [16, 8].
The budget is not only a financial document but it represents a managerial instrument, which, in financial expression, ensures the dimension of the objectives, expenditure, actions that can be funded from forecast income to be achieved, but also the evaluation of the results and their socio-economic efficiency in the community [2, 12]. Thus the fundamental strategy, planning, achievemnt and control of actions of local public administration are found in the territorial administrative units budget in case of communes, towns and municipalities and the county budget in case of counties [11,15].
The meaning of the concept of budget was defined under the economic aspect, in the

conditions where the state started drawing up income and expenditure lists regarding the activity of its institutions. In the contemporary period, the budget became a privileged instrument of economic policy, both in terms of means and of achieving certain political and social justice goals. Taxes, fees, budget allocations, subsidies, transfers, etc. there are just as many instruments, levers of an economic-financial nature, through which the state intervenes to achieve its policy in various fields of interest [1, 7]. All public institutions, regardless of the form of financing, are obliged to use the same accounts and the same indicators from the economic classification, for good centralization at the level of central and local public administration [9, 14].

The budget is the estimate of income and expenses for a certain period of time, usually a year. The government prepares the budget proposal and presents it to the Parliament for approval. After approval, the budget becomes a law, the implementation of which is mandatory, like any other law of the country [11, 17]. Understanding the political and social structure of a country requires understanding the budgetary process in that country. Thus, specialists refer to this process as a nerve center of the government. From a certain perspective, the budget provides a picture of expenses on education, health, social programs, military expenses and other various priorities. From another perspective, the budget shows us who will pay for these expenses. An examination of the budget can also reveal how a country plans, controls, improves the state of the nation [1, 5, 17].

The appropriate budgetary relations are manifested in a double sense: on the one hand, as relations through which the financial resources available to the state are mobilized, and on the other hand, as relations through which these resources are distributed to their users [5, 6].

The purpose of the paper is to analyze the accounting and information values of the income and expenditure budget of a town hall in Călărași county, in order to know the impact of its structure and management on the development of the rural community.

MATERIALS AND METHODS

In the study we started from the premise that the purpose of local public administration is to provide a satisfactory level of goods and services to citizens, having a direct responsibility for the quality of socio-economic transformations within a community that induces economic development. The effect of local public authorities on development is directly proportional to their ability to facilitate initiatives leading to the achievement of the goal and to involve other public and private actors in the process [2, 3].

In the analysis of the analyzed locality budget, we started from the overall analysis of revenues and expenses in the period 2021 - 2023, and then we carried out an analysis of the structure of revenues and expenses of the local budget, of the components, of their dynamics, of some of the causes that determined the respective evolution.

Documentation, information and analysis were used in several stages undertaken in the research, in the analysis of information from the specialized literature, in the collection of information regarding the study of factors specific to the analyzed rural community and to identify the positive and negative aspects associated with each factor, when drawing up the correlation table of factors with specific aspects. The comparative analysis method was used for the comparative and dynamic analysis, over a period of 3 years, of the budget revenues and expenses, but also for the comparative analysis of their structure and the percentage ratio between the structures.

Graphical representation is another way to analyze quantitative data in the form of diagrams, which allow a better interpretation of the relationship between cause and effect, as well as a better adaptation to measure the degree of change of a variable, when there are changes in the value this one.

RESULTS AND DISCUSSIONS

The locality where the case study was carried out, has a total surface of 11,019 ha and a population of 9,684 inhabitants, accoding to the last census. In Table 1, the general characteristics of the main factors in the community are presented, analyzed in terms of their positive and negative aspects.

Table 1. Analysis of positive and negative aspects of the studied commune

Factors	Positive aspects	Negative aspects
1.**Natural framwork**	- Proximity of the commune to the river; - The soils in the commune are mostly chernozems, being suitable for agriculture.	- The existence of floodable agricultural areas in the commune; - the emergence of the drought phenomenon considering the location of the commune in an area with high temperatures during the summer.
2. **Population and work force**	- The existence of a segment important part of the active population in the commune; - The workforce available and responsive to training actions and professional conversion	-The low level of opportunities of employment in the commune; - High level of unemployment in the commune; - The significant share held by the inactive population in the total population; - Large number of pensioners in the commune; -Lack of programs to promote traditional trades practiced by the inhabitants of the commune.
3. **Economic framework**	- Agricultural potential, zootechnical and fish potential; -The high share of private property on arable land, suitable for some varied crop ranges; - Favorable geographical position for tourism development	- Excessive parceling of agricultural land; - Insufficient endowment of the private owners of lands from the commune with agricultural machinery; - Reduced diversification of economic activities carried out by the population of the commune; -Small number of SMEs with activities in the processing and recovery of food products; - Poorly represented antrepreneurial culture - The lack of a tourist infrastructure in the commune.
4. **Health and social assistance**	- Near Călărași municipality	-Low number of medical and sanitary staff, in relation to the number of inhabitants of the commune, which determines the limitation of their access to medical services; -Lack of adequate spaces for providing medical assistance; -Insufficient number of doctors specialty in the commune; -Increased risk of illness of the population as a result of non-compliance with the rules regarding sanitary protection zones.
5. **Education and culture**	-Adequate infrastructure for educational activities in the locality;	-Existence of an important segment of population with low educational level; -Lack of a modernized sports base; - The existence of some not modernized educational units .
6.**Transport** i**nfrastructure**	-Road DN 3B that ensures connection to Călăraşi and Feteşti localities ; - Carrying out some road rehabilitation a modernization projects at the level the commune; - The high degree of accessibility of the population to the means of transport with the connection to Călăraşi	- The existence of communal roads that requires modernization works; -Traffic congestion along DN 3B on the segment where it crosses the commune.

	municipality.	
7. **Social infrastructure and technical-sanitary equipping**	- The public lighting network in the commune; -Modern telephone station; - The existence of a project regarding location of an agrifood market in the commune. -Establishment of a thermal energy supply service in the commune.	-Existence of dwellings that require modernization and insufficienlty equipped with technical-sanitary equipment.
8. **Institutional infrastructure**	-Existence of a basic administrative infrastructure in the commune. -Existence of an informational system be public administration and citizens.	- Inadequate skills for investment planning or project preparation in local institutions; -Limited involvement of citizens and communities in decision-making at the local level; -Limited capacity and inadequate skills for the implementation, operation and maintenance of infrastructure in local institutions.
9. **Environment**	-Existence of water resources; -Existence of a public sanitation service taht serves the whole commune ; -Establishing sewerage network.	-The existence of agricultural areas with excess humidity in the commune; -Pollution of aquifer layers through the discharge of waste water and through the use of chemical fertilizers in agriculture; -The water table at a relatively shallow depth; - existence of areas with natural risk in common; -Faulty waste management.

Source: Processing according to analyzed Strategy of commne development, 2021- 2027 [18].

Studying the data contained in the budget of the analyzed municipality are presented in Figure 1.

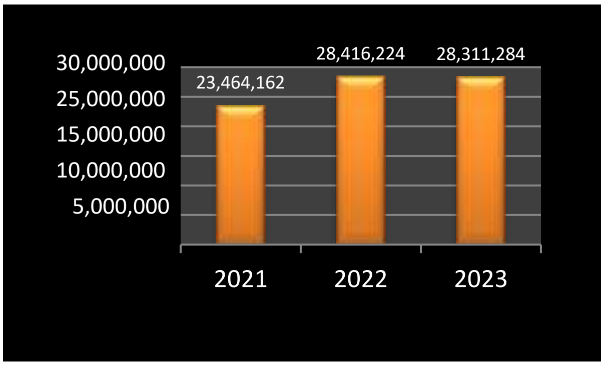

Fig. 1. Evolution of total revenue in the period 2021-2023 (RON)
Source: Processing to revenue and expenses budget of commune council [19].

From Figure 1, we notice that the total revenues (collected) of the local budget, increased during the analyzed period from 23,464,162 lei in 2021, when the restrictions imposed by the Covid-19 pandemic prevented the development of some economic activities that bring income to the local budget, to 28,416,224 lei in 2022, increasing by 21.10%, and then in 2023, to note a slight decrease of them by 0.04%. Analyzing the share of own revenues in total revenues at the level of the municipality's budget, from Table 2 and Figure 2, it can be seen that the self-financing capacity in the period 2021-2023 is quite fluctuating.

The capacity for financial autonomy is increasing in 2022 compared to the atypical year 2021, respectively, an increase of 62.15%, the share of these revenues in total revenues reaching 26.39%. In the year 2023 compared to the year 2022, however, a decrease of these revenues is recorded, with a percentage of 4.5%, although, taking into account the analyzed period, which from an economic and social point of view is not really representative, we can say that after 2021 the degree of self-financing increases. The evolution of own revenues is determined by the way in which the local authorities decide to realize them, having the freedom to dispose and the way in which they will be spent.

Table 2. Evolution of own revenue and share of total revenue, in the period 2021 – 2023 (RON)

Crt. No.	Year	Value	% in total income
1.	2021	4,625,187	19.71
2.	2022	7,499,940	26.39
3.	2023	7,162,446	25.30

Source: Budget of revenue and expenses of commune council [19].

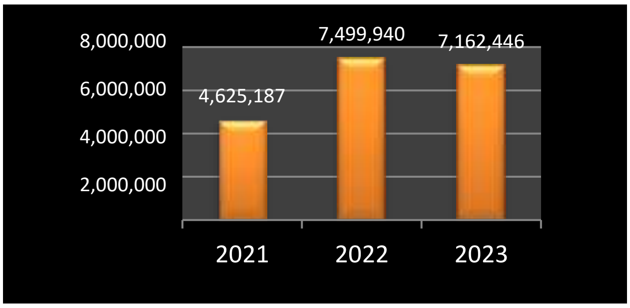

Fig. 2. Evolution of own revenue in the period 2021-2023 (RON)
Source: processing Budget of revenue and expenses of commune council [19].

Total revenues are made up of: current revenues, capital revenues, revenues with special purpose, respectively, revenues from financial operations and revenues from subsidies, as shown in Table 3.
It is noted that, during the entire analyzed period, the share in the structure of revenues is owned by current revenues, which increased from 13,475,217 lei in 2021, to 18,497,506 lei in 2023.
As a share in the structure of total revenues, it is between 57.43% at the level of 2021 and 65, 64% in the year 2022, with a slight setback in the year 2023. It should be noted that, for the entire analyzed period, the income from capital operations, respectively, from the capitalization of some assets of the public institution, remain constant, at the level of the value of 157,940 lei, with insignificant weights in total revenues, below 1%. A similar situation is recorded in the category of income from financial operations, respectively, receipts from the repayment of loans granted, which have values between 3,156,176.lei in 2021 and constant values in 2022 and 2023, of 3,709,768 lei. As a share in the structure of total revenues, it registers approximately 13%.
Subsidies have a weight between 5.52% in 2023 and 6.21% in 2021. It should be noted the category of revenues from subsidies received from the EU, which in 2021 have a weight of 22.23% in total revenues and about 16% in the years 2022-2023. Current revenues are made up of fiscal and non-fiscal revenues. The largest share of current revenues was achieved in 2022, in the amount of 17,952,000 lei, as shown in Table 4.
Fiscal revenues have the following composition: direct taxes and indirect taxes. From Table 4., and Figure 3., we can see the very high share of tax revenues in total current revenues, which exceeds 95% every year of the analyzed period.

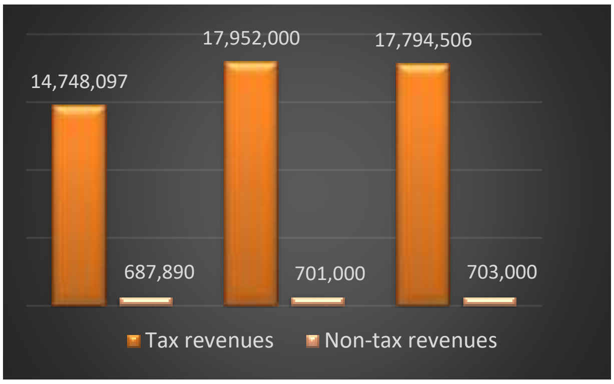

Fig. 3. Evolution and structure of current revenue (RON)
Source: processing Budget of revenue and expenses in the period 2021-2023 [19].

Direct taxes as revenues of local budgets are made up of: profit tax, taxes and fees from the population, tax for the use of state-owned land, tax on buildings and land from legal entities and other direct taxes.
Direct taxes, as a source of revenue for local budgets, have the largest share in the total tax revenue of these budgets.
The share of tax revenues is held by taxes collected from the sale of goods and the provision of services, with a percentage between 65.52% and 67.11% (Table 5).

Table 3. Evolution and structure of total revenue in the period 2021 – 2023 (RON)

Structure	2021	2022	2023	Share in total income %		
				2021	2022	2023
Current revenue	13,475,217	18,653,000	18,497,506	57.43	65.64	65.34
Revenue of capital	157,940	157,940	157,940	0.67	0.56	0.57
Financial operations	3,156,176	3,709,768	3,709,768	13.45	13.06	13.10
Subsidies	1,458,864	1,536,541	1,562,960	6.21	5.40	5.52
Subsidies received from EU	5,215,965	4,458,975	4,483,090	22.23	15.69	15.84
Total	23,464,162	28,416,224	28,311,264	100	100	100

Source: Budget of income and expenses of the commune, in the period 2021-2023 [19].

Table 4. Evolution and structure of current revenue in the period 2021 – 2023 (RON)

Structure	2021	2022	2023	Share of current income %		
				2021	2022	2023
Fiscal income	14,748,097	17,952,000	17,794,506	95.54	96.24	96.20
Non fiscal income	687,890	701,000	703,000	4.46	3.76	3.80
TOTAL	15,435,987	18,653,000	18,497,506	100	100	100

Source: Budget of revenue and expenses of the commune, in the period 2021-2023 [19].

Table 5. Evolution and structure of fiscal revenue in the period 2021 – 2023 (RON)

Structure	2021	2022	2023	Share of fiscal revenue %		
				2021	2022	2023
Tax on revenue, profit and gains of capital	3,124,560	4,342,000	4,004,506	21.18	24.19	22.50
Taxes and taxes on property	1,780,000	1,780,000	1,780,000	12.07	9.92	10.06
Taxes and taxes on goods ans services	9,787,537	11,762,000	11,942,000	66.20	65.52	67.11
Other taxes and fiscal taxes	56,000	68,000	68,000	0.55	0.37	0.33
TOTAL	14,748,097	17,952,000	17,794,506	100	100	100

Source: Budget of revenue and expenses of the commune, in the period 2021-2023 [19].

Table 6. Evolution and structure of non fiscal revenue in the period 2021 – 2023 (RON)

Structure	Year 2021	Year 2022	Year 2023	Share of non fiscal revenue %		
				2021	2022	2023
Revenue of property	216,560	233,000	233,000	35.05	33.24	33.14
Sales of goods and services	401,330	468,000	470,000	64.95	66.76	66.86
TOTAL	617,890	701,000	703,000	100		

Source: Budget of revenue and expenses of the commune, in the period 2021-2023 [19].

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From Table 5, we note that taxes and property taxes remain constant during the analyzed period, at the level of 1,780,000 lei, although as a share, they vary between 9.92% and 12.07%. We mention that the decision was made in the Council not to increase these taxes, in order not to burden the population, as a result of the socio-economic context that our country went through during this period, respectively, the Covid-19 pandemic and the economic crisis.

Taxes and taxes from the population. The share of these taxes from the population in the total revenue is more significant in the years 2021 and 2023, with an insignificant reduction in the year 2022, reaching 9.92%. As in the case of fiscal taxes, also in the structure of non-fiscal taxes, the share is held by the taxation of the activity of sales of goods and services, with a percentage between 64.95% and 66.86% for the entire analyzed period, as shown in Table 6 .

Table 7 is made up of the evolution of **indirect taxes**, which includes Value Added Tax, excise duties and customs duties. In the absence of proper forecasting and management, indirect taxes can have an extremely strong impact on the cash flow of a public institution. Given that indirect taxes expose all types of activities to significant risks, they require special attention and management.

Total expenses of the analyzed commune budget, have in the studied period the same trajectory as the budget revenues, in which they were totally incorporated, respectively, they increased from 23,464,162 lei in 2021, after the restrictions imposed by the Covid-19 pandemic prevented the carrying out of economic activities bringing income to the local budget, to 28,416,224 lei in 2022, increasing by 21.10%, and then in 2023, we note a slight decrease in them by 0.04%, as shown in the Figure 4.

Table 7. Evolution and share of indirect taxes in the period 2021-2023 (RON)

Crt. no.	year	Value	% of fiscal revenue
1.	2021	77,000	0.61
2.	2022	7,000	0.60
3.	2023	69,000	0.66

Source: Budget of revenue and expenses of the commune, in the period 2021-2023 [19].

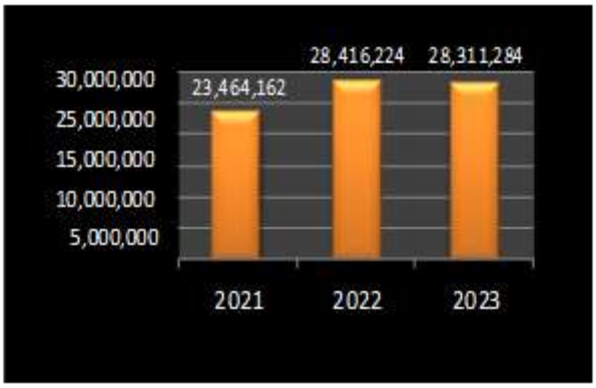

Fig. 4. Evolution of total expenses in the period 2021-2023 (RON)
Source: processing of Budget of revenue and expenses of the council [19].

Table 8. Evolution and structure of total expenses in the period 2021 – 2023 (RON)

Structure	Year 2021	Year 2022	Year 2023	Share in total expenses %		
				2021	2022	2023
General public services	5,125,890	4,988,807	5,000,807	21.85	17.56	17.66
Defense, public order and national safety	987,940	833,000	833,000	4.21	2.93	2.94
Social cultural expenses	12,825,322	16,667,897	16,504,113	54.66	58.66	58.30
Services and public development, dwellings, environment and water	1,867,000	1,956,195	2,023,019	7.96	6.88	7.15
Economic actions	2,658,950	3,950,325	3,950,325	11.32	13.97	13.95
Total	23,464,162	28,416,224	28,311,284	100		

Source: Budget of revenue and expenses of the commune, in the period 2021-2023 [19].

Table 9. Evolution and structure of social cultural expenses in the period 2021 – 2023 (RON)

Structure	Year 2021	Year 2022	Year 2023	Share in social cultural expenses %		
				2021	2022	2023
Education	7,886,000	8,599,222	8,425,438	61.49	51.56	51.05
Health	389,560	342,000	342,000	3.04	2.33	2.07
Culture, recreation and religion	1,342,000	2,369,635	2,369,635	10.46	14.21	14.35
Insurance and social assistance	3,207,762	5,367,040	5,367,040	25.01	31.9	32.53
Total	12,825,322	16,677,897	16,504,113	100		

Source: Budget of revenue and expenses of the commune, in the period 2021-2023 [19].

Table 10. Evolution and structure of current expenses in the period 2021– 2023 (RON)

Structure	Year 2021	Year 2022	Year 2023	Share of current expenses %		
				2021	2022	2023
Staff expenses	5,126,000	5,318,500	5,318,500	26.85	22.12	22.27
Goods and services expenses	3,987,000	4,124,159	4,139,059	20.88	17.15	17.33
Subsidies	599,173	599,173	599,173	3.14	2.49	2.51
Reserve funds	20,000	20,000	20,000	0.10	0.07	0.08
Transfers between public administration units	1,507,894	1,403,600	1,403,600	7.90	5.84	5.87
Social assistance	2,987,000	4,313,540	4,313,540	15.65	17.94	18.06
Non reimbursable financing	3,876,000	6,636,157	6,636,157	20.30	27.70	27.78
Other expenses	988,000	1,628,000	1,628,000	5.18	6.79	6.10
Total	19,091,067	24,043,129	23,884,845	100		

Source: Budget of revenue and expenses of the commune, in the period 2021-2023 [19].

As it results from the information presented in Table 8., in the structure of total expenses, the share is held by the category of **social and cultural expenses**, which registered an increase of 28.68% in 2023 compared to 2021, and as a share of the period, has percentages between 54.66% in 2021 and 58.3% in 2023, followed by the category of **expenses with general public services**, which, in the analyzed period, registered a share between 17.56% and 21.85%. **Defense, public order and national security expenses** have constant values in the last 2 analyzed years, with a decrease of approximately 18% compared to 2021, and as a share, they hold percentages between 2.93% and 4.21% in expenses annual totals. The same situation is recorded for the **expenses with economic actions**, which have constant values in the last 2 analyzed years, registering an increase compared to the year 2021, when, as a percentage, they were at the level of 11.32% of the total expenses, reaching the years 2022 and 2023 at a percentage of approx. 13.95% in total annual expenses.

Since the social-cultural expenses hold the share in the structure of the total expenses, next, as presented in table 9., the structure and share of each structure in the total of these expenses allocated from the Council budget are analyzed. Thus, we find that in the structure of these expenses, the share is held for the entire period by the expenses allocated to **education**, which comprise percentages between 51% and 61% in the analyzed period. It is a situation adapted to the period of the Covid-19 pandemic, when IT and office equipment were purchased for the online education process, which is why, in 2021, these expenses represented 61.49% from the total social-cultural expenses. In the analyzed period, **insurance and social assistance expenses** rank second in share, registering percentages between 25% and 32.53%. In

2021, an amount of 389,560 lei was assigned to **Health**, and in the years 2022 and 2023, constant amounts, at the level of the value of 342,000 lei, a decrease of about 13%. As for the expenditure segment "**Culture, recreation and religion**", 2,369,000 lei were spent in 2022 and 2023, 76.57% more than in 2021.

Table 10 presents the evolution and structure of current expenses, related to the period 2021-2023, within the budget of the analyzed council. We note that these increased in 2022 compared to 2021, by a percentage of 25.94%, with a slight setback in 2023 compared to 2022, by 0.07%. By expenditure category, the share is held differently in the years of the analyzed period, although as an absolute value, the reserve funds and subsidies register the same value for the three years analyzed. At the level of 2021, the share is held by staff expenses, with a percentage of 26.85%, followed by expenses with goods and services - 20.88% and by non-reimbursable financing, with 20.30%, this year, this category registering the lowest percentage of the period, as a result of the impossibility of implementing some activities under grant programs because of Covid-19 pandemic.

In the years 2022 and 2023, the share in the structure of current expenses is reversed between the first 2 categories of the year 2021, respectively, non-reimbursable financing holds the share with a percentage of about 27%, followed by staff expenses with a percentage of about 22%. Over the entire period, in last place, in terms of share, are the expenses for setting up the reserve fund, with shares of 0.07 to 0.10%.

CONCLUSIONS

Compliance with the principle of reality in budgetary practice requires the sizing of revenues and expenses entered in the revenue and expenses budget, so that the public entity does not have financial difficulties during the year, after the approval of the budget, under conditions considered normal from an economic-financial point of view for that understanding the political and social structure of a country requires understanding the budgetary process carried out in that country.

Local public administration authorities have complex responsibilities and competences, strating from the administration of public domain as well as the private domain of the locality, urban planning and territorial planning, infrastructure maintenance, provision of public services - water supply, sewage, purification, sanitation, public lighting, assistance social security, child protection, local public transport etc.

All these services are influenced by the capacity to generate and administer revenue efficiently (financial performance), and the quality of provided services infleunce the wellfare of the community members and have an effect on the economic development level.

Local public administration authorities have responsibilities in the budgetary process for the development and approval of local budgets in conditions of budgetary balance, as well as in establishing, ascertaining, controlling, tracking, and collecting local taxes and fees. Local governments play an important role in public finances and, to the extent that they are politically independent and financially accountable, they provide a basis for democratic market systems to have a greater chance of success.

Local administrations have many problems regarding the collection of taxes, the purposes of their expenditures and the methods of administration and promotion of economic development. Therefore, we can affirm the fact that local budgets have a very important role within the consolidated general budgets, as they occupy a constant position, which the states try to keep balanced, regardless of the periods crossed, but this aspect also depends a lot on the level of decentralization of the countries. The more decentralized a country is, the more important the role of local budgets is.

Studying the data contained in the budget of the analyzed commune, we notice that the total revenues of the local budget increased during the analyzed period from 23,464,162 lei in 2021, when the restrictions imposed by the Covid-19 pandemic prevented the development of economic activities bringing revenues to the budget locally, to 28,416,224 lei in 2022, increasing by 21.10%, and then in 2023, we note a slight decrease of them by 0.04%.

In the structure of total expenses, the share is held by the category of **social and cultural expenses**, which registered an increase of 28.68% in 2023 compared to 2021, and as a share of the period, it has percentages between 54.66% in 2021 and 58.3% in 2023, followed by the category of **expenses with general public services,** which, in the analyzed period, registered a share between 17.56% and 21.85%.

Although they have relatively small values in the structure of the council budget, in the absence of a proper forecast and management, indirect taxes can have an extremely strong impact on the treasury flow of the public institution. Given that indirect taxes expose all types of activities to significant risks, they require special attention and management. Although investments were made in the area of education, it is necessary to continue them, because the formation of human capital is the most important in a community. It is also very important to continue investing in the health sector, where there is a large shortage of staff as a result of the non-allocation of adequate spaces by the mayor office. At the same time, we appreciate the fact that the representatives of the local public authority are concerned with attracting European funds to the community and implemented projects with European funding, which supported the community, the socio-economic development of rural communities also depends on these funds.

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SEASONAL FLUCTUATIONS IN TOMATO PRICES AND THEIR CORRELATION WITH EXPORT PRICES: THE CASE OF TÜRKİYE

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Abstract

Tomatoes are emphasized as an important agricultural product both globally and in Türkiye; this product has a large domestic market and export volume. This study examines the seasonal fluctuations and price trends of tomatoes using data from the Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate. The results revealed that tomato prices in Türkiye exhibit significant seasonal changes throughout the year, with prices generally being high in the first months and low during the summer months. Additionally, despite a decrease in Türkiye's tomato export volume from 2018 to 2022, export values increased, and unit prices rose. The correlation analysis of export prices identified relationships between Türkiye and other tomato-producing countries, showing that these relationships have significant impacts on price dynamics and trade strategies. The study emphasizes the importance of continuous monitoring and strategic planning to adapt to changes in agricultural conditions and market demands.

Key words**:** *price analysis, tomatoes, export, Türkiye*

INTRODUCTION

Vegetable cultivation, as a sub-sector of agriculture, is directly related to nutrition. It is also an important sector it supplies raw materials to the vegetable processing industry and makes a positive contribution to the national economy through foreign trade [7].
After potatoes, tomatoes are the second most important vegetable worldwide and are among the most widely produced vegetables globally [23, 26]. Tomato production is of great importance not only for domestic consumption but also for export. Bashimov [6] stated that tomatoes hold a significant place in global agricultural trade. Tomato exports make substantial contributions to countries' economies and are crucial to trade balances and foreign exchange earnings. Additionally, as a major agricultural export, it supports economic development in rural areas. According to the 2016-2021 average, tomatoes ranked first in vegetable production in Türkiye, with a 50.57% share [21]. In terms of tomato production, Türkiye ranks third in the world [14] and eighth in terms of tomato exports [22].

Considering the importance and economic contribution of tomatoes to global agricultural trade, analysing prices and examining seasonal fluctuations are crucial. Price transmission for perishable products like tomatoes is expected to exhibit seasonal variations, especially in low-income countries [3]. Factors affecting agricultural product prices include farmers' production decisions, market conditions, unique characteristics of agriculture (numerous risks and uncertainties, climate conditions, diseases and pests, regional differences), and fluctuations in product supply [27].
In products significantly affected by seasonal changes, such as tomatoes, accurate analysis of price changes plays a critical role in strategic planning for producers and exporters. Calculating seasonal indices is an important tool for understanding how tomato prices change during specific periods. Al-Hiyali [2] emphasizes that neutralizing changes and seasonal effects in tomato prices is crucial for making more reliable forecasts, thereby playing a significant role in future planning. In this context, studies conducted in various countries contribute to a better understanding

of seasonal fluctuations in tomato prices and the economic impacts caused by such fluctuations.

Previous studies have identified price analysis studies on tomatoes [1, 2, 4, 11, 13, 15, 17, 24] and various other products in Türkiye and other countries. Erdal [13] examined how tomato production in Türkiye affects prices using the Koyck model. The study found that changes in tomato prices have a significant and diminishing effect on production over time. Mani et al. [24], in their study conducted in Nigeria, analysed seasonal fluctuations in tomato and ginger prices. They found that tomatoes had higher fluctuations than ginger. Areef et al. [4] analysed seasonal fluctuations in the prices of tomatoes, onions and potatoes in Indian markets using the moving average method with data collected over 15 years. According to the study results, the highest seasonal price indices were observed in November for tomatoes (169.23), in October for onions (141.65), and in November for potatoes (132.08). Al-Hiyali [2] analysed the seasonal fluctuations in the prices of tomatoes in Baghdad, Iraq, between 2014 and 2019 using simple averages. The study concludes that tomato prices are significantly affected by seasonal changes and decrease during the hot seasons because of high storage costs.

This study aims to analyse the trends and dynamics of tomato prices in Türkiye between 2010 and 2023. This study highlights the importance of tomatoes as a major agricultural product both globally and in Türkiye, emphasizing production and export volumes. Additionally, the study aims to reveal the correlation between export prices among leading tomato export countries.

MATERIALS AND METHODS

In this study, product prices were examined using data from the Statistics Department of the Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate [20]. The Producer Price Index (PPI, 2003=100) from the Turkish Statistical Institute was used to adjust prices to real values [29]. This study details the monthly prices of tomatoes from 2010 to 2023. Simple indices were created to compare price series, and simple ratios, trend ratios, and moving ratios were used to evaluate seasonal fluctuations in prices [19]. Additionally, to determine the relationships between the tomato export prices of leading countries, correlations among these prices were analysed using Pearson's correlation coefficient.

RESULTS AND DISCUSSIONS

Tomatoes in Türkiye and the World

Table 1 shows changes in tomato cultivation areas worldwide and their distribution among different countries between 2000 and 2022. Worldwide, tomato’ areas production increased from 3.847.943 hectares in 2000 to 4.917.735 hectares in 2022, representing a 28.09% increase.

As of 2022, China accounted for 23.22% of the global tomato production area. India holds a 17.14% share of the global total. Türkiye reduced its production area from 208,410 hectares in 2000 to 158,719 hectares in 2022, representing a 23.84% decrease, with Türkiye's share of the global total at 3.23% as of 2022. The United States reduced its production area from 168,509 hectares in 2000 to 106,757 hectares in 2022, showing a 36.65% decrease and a global share of 2.17%. Nigeria increased its production area from 210,000 hectares in 2000 to 702,275 hectares in 2022, representing a significant 234.42% increase. Nigeria's share of the world's total tomato cultivation area is 14.28%.

Egypt, Italy, Mexico, Brazil, and Spain have also experienced various changes in production areas. While countries like China and India have significantly increased their production areas, there have been decreases in some countries, such as Türkiye, the United States, and Italy. These changes can be attributed to shifts in global agricultural production dynamics and differences in countries’ agricultural policies.

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Table 1. World tomato production area (hectares)

	2000	2010	2020	2021	2022	2022 share (%)	Index (2000=100)
China	674,355	951,735	1,108,002	1,115,035	1,141,663	23.22	169.30
India	460,000	634,400	818,000	845,000	843,000	17.14	183.26
Türkiye	208,410	179,125	174,437	165,204	158,719	3.23	76.16
USA	168,509	158,720	110,440	108,821	106,757	2.17	63.35
Egypt	195,444	216,385	159,668	149,956	143,618	2.92	73.48
Italy	137,155	118,822	99,780	102,060	97,610	1.98	71.17
Mexico	124,575	98,189	84,926	90,306	90,696	1.84	72.80
Brazil	56,720	67,892	52,006	51,908	54,502	1.11	96.09
Nigeria	210,000	272,950	766,445	809,602	702,275	14.28	334.42
Spain	62,285	59,267	55,470	56,110	45,150	0.92	72.49
Others	1,550,490	1,703,019	1,535,773	1,552,594	1,533,745	31.19	95.26
World	3,847,943	4,460,504	4,964,947	5,046,596	4,917,735	100.00	128.09

Source: Own calculation from FAOSTAT data [14].

Table 2 shows changes in global tomato production quantities and their distribution among countries between 2000 and 2022. The global tomato production quantity increased from 109.29 million tons in 2000 to 186.11 million tons in 2022, representing a 70.28% increase. China increased its production from 22,325 thousand tons in 2000 to 68,341 thousand tons in 2022, representing an increase by 206.12%. As of 2022, China accounted for 36.72% of global tomato production. Türkiye increased its production from 8.89 million tons in 2000 to 13 million tons in 2022—a 46.23% increase. Türkiye's global share was 6.99%. Due to climate conditions and soil characteristics, tomatoes are among the most produced, consumed, and traded important products in Türkiye [5, 16, 32]. Tomato production in Türkiye is carried out in open fields and greenhouses. Especially in recent years, tomato production has become widespread in the highland regions to meet the demands of consumers in the summer months [18]. Nigeria stands out for its high production quantity growth rate. Nigeria increased its production from 1.26 million tons in 2000 to 3.68 million tons in 2022, representing an increase of 192.15%. Among major tomato-producing countries, China, India, and Nigeria have experienced significant growth in tomato production, whereas other major countries have seen decreases in production. Due to the increasing population, decreasing arable land area, and generally low-quality soil, China has prioritised the use of more modern technologies in agricultural production since 2013 [31]. Yuan and Zhang [33] noted that Chinese producers use a significant amount of chemical fertilizers and pesticides in vegetable production, which may explain the increase in China’s tomato production. Dastagiri et al. [10] stated that India is the world’s largest fruit and vegetable market.

Table 2. World tomato production quantity (1,000 tons)

	2000	2010	2020	2021	2022	2022 share (%)	Index (2000=100)
China	22,325	46,876	64,839	67,637	68,341	36.72	306.12
India	7,430	12,433	20,550	21,181	20,694	11.12	278.52
Türkiye	8,890	10,052	13,204	13,095	13,000	6.99	146.23
USA	12,622	14,053	10,939	10,475	10,199	5.48	80.80
Egypt	6,786	8,545	6,494	6,246	6,275	3.37	92.47
Italy	7,538	6,025	6,248	6,645	6,136	3.30	81.40
Mexico	2,666	2,998	4,137	4,149	4,207	2.26	157.80
Brazil	3,005	4,107	3,754	3,679	3,809	2.05	126.76
Nigeria	1,261	1,800	3,689	3,576	3,684	1.98	292.15
Spain	3,766	4,313	4,313	4,754	3,651	1.96	96.95
Others	33,005	42,337	46,620	47,696	46,106	24.77	139.69
World	109,294	153,539	184,786	189,134	186,108	100.0	170.28

Source: Own calculation from FAOSTAT data [14].

Table 3 shows changes in tomato yields (tons/hectare) worldwide and their distribution among different countries between 2000 and 2022. Accordingly, global tomato yield increased from 28.43 tons/hectare in 2000 to 37.84 tons/hectare in 2022. This trend indicates an overall upward trend, with a 33.10% increase in the yield index. Yield increases have been observed in China, India, the USA, Egypt, Italy, Mexico, Brazil, Spain, and Türkiye compared with 2000, whereas Nigeria experienced a 12.61% decrease in tomato yield. Although there is currently an increase in tomato production in India compared with 2000, it is noteworthy that India's average yield is significantly lower than the world average. Murthy et al. [25] found that most inputs used by tomato producers in India were below the recommended doses. This indicates that output, production, and productivity could be increased by applying more inputs. Türkiye increased its yield from 42.66 tons/hectare in 2000 to 81.91 tons/hectare in 2022, representing a 92.01% increase.

This table presents significant increases in tomato yields and highlights that some countries have substantially improved their productivity during this period. Countries like Türkiye, the United States, Mexico, and Spain have significantly increased their productivity, whereas countries like Nigeria have experienced yield declines. These changes can be attributed to differences in agricultural technologies, cultivation techniques, and agricultural policies among countries. Low productivity in agriculture is mainly due to farmers not fully utilizing available technologies, which leads to reduced production efficiency [25].

Table 3. World tomato yield (tons per hectare)

	2000	2010	2020	2021	2022	Average Yield Index[1]	Index (2000=100)
China	33.11	49.25	58.46	59.73	59.86	158.18	180.82
India	16.15	19.60	25.12	25.07	24.55	64.87	151.98
Türkiye	42.66	56.12	75.70	79.27	81.91	216.43	192.01
USA	74.91	88.54	99.05	95.89	95.54	252.46	127.55
Egypt	34.72	39.49	40.67	42.61	43.70	115.46	125.85
Italy	54.96	50.70	62.62	65.11	62.87	166.12	114.38
Mexico	21.40	30.53	48.72	45.95	46.40	122.60	216.77
Brazil	52.98	60.49	72.24	70.88	69.91	184.72	131.96
Nigeria	6.00	6.59	4.42	4.30	5.25	13.86	87.39
Spain	60.47	72.77	77.75	84.73	80.88	213.73	133.76
World	28.43	34.49	37.31	37.51	37.84	100.00	133.10

Source: Own calculation from FAOSTAT data [14].

[1]The 2022 global average tomato production yield is indexed.

Van Rijswick [30] stated that the high perishability of vegetables is directly related to factors such as growing conditions (climate, water availability), production costs, exchange rates, and trade agreements, which can determine the direction of the vegetable trade. In this context, easy market access is critically important for countries producing vegetables for export. Türkiye is one of the world's leading tomato producers and exporters. In the 1970s, Türkiye exported almost no tomatoes, but by the 1980s, it had become a significant exporter. Since the 1990s, the country's exports have doubled or tripled [9]. Table 4 shows the main export markets for Türkiye's tomato exports in terms of quantity and value and the changes in these markets. Türkiye's total tomato export quantity decreased from 530,087 tons in 2018 to 520,179 tons in 2022. In contrast, tomato exports increased from $289.83 million in 2018 to $373.59 million in 2022. This indicates that the unit value of exported tomatoes has increased. Türkiye's main export markets are Syria, Ukraine, Romania, Bulgaria, Israel, and Russia. Exports to Syria increased from 8.19% to 18.58%. Syria does not appear in the export value table, that exports to Syria are generally low. There was an increase in both quantity and value of exports to Ukraine, Romania, Bulgaria, and Israel, whereas exports to Russia decreased in both quantity and value. In countries like Germany and Poland, export increases were observed in terms of both quantity and value. Germany's share increased from 1.09% to 4.52% in quantity and from 2.01% to 8.82% in value. Poland's share increased from 3.18% to 4.26% in quantity and from 5.56% to 7.42% in value.

In conclusion, countries such as Syria, Ukraine, Romania, Bulgaria, and Israel have emerged as the main markets for Türkiye's tomato exports (Figure 1). These countries have shown increases in both quantity and value. While there was a decrease in the quantity of Russia's exports, there was also a decrease in value. Tomato trade between Türkiye and Syria began in 2012 and began in 2013 with Israel. Initially, tomato trade between Türkiye and Russia was high. However, since 2020, this market has shifted toward Syria [5]. This shift may be due to strengthened trade relations with Syria, Türkiye offering more competitive prices and conditions in the Syrian market, or political or economic tensions in trade with Russia. Exports to new markets, such as Germany and Poland, have increased in both quantity and value. Accordingly, it is observed that there have been market diversification and strategic changes in Türkiye's tomato exports, with increases in some markets and decreases in others. Fidan and Tanrıvermiş [16] stated that approaches toward environmentally friendly tomato cultivation should be developed to increase Türkiye's export volume share within the total production volume.

Table 4. Countries where Türkiye exports tomato

EXPORT QUANTITY AND SHARE (1,000 TONS)										
	2018	%	2019	%	2020	%	2021	%	2022	%
Syria	43,422	8.19	55,480	10.37	80,329	15.48	129,544	21.01	96,625	18.58
Ukraine	52,801	9.96	63,449	11.86	68,095	13.12	92,644	15.03	68,842	13.23
Romania	45,974	8.67	38,783	7.25	56,587	10.91	61,854	10.03	56,070	10.78
Bulgaria	23,601	4.45	32,257	6.03	38,282	7.38	51,803	8.40	47,601	9.15
Israel	28,061	5.29	38,984	7.29	41,237	7.95	34,250	5.55	46,270	8.90
Russia	36,865	6.95	96,800	18.10	68,517	13.20	77,966	12.65	36,244	6.97
Germany	5,790	1.09	6,858	1.28	9,170	1.77	16,576	2.69	23,503	4.52
Poland	16,880	3.18	7,399	1.38	10,116	1.95	18,835	3.05	22,144	4.26
Georgia	40,228	7.59	16,853	3.15	15,676	3.02	19,079	3.09	19,547	3.76
Netherlands	7,507	1.42	5,273	0.99	5,353	1.03	8,962	1.45	15,339	2.95
Others	228,958	43.19	172,642	32.28	125,529	24.19	105,054	17.04	87,994	16.92
TOTAL	530,087	100.00	534,778	100.00	518,891	100.00	616,567	100.00	520,179	100.00
EXPORT VALUE AND SHARE (1,000 DOLLARS)										
	2018	%	2019	%	2020	%	2021	%	2022	%
Romania	43,650	15.06	36,304	11.98	50,100	16.06	57,870	16.05	64,810	17.35
Ukraine	25,302	8.73	29,736	9.81	36,286	11.63	39,989	11.09	44,669	11.96
Bulgaria	20,547	7.09	23,852	7.87	28,625	9.17	40,564	11.25	37,537	10.05
Israel	18,791	6.48	23,954	7.90	24,700	7.92	21,765	6.04	35,689	9.55
Russia	30,454	10.51	85,456	28.20	61,564	19.73	67,414	18.70	33,470	8.96
Germany	5,831	2.01	6,968	2.30	9,538	3.06	16,915	4.69	32,947	8.82
Poland	16,121	5.56	7,106	2.34	9,583	3.07	16,778	4.65	27,725	7.42
Netherlands	7,174	2.48	4,295	1.42	4,822	1.55	7,903	2.19	19,392	5.19
Moldova	6,903	2.38	8,042	2.65	8,126	2.60	8,906	2.47	10,380	2.78
Belarus	24,210	8.35	7,333	2.42	11,672	3.74	10,508	2.91	7,378	1.97
Others	90,848	31.35	70,013	23.10	67,016	21.48	71,877	19.94	59,594	15.95
TOTAL	289,831	100	303,059	100	312,032	100	360,489	100	373,591	100

Source: Own calculation from TRADEMAP data [28].

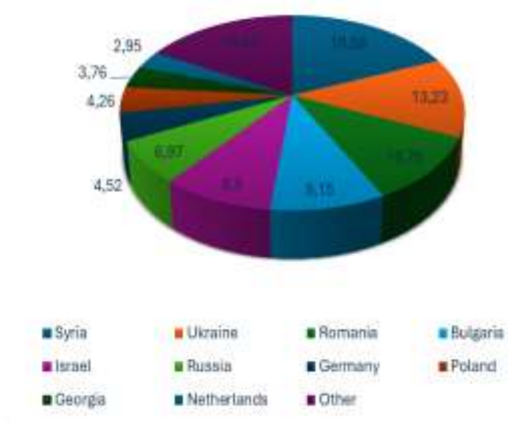

Fig. 1. Countries where Türkiye exports tomato
Source: Own calculation from TRADEMAP data [29].

Table 5 presents monthly average real prices, standard deviations, coefficients of variation, and seasonal indices of tomato prices from 2010 to 2023. The data in the table are expressed in TRY/ton and are evaluated separately for each month. Accordingly, the highest average prices were observed in April (1,358.51 TRY/ton), February (1,336.46 TRY/ton), and January (1,315.46 TRY/ton). The lowest average prices were seen in August (880.39 TRY/ton) and June (895.32 TRY/ton). This indicates that tomato prices are higher in the first months of the year and in autumn and lower in the summer. The highest standard deviations were observed in April and May, indicating more price fluctuations during these months. The lowest standard deviations were in September and February, indicating that prices were more stable during these months. The highest coefficients of variation were found in July and August, indicating that prices were more variable than average during these months. The lowest coefficients of variation were observed in February and March, that prices were less variable during these months. Looking at the seasonal index values, the highest seasonal indices were identified in February (118) and April (119), indicating that prices were above the annual average in these months. The lowest seasonal indices were recorded in August (77) and June (79), showing that prices were below the annual average during these months. Akpınar and Gül [1] reported that tomato prices in Adana province during the years 1988-1995 were below the seasonal average in May, June, July, August, September, and October. They noted that the real price of tomatoes reached its highest value in December and lowest value in September, and prices began to decline starting in May when the product supply began to increase. They also stated that, for the period studied, prices in March were more stable than those in other months. Demirtaş and Erkan [11] analysed the wholesale prices and seasonal fluctuations of tomatoes, the leading vegetable type in Mersin province in terms of production area, quantity, and number of producers over 10 years. They found that between 1988 and 1997, the relationship between tomato prices and agricultural input prices developed unfavourably for tomato prices in nominal terms, while the general trend of real tomato prices showed an upward direction, although not significantly, except in 1993 and 1994. They determined that real tomato prices experienced significant seasonal fluctuations, reaching their highest values in February and March and their lowest values in September. According to seasonal fluctuations and coefficients of variation, they suggested that March is the most suitable period for a product to be marketed. In a study examining the price developments of tomatoes and other important vegetables using data from 1999 to 2013 in Türkiye, it was also found that the real price of tomatoes reached its highest value in April. It was recommended to producers that the most suitable period for marketing tomatoes is from March to April [17].

In conclusion, tomato prices exhibit significant seasonal fluctuations throughout the year. Prices are generally higher in spring and winter, but they tend to be lower in summer. Additionally, the standard deviation and coefficients of variation indicate that price fluctuations are more pronounced in certain months. These data provide important information for producers and sellers in price forecasting and strategic planning.

Table 5. Seasonal index of tomato prices during the 2010–2023 production period

	Arithmetic Mean (TRY, ton)	Standard deviation	Coefficient of variation	Seasonal index
January	1,315.46	178.94	13.60	116
February	1,336.46	152.45	11.41	118
March	1,297.63	173.87	13.40	114
April	1,358.51	292.23	21.51	119
May	1,125.23	286.40	25.45	99
June	895.32	188.30	21.03	79
July	952.68	245.33	25.75	84
August	880.39	226.18	25.69	77
September	939.57	134.30	14.29	83
October	1,193.69	186.12	15.59	105
November	1,158.98	194.32	16.77	102
December	1,188.70	273.96	23.05	105

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Table 6 shows changes and volatility in tomato prices in Türkiye between 2010 and 2023. During the 2010-2014 period, tomato real prices per ton ranged from 261.92 TRY to 1,592.33 TRY. The average real price during this period was 1,052.05 TRY, with volatility at its highest level of 36.82%. This period was characterised by significant price fluctuations. In the 2015-2019 period, the maximum price was 1,948.97 TRY, the minimum price was 756.21 TRY, the average price was 1,238.68 TRY, and the volatility was reduced by 18.56%. During this period, prices followed a more stable trend. In the 2020-2023 period, prices ranged from 720.28 TRY to 1,563.30 TRY, with an average price of 1,115.67 TRY and the lowest volatility at 15.77%. Overall, between 2010 and 2023, the average price was 1,136.88 TRY, with a volatility of 25.85%. These data indicate that tomato prices have become more stable over time, with decreased volatility in recent years. The highest maximum price reached during the 2015-2019 period may be attributed to the effects of economic changes. The general increase in average prices points to an increase in the market value or production costs of tomatoes. In their study examining the price movements of tomato products, Bozdemir et al. [8] stated that brokerage activities did not affect prices, whereas markets had an impact on increasing costs, and the new wholesale market law could lead to increased costs.

Table 6. Changes and volatility in tomato real prices in Türkiye between 2010 and 2023

	Maximum (TRY, ton)	Minimum (TRY, ton)	Average (TRY, ton)	Volatile
2010-2014	1,592.33	261.92	1,052.05	36.82%
2015-2019	1,948.97	756.21	1,238.68	18.56%
2020-2023	1,563.30	720.28	1,115.67	15.77%
2010-2023	1,948.97	261.92	1,136.88	25.85%

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Table 7 shows the average real prices per ton of tomatoes in Türkiye from 2010 to 2023 and price indices calculated based on 2010. In 2010, the average tomato price was 850.5 TRY, which was 31% to 1,114.8 TRY in 2011. In 2012 and 2013, prices remained relatively stable. In 2015, prices rose significantly to 1,198.8 TRY. This increase peaked in 2017, with the average tomato price being 1,293.8 TRY.

Table 7. Average prices of tomatoes in Türkiye

	Average (TRY, ton)	Index (2010=100)
2010	850.5	100
2011	1,114.8	131
2012	1,110.2	131
2013	1,082.6	127
2014	1,102.2	130
2015	1,198.8	141
2016	1,150.7	135
2017	1,293.8	152
2018	1,159.5	136
2019	1,390.6	164
2020	1,277.2	150
2021	1,133.9	133
2022	1,050.7	124
2023	1,000.8	118

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

In 2020, average prices were 1,277.2 TRY, followed by a decrease in 2021 and 2022. By 2023, the average price was 1,000.8 TRY, representing an 18% increase over 2010.

These data indicate that tomato prices fluctuated between 2010 and 2023 and experienced significant changes over the years due to various factors.

Table 8 compares seasonal indices using three different methods: simple average, moving average, and trend analysis. Seasonal indices show how a value observed during a specific period changes relative to the annual average. It is generally found that prices are higher in January, February, March, and April and lower in May, June, July, and August. September and October are periods when prices start rising again. This indicates that tomato prices are high in the early months of the year and fall and low in the summer. Another study analysed the seasonal fluctuations of tomato prices in Indian markets and observed the highest seasonal price index in November (169.23) [4]. Mani et al. [23] found high fluctuations in tomato prices in their study in Nigeria. A study conducted in Baghdad, Iraq, between 2014 and 2019 found that tomato prices were significantly affected by seasonal changes and declined during the hot seasons [2].

Table 8. Seasonal indices of tomato prices calculated by different methods

	Seasonal index with simple average	Seasonal index with a moving average	Seasonal index with rate on trend
January	116	112	116
February	118	116	118
March	114	117	115
April	119	111	120
May	99	99	99
June	79	87	79
July	84	80	84
August	77	81	77
September	83	88	83
October	105	97	105
November	102	104	102
December	105	107	104

Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data[20].

Figure 2 shows monthly tomato prices (TRY/ton) from January 2010 to January 2023. The equation of the trend line is y=0.02194x+199.78240. The R-squared value

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was very low at 0.014380. This indicates that the trend line explains only 1.44% of the variance in monthly tomato prices. Therefore, most price changes are due to factors other than time. Figure 2 illustrates significant fluctuations in tomato prices throughout the period. A previous study found that the cobweb theorem is valid in the Turkish tomato market and that price fluctuations lead to supply-demand imbalances [12]. Accordingly, producers make their production decisions based on previous year's prices, which leads to price fluctuations and imbalances.

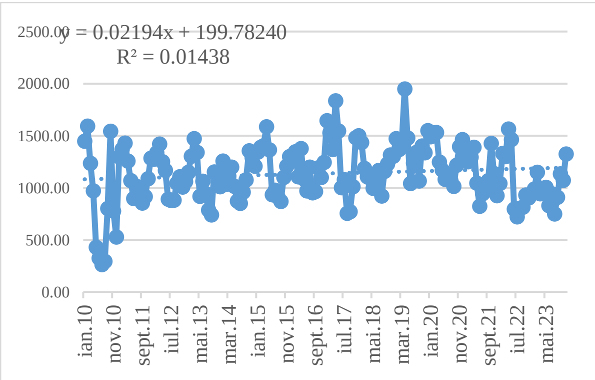

Fig. 2. Trend analysis of monthly tomato prices
Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Figure 3 shows monthly percentage changes in tomato prices from January 2010 to December 2023. In particular, at the beginning of 2010, very high fluctuations in tomato prices were observed. However, after this period, the fluctuations became less pronounced. In the following years, especially from 2011 onwards, price changes occurred more steadily and in smaller proportions. This indicates that the tomato market has become more balanced over time, and large price fluctuations have decreased.

Table 9 shows the correlation between tomato export prices in different countries. Using the Pearson correlation coefficient, price relationships between countries were analyzed.

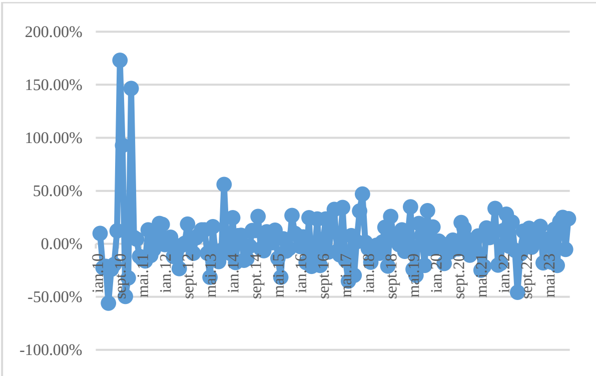

Fig. 3. Monthly changes in tomato prices
Source: Own calculation from Istanbul Metropolitan Municipality Wholesale Fruit and Vegetable Market Directorate Statistics data [20].

Accordingly, a strong negative correlation between Türkiye and Spain (r=−0.705, p<0.01), indicating that the tomato export prices of these two countries tend to move in opposite directions. On the other hand, a strong positive correlation between Türkiye and Iran (r=0.660, p<0.05), indicating that prices tend to move similarly between these countries.

Table 9. Correlations among tomato export prices of leading exporting countries

	Mexico	**Netherlands**	**Morocco**	**Spain**	**Türkiye**	**Iran**	**World**
Mexico	1	0.216	0.578*	0.369	-0.102	-.0388	0.593*
Netherlands	0.216	1	0.640*	0.894**	-0.105	-0.550	0.777**
Morocco	0.578*	0.640*	1	0.632*	-0.487	-0.844	0.650*
Spain	0.369	0.894**	0.632*	1	0.079	-0.449	0.931**
Türkiye	-0.102	-0.105	-0.487	0.079	1	0.660*	0.178
Iran	-.0388	-0.550	-0.844	-0.449	0.660*	1	-0.361
World	0.593*	0.777**	0.650*	0.931**	0.178	-0.361	1

Source: Own calculation from FAOSTAT data [14].
**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Regarding the correlation coefficients between other countries, a strong positive relationship was found between the Netherlands and Spain (r=0.894, p<0.01). This indicates that tomato prices in these countries increase or decrease. Conversely, a strong negative relationship between Iran and Morocco (r=−0.844, p<0.01), indicating that their prices move in opposite directions.

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Looking at countries with correlations to world prices, Spain shows a strong parallel with global price movements, with a high positive linear relationship (0.931, $p<0.01$). Such correlations can provide important insights that can be considered in countries' export strategies.

CONCLUSIONS

This study analyses the trends and dynamics of tomato prices in Türkiye from 2010 to 2023. The importance of tomatoes as a significant agricultural product, both globally and within Türkiye, is highlighted by substantial production and export volumes.

Export data from 2018 to 2022 indicate that although Türkiye's tomato export volume slightly decreased, the value of these exports increased, and the unit price of exported tomatoes rose. Türkiye's primary tomato markets include Syria, Ukraine, Romania, Bulgaria, Israel, and Russia.

Despite a decrease in tomato cultivation in Türkiye from 2000 to 2022, production volumes increased by 46.23%, indicating productivity improvements. Additionally, tomato yields in Türkiye almost doubled during this period, reflecting advances in agricultural practices and technology. The study also revealed distinct seasonal fluctuations in tomato prices, with the highest prices observed in the early months of the year and the lowest prices during the summer months. The analysis of monthly tomato prices from 2010 to 2023 reveals significant fluctuations, particularly in the early years of the period. However, over time, price fluctuations became more stable, and a balance was achieved in the market.

The study analyses the relationships between tomato export prices in prominent exporting countries from 2010 to 2023 using correlation coefficients. This analysis provides valuable information on the export strategies of these countries. Key findings include a negative correlation between Türkiye and Spain, a positive correlation between Türkiye and Iran, a positive relationship between the Netherlands and Spain, and a negative relationship between Iran and Morocco. Additionally, Spain's tomato prices demonstrated a high degree of parallelism with global price movements. These findings offer important insights that can shape the price dynamics and trade strategies of leading tomato exporting countries.

In conclusion, this study revealed the dynamic nature of tomato production and pricing both globally and within Türkiye. This underscores the importance of continuous monitoring and adaptation to changes in agricultural conditions, market demands, and economic policies.

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ANALYSIS OF PERFORMANCE CHARACTERISTICS OF BROILER FARMS IN TÜRKİYE USING MULTIDIMENSIONAL SCALING (MDS) METHODS

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Abstract

Poultry farming is an important sector in terms of meeting the need for animal protein for human health, realizing production in a short time and converting feed into meat in the best way. In this study, it was aimed to analyze the performance characteristics of broiler farms in Turkey. The main material of the study consists of data obtained from face-to-face interviews with 139 producers for the production period of 2022. Multidimensional Scaling (MDS) analysis was used to determine the similarities and differences between farms in terms of performance characteristics. The following variables were used in the analysis: duration of training, experience in broiler rearing, production period, mortality rate, chick entry weight, live weight, number of veterinary visits and feed intake per chick. The farms were divided into three groups according to their capacities and analyzed. According to the results of the research, it was determined that the similarities and differences changed as the size of the farms changed. Since there is a close relationship between education level and breeding experience and live weight of broiler chickens, it is thought that extension activities should be increased for producers on broiler breeding. In addition, a heterogeneous structure emerged due to the difference between the chick weights given by the companies among the farm size groups. For this reason, it is thought that producers should form an agricultural organization that will enable them to be strong in the face of the companies they contract with.

Key words: *Broilers, performance characteristics, Multidimensional analysis, Türkiye*

INTRODUCTION

It is important for producers and consumers to increase the production of broiler meat due to its high nutritional value, the best use of a small area, fast production process, efficient feed use and low-cost advantages [2].

Broiler production is also increasing in the world thanks to the increasing population, changing consumer preferences and technological developments in production [12].

As of 2022, there are 26 billion chickens in the world, while Turkey ranks 11th in the world with a share of 1.4% and 361 million chickens. Chicken meat production, which has an important share in the white meat group, has entered a continuous and rapid increasing trend in the world since 1960, and chicken meat production was realized as 124 million tons in 2022. In the same period, Turkey ranked 9th in the world with 2.42 million tons of chicken meat production [10].

In Turkey, the production activity of the sector started in the 1970s, mostly in the form of small family farming, and with the structural changes in the 1980s, the integration process was started and contracted production was started. In addition, the implementation of the "Resource Utilization Support Fund", which entered into force in 1986, pioneered large-scale investments. In the 1990s, the number of modern facilities and production capacity increased rapidly with new investments in the sector [6, 16].

In the 2000s, investments continued and production at European standards became widespread. Today, the poultry sector is an important production branch that can make its own production planning and meet a large part of the country's animal protein requirement. With its current technological infrastructure, the sector produces at European

Union (EU) standards and is in a position to compete. In Turkey, poultry farming has a distinct and important place among other animal production industries because it provides cheap, healthy and high-quality animal protein, facilitates R&D studies in breeding and nutrition, and contributes to rural development. The sector also contributes to the development of feed industry, production of tools and equipment such as cages, drinkers and feeders, vaccine and pharmaceutical industry and food industry [21].

There are many studies in the literature (Yeni [26], Tandogan [22], İkikat Tümer et al. [12], Cimrin [5], Yeni and Dagdemir [27], Karaman et al. [15], Sarica [20]) in which the current situation and problems of broiler farms are revealed. However, the use of the MDS analysis method in animal husbandry is limited and there are no studies based on original data in broiler breeding.

Dogan [8] analyzed the growth traits of lambs belonging to two breeds raised in Eastern and Central Anatolia Region according to birth type and sex variables by MDS. Celik [4] analyzed the similarities and differences of livestock breeding in 81 provinces with MDS based on the number of animals by species. Gevrekci et al. [11] analyzed the structural characteristics of sheep breeding in 11 provinces in the Western Anatolia Region with MDS analysis according to seven variables. Mastrangelo [17] tried to reveal similar and different aspects of endangered sheep breeds with MDS analysis. Adanacıoglu [1] made a comparison of the goat breeding economy in Turkey according to regions with MDS according to five different variables. Kandemir et al. [14] revealed the similarities and differences of some regions in Turkey in terms of live sheep and mutton prices with MDS analysis. Fabbri [9] made a clear distinction between breeds with clusters related to production purposes with population structure and genetic differences, principal components and multidimensional scaling analyses.

Deri et al. [7] in their MDS analysis of the situation of animal husbandry in rural Izmir province according to four variables; similarities and differences were revealed in the neighborhoods in rural Bornova, and neighborhoods with advantages in terms of animal husbandry were determined.

The performance status of broiler farms in Türkiye was evaluated by MDS analysis according to eight variables (training period, broiler experience, production period, mortality rate, chick entry weight, live weight, number of veterinary examinations and feed consumption per chicken). In this study, it is aimed to reveal the similarities and differences in the performance characteristics of farms according to farms size groups. Similarities and differences according to the variables at hand were examined by visualizing them on a coordinate plane with MDS analysis.

MATERIALS AND METHODS

Materials

According to TSI [24] data, the regions selected as the research area account for 57.12% of Türkiye's total meat chicken presence. It can therefore be said that the research area has the qualifications to represent the farms that are engaged in meat chicken farming in Türkiye.

The Neyman Method is a layered sampling method used to determine the number of samples to be applied to the survey [25]. The number of samples is calculated using equation number 1.

$$n = \frac{(\sum \mathrm{Nh\ Sh})^2}{\mathrm{N}^2\ \mathrm{D}^2 + \sum \mathrm{Nh\ Sh}^2} \qquad \text{............ (1)}$$

In the formula: n: sample size, N: population size, Nh: h. The number of units in the layer, Sh: h. The standard deviation of the layer Sh^2: h. shows the variance of the layer, D: d / z d : the amount of error permitted from the main mass average, (%5 deviation from the average) z : the value of the permitted safety limit in the distribution table (%2.58 for the 99% confidence limit).

The number of samples to represent the main audience using equation 1 has been calculated as 139. Farms to be surveyed were randomly selected. Since the number of meat chickens own vary, it has been decided that to bring the population to a homogeneous state, meat poultry should be examined in layers. The farms that are engaged in chicken breeding are divided into three layers according to the distribution of frequency, taking into account the number of chickens. Equation 2 was used in the distribution of operations to layers [25].

$$n_h = \frac{N_h S_h}{\sum N_h S_h} * n \qquad ....(2)$$

In the formula; nh: represents the number of specimens selected for each layer, n: the total number of samples.

According to equation 2, farms with 0-15,000 chickens (37 farms) are classified as group I, farms having 15,001-30,000 chicks (65 farms), group II, 30,001 and more chicks (36 farms) as group III.

Methods

Multidimensional Dimensional Scaling (MDS) is included in classification and grouping analyses [23;18] MDS n is a method that aims to obtain the representation of objects in a k-dimensional (k<p) space based on the distances determined by the p variable between individual objects (individual-observation) or units, thereby determining the relationships between objects. The general objective of MDS analysis is to reveal the structure of objects as close to their original shape, using distance values, with as few dimensions as possible [19; 26]. In MDS, the stress value is calculated to indicate the difference between a multi-dimensional (p-dimension) real shape and a shape cut in k-dimensial space. So, the measure that measures the compatibility between the original distances and the display distances is called a stress measure. The stress value for non-metric scaling is as below. It is desirable that the stress value should be close to zero [13; 23].

Considering the performance characteristics of the broiler breeding farms, MDS analysis was applied separately in each group and explained with a graphical representation. Euclidean distance was used for similarity/distance calculations during MDS analysis. Z-value conversion method was used to standardize the data. Stress values were also interpreted to examine the fit after MDS analysis (Table 1).

Table 1. Stress values and compatibility

Stress value	Compatibility
>0.2	Incompatible notation
0.1<stress value<0.2	Low compliance
0.05<stress value<0.1	Good compliance
0.025<stress value<0.05	Perfect compliance
0.000<stress value<0.025	Exact compliance

Source: Borg and Groenen (2005) [3].

RESULTS AND DISCUSSIONS

General Information on Broiler Farms in Türkiye

The average age of poultry farmers was 47.87 years, and the average age for small farmers in group 1 (48.18) was relatively higher than for other farms groups.

The educational levels of farmers in poultry farming were estimated at an average of 8.31 years, and the educational level was higher for those in group 3 (10.28). On average, farmers had 21.33 years of experience in agriculture, and farms in group 3 (22.86) had higher experience in farming than other farm groups.

The average broiler breeding experience of the producers was determined to be 16.63 years. When analyzed according to the farming groups, it was determined that the broiler breeding experience decreased as the farming group increased.

The average mortality rate of the farms throughout the year was found to be 4.40%. No significant difference was observed between farm size groups. Accordingly, the average mortality rate of the farms in the first group was calculated at 4.20%, in the second group at 4.67%, and in the third group at 4.29%.

According to the farm groups, chick entry weights were between 40.46 g and 40.64 g, and the general average was 40.51 g.

When producers looked at the population of households, they found an average of 3.31 people, and the group of with the highest household population was found to be in Group 3 (3.75).

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When looking at receiving meat chicken training, it was found that 51.08% of farmers received training from the Ministry of Agriculture and Forestry or from the integrated facilities to which they are affiliated. Again, farms in Group 3 (66.67) have a higher percentage than other farms groups. It has been determined that all undertakings have a record of their production activities as they are subject to contractual production (Table 2).

Table 2. General information about broiler producers and farms in Türkiye

	Farm groups			Average
	I. Group	II. Group	III. Group	
Age (years)	48.18	47.83	47.61	47.94
Education (years)	7.53	8.51	10.28	8.31
Agricultural experience (year)	21.68	20.75	22.86	21.33
Broiler experience (year)	17.45	16.22	15.62	16.63
Production time (day/period)	42.79	42.49	42.78	42.63
Mortality rate (%)	4.20	4.67	4.29	4.40
Chick weight (gr/chick)	40.46	40.52	40.64	40.51
Live weight (kg/broiler)	2.65	2.58	2.60	2.61
Number of meetings with the veterinarian	18.36	24.60	31.94	21.48
Feed consumption (kg/broiler)	4.40	4.19	4.18	4.27
Family population (person/family)	3.24	3.11	3.75	3.22
Receiving education (%)	50.00	43.08	66.67	51.08
Record keeping (%)	100.00	100.00	100.00	100.00
Non broiler farm (%)	26.32	36.92	58.33	39.57

Source: Own calculation.

Table 3 is considered, a negative correlation coefficient of 0.504 was calculated between the level of education of the producers and their experience in broiler breeding, and it is seen that while one of the characteristics increases, the other decreases. This is due to the fact that people with higher education level start broiler farming at an older age and have less experience.

The degree of this decrease is also statistically significant (p<0.01). There was a positive correlation between the number of meetings with the veterinarian during the one-year production period and the level of education.

Table 3. Correlation coefficients of variables

Pearson correlation	**Education (year)**	**Experience (year)**	**Production time (day/ period)**	**Mortality rate (%)**	**Chick weight (gr/chick)**	**Live weight (gr/ broiler)**	**Number of meetings with the veterinarian**	**Feed consumption (kg/ broiler)**
Education (year)	1	-0.504**	-0.095	0.119	-0.014	0.035	0.231**	-0.102
Experience (year)	-0.504**	1	0.107	-0.019	0.005	-0.043	-0.014	-0.017
Production time (day/period)	-0.095	0.107	1	-0.034	0.214*	0.312**	-0.016	0.107
Mortality rate (%)	0.119	-0.019	-0.034	1	0.182	-0.191*	0.003	-0.182*
Chick weight (gr/chick)	-0.014	0.005	0.214	0.182	1	0.062	0.041	0.022
Live weight (kg/broiler)	0.035	-0.043	0.312**	-0.191*	0.062	1	-0.005	0.686**
Number of meetings with the veterinarian	0.231**	-0.014	-0.016	0.003	0.041	-0.005	1	-0.310
Feed consumption (kg/broiler	-0.102	-0.017	0.107	-0.182*	0.022	0.686**	-0.310	1

**: p<0.01, *:p<0.05
Source: Own calculation.

The correlation coefficient of the relationship was calculated as 0.231 and it was determined that when one of the characteristics increased, the other also increased. There has been a statistically significant increase in this amount ($p<0.05$). The live weight of a chicken that was ready for sale and the amount of time it took to produce it were found to have a positive linear connection. The relationship's correlation coefficient was 0.312, which was statistically significant ($p<0.01$). The correlation coefficients of the association between the mortality rate, live weight, and feed consumption were found to be 0.191 and 0.182, respectively, and were statistically significant ($p<0.05$). The relationship was found to be negative. Additionally, feed consumption and live weight features showed a positive linear association, with a degree of 0.686 and statistical significance ($p<0.01$) discovered in the relationship.

Analysis of Performance Characteristics of Broiler Farms in Turkey by Multidimensional Scaling Method

When the coordinate values in Table 4 obtained as a result of the MDS analysis in terms of the traits in the broiler holdings in Group 1 and Figure 1, which shows the two-dimensional graph, it is seen that mortality rate, chick entry weight and live weight, education level and feed consumption traits are close to each other in terms of dimension 1. These first two traits (chick entry weight and mortality rate) were more distant from the other three traits (live weight, education level and feed consumption).

Table 4. Coordinates of 1st group broiler farms calculated in terms of characteristics

Characteristics	Dimension 1	Dimension 2
Education (year)	0.477	0.065
Experience (year)	-0.306	-0.477
Production time (day/period)	-0.592	0.526
Mortality rate (%)	-0.590	-0.150
Chick weight (gr/chick)	-0.678	0.152
Live weight (kg/broiler)	0.700	0.318
Number of meetings with the veterinarian	0.233	-0.488
Feed consumption (kg/broiler)	0.756	0.053

Source: Own results.

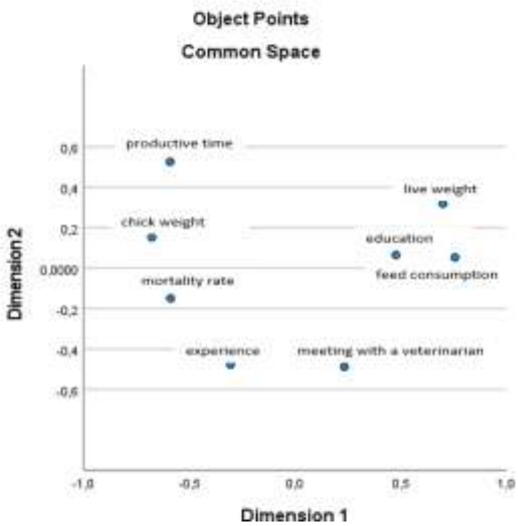

Fig. 1. Coordinates of 1st group broiler farms calculated in terms of traits
Source: Own results.

In terms of Dimension 2, the characteristics of production period and the characteristics of broiler farming experience and number of meetings with the veterinarian can be interpreted as distant from each other.

It was found that the mortality rate, live weight, and feed consumption characteristics were further apart in terms of dimension 1 when Table 5 and Figure 2, which include the coordinate values obtained as a result of the MDS analysis in terms of the characteristics of the broiler farms in the second group, were examined. It was determined that the production period and the number of consultations with the veterinarian were closer to each other. In terms of dimension 2, it is seen that the two most distant traits are feed consumption and education.

Table 5. Coordinates of 2nd group broiler farms calculated in terms of characteristics

Characteristics	Dimension 1	Dimension 2
Education (year)	0.675	-0.648
Experience (year)	-0.438	0.371
Production time (day/period)	-0.121	0.059
Mortality rate (%)	-0.873	-0.107
Chick weight (gr/chick)	-0.175	-0.519
Live weight (kg/broiler)	0.674	0.177
Number of meetings with the veterinarian	-0.205	0.006
Feed consumption (kg/broiler)	0.462	0.660

Source: Own results.

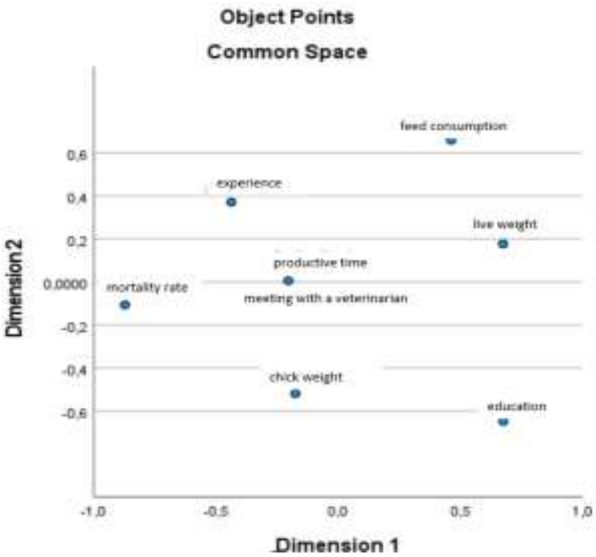

Fig. 2. Coordinates of 2nd group broiler farms calculated in terms of traits
Source: Own results.

When Figure 3 and Table 6, which include the two-dimensional graphs obtained as a result of the MDS analysis in terms of the characteristics of the broiler farms in Group 3, it was found that in terms of dimension 1, the characteristics of broiler experience and production time, live weight and feed consumption, and live weight and breeding experience were close to each other. It was determined that the number of meetings with the veterinarian and chick entry weight characteristics were farther away from the other characteristics.

Table 6. Coordinates of 3 rd group broiler farms calculated in terms of Characteristics

Characteristics	Dimension 1	Dimension 2
Education (year)	0.677	0.569
Experience (year)	-0.455	-0.212
Production time (day/period)	-0.276	-0.441
Mortality rate (%)	0.101	0.451
Chick weight (gr/chick)	0.664	-0.203
Live weight (kg/broiler)	-0.679	0.052
Number of meetings with the veterinarian	0.542	-0.541
Feed consumption (kg/broiler)	-0.574	0.324

Source: Own results.

In terms of Dimension 2, education level and number of meetings with the veterinarian were found to be far from each other. The reason for this is that the producers in this group have higher education levels and they employ veterinarians or veterinary technicians in their farms, so if they encounter any problems, they can solve the problems themselves without consulting the veterinarians of the contracted farms.

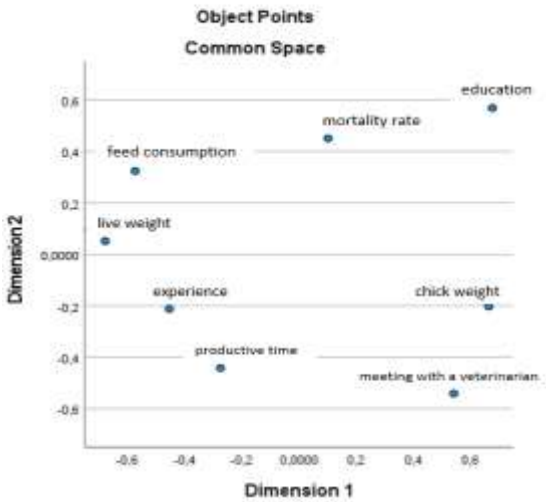

Fig. 3. Coordinates of 3rd group broiler farms calculated in terms of traits
Source: Own results.

CONCLUSIONS

It was determined that the average age of the farmers engaged in broiler breeding activities in Türkiye was 48 years, their education level was 8.31 years, and their broiler breeding experience was 16.63 years. The average mortality rate of the farms throughout the year was found to be 4.40%. According to the average of all farms, the average live weight of broiler chick entry weight was 40.51 g and the average live weight of broiler chick ready for sale was 2.61 kg. It was found that farmers and veterinarians met an average of 22 times a year to discuss matters pertaining to broiler breeding. It was found that the broiler chicks consumed 4.27 kg of feed on average.

It was determined that all the farms kept records because of contracted production, but approximately half of them (51.08%) received training on broiler breeding.

In group 1 broiler breeding farms, mortality rate, chick entry weight and live weight, education level and feed consumption are close to each other in terms of dimension 1. These first two traits (chick entry weight and mortality rate) are more distant than the other three traits (live weight, education level and feed consumption). In terms of dimension 2, the characteristics of production period, broiler breeding experience and number of meetings with veterinarians were found to be distant from each other. In group 2, according to the results of MDS analysis in terms of the characteristics of broiler farms, it was determined that mortality rate, live weight and feed consumption characteristics were more distant from each other in terms of dimension 1. Production time and number of veterinary consultations were found to be closer to each other. In terms of dimension 2, it was seen that the two most distant characteristics were feed consumption and education, while education level and live weight characteristics were very close to each other. In the 3rd group, broiler experience and production period, live weight and feed consumption, live weight and breeding experience were found to be close to each other in terms of size 1. It was found that the chick entry weight and the number of veterinarian meetings were more disassociated from the other characteristics. The number of meetings with veterinarians and education level were shown to be dissimilar in Dimension 2.

As a result of this study, it was determined that similarities and differences in terms of characteristics changed as the size of the farms changed.

As expected, live weight and feed consumption were found to be close to each other in all 3 farming groups. In the 1st and 2nd group farmers, the level of education and live weight characteristics were found to be close, while in the 3rd group farms, the experience of the producers in broiler breeding and live weight characteristics were found to be close. Accordingly, it is thought that studies should be carried out to increase the extension activities related to broiler breeding to producers.

It was determined that the mortality rates and live weight characteristics of the chicks obtained from the contracted companies from which the farms procured chicks differed due to the inhomogeneity in terms of entry weights. When these results are evaluated, it is thought that an effective and strong agricultural organization should be established to defend their rights in order to act more fairly between contracted firms and farmers.

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THE IMPACT OF COVID ON TOURISM AT THE EUROPEAN UNION LEVEL AS AN ELEMENT OF FINANCIAL RISK

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Abstract

Tourism holds significant importance due to its multifaceted nature, encompassing economic, social, cultural, educational, and political dimensions. It plays a vital role in supporting and boosting a country's economy, motivating those who have been traveling for a long time and are doing it more frequently. Globally, the COVID-19 pandemic's quick and widespread spread has had a big impact, particularly on the travel and tourist industry. People's ability to travel plays a crucial role in the growth of this industry, which is why the strict measures implemented by authorities to curb the virus greatly hindered tourism's progress. This article aimed to explore the impact of the COVID-19 global pandemic on the tourism industry, highlighting the importance and sensitivity of crisis situations in this sector. The research methodology involved analyzing internal and international databases, calculating, analyzing, and interpreting statistical indicators regarding tourism flow. The findings of this study indicate that, by 2023, tourism demand had reached nearly 96% of the levels observed in 2021-2022. This demonstrates a remarkable recovery for the EU overall, with certain countries, such as Belgium, Germany, France, Italy, and Ireland, even surpassing their pre-pandemic levels.

Key words: *Covid-19 pandemic, tourism, tourist arrivals, overnight stays, accommodation occupancy rate, EU*

INTRODUCTION

Tourism plays an important role in the economy by generating income, creating jobs, stimulating investment in infrastructure and promoting regional development, thus contributing to economic growth and diversification of a country's income sources [7].

The COVID-19 pandemic has had a significant impact on the tourism industry, at the global level and especially in the EU countries as the industry was closely tied to people's ability to travel [2, 6, 9, 11]. For this reason, the restrictions imposed by authorities to stop the spread of the virus severely hindered the tourism industry.

In 2020, the United Nations World Tourism Organization reported widespread travel restrictions in most destinations worldwide. Affected by this, the tourism industry suffered more than other industries.

In December 2019, the first cases (41 infected individuals) of a previously unknown respiratory illness appeared in the Wuhan region of China [5], particularly at a market known for trading live animals.

The recently discovered coronavirus was officially named SARS-CoV-2, and the resulting disease is called COVID-19. The acronym "COVID" stands for "Coronavirus Disease," while "19" represents the year it was identified [12]. Hubei Province, where approximately 80% of confirmed cases were reported, continues to serve as the epicenter of this outbreak. It is noteworthy that the global tourism industry has faced widespread crises in the past. The September 11 terrorist attacks (2001), the Severe Acute Respiratory Syndrome (SARS) outbreak (2003), the global economic crisis of 2008/2009, and the Middle East Respiratory Syndrome (MERS) were among the main disruptive events that occurred between 2000 and 2015. This demonstrates how adaptable the tourist industry is to outside shocks, but there is strong indication that the COVID-19 pandemic will have an extraordinary impact and recovery [10]. The COVID-19 epidemic substantially impacted the amount of travelers worldwide and had a major impact on how the international tourism business evolved. The global outbreak of the 2019 pandemic led to substantial transformations within the industry.

Travel restrictions and measures were implemented by governments worldwide in response to international tourism [8]. The enforcement of social distancing measures led to the temporary closure of popular tourist sites and a significant decrease in the number of tourists.

Restrictions put in place to stop the infection's spread are already having a significant negative impact on tourist areas whose economies rely significantly on tourism. For instance, the drop in tourism cost Egypt $50 billion in just six months.

In this regard, the paper's goal is to investigate how the COVID-19 worldwide epidemic has affected traveler arrivals, revenues, accommodation units and their occupancy rate highlighting the importance and sensitivity of crisis situations in this economic sector.

MATERIALS AND METHODS

The research methodology was focused on the indicators characterizing the pandemic's impact on international tourism.

These included tourist arrivals and overnight stays in accommodation establishments.

Additionally, the number of accommodation units and their occupancy rates were also considered. Spending per trip was also emphasized reflecting the changes in tourist options for the duration of stay.

To observe the effects of the pandemic, empirical data from the World Tourism Organization (UNWTO) and Eurostat data base on Tourism were used.

The analysis of the tourism sector is segmented into two distinct time intervals: the pre-COVID period (2021-2022) and the post-COVID period (2023). Comparison method allow to quantify the differences among various EU members states.

Ultimately, this allows for observing the pandemic's consequences and the influence of potential crises on the global tourism industry.

Following a visual representation of the researched indicators' level, a comparison between the pre-Covid and post-Covid pandemic was made.

RESULTS AND DISCUSSIONS

The case study made it possible to provide a thorough examination of how travel agencies handled the extraordinary circumstances of the COVID-19 epidemic on a global scale.

Table 1. Global COVID-19 Case Situation

The number of COVID-19 cases recorded in the 28 days leading up to October 6, 2024
increased by 322,343 + 63,728 over the previous 28 days
COVID-19-Related Deaths Reported
4,591 - 1,295 less over the previous 28 days
13.64 billion COVID-19 vaccine doses were administered in total
Total Doses of the COVID-19 Vaccine Given

Source: own processing [13].

Number of arrivals in accommodation establishments in the pre and post-pandemic years

The number of arrivals at lodging facilities in different nations prior to the COVID-19 pandemic's start is clearly seen in Figure 1. A general upward trend can be seen when comparing statistics from 2021 and 2022, with an increase in arrivals at the majority of the EU destinations listed. Among these, Germany and France, the most prominent on the chart, confirm their status as leaders in European tourism, both countries recording impressive visitor numbers. Germany and Italy also demonstrate their attractiveness, with a strong tourist presence and a significant number of arrivals.

On the other hand, countries like Luxembourg and Malta maintain a lower profile, with relatively stable figures between the compared years, suggesting a steady but less intense tourist flow. Overall, the chart reflects a flourishing tourism industry in pre-pandemic Europe, with high hopes and expectations for the future of tourism during those times.

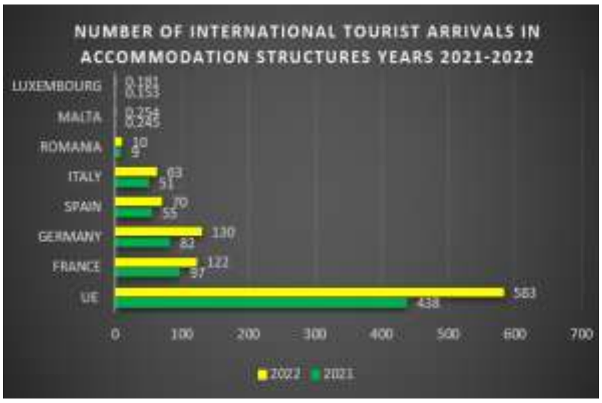

Fig. 1. Change in the Number of Foreign Visitors to Tourist Accommodations in the EU and a Few Selected Countries in 2022 Compared to 2021 (million)
Source: own processing [4].

Figure 2 presents arrivals in tourist accommodation establishments by country in the post-pandemic period, with data for the year 2023. Examining the profound impact of the pandemic in the past, the well-known worldwide travel restrictions and, as a result, the closing of borders are reflected in the sharp decline in arrivals in all represented nations.

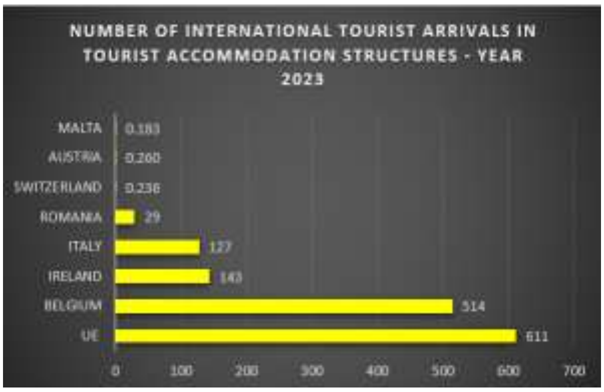

Fig. 2. Changes in the quantity of foreign visitors staying at lodging facilities (million)
Source: own processing [4].

The year 2023 indicates a recovery in the tourism industry, with a noticeable increase in arrivals compared to the previous year.
Similar changes were noticed in other EU countries like Bulgaria and Romania [1, 3, 14].
This upward trend is expected to continue into the next year, 2024, although no data is currently available to analyze this further. This is an encouraging sign that tourism is beginning to stabilize and recover from the shock of the pandemic.

As observed, the EU recorded a total of 611 million international tourist arrivals, with the highest numbers recorded in countries like Belgium, with 514 million international tourist arrivals, and Ireland, with 143 million international tourist arrivals. In contrast, the lowest figures were registered in Malta, with 1.83 million international tourist arrivals, and Switzerland, with 2.36 million international tourist arrivals.

Spending per trip in the pre and post-pandemic years

Comparatively, Figure 3 illustrates the average spending per trip in various countries for the years 2021 and 2022, providing insight into tourist expenditures prior to the impact of the COVID-19 pandemic.
In 2022, almost all countries show an increase in spending per trip compared to the previous year. Luxembourg stands out with the highest spending per trip in both years, closely followed by Austria and Norway. At the other end of the spectrum, Turkey and Albania have the lowest spending per trip. The general increase in 2022 suggests a positive trend in the European tourism industry pre-pandemic.

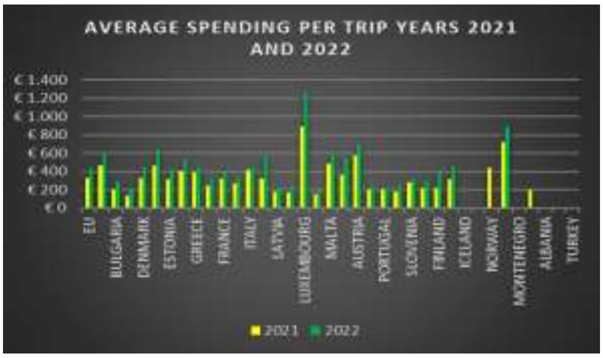

Fig. 3. Pre-Pandemic Average Spending per Trip in 2021 and 2022 (Euro per trip)
Source: own processing [4].

For the post-pandemic period, which includes 2023, Figure 4 displays the progression of the average expenditure per trip in the same nations as shown in the pre-pandemic picture.
Reflecting the direct impact of the COVID-19 pandemic, a continuous increase in spending is observed in 2023, with clear signs of recovery.
Luxembourg again stands out with considerable amounts spent per trip, suggesting that the tourism industry is

gradually recovering and adapting to new post-pandemic conditions.

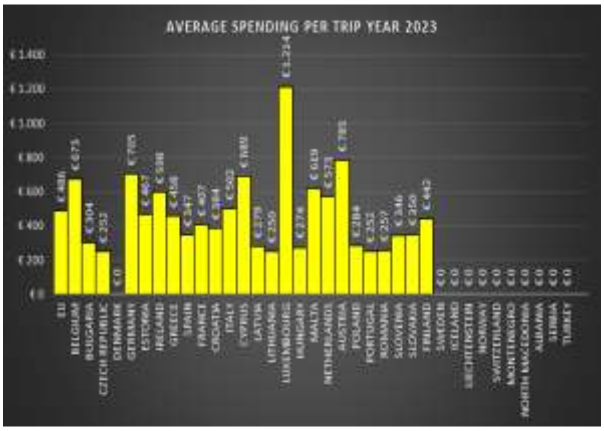

Fig. 4. Analysis of Post-Trip Spending per trip (Euro per trip) in 2023
Source: own processing [4].

Number of accommodation units in the pre-and post- pandemic period

Figure 5 compares the number of tourist accommodation establishments available in various European countries before the pandemic, over two consecutive years: 2021 and 2022.

It can be observed that Italy, Croatia, and France lead the rankings with a remarkable number of accommodation units, with significant peaks in 2022, highlighting their popularity as top tourist destinations in Europe.

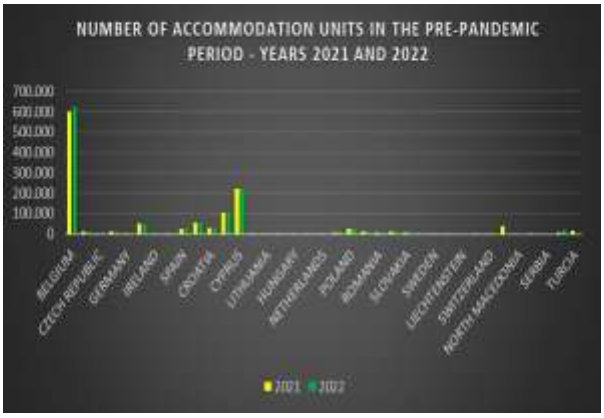

Fig. 5. Evolution of the number of tourist accommodation units in 2021-2022
Source: own processing [4].

On the other hand, countries like Liechtenstein and Albania show much smaller numbers, reflecting a more limited accommodation capacity. The general trend in these countries indicates stable growth or consistent maintenance in the number of accommodation units from year to year, suggesting a relatively stable market and possibly careful planning to accommodate tourist flows before the onset of the global pandemic.

The chart provides insight into the accommodation infrastructure, useful for analyzing the industry's preparedness for tourism demand in the pre-pandemic period.

An overview of the shifts in the quantity of accessible visitor lodging options throughout many European nations, illustrating the consequences of the COVID-19 pandemic in 2023, is given in Figure 6.

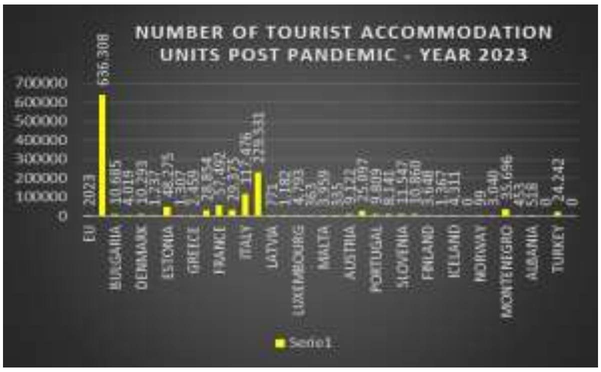

Fig. 6. Changes in the quantity of lodging units for tourists in 2023
Source: own processing [4].

After a noticeable decline in the last years of the COVID-19 pandemic, attributed to the impact of travel restrictions and closures, a partial recovery can be observed in 2023.

In 2023, data shows a continuation of this recovery trend, with numbers suggesting a possible rebound in the tourist accommodation sector.

Italy and Croatia remain at the forefront with a large number of accommodation units in 2022, indicating a capacity for recovery and adaptation to the new conditions.

In contrast, other countries, such as Liechtenstein and North Macedonia, show relatively constant values over the three years, due to a more limited tourist accommodation supply.

Unemployment rate level in the pre and post-pandemic years

Figure 7 compares the unemployment rates from the years 2021 and 2022 for a selection of European countries.

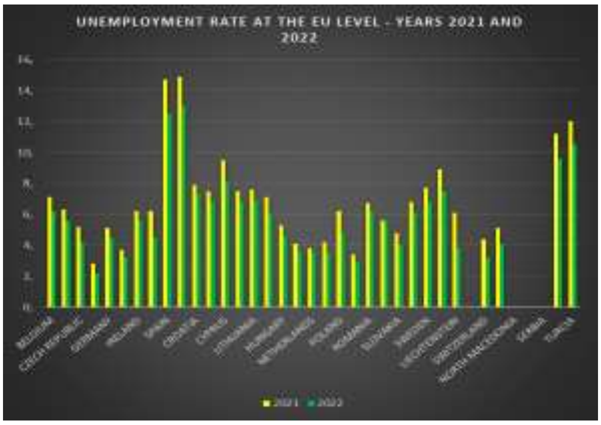

Fig. 7. Unemployment Rate Level Before the Pandemic in 2021 and 2022 (%)
Source: own processing [4].

Spain shows the highest unemployment rates during this period, with a slight downward trend from year to year, while countries such as Germany and Switzerland exhibit relatively low and stable unemployment values.

Thus, the graph indicates economic and social variations among these countries before the global economic impact of the pandemic.

In Figure 8, the unemployment rates for the year 2023 are presented. A general recovery of the post-pandemic labor market can be observed, with unemployment rates decreasing in most countries as economies adapt and begin the recovery process after the initial shock of the pandemic.

For example, countries that had a high unemployment rate during the pre-pandemic period, such as Greece and Spain, appear to be experiencing a decline in this post-pandemic period, signaling a possible recovery of jobs.

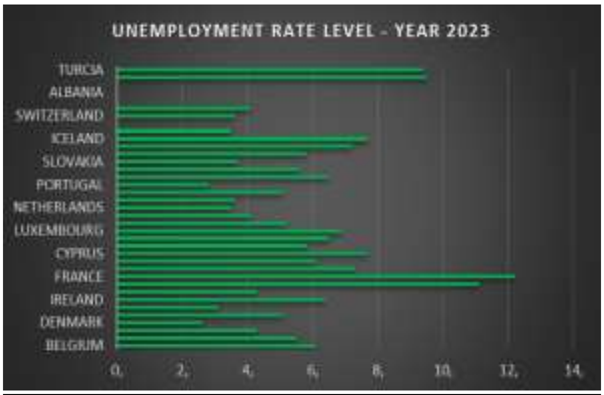

Fig. 8. Unemployment Rate Level Post-Pandemic in 2023 (%)
Source: own processing [4].

This graph indicates the adaptability and resilience of European labor markets in the face of an unprecedented global crisis.

Number of overnight stays in the pre and post pandemic years at the EU Level

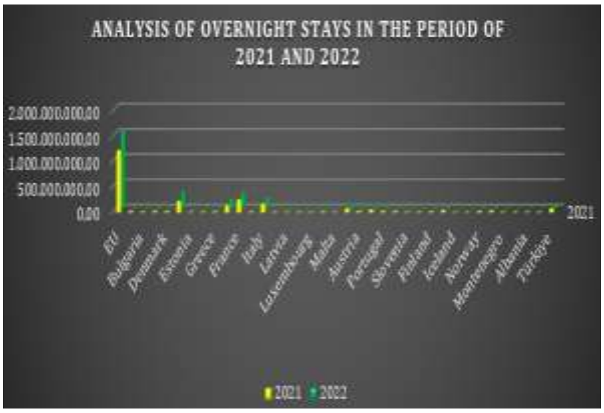

Fig. 9. Analysis of the Number of Overnight Stays in the years 2021 and 2022
Source: own processing [4].

Figure 9 compares the total number of nights spent by tourists in various European countries during the years 2021 and 2022.

It is clear that France, Germany, and Italy are the most popular destinations, with a significantly higher number of nights spent by tourists compared to other countries, especially in 2022. Italy also stands out with a large figure, underscoring the status of these countries as some of the main European tourist destinations. In contrast, countries like Liechtenstein and North Macedonia show a much lower number of nights spent, reflecting a more modest tourist flow. The data indicate a vibrant tourism industry in these countries during the pre-pandemic period, with Germany, France, and Italy clearly leading in tourist preferences.

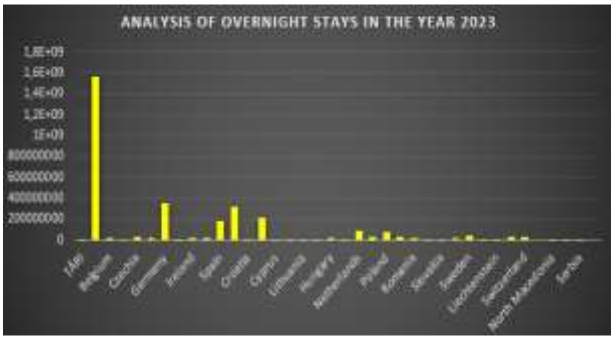

Fig. 10. Evolution of the Number of Overnight Stays in 2023 (million)
Source: own processing [4].

Figure 10 shows the number of nights spent by tourists in different European countries for the year 2023.

The year 2023 continues this upward trend, suggesting an even stronger recovery of the tourism industry. Despite the recovery, the number of nights spent has not yet returned to pre-pandemic levels, which may indicate ongoing caution in travel behavior or lasting changes in the tourism industry. However, it is important to also note the significant differences between countries.

Net occupancy rate index in the pre and post pandemic years

Fig. 11. Analysis of the Net Occupancy Rate Index for Accommodation from 2021 to 2022
Source: own processing [4].

Analysing the graph of the net occupancy rate index for accommodation between 2021 and 2022, a significant increase can be observed in most countries after the pandemic, especially in Greece and Spain, where the 2022 values far exceed those from 2021. Furthermore, countries like France and Italy showed a strong recovery, reflecting a swift rebound in tourism. However, some countries, such as Latvia and Lithuania, demonstrate a more modest increase, suggesting a slower recovery in these regions.

Figure 12 illustrates the net occupancy rate index for accommodation in 2023 which shows varied levels of recovery among European countries. Notably, Greece reached an occupancy rate of around 55%, indicating significant recovery compared to earlier years. Similarly, France also performed well, with a rate of around 50%. On the other hand, countries like Latvia and Albania showed lower occupancy rates, approximately 34% and 27% respectively, indicating that the recovery has been uneven across different regions. The EU average reached around 49%, suggesting an overall positive trend with certain countries performing above or below the average.

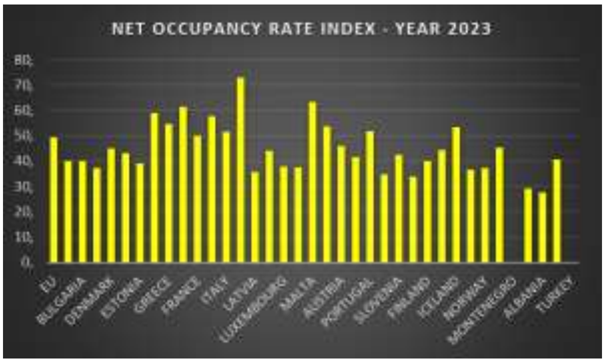

Fig. 12. Net Occupancy Rate Index in the year 2023
Source: own processing [4].

CONCLUSIONS

The COVID-19 pandemic had a profound and unprecedented impact on the tourism industry, causing dramatic declines in tourist activities globally due to severe travel restrictions and imposed health measures.

However, in the post-pandemic period, the sector has demonstrated a remarkable capacity for recovery, with international arrivals and tourism spending nearly reaching pre-pandemic levels in many regions.

By 2023, tourism demand had returned to almost 96% of the levels observed in 2021-2022, with a remarkable recovery in the EU, where some countries even recorded increases compared to the pre-pandemic period.

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ANALYSIS OF SOME PERFORMANCE INDICATORS OF AGRIBUSINESS FIRMS IN ROMANIA IN THE PERIOD 2020-2023

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Abstract

This study analyzes the financial performance of agribusiness firms in Romania, focusing on the determinants of profitability and economic sustainability. Various aspects of financial performance will be examined, including number of agri-business companies, as a whole and also by sub sectors; their turnover; the number of employees; import and export value of agricultural products; basic prices of agricultural products; production cost index for cereals, fruit and vegetable and livestock; government support (aid per ha) in 2023, to better understand the dynamics of this crucial sector of the economy. The study gives a summary of the difficulties and possibilities that agricultural companies encounter, emphasizing how market volatility and economic policies affect these businesses' financial stability. The report, which covered the years 2020–2023, offers a thorough examination of Romanian agriculture companies' financial performance, focusing on the essential factors that determine profitability and economic sustainability in this sector. The results show a significant diversity in the distribution of firms by sub-sector, with a predominant focus on grain and livestock production, while highlighting the importance of exports and government support per hectare in maintaining financial stability. Analysis of turnover, number of employees and value of imports and exports highlights the challenges of high production costs and volatility of base prices. The study also reveals the influence of government financial support, showing that firms in subsectors with higher subsidies tend to be more financially stable. The research methodology of the financial performance of Romanian agribusiness companies involved the collection of data from official sources, the analysis of time series to identify trends and financial stability, the comparison of performances between subsectors and the assessment of the impact of government policies, especially subsidies, on financial stability. The obtained methodology allowed for the formulation of some strategic conclusions and recommendations for the long-term support of the agricultural sector.

Key words: *agriculture, performance, agribusiness companies, Romania*

INTRODUCTION

The agribusiness sector in Romania is an important pillar of the national economy, having a significant impact on rural development, food security, and exports. However, the financial performance of firms in this sector varies considerably, influenced by economic, political, and climatic factors [14, 5, 6].

Sustainability in agribusiness is the ability to carry out agricultural activities in the long term, protecting the environment, maintaining economic profitability and supporting social well-being. This involves using green technologies, reducing the impact on natural resources, ensuring a sustainable profit for adapting to market demands and supporting rural communities through fair working conditions [15]. At its core, sustainability in agribusiness involves a balance between environmental protection, economic viability and social responsibility, thus ensuring the continuity of resources and communities [13].

Sustainability in agribusiness also involves constant innovation to improve the efficiency of the use of resources such as water, soil and energy, thereby reducing waste and optimizing production processes. In addition, it involves adapting to climate change through resilient farming methods, such as growing drought-resistant varieties or improving water management. Sustainability also aims at traceability and food safety, ensuring quality products that meet consumer demands for ethical and ecological practices. Thus, sustainability in agribusiness means not only maintaining current resources, but also ensuring an agricultural system capable of responding to future challenges.

Therefore, sustainability in agribusiness is directly linked to farm management which has to be flexible to adapt to the variations in the business environment [4, 11].

In recent years, agribusiness companies have faced major challenges, such as fluctuations in raw material prices, legislative changes, and many other obstacles.

This article aims to evaluate the performance of firms in the Romanian agricultural sector using various indicators.

Through a data-driven approach and case studies, the paper explores how agricultural policies, financing, and market conditions influence the performance and sustainability of companies [12].

The financial study aims to provide a comprehensive understanding of the factors that determine success in agribusiness, thus contributing to the development of effective strategies for enhancing competitiveness.

MATERIALS AND METHODS

The analysis is made during the period 2020-2023.

Empirical data were used from the National Institute of Statistics (INS) [10], EUROSTAT, [8] and the Ministry of Agriculture and Rural Development (MADR) [9].

The research methodology aimed to identify the indicators that formed the basis for analyzing the impact of the pandemic on agribusiness entities at the national level. These included:

- number of agri-business companies, as a whole and also by sub sectors;
- their turnover;
- the number of employees;
-import and export value of agricultural products;
- basic prices of agricultural products;
- production cost index for cereals, fruit and vegetable and livestock;
- government support (aid per ha) in 2023.

The research methodology regarding the financial performance of Romanian agribusiness companies involved the collection of secondary data from official sources (National Institute of Statistics, Ministry of Agriculture and Rural Development, Eurostat).

Statistical analysis was based on time series analysis to identify trends and growth rate to assess the stability of financial indicators.

The performance comparison between various sub-sectors (cereals, vegetables-fruits, animals) aimed to present the particularities of each activity, and examining how government policies, particularly subsidies, affect financial stability in order to show how they affect it.

RESULTS AND DISCUSSIONS

The Agribusiness Sector's Economic Entities' Situation from 2020 to 2023

A thorough examination of the quantity of operational economic entities in the agricultural sector is shown in Figure 1, contributing to a comprehensive understanding of their distribution and dynamics across the analyzed period 2020-2023. The number of agri-business companies increased from 19,995 in the year 2020 to 20,832 in 2023, meaning + 4.18%.

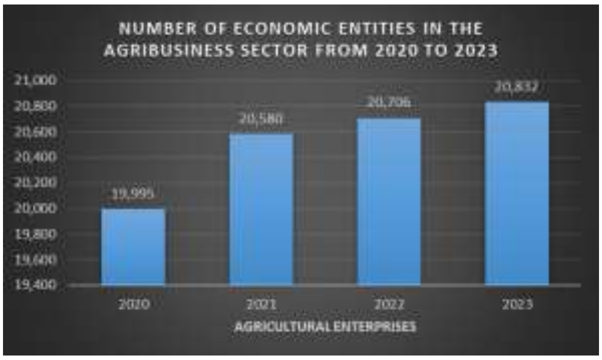

Fig. 1. Evolution of the Number of Economic Entities in the Agribusiness Sector
Source: own processing based on the data from [10].

Distribution of Economic Entities by Sub-Sectors (2020-2023)

Table 1 reflects the number of agri-business companied by CAEN Code of the subsectors and years.

The figures show the adaptability and stabilization of the Romanian agribusiness in the context of recent challenges.

In 2023, there were 13,065 agri-business firms, by +6.56% more than 12,260 in the year 2020. During the researched period of

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2020-2023, the agribusiness sector in Romania exhibited stable evolution and even growth in some sub-sectors, reflecting companies' adaptation to market demands and economic and climatic challenges.

Table 1. Distribution of Economic Entities by Sub-Sectors (2020-2023)

	Description Sub-sector	2020	2021	2022	2023	Growth in 2023 compared to 2020 (%)
111	Cultivation of cereals, legumes and oilseeds	8,094	8,582	8,831	8,900	9.96%
113	Cultivation of vegetables, melons, roots and tubers	1,094	1,167	1,078	1,100	0.55%
121	Cultivation of grapes	246	241	247	250	1.63%
124	Cultivation of stone and seed fruits	297	293	267	270	-9.09%
125	Cultivation of shrubs	652	658	636	640	-1.84%
141	Breeding of dairy cattle	557	556	562	570	2.33%
143	Breeding of horses and other equines	23	27	29	30	30.43%
145	Breeding of sheep and goats	215	238	243	250	16.28%
146	Raising pigs	358	343	324	330	-7.82%
147	Bird breeding	452	462	457	460	1.77%
149	Breeding other animals	272	274	262	265	-2.57%

Source: own processing based on the data from [10].

Cereals, legume, and oilseed cultivation has shown consistent growth, suggesting strong demand and export opportunities. The vegetable and fruit cultivation sector exhibited fluctuations influenced by climatic factors and variations in production costs.

Livestock farming remained relatively stable, with a slight decline in the pig sector, where main issues were related to animal health.

Overall, the distribution of economic entities in agribusiness shows a trend of consolidation and adaptation to market conditions, with well-established sectors and the capacity to attract new economic entities in essential fields.

Evolution of the Turnover of Economic Entities in Agribusiness (2020-2023)

The evolution of turnover shows how the total revenues of agribusiness entities have changed during the researched period.

Figure 2 highlights a significant increase in turnover in the agribusiness sector of Romania between 2020 and 2023, starting from 32,910 million RON in 2020 and reaching an estimated value of 114,158 million RON in 2023.

These results show an increase of 246.68% of turnover and also in demand and the economic performance of entities in the field.

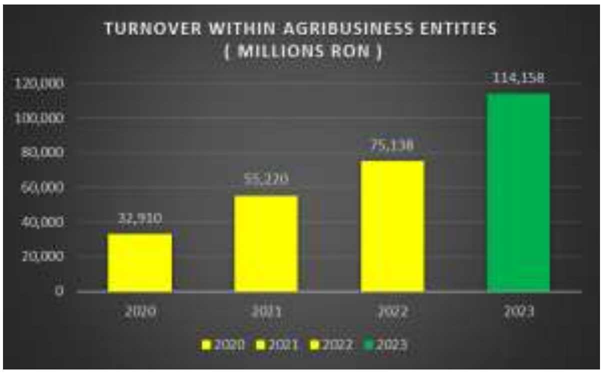

Fig. 2. Turnover within Agribusiness Entities
Source: own processing based on the data from [10].

Number of Workers in Agribusiness Organizations from 2020 to 2023

Figure 3 highlights the evolution of the workforce needed to support the growth of this sector.

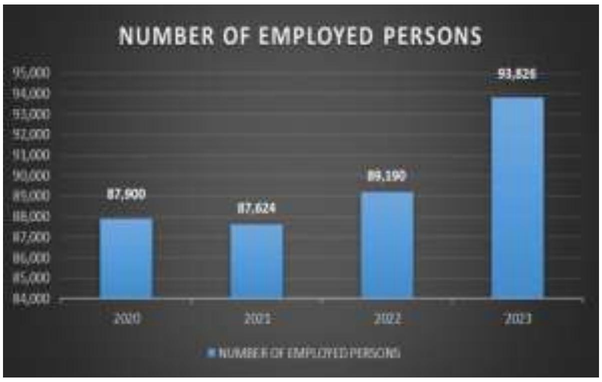

Fig. 3. Number of Employed Persons in agri-business in the Period 2020-2023
Source: own processing based on the data from [10].

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This indicator provides insight into the development and adaptation of the agricultural sector in the context of increasing demand and economic changes. The above graph shows how the number of employed people changed between 2020 and 2023. The number of employees increased gradually throughout the course of the four years, according to data analysis. Beginning with 87,900 workers in 2020, there was a little decline in 2021 as a result of the pandemic, followed by consecutive gains in 2022 and a more noticeable increase in 2023. There were 6.74% more employees in the last year than there were in 2020.

Import and Export of Agricultural Products in the Period 2020-2023

The evolution of imports and exports in agribusiness was analyzed in order to understand the sector's relationship with international markets. Imports and exports have shown an increasing trend during the period 2020-2023 (Figure 4). However, imports were significantly higher than exports each year, indicating a trade deficit and suggesting that new reforms in the agricultural sector may be needed.

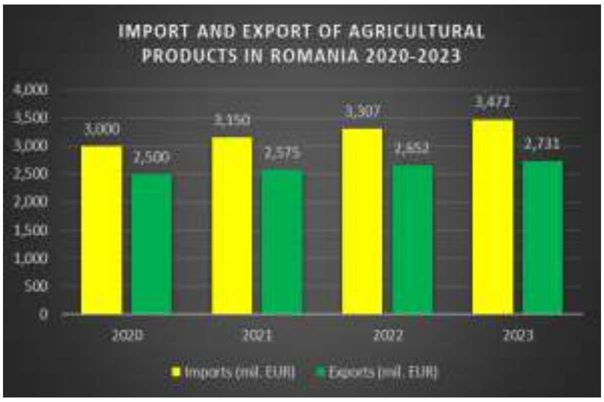

Fig. 4. Imports and Exports of Agricultural Products in Romania – 2020 – 2023 (Million Euro)
Source: own processing based on the data from [8].

In the studied interval, imports increased from 3,000 million Euro in 2020 to 3,472 million Euro in 2023 (+15.73%), while exports raised from 2,500 million Euro to 2,731 million Euro (+9.24%).

Evolution of Basic Agricultural Product Prices (2020-2023)

Figure 5 shows the evolution of prices for basic agricultural products in Romania between 2020 and 2023, expressed in lei per kilogram for each product: wheat, barley, two-row barley, oats, and corn. All analyzed products experienced a significant price increase until 2022, followed by a decrease in 2023 [3].

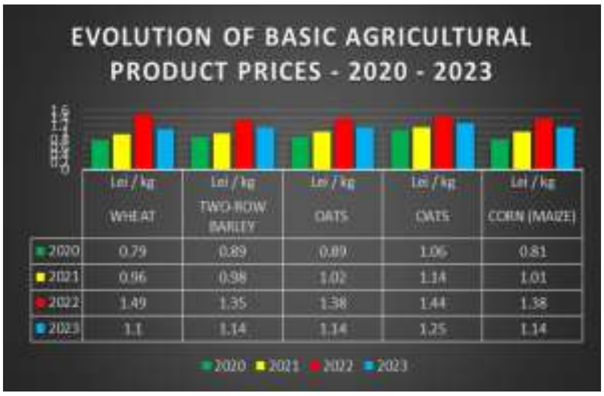

Fig. 5. Evolution of Basic Agricultural Product Prices in the Period 2020-2023 (RON/kg)
Source: own processing based on the data from [10].

The year 2022 appears to have been a peak year for the prices of basic agricultural products, followed by a decline in 2023, because of the unfair competition of the cereals coming from Ukraine on the Romanian market at lower prices and of a low quality, which raised the offer and affected the Romanian producers who carried out higher production prices and harvests were affected by the severe and longue drought.

However, in 2023, basic price for each cereal was higher compared to its level in the year 2020.

Evolution of Production Costs in Agribusiness (2020-2023)

Figure 6 presents the evolution of production cost indices in various sub-sectors of agribusiness in Romania between the interval 2020 - 2023.

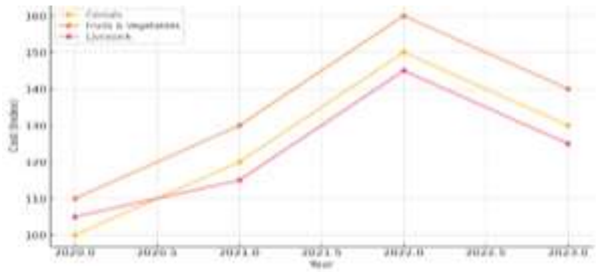

Fig. 3. Evolution of Production Cost index in Agribusiness (2020-2023) (%)
Source: own processing based on the data from [10] and [9].

In 2022, production cost index attained a peak for all the selected agricultural products. The trend lines show that the cost index in fruit and vegetable subsectors has the highest level, compared to cereals which come on the 2nd position and livestock which come on the last position.

Degree of Government Support for Agribusiness (2020-2023)

In the period from 2020 to 2023, government support for the agricultural sector in Romania experienced a significant evolution, particularly through the implementation of the National Strategic Plan (NSP) 2023-2027 [1], approved by the European Commission in December 2022. This plan allocates €15.83 billion for agriculture and rural development, focusing on modernizing farms, supporting young farmers, and promoting sustainable agricultural practices.

Starting in 2023, new payment schemes have been introduced, such as the Basic Income Support for Sustainability (BISS), with a planned amount of €96.47/ha in 2023, progressively increasing to €103.06/ha by 2027 [2].

Additionally, coupled support schemes for various crops and sectors have been implemented, such as for vegetables grown in greenhouses and tunnels, with an indicative amount of €2,100/ha in 2023.

For small farmers, the NSP provides support of up to €50,000 per farm, with a public non-repayable support intensity of up to 85% of eligible costs [7].

CONCLUSIONS

The agribusiness sector in Romania has demonstrated remarkable adaptability during the period from 2020 to 2023, with a significant increase in turnover, reflecting high demand and economic performance.

In particular, sub-sectors dedicated to cereal cultivation and livestock raising have strengthened, adapting to economic and climatic conditions; however, the trade imbalance persists, with imports exceeding exports. This trade deficit highlights the need for policies that support local production and stimulate competitiveness in the international market.

The vegetable sector, for example, has experienced fluctuations in production, being affected by climatic conditions and variable production costs, highlighting vulnerabilities to external factors.

Government support has played a crucial role in the stability of the sector, especially through the National Strategic Plan 2023-2027, which allocated significant funds for farm modernization and support for young farmers. Through these funds, the agribusiness sector benefits from new subsidy schemes, including for essential crops and rural development projects.

The new measures have the potential to support the adoption of sustainable agricultural practices and attract additional investments in future technologies.

In conclusion, the agribusiness sector in Romania is on a positive trajectory and benefits from significant government support to maintain growth and ensure long-term sustainability.

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SUPPORT AND PROTECTION OF THE WINE SECTOR IN ROMANIA IN THE EUROPEAN CONTEXT

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Abstract

The wine sector has a significant importance in the economy of the European Union, contributing to the increase of exports, the preservation of traditions and the generation of jobs in rural regions. Romania, recognized for its wine-growing tradition, ranks sixth in Europe in terms of wine-growing area and benefits from considerable support through the Common Agricultural Policy (CAP). The paper analyzes the support and protection measures of the Romanian wine sector within the rural development programs of the two programming periods, 2007-2013 and 2014-2020, which Romania went through after joining the European Union. The allocated funds supported the restructuring and reconversion of the vineyards, the modernization of the viticultural infrastructure and the promotion of exports. At the same time, measures were implemented to adapt to climate change and improve sustainability. In conclusion, it emphasises the need to continue European support for maintaining the competitiveness of Romanian wine on international markets, considering the climate challenges and global competition.

Key words*: *viticulture, Common Agricultural Policy, Romania, viticulture protection, subsidies, sustainability

INTRODUCTION

The European Union holds a dominant position in the global wine industry, accounting for 60% of the world's wine production and 70% of its exports. Wine is not only a key consumer product in the EU but also deeply intertwined with the cultural heritage and national identity of several member states. Romania, with its rich history in viticulture, is a notable player in this sector, ranking sixth in Europe in terms of vineyard area, following France, Italy, Spain, Portugal, and Greece [17].

In response to international competition and the challenges posed by climate change, the European Union has implemented a range of support and protection measures under the Common Agricultural Policy. These initiatives aim to ensure the ongoing competitiveness of the wine sector, helping producers adapt and thrive in a rapidly changing global market. [1], [2], [13].

In Romania, these measures had a significant impact, supporting the restructuring of vineyards and the promotion of Romanian wines on the European and international markets [18]. The article aims to analyze how the EU provides protection and supports the wine sector, with a special focus on Romania.

MATERIALS AND METHODS

In this article, the research used a qualitative methodology based on the analysis of European policies, European Commission reports and statistical data on the wine sector in Romania from the National Institute of Statistics of Romania.

The National Rural Development Program for the 2007-2013 and 2014-2020 programming periods was also examined, focusing on the support provided to the wine sector. Additionally, reports on the impact of implementing the Common Organization of the Wine Market within the framework of the Common Agricultural Policy were analyzed.

RESULTS AND DISCUSSIONS

The support offered by the European Union through the Common Organization of the

Wine Market, within the Common Agricultural Policy, is very important for supporting the global competitiveness of this strategic sector [6], [14], [16]. Subsidy policies, protection of designations of origin and climate change adaptation measures contribute to ensuring a balance between tradition and innovation [5], [4]. However, the sector faces major challenges, including external pressures from emerging markets and the effects of climate change. In the future, the success of European wine will depend on the adaptability of producers and the continued support of European public policies [3].

The Common Agricultural Policy (CAP) has consistently offered financial support to the viticulture sector through the European Agricultural Fund for Rural Development. [7], [8], [9], [10]. Starting with 2007, the year of Romania's accession to the EU, CAP subsidies were essential for restructuring the Romanian wine sector, modernizing plantations and increasing competitiveness and sustainability in the international market [11], [15]. Romania has benefited from substantial funds for the reconversion of vineyards, the development of viticultural infrastructure and investments in modern technology to improve the quality of wines.

A significant example is the vineyard restructuring program, which allowed the replacement of ageing vines with new, more competitive and climate-resistant varieties. Also, through the PAC, Romanian producers were able to access subsidies for promoting exports and participating in international wine fairs. This financial support played a crucial role in the recovery of the Romanian wine industry, which, after the years of post-communist transition, had lost competitiveness in international markets.

At the EU level:

-*Area under vines*: the areas cultivated with vines in the EU amount to around 3.2 million hectares, concentrated in particular in southern European countries.

-*Wine production*: The EU is responsible for around 60% of world wine production, with a production of around 167 million hectoliters in 2022.

-*Exports:* the EU accounts for around 70% of global wine exports. The largest exporting countries in the EU are France, Italy and Spain, which contribute around 85% of the total EU wine production.

-*Economic value*: in 2021, EU wine exports generated revenues of over €30 billion and the wine sector is responsible for a significant number of jobs, especially in rural regions.

In Romania:

-*Vineyard area*: after 2007, Romania had vineyard areas that varied between 161,000 – 187,000 ha [12] (Fig. 1).

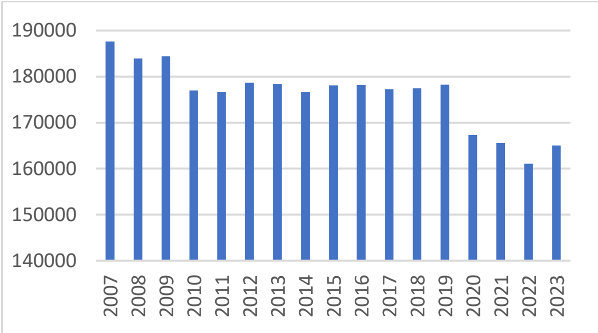

Fig. 1. The area of vineyards per fruit 2007-2023
Source: NIS, Tempo online, accessed on date15.09.2024 [12].

-*Grapes production* after 2007 varied depending on the climate conditions between 740,000 and 1.140.000 tons of grapes [12] (Fig. 2).

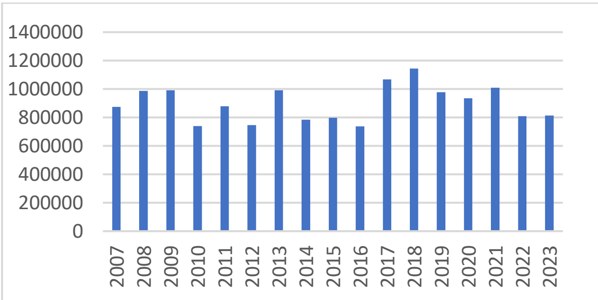

Fig. 2. Total grape production 2007-2023
Source: NIS, Tempo online, accessed on date 15.09.2024 [12].

- *Wine production*: Romania is one of the largest producers of wine in Central and Eastern Europe, occupying the 6th place in the EU. In 2022, Romania produced approximately 4.5 million hectoliters of wine, representing a slight increase compared to previous years.

-*Romania's exports*: Despite the significant viticultural potential, Romania's wine exports are relatively modest, registering a value of approximately 40 million euros annually. The main export markets are Great Britain, Germany, and China.

-*Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI):* Romania has registered several wines under PDO and PGI protection, the most famous of which are the wines from Cotnari, Murfatlar, Dealu Mare and Jidvei.

-*The impact of the PAC in Romania*: during the 2014-2020 period, Romania accessed over 230 million euros in European funds aimed at restructuring and modernizing the wine sector, according to data provided by the Ministry of Agriculture.

The support and protection of the wine sector in the European Union have advanced considerably over the two programming periods of 2007-2013 and 2014-2020, focusing on modernization, sustainability, and climate change adaptation. As a member state since 2007, Romania has benefited from these initiatives, which have played a key role in the transformation of its wine sector.

In the period 2007-2013, the CAP and the reform of the Common Organization of the Wine Market implemented a series of measures for the wine sector. These initiatives focused on restructuring and modernizing vineyards, reducing excess wine production, and enhancing competitiveness by promoting quality and facilitating access to foreign markets. For this timeframe, the EU allocated over 5 billion euros to the wine sector, with approximately 336 million euros earmarked for Romania. These funds were mainly used for:

-*Restructuring and reconversion of vineyards*: The funds allowed the replanting of over 40,000 hectares of vineyards in Romania.

-*Modernization of the winemaking infrastructure*: Technological improvements in the winemaking process and modern equipment.

-*Promotion on foreign markets*: Romania has started to invest in the promotion of wines in foreign markets, especially in the EU, but also in the markets of Asia and North America.

Thus, during the 2007-2013 programming period, Romania benefited from significant subsidies for the restructuring of the sector. More than 16,000 hectares of vineyards have been restructured and modernized, and investments in modern wineries have increased production quality and competitiveness in the EU market. Romanian wine exports began to grow modestly during this period, and Romanian wines gained recognition at international fairs.

During this period, support for the restructuring and reconversion of the vine in Romania focused on the modernization and replanting of vineyards. The available funds were distributed according to the measures adopted, and the amount granted per hectare varied according to the type of activity carried out (replanting, reconversion or modernization).

Thus, in the period 2007-2013, the amount allocated for the restructuring and reconversion of the vines in Romania varied between 7,500 and 10,000 euros per hectare, depending on the complexity of the works and the type of varieties planted. Replanting (replacing old vines with new varieties) benefited from the highest support, around 10,000 euros per hectare, due to the high costs of the work. The reconversion of varieties (the replacement of less productive varieties with more valuable varieties) benefited from somewhat lower support, of approximately 7,500 euros per hectare.

In the 2007-2013 programming period, viticulture in Romania was supported mainly through the National Rural Development Program (NRDP), but the specific funds intended for the wine sector came mostly through the Common Wine Market Organization, which had measures dedicated to the restructuring and modernization of this sector. However, certain measures in the NRDP have been indirectly used to support the wine sector, especially for investments in agricultural infrastructure and rural development:

-***Measure 121 - "Modernization of agricultural holdings***". This measure had an impact on viticulture, providing support for the modernization of equipment and infrastructure in wine farms. Winegrowers were able to access funds to purchase modern winemaking equipment, irrigation systems and agricultural machinery for vineyards.

-***Measure 123 - "Increasing the added value of agricultural and forestry products".*** Winegrowers benefited from this measure to invest in wine processing and marketing, by modernizing wineries and winemaking facilities, improving product quality and increasing market competitiveness.

-***Measure 112 - "Installation of young farmers"*** although it was not specific to viticulture, it allowed young farmers to access funds to establish wine holdings. The support was in the form of a grant for initial investments.

In the 2014-2020 period, support for viticulture focused on adaptation to climate change, sustainability and diversification of export markets. The Common Agricultural Policy continued to support the modernization of vineyards and the promotion of exports, but introduced new objectives related to sustainability: encouraging the production of ecological wines and sustainable agricultural practices and competitiveness: support for small producers and increasing the quality of products through the adoption of new technologies.

For the period 2014-2020, Romania benefited from an allocation of over 238 million euros for the wine sector. These funds were mainly distributed through:

-*Restructuring and reconversion*: Romania replanted another 18,000 hectares of vineyards during this period, using resistant varieties adapted to modern climatic conditions.

-*Investments in technology*: Romanian producers received subsidies to modernize the winemaking infrastructure and to introduce ecological technologies.

-*Promotion of exports*: EU subsidies supported the participation of Romanian producers in international fairs, and exports increased constantly. In 2019, Romania exported wines worth over 44 million euros, which represents an increase of almost 20% compared to 2014.

During the 2014-2020 programming period, Romanian wines gained greater visibility on foreign markets, especially thanks to investments in the promotion and modernization of vineyards. Romania's wine production has become more competitive, and the quality of wines has increased significantly. Also, climate change imposed new challenges for Romanian winegrowers, but European funds were accessed for adaptation to the new conditions (for example, by introducing drought-resistant varieties).

During this period, support continued for the restructuring and conversion of vineyards, but additional measures were also introduced to promote sustainable agriculture and adapt to climate change.

In the period 2014-2020, the support per hectare granted for restructuring and reconversion increased, varying between 12,000 and 13,500 euros per hectare, depending on the works carried out and the technologies applied. Replanting continued to be one of the most funded activities, with average subsidies of around €13,000 per hectare.

The conversion and modernization of vineyards benefited from subsidies of around 12,000 euros per hectare, with additional support for investments in irrigation infrastructure and sustainable technologies.

Compared to the previous period, this period brought an increase in funds per hectare, reflecting the rising costs of replanting, new sustainability requirements and the need to implement modern technologies to meet climate challenges. At the same time, producers who opted for drought-resistant varieties and sustainable agricultural practices were able to access additional funds.

In the 2014-2020 programming period, the National Rural Development Program (NRDP) continued to indirectly support the wine sector through certain measures, but direct support for viticulture was again mostly allocated through the Common Wine Market Organization. In addition, there were specific measures in the NRDP that contributed to the modernization and development of this sector:

-*Measure 4.1* - "Investments in agricultural holdings". This measure provided support for investments in the modernization of agricultural holdings, including vineyards. Winegrowers were able to access funds for the purchase of modern equipment for investment in equipment, improvement of winemaking technologies and construction and renovation of production premises.

-*Measure 4.2* - "Support for investments in the processing and marketing of agricultural products". Winegrowers benefited from funds to improve wine processing and marketing. This measure was intended to increase the added value of the wines produced, by investing in technology and infrastructure for winemaking and marketing.

-*Measure 6.1* - "Support for the establishment of young farmers". Young winegrowers could access this measure to set up and develop wine holdings. This measure encouraged the involvement of young people in viticulture, offering them financial support to start the activity.

-*Measure 16* - "Cooperation". This initiative promoted collaboration and association between wine producers to stimulate the development of new products and increase the added value of existing ones. Winegrowers who formed groups received support to develop their winemaking technologies, but also for marketing.

CONCLUSIONS

The European Union'spolicies positively impacted the development of the wine sector in Romania, providing financial support for the modernization of plantations and promotion of international markets. Protection measures, such as designations of origin and protected geographical indications, have contributed to increasing the quality and visibility of Romanian wines. However, challenges related to climate change and international competition persist, requiring continued adaptation and further investment in technology and sustainability. In the future, Romania's success in the international market will depend on the ability to capitalize more effectively on European support and to continue investing in innovation and quality.

The support provided by the EU to Romania's wine sector during the two programming periods was very important for modernization and enhancing competitiveness. While the 2007-2013 period concentrated on restructuring and modernization, the 2014-2020 period placed greater emphasis on sustainability and adapting to climate change:

-Increase in available funds: during the 2014-2020 period, Romania received higher funding than in 2007-2013, reflecting the EU's increasing focus on viticulture and modernization.

-Area restructured: while Romania restructured over 16,000 hectares during the 2007-2013 period, an additional 18,000 hectares were restructured in the 2014-2020 period.

-Sustainability and ecology focus: the second programming period placed greater emphasis on sustainability and ecology, promoting organic wines and environmentally friendly technologies.

-Growth in exports: Romanian wine exports experienced steady growth during 2014-2020, increasing by nearly 20% compared to the previous period, although Romania has yet to reach the levels of major EU producers like Italy and Spain.

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MODEL SCHEME FOR INCUBATING ENTREPRENEURS FOR THE FORMATION OF A VIABLE BUSINESS IN THE REPUBLIC OF MOLDOVA

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Abstract

The university business incubators represent an opportunity for students to learn and initiate small businesses through which they can materialize their innovative ideas. The incubator is a beneficial environment to integrate the knowledge of the faculty, institutional academic support, and the innovative enthusiasm of young entrepreneurs. Through this work, we aimed to investigate the willingness of universities to create and develop such incubators, the extent to which university openness aligns with state objectives in this field, and whether they are in line with the "Education 2030" development strategy. We also emphasized that any incubator must start with the idea that it is also a indirect profit centre; thus, all activities must be efficiently managed in terms of administration, marketing, and finance. Visibility and awareness of these incubator opportunities by students and teachers are crucial so that they can capitalize on their potential. In this value chain, there are also numerous challenges, which we highlighted in this study. Challenges that discourage potential companies proposed for incubation are due to students' poor knowledge of entrepreneurship, as well as ambiguous legislation and discouraging financing possibilities. Research from various states has shown that novice and recently established entrepreneurs are vulnerable to failure and bankruptcy, considering the current economic and financial policy situation. This phenomenon occurs because entrepreneurs starting a business lack experience and business skills, affected by various factors that make them more vulnerable to challenges during their activities.

Key words: *business incubator, business, entrepreneurship, model scheme for incubating entrepreneurs*

INTRODUCTION

Currently, startup businesses are becoming a necessity and a much more viable alternative for students and young graduates nationwide. They ensure an increase in motivation for personal achievement, encourage innovation, initiative, creativity, independence, dynamism, and diversity, thus contributing to the overall development of society. The development of family businesses provides a potential avenue for engaging young, minimally experienced labour. An increasing number of young individuals perceive starting their own business as a suitable career choice, and, in many cases, initiating a business can be the best, if not the only, option for self-employment in the labor market [11].

A viable business is the stage at which a business can start and, as projected, can withstand all challenges, being capable of self-sustainability over an extended period, generating profit and liquidity.

In the work "The Path from Business Idea to Viable Business," we can find the answer to the question: "What are the steps to be followed in establishing a viable business?" These steps include: analysing business ideas and selecting the one that suits you; deepening the analysis of the selected business idea; developing entrepreneurial skills; initiating the planning process (identifying customers, determining what you will produce, who your competitors are, setting prices, and sales strategies); choosing a business location; studying the production and service delivery process; selecting a business name; determining the legal form of business operation; financial forecasting; identifying the best sources of support; creating a database of useful contacts; selecting sources of financing for the business; continuous planning; establishing the main economic and financial means of the business; analysing projections, revising, and improving them [10].

At the same time, to start entrepreneurial activity, it is necessary to use the factors presented by Michael E. Gordon in the business plan: Culture, Uniqueness, Strategy, Technology, Opportunity, Management, Execution, Resources, which, through their forecasting, can help avoid the influence of negative factors and allow the entrepreneur to focus on spontaneously arising issues for their resolution or removal as quickly as possible. Furthermore, before launching a business, a detailed study of the obstacles and opportunities offered by the entrepreneurial environment is necessary. The entrepreneurial sector has strengths and weaknesses: a successful entrepreneur will amplify the impact of strengths and focus on minimizing the impact of disadvantages [1].

Table 1. Characteristics of Business Incubators in the Academic Environment

Type	Context and Characteristics	Priorities
Business Incubators located in the academic environment	• Universities or academic institutions serve as founders and provide resources for research, expertise, space, and/or support funds.	• It can lead to bridging the gap between research and commercialization. • Access to intellectual property and the potential for developing competitive businesses. •Often ensures financial stability.
Sector-specific incubators or Multisectoral incubators located in the academic environment	They provide a full range of services required for individuals with a viable idea applicable in a specific sector, which reflects the existing endogenous potential in that territory.	•They can easily become clusters. •Entrepreneurs receive assistance from the pre-incubation period to the post-incubation period.

Source: [1].

For members of the academic community, it is important to cooperate, support, and participate in innovation incubators since students are inclined to start their own businesses.

Therefore, the services provided by academic business incubators established by universities can be an attractive and decisive factor for young individuals when choosing a university, as it provides the opportunity to implement business ideas and accumulate entrepreneurial skills and competencies, and more.

In this context, this paper aimed to strengthening the collaboration of business incubators located in the university environment and the entrepreneurial environment on the development of the entrepreneurial skills and competencies of students for the formation viable business in the Republic of Moldova.

MATERIALS AND METHODS

Based on the information analyzed and presented, it is worth mentioning that the purpose of creating the University Center for Young Entrepreneurs, which may include the Innovation Incubator, aims to promote not only innovative ideas (not just with an innovative aspect) but also their transformation into successful businesses to develop and increase economic growth, including at the regional level. This will also enhance the efficiency of interaction between education, science, and business.

Research objectives:

• Development of a model scheme for the incubation process of potential entrepreneurs in the university environment, *Phase I;*

• Development of a model scheme for the incubation process of entrepreneurs from the business environment, *Phase II;*

• Development of a model scheme oriented towards incubating (potential) entrepreneurs to create a viable business and promote regional development.

The research is based on the results obtained from a questionnaire developed as part of the project, which includes the following sections:

-For teaching staff: (A) General information about the respondent; (B) The level of knowledge in the field of entrepreneurship developed within business incubators; (C) The perception of university professors regarding

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the establishment of university incubators; (D) The perception of university professors regarding the development of entrepreneurial skills among students within university incubators.

-For students: (A) General information about the respondent; (B) The necessity of university incubator activities; (C) The development of skills and abilities in students/graduate students/doctoral candidates.

As the research object (in the survey process), 118 teaching staff and 232 students were involved (participated) from the faculties (1) Faculty of Economic Sciences (FSE); (2) Faculty of Psychology, Educational Sciences, Sociology and Social Work (FPSESAS); (3) Faculty of International Relations, Political and Administrative Sciences (FRISPA); (4) Faculty of Letters (FL); (5) Faculty of Mathematics and Informatics (FMI) in the Moldova State University [3].

Research based on the results obtained from the questionnaire, which was completed by university staff, has revealed the following: regarding the question "What services should a university incubator offer?" as seen in Figure 1, training in entrepreneurship (accounting, human resources, finance, taxation, marketing) is in the first place with 84.6%. This provides an opportunity for academic staff to engage in training not only for students and faculty from non-economic faculties but also for external individuals in need of knowledge in the field. Training in the legal field is in second place with 64.2%, which is essential for directing businesses in terms of decisions, laws, legislative changes, legal framework that are relevant to start-ups and existing businesses facing certain obstacles. The laboratories available in universities have accumulated 46.8%, as perceived by faculty members as an opportunity for practicing, experimenting, and implementing ideas. Services such as rented office space and secretarial services (telephone, internet, printer, mail) have accumulated 39.6% and 36.6%, respectively. Other types of services that can be offered by university incubators account for 15.2% of respondents, and 6.2% do not know what services such a structure within the university environment can provide.

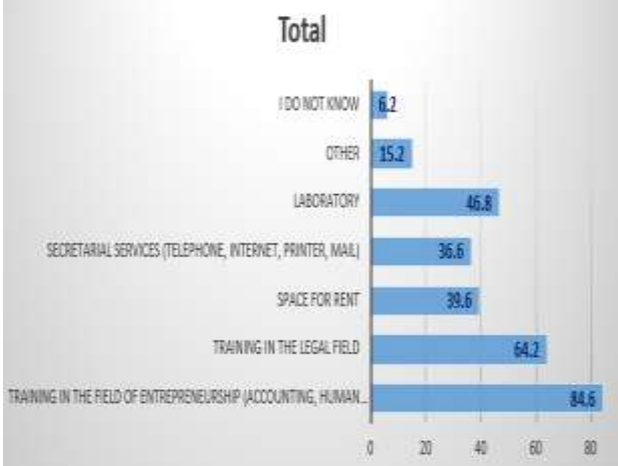

Fig. 1. Distribution of the services that an university incubator should offer in the opinion of the respondents, %
Source: [7].

RESULTS AND DISCUSSIONS

University incubators address the need for actions to support enterprises, primarily resulting from the activities of universities (spin-offs and start-ups). Their main objective is to transform research results into productive technological activities with efficient economic results.

Research from several countries has demonstrated that novice and recently established entrepreneurs are vulnerable to failure and bankruptcy, considering the current economic and financial policies. This phenomenon occurs because entrepreneurs who start a business lack experience and the ability to conduct business. They are also affected by various factors that make them more vulnerable to the challenges they face during their activities. The likelihood of failure is even greater if they are not supported, and they themselves do not understand their place in the market. If they do understand, they often lack the skills to cope with changes that are often introduced or not introduced by state institutions in the business environment.

It is essential to understand that in a situation of unequal competition and external economic challenges, entrepreneurs become vulnerable and, therefore, expend valuable resources (valuable) of effort and financial means to rectify mistakes and incorrect decisions [7].

The implementation program of the "Education 2030" Development Strategy approved by the Government allows us to highlight the following objectives regarding the development of education in the medium and long term:

General Objective 1: Aligning education with the labour market's requirements and needs from a sustainable development perspective by restructuring the mechanisms for human capital development.

Specific Objective 1.11 Promoting entrepreneurial, economic, and financial education in the curriculum for all levels of the education system so that by 2025, at least 60% of learners possess the respective competencies (in relation to age-specific and projected purposes) [9].

According to the action plan for achieving specific objective 1.11, the implementation costs until the fourth quarter of 2025, funded by the National Public Budget, will amount to approximately USD 38,931 (700,000 lei MD), distributed annually in the amount of USD 12,975 (233,300 lei MD).

Furthermore, in line with ***General Objective 2:*** Enhancing territorial cohesion and preventing exclusion within the National Regional Development Strategy of the Republic of Moldova (NRDS) 2022-2028, it is worth mentioning that:

Specific Objective 2.2 focuses on the development of support infrastructure for businesses, including 7 Free Economic Zones with 34 sub-zones, 10 industrial parks, *11 business incubators*, and *4 innovative incubators* (within the university environment).

However, despite certain noticeable progress in the activities of these business support structures, when viewed collectively, the results obtained by these structures continue to be modest. The volume of investments attracted and the number of jobs created are far from expectations. Moreover, the related services designed to support business development within these institutions are still underdeveloped, mainly offering basic entrepreneurial skills.

In this context, one of the priorities of the National Regional Development Strategy of the Republic of Moldova (NRDS) 2022-2028 is the consolidation and expansion of business infrastructure in each development region, this includes: *Extending and diversifying existing support infrastructure for business development, such as business incubators and accelerators, technological innovation centers, and business centers, among others.* [12].

In the current educational context, entrepreneurial competencies and an entrepreneurial spirit have become increasingly important. This is in line with the recommendation from the European Parliament and the Council of Europe, as outlined in the Entrepreneurship Promotion and Competitiveness Enhancement Program (PACC) for the years 2023-2027. Key competencies for lifelong learning include entrepreneurial skills. The recommendation is to develop key competencies, with a focus on entrepreneurial competencies gained through practical entrepreneurial experience. This emphasis on entrepreneurship is crucial for the new pedagogical paradigm in education. This approach implies fostering the formation and development of an entrepreneurial and university environment in which every member of society is encouraged to contribute business ideas that are appreciated for their true value.

The challenges mentioned in PACC which are directly related to the educational system (university environment) are shown in Fig. 2.

Although the Republic of Moldova has adapted its curriculum to include the key competence of entrepreneurship, applying the provisions of the EU EntreComp11, entrepreneurship in higher education remains limited at some universities such as Moldova State University, Technical University of Moldova, Cahul State University, and so on. Additionally, cooperation between the academic and business sectors remains limited in its application.

Universities and the broader higher education community, especially teaching and research staff, are not well integrated into the broader economic dynamics of the country.

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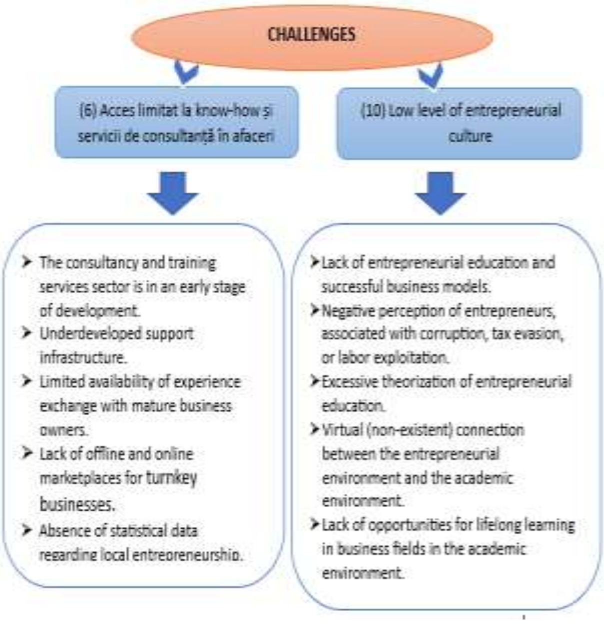


Fig. 2. Challenges Focused on the Educational System (University Environment)
Source: [12].

A major challenge is how to prepare trainers to teach skills-based programs. The initial training of teachers should be institutionalized and consistently addressed at different levels of education. Practical entrepreneurial experience, which is key to the new entrepreneurial pedagogical paradigm and is part of the EU recommendations in the field of education and business policies, should also be addressed, possibly through vocational and technical education.

The skills and competencies accumulated during one's university career have allowed the respondents to respond positively (55%) to the question "Would you like to be involved as a mentor/teacher in a university incubator?" If we analyze this by faculty, we have the following results: at the Faculty of Economics - 41% are in favor, and 15% are against; in the Faculty of Psychology, Educational Sciences, Sociology, and Social Assistance - 25% are in favor, compared to 19% against; at the Faculty of Letters, 24% are in favor, and 16% are against. It is worth noting that a significant portion of the respondents from the Faculty of International Relations, Political Science, and Public Administration - 33%, and the Faculty of Mathematics and Computer Science - 29%, do not have the desire to be mentors/teachers in the university-based incubator, according to the survey conducted in the university environment [3].

Additional improvements can be made in the development of entrepreneurial skills in the following areas: Inclusion of the European Competence Framework for Entrepreneurship (European Entrepreneurship Competence Framework) in the curriculum reform plans, supported by the initial and ongoing training of teaching staff [13].

Specific Objective 1.2. Strengthening the culture and entrepreneurial capacities by focusing on the Expected Policy Outcome Indicators forecasted until 2025, such as:

✓Increasing the number of entrepreneurs with improved entrepreneurial skills aligned with current trends.

Increasing the share of Small and Medium Enterprises (SMEs) managed by young people, women, and migrants in the total number of enterprises (by 13 percentage points) [13].

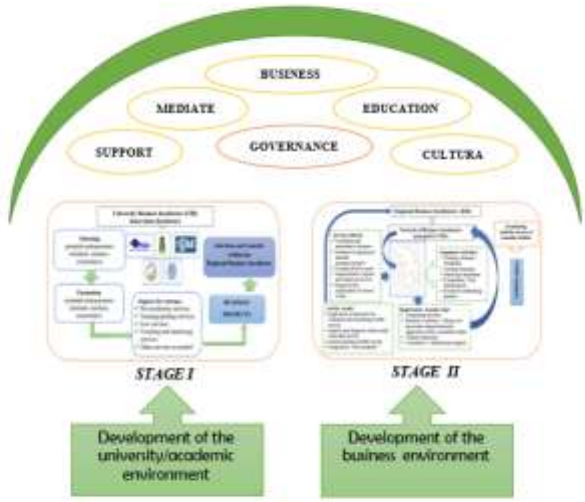


Fig. 3. Model Scheme of the Incubation Process
Source: elaborated by the authors.

Based on the conducted research, a model scheme for the incubation process has been developed, which, according to the authors' opinion, will ensure the successful transition of potential entrepreneurs through the two stages: starting from the University Incubator within the *University Entrepreneurship* Centre and transferring to one of the Business Incubators in the *Business Incubator Network.* These two stages are crucial in establishing a viable business and fostering rural development.

Additionally, it is mentioned that the model for the incubation process of potential entrepreneurs involving the university and business environments can be presented schematically as shown in Fig. 3.

The important elements that fit into their structure, each of them having a significant influence, are necessary for the sustainable development of both the academic/university environment and the business environment.

Among these elements that are part of the entrepreneurial ecosystem are the following:

-*Government:* Entrepreneurial public policies, administrative support, legislative framework, entrepreneurial strategies, government institutions and agencies, and the framework for attracting investments and external funding.

-*Entrepreneurs:* Developing collaborations among entrepreneurs, mentoring, guidance, innovative ideas, and more.

-*Education:* Preparation of human resources, support in research, educating young people, entrepreneurial skills, and conscious consumers.

-*Culture:* Tolerance for risk and failure, innovation, the entrepreneurial status in society, ambition, promotion of initiative, fair competition, success stories.

-*Support:* Support infrastructure, financial support, support for conferences, promotional events, and professionals providing entrepreneurial support as research organizations.

Media: Information and education, promoting entrepreneurship as a career, understanding specific industries, clarity and development of entrepreneurial language, creating a national and international reputation, and inspiring [4].

However, ***for the first stage***, the University Business Incubator to be established and operate successfully, we need young people with entrepreneurial skills, co-interested teaching staff in initiating a business, who will be well-prepared and trained both theoretically and practically [8].

Taking into account this necessity, the team members have developed the "Entrepreneurship Education" module, which will allow both teaching staff and students from various non-economic fields to acquire certain basic skills that would favour the approach of potential entrepreneurs to become members of the labor market. They have the opportunity to launch their own businesses, form economic and financial thinking, and be oriented towards choosing to be employers with a well-developed business plan guided by the team members within the Incubator.

The main components of the *"Entrepreneurship Education"* guide oriented towards initiating a business are as follows:

Subject 1: MANAGEMENT: Identifying business development opportunities; Business plan: Steps in preparing a business plan, step by step; Human resource management.

Subject 2: FINANCIAL PLANNING: Determining the investment budget; Forecasting financial flows; Analyzing the profitability and financial sustainability of investments.

Subject 3: ACCOUNTING: Accounting in business: concept; Users of accounting information; Regulation of accounting in business; General rules regarding the accounting of patrimonial elements; Accounting method and its procedures; Documenting economic operations; Method of elaboration and application of accounting policies; Accounting systems and forms within the economic entity.

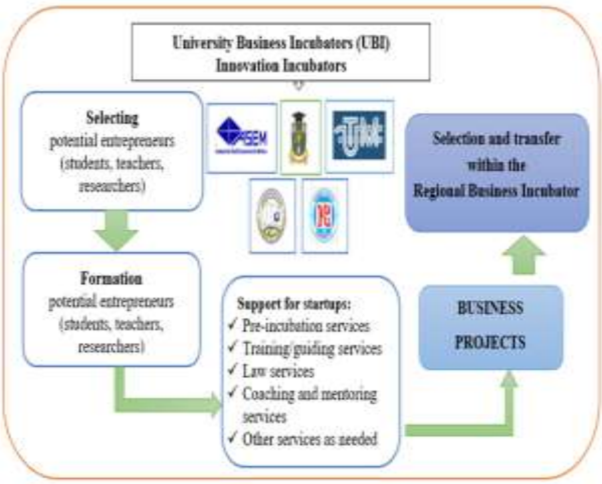
Subject 4: FINANCE: Sources of financing at different stages of business development; Bank loans: application and repayment; National business support projects; Business Incubator vs. Innovation Incubator.

Subject 5: MARKETING: Strategies and techniques of the marketing mix in initiating a business; Marketing research and consumer behavior in designing a new product.

One of the most significant elements of the university's innovation ecosystem is the education system. It should also be noted that during the studies focused on entrepreneurship and the business environment in Western universities, students are actively involved in research activities and project development, under the guidance of university professors and business trainers who, in turn, form multidisciplinary teams (of students) and implement projects based on innovation.

Regarding specific knowledge and skills, it is observed that the majority of respondents have expressed the opinion that the national economy's requirements for entrepreneurial education are higher than what students obtain during their university studies.

Based on the results obtained, most respondents believe that the main challenge and opportunity for entrepreneurial education at the national level is innovation and entrepreneurship, which have been allocated from 50% to 70%. Analysing the responses of students, master's students, and doctoral candidates, it can be confirmed that the majority of respondents expect a strong impact of information technologies on entrepreneurial education in the Republic of Moldova.



*ASEM - Academy of Economic Studies of Moldova
USM - State University of Moldova
UTM - Technical University of Moldova
USC - State University of Comrat
USBPH - "Bogdan Petriceicu Hasdeu" State University of Cahul

Fig. 4. Stage I - Model Scheme of the Incubation Process for Potential Entrepreneurs from the University Environment

Source: elaborated by the authors.

Regarding the question of whether universities should be involved in entrepreneurial education that replaces part of the educational programs, the following selection areas were proposed for participation: Business creation; Business Incubator activity; Management of international projects. The response to the item about collaboration between companies and higher education institutions in the development of skills and competencies in entrepreneurial education highlights that 51% of respondents do not know if these two players are prepared for collaboration, 37% believe they are ready, and 12% do not believe in this collaboration [14].

Currently, there is a need for creating an integrated model for the development of innovative SMEs in the university environment, in which the "student entrepreneurs" team collaborates with scientists (researchers) within the university. The "student entrepreneurs" team develops a project (with a business plan presentation) for the university's existing infrastructure, actively participates in competitions based on investments, and receives financial support for the implementation of business ideas, which leads to the launch of the enterprise [2, 6].

Startups emerging from the academic environment play an essential role in the knowledge-based economy. These are economic entities that are searching for a scalable, efficient, and profitable business model, which essentially defines a startup as newly created enterprises aiming to produce a new product or service under extreme uncertainty.

The activities of a business incubator are regulated by Law nr. 138 of 21.07.2007, which outlines the stages of creating and activating such an institution. However, this law is still relatively unknown among potential entrepreneurs in our country. Establishing a business incubator alone does not necessarily attract potential entrepreneurs. The institution not only needs to comply with the legal framework but also must operate as a results-oriented centre with clearly defined objectives. In this case, all incubator activities should follow a strategic management plan divided into several directions.

1.Whether we are talking about an innovation incubator or a regional incubator, it must be made known to potential entrepreneurs. Therefore, a well-established communication plan tailored to the expected profile of future business operators is a mandatory requirement. The incubator's website and social media pages must contain relevant information for potential incubates. This information should be regularly updated to maintain the institution's credibility and visibility.

2.The visibility of a regional incubator requires informing all local residents about the possibility of starting small businesses and incubating newly established companies in the regional incubator. Information can be disseminated through cooperation with local public institutions, training sessions, informative brochures, and announcements in local media. For university incubators, active involvement in informing students about the opportunity to start businesses is required. This can be done through various mini-sessions, trial lessons, and open days for student entrepreneurs.

Transparent information increases the chances of encouraging and motivating future entrepreneurs, changing the reticent attitudes of local residents and nurturing an entrepreneurial spirit among students from various faculties.

It is a misconception that only students with an economic background should engage in entrepreneurial activities. Any skill or competence can be transformed into a product or service, which can become an innovative business idea. For example, translation schools, online tutoring services, and creating courses for students can all be pursued by students from technical and humanities faculties, not just those in economics, as mentioned earlier.

Transparent communication is desirable both with the business incubator's funders, the administrators, and potential residents. This transparency ensures that all parties are informed about the stages of selection and incubation of companies within the incubators, which helps avoid any disputes regarding the selection process.

3.Once a business incubator's communication and promotion plan is put into practice, transparent selection criteria for candidates are mandatory. These criteria should enable candidates to understand the viability and sustainability of their business idea. In a globalized world, companies with significant growth potential, as well as those with social impact, need to be taken into account. For academic-based business incubators, criteria related to impact, innovation, and alignment with the institution's values should be set. Criteria for selecting future incubates should be established based on the region's specific characteristics and the local population's traditions.

4.After candidate selection, the incubator's management should provide full support for the necessary paperwork to finalize contracts, which should clearly define the conditions of incubation and the support offered by the incubator, including legal advice, financial guidance, HR, marketing, IT, auditing, and other consultancy services.

The goal of a business incubator is to assist and guide potential incubates correctly to create new companies and develop them, aiming for a 100% incubation rate. The objective of achieving a 100% incubation rate will enhance the local perception of the business incubator as a link between state institutions and create a favourable climate for recruiting other incubates. Newly created companies are value generators, subject to taxation, job creators, and a driving force for change. This means that rigorous, transparent, and fair management is mandatory for any business incubator, whether regional or within an academic environment. Information, selection, consultancy, and mediation of incubates are steps that should be included in the statute of each business incubator, with regular audit plans ensuring a correct understanding of the economic and social impact of business incubators.

In the second stage, Regional Business Incubators will select and implement the business projects developed within University Business Incubators that fit the region in which the regional incubator is located. The regional incubator will provide conditions for business development, guidance, and achieving outstanding business results. This contributes to the development of the regional and local economy.

The main objectives of business incubators within the academic environment and regionally are as follows: promoting entrepreneurial spirit among specialists, researchers, designers, teachers, and students, and stimulating private initiatives;

strengthening the link between the university and the business environment to enhance economic competitiveness; efficiently using the existing economic and human potential in universities and local areas by focusing on advanced technologies; attracting private investments in research and development; familiarizing students with the dynamic and constantly changing domestic business environment; supporting students in developing practical skills necessary for business and management; channelling intellectual and financial resources into priority areas of the economy: implementing new technologies, promoting exports, developing the agri-food sector, rural tourism, and more; promoting entrepreneurial culture and improving the level of entrepreneurial knowledge in rural areas; and strengthening a dynamic private sector capable of withstanding competitive forces and international competition [7].

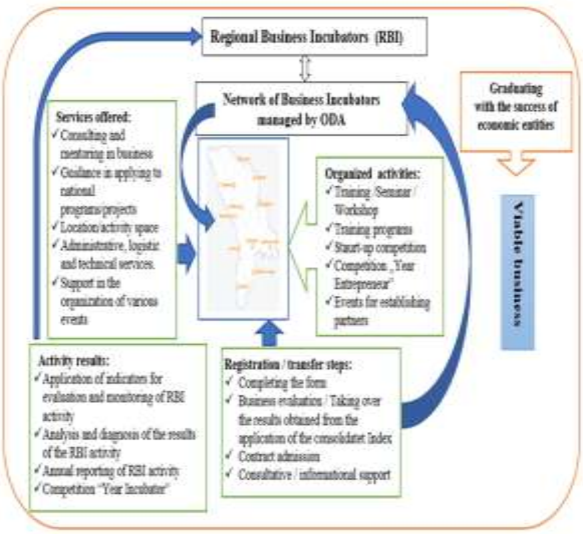


Fig. 5. Stage II - Model scheme of the incubator process of young entrepreneurs from businesses sectors
Source: elaborated by the authors.

To prevent the mentioned (negative) factors from directly influencing entrepreneurial activities, we have proposed using the CUSTOMER model created by Michael E. Gordon. This model would allow the formation of a "partial" shield or barrier that would selectively impede the factors affecting entrepreneurship while positively impacting entrepreneurial performance. These factors would enable young entrepreneurs to easily navigate the stages of initiating their own business and operate with a competitive edge. In his model, the American researcher utilizes eight interconnected positive factors that are not independent and influence the performance of entrepreneurs [5].

A business incubator located within the university environment is a crucial component of a complex system whose success depends on external factors such as the macroeconomic situation, the legal framework within which the incubator operates, and the entrepreneurial culture. It also relies on internal factors, including technical and scientific knowledge, the skills of academic staff, teamwork, access to financial resources, and programs, among others. It's important to note that the methodology applied within university incubators plays a significant role in shaping their structure, internal processes, and the ability to evaluate and monitor their activities.

To enhance the efficiency of universities in promoting and developing incubators within the academic environment, there is a need to redirect interdisciplinary efforts toward project-based activities involving students from all academic levels. These projects should focus on research and practical applications to foster innovation and entrepreneurial activities.

We believe that a business incubator has a dual mission. On one hand, it aims to create a sustainable strategy to self-finance and reduce dependence on university projects, thus increasing the efficiency and effectiveness of these institutions within universities. On the other hand, its mission is to assist newly created companies in becoming financially and managerially independent within just 3 years of incubation.

The initial period for small businesses is critical, considering that the business grows alongside the entrepreneurial mindset of its founder. Incubator management must implement control and audit mechanisms to assess the knowledge (financial, managerial, legal, tax, etc.) of the business initiator. They also need to create controls and audits for the vitality of the business, provide constant market support, and continuously evaluate its opportunity to capitalize on new opportunities.

Entrepreneurial thinking, although it may seem abstract, can be modified through continuous training organized by the business incubator, which can initiate partnerships with the academic university environment. A recommendation is made to the academic environment to implement practical course hours with information derived from the concrete realities of companies incubated in the university setting.

There is a win-win situation for everyone: students fulfil their individual tasks for course hours, having concrete data from incubated companies, while the incubated companies gain access to innovative ideas for free, which they can implement immediately and quantify rapidly. Community support within business incubators creates added value, entrepreneurial motivation among students, and measurable results for the academic environment as a whole.

The business incubator needs to be reconsidered as a profit center for the university, as well as a place of cohesion between practical and theoretical knowledge. Business incubators are tools with great potential for the academic environment, and in this work, we aimed to schematically present all interested parties and all related processes.

The external environment is extremely important for a business incubator; legislative changes, changes in the capital market (such as increased lending rates), discourage young entrepreneurs. Therefore, the business incubator also acts as a guarantor for the incubated companies in the credit market. Business incubators are not just physical spaces for potential entrepreneurs to rent; they are spaces for the exchange of ideas, business partnerships, and added value for incubators, young entrepreneurs, the academic environment, and the local and regional economic environment.

CONCLUSIONS

The development of business incubators at the regional level and within the academic environment involves the engagement of multiple decision-makers, namely state institutions through the approval of coherent strategies, educational institutions by creating efficient conditions for the development of such incubators, and promoting them among students and faculty. The latter should be informed, involved, and motivated to actively participate in this value chain by creating new companies within the incubators by students and continuously leveraging theoretical knowledge.

State institutions have approved the 2030 Strategy, transparently stating their willingness to create a legal framework and set a clear vision in the field by promoting entrepreneurial, economic, and financial education in the curriculum at all levels of the education system. By 2025, at least 60% of learners should possess these competencies (in relation to the age-specific and projected purposes). The strategy also emphasizes the development of business support infrastructure, focusing on an extended infrastructure of business support structures, including 7 Free Economic Zones with 34 sub-zones, 10 industrial parks, and 11 business incubators, including 4 innovative incubators within the academic environment.

In this study, we highlighted ideas regarding the expectations of the academic environment and their perception of potential services offered by academic institutions. Therefore, 84.6% of respondents consider entrepreneurship training (in accounting, human resources, finance, taxation, marketing) necessary-an opportunity for the academic environment to engage in extracurricular training for both students and faculty in non-economic faculties, as well as for individuals from outside requiring knowledge in the field.

The existence of an incubator also entails facing a series of challenges, from the creation of the entity to the acceptance of the first incubated companies. The challenges mentioned in this study are legislative, financial, human resources-related, and involve raising awareness among all participants about the benefits of harnessing the potential of incubators developed both at the regional level and within the academic environment.

The proposed models in this study aimed to highlight the tools needed to create and efficiently manage incubators, to establish and incubate small enterprises correctly. This way, upon completion of the program, both the incubated company and the individuals benefiting from such opportunities are competent to exist and grow in a competitive, innovative market with a global perspective.

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THE IMPACT OF WATER AND NUTRIENT STRESS ON FOUR POTATO VARIETIES GROWN IN THE CENTRAL AREA OF ROMANIA

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Abstract

The experiment in this article is an approximate replica of the experiment in the article "The Growth And Development Of The Potato According To Their Variety In The Central Area Of Romania" published in the "Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture", but in a different location in central Romania and with a slight resizing of the experimental plots. This research exposes the adaptability to water and nutrient stress conditions of three potato varieties (`Alouette`, `Salad Blue`, and `Paradiso`) compared to the control variety, `Productiv`, which is a native variety maintained in conservation by research stations. The three potato varieties (`Alouette`, `Salad Blue`, and `Paradiso`) were cultivated under the same conditions as the control. The experimental field was established in central Romania, in Brașov County, Mandra village. During the vegetation period, the following criteria were monitored: height of the main stem, number of main stems, number of leaves on the main stem, length of the median leaf on the main stem, and chlorophyll content of the leaves. Precipitation and daily temperatures were also recorded during the vegetation period. After data centralization and statistical analysis, it was concluded that the variety `Alouette` had the best development.

Key words: *Solanum tuberosum L., variety, adaptability, water stress, SPAD.*

INTRODUCTION

The potato is a plant introduced into cultivation around 8-10 thousand years ago, adapted to the cultivation environment from its wild forms, originating from the Andes region [23]. As for growing conditions, it was initially adapted to be cultivated at altitudes of over 3,000 meters above sea level, on saline soil, with high solar radiation [16]. Currently, potato varieties are acclimatized in areas with maximum altitudes of 1,000-1,500 meters above sea level, as opposed to sea level [4]. In Romania, it was introduced at the end of the 18th century, being cultivated for the first time by pharmacists in the botanical gardens of Transylvania [20]. In terms of caloric contribution, the potato tuber provides the highest energy content (5,600 kcal/m^3) and protein content (150 g/m^3) per unit of water compared to other cultivated plants [12]. Currently, according to the Food and Agriculture Statistics website, globally, potatoes rank sixth, following sugar cane, which holds the first position, followed by corn, wheat, rice, and oil palm fruits [1]. In Romania, potatoes rank fifth, after wheat, which holds the first position, followed by corn, sunflower, and barley – la fel si aici [1]. The potato is a cultivated plant that prefers moist and cool soils [14]. In Romania, the total quantity harvested annually of potato tubers experienced a sharp downward curve during the period 2019-2022. Specifically, the harvested quantity decreased from 2,626,790 tons in 2019 to 1,345,780 tons in 2022, indicating a decrease of 1,281,010 tons, nearly half, between 2019 and 2022 [13]. According to the Official Catalog of Cultivated Plants in Romania for the year 2023, there are 28 varieties cultivated, including the variety `Productiv` (which is chosen as the control variety in this experiment) [24]. Unofficially, in Romania, several potato seed varieties are sold according to specialized websites that commercialize seed material. Currently, one of the problems encountered in practice is the nitrogen fertilization of potato crops. Excessive fertilization can lead to excessive vegetative growth, poor tuber quality due to delayed maturity, low dry matter content in small quantities, and probably the biggest issue in this case, water pollution, and inefficient use of nitrogen-based fertilizers [11]. To observe the effectiveness of certain varieties in utilizing the nitrogen present in the soil reserve, without initial fertilization or during vegetation, the morphological characteristics of the plant were monitored from the soil surface and correlated with the results provided by the SPAD 502 [2]. Through the SPAD (Soil Plant Analysis Development) technology, it is possible to monitor the state of the vegetation of the crop through non-invasive techniques [22]. The use of SPAD technology offers a practical and convenient method for its use in the field with which the amount of nitrogen in the plant can be observed [22]. In this paper, four varieties of potato were studied, more precisely: \`Productiv\`, \`Alouette\`, \`Paradiso\` and \`Slad Blue\`. They were cultivated in the Mandra village, in Brașov county (GPS position 45°81\`59.92\`\`N; 25°04\`52.04\`\`E).

Fig. 1. The location of the experimental site situated between Fagaras city and Brașov city
Source: QGIS - qgis.org.[29]

MATERIALS AND METHODS

Description of the experimental site

The present study was developed on Mandra, a village near Fagaras city, Brașov County (Fig.1).

Climatic conditions

Climatic conditions during the vegetation period, specifically maximum and minimum temperatures of the days, along with precipitation, are presented in the graph in Fig. 2. Temperatures and precipitation are recorded starting from the day the tubers were planted (22nd April) until the day of harvest (8th September). The sum of the degrees was 2,536 ^{0} [17], and the total precipitation was observed with the help of a rain gauge installed near the plots, amounting to 381 mm during the entire vegetation period.

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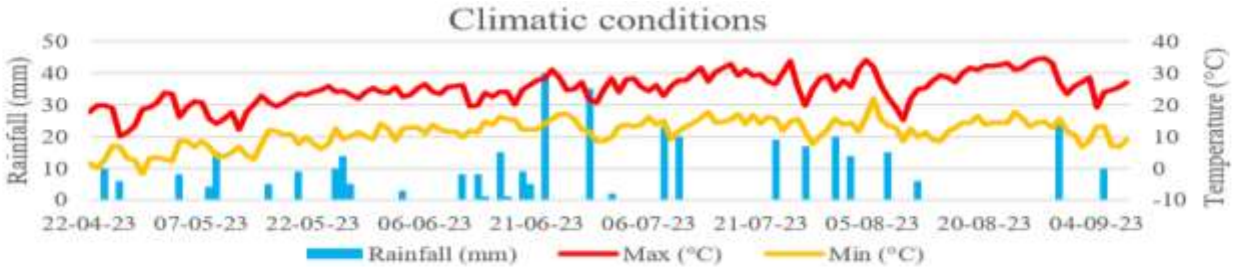

Fig. 2. The climatic conditions during the experimental period in Mandra, Brașov County
Source: meteoblue.com [17].

Description of varieties

The varieties used in this research are the same as in the experiment in Rusciori village, Sibiu county [8]. All of them are certified plant material obtained from Potato Research – Development Stations from Targu Secuiesc (SCDCTS), Romania and Potato Research - Development Stations from Miercurea Ciuc (SCDCMC), Romania and they are:
-`Alouette`, native from the Netherlands;
-`Paradiso`, native from the Netherlands; -`Productiv`, an autochthonous variety, developed at SCDCTS, currently maintained in the conservation stage according to the Official Catalog Of varieties, from Romania;
-`Slad Blue`, native from Scotland.
All four varieties are described on the Table 1, in order to their provider, type of variety, shape of tuber, epidermis and flesh color [8].

Experiment design

The experiment was designed on a plot with dimensions of 11 x 10 m (Lxl), which means 110 m^2, where the four varieties were planted. Each variety was planted on a subplot with a size of 2.50 x 11 m (Lxl), with a total area for each variety 27.5 m^2. The distance between the subplots was 0.5 m with a 0.8 m protection strip for each outer side of the plot. The tubers were planted at a distance of 0.5 m between rows and 0.25 m between tubers per row, as in the case of the experiment in Rusciori village, Sibiu county [8], resulting in 33 plants per row.

The experimental procedure

The land preparation was carried out through autumn plowing, and the seedbed preparation was done by soil tillage using a motorized cultivator. No fertilizers or amendments were applied to the plots, and no irrigation was applied. Planting was done manually at the beginning of April 2023. Hilling of the rows was performed at the beginning and end of May 2023, and the plots were weeded after plant emergence. During the vegetation period, four treatments were applied against manna (*Phytophthora infestans*) with phytosanitary products containing dimethomorph, propamocarb, zoxamid, cimoxanil and metiram, and phytosanitary products were used for harmful pests (*Leptinotarsa decemlineata* L.) based on cyhalothrin and metaflumizone (Table 2). Tubers were harvested on September 8th, 2023.

Table 1. Summary characterization of *Solanum tuberosum* L. varieties studied

Variety	Provider	Variety	Shape of Tuber	Epidermis Color	Flesh Color
`Alouette`	SCDCMC	Early	Oval-long	Red	Yellow
`Paradiso`	SCDCMC	Early	Oval-long	Yellow	Yellow
`Productiv`	SCDCTS	Early	Round-oval	Yellow	Yellow
`Salad Blue`	SCDCTS	Early	Oval	Blue	Purple to blue

Note: SCDCTS – Potato Research - Development Stations from Targu Secuiesc; SCDCMC – Potato Research – Developmen Stations from Miercurea Ciuc

Source: Original.

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Table 2. Phytosanitary treatments performed on the experimental site

Crt. No.	Date of treatment	Vegetation phenophase	Active substance	Pest/disease
1	01.05.2023	Leaf development	Metribuzin	Weeds
2	04.06.2023	Formation of side shoots	Metiram	*Phytophthora infestans*
			Cyhalothrin	*Leptinotarsa decemlineata* L.
3	15.06.2023	Flowering	Metaflumizon	*Leptinotarsa decemlineata* L.
4	30.06.2023	Development of fruits	Metaflumizon	*Leptinotarsa decemlineata* L.
			Zoxamid + cimoxanil	*Phytophthora infestans*
5	10.07.2023	Development of fruits	dimetomorf +propamocarb	*Phytophthora infestans*

Source: Original by own determination.

Data collection and analyzing

On June 16th, June 30th, and July 16th, biometric observations were collected on 10 plants from each variety. The plants were randomly selected from within the experimental plots to determine the influence of each variety on the height of the main stem, the number of main stems, the number of leaves on the main stem, and the length of the median leaf. The height of the main stems was measured by assessing each stem from the soil level to the top (Photo 1).

Subsequently, the number of main stems, the number of leaves on the main stem, and the length of the median leaf were determined using a similar determination method as used by Tessema et al [25; 26]. All determinations were made on 10 different plants from the same variety. Additionally, the average of twenty determinations was determined for the chlorophyll content of the leaves for each plant. The determination of chlorophyll content was performed using the SPAD-502PLUS device created by Konica Minolta, Japan. The device measures the wavelengths of light in the red light spectrum (650 nm) and near-infrared (960 nm) (Photo 2).The SPAD-502PLUS device is capable of measuring the chlorophyll content of the plant by applying the measuring sensor to the plant`s leaves [27]

All collected data were processed using the IBM SPSS software, applying the Duncan test, using a one-way analysis of variance with four variables. Each variable represents one of the studied varieties.

Photo 1. Determination of the height of the main stem in the experimental field. Each segment of the ruler is 10 cm

Source: Original by own determination.

Photo 2. Measuring the chlorophyll content with the SPAD-502PLUS device, on a potato leaf from the experimental field in Rusciori
Source: Original by own determination

RESULTS AND DISCUSSIONS

During the vegetation period, to protect the plants from pathogens and pests, 6 treatments were applied exactly as presented in the materials and methods section. The pathogens targeted by the treatments are the main agents of potato infestation globally, including *Phytophthora infestans* [15] and *Alternaria solani* [19] . Generally, potato diseases can be prevented through three general methods of control, namely: inducing greater plant resistance to a specific pathogen through selection and improvement, creating resistant varieties in this manner [21], selecting seed material that shows no signs of infection with pathogens and ultimately applying phytosanitary treatments to plants in the vegetative stage [9]. For the height of the main stem, significant differences were observed only between the `Salad Blue` variety, having the shortest height (35.90 cm), and the other three varieties, with the `Alouette` variety having the tallest main stem (64.60 cm). The results of the test regarding the number of main stems were the same for the control `Productiv` variety and the `Alouette` variety (4.33), with the lowest result recorded by `Salad Blue`. `Alouette` had the highest average (12.90) for the number of leaves per main stem, compared to the lowest average recorded by the control variety `Productiv` (11.33). The highest average length of the median leaf was recorded by the `Alouette` variety (22.06 cm), while the lowest average was recorded by the `Salad Blue` variety (16.60 cm). In conclusion, the most relevant indicator for this study was the chlorophyll content that the plants had at the time of observations. `Alouette` was classified as the best following the Duncan test on field-collected data (37.90 SPAD units), followed by `Productiv` (36.31 SPAD units), `Paradiso` (33.65 SPAD units), and lastly `Salad Blue` (32.78 SPAD units) (Table 3). The value Several expressed in the SPAD index is closely related to the nutrients contained in the potato plant on which the measurement is applied [7].

Table 3. Biometric observations on the experimental site regarding the growth of plants

Variety	Height of the main stem (cm)	No. of principal stems	Leaves no. on the main stem	Length of leaf (cm)	The clorophyll content of leaves (SPAD units)
`Alouette`	64.60^{a}	4.33^{a}	12.90^{a}	22.06^{a}	37.90^{a}
`Paradiso`	60.66^{a}	3.70^{ab}	12.13^{a}	18.26^{b}	33.65^{bc}
`Productiv`	60.40^{a}	4.33^{a}	11.33^{a}	20.66^{a}	36.31^{ab}
`Salad Blue`	35.90^{b}	3.16^{b}	12.90^{a}	16.60^{b}	32.78^{c}

Note: The means in the column inside the table followed by different letters are significant according to Duncan`s MR test ($p<0.05$).
Source: Original by own calculation.

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Researchers have demonstrated that if the SPAD index is between 49 and 56, the plants are very well supplied with nitrogen and can achieve maximum yield if other environmental conditions are optimal [3; 6; 10; 18].

A similar research took place in Brașov County, in the years 2013 and 2014, on two local potato varieties, but unlike the experiment in this article, the plots were fertilized. Similar to the present experiment, Barascu and colleagues performed biometric measurements for: main stem height, average leaf length, number of main stems, and chlorophyll content in leaves using the SPAD [2]. The data obtained by the authors from June 19th, July 1st, and July 16th, 2013, and June 10th, June 23rd, July 7th, and July 21st, 2014, were compared, these days coinciding with the vegetation periods in the present article for which the same data were collected. Following centralization, the Duncan test was applied, using the IBM SPSS program (Table 4), to identify if there are similarities, especially for chlorophyll content. The results of the Duncan test indicate significant differences for main stem height, average leaf length, and number of main stems, which can be explained by the fact that the two varieties in Barascu`s experiment had a greater development of the upper part due to optimal nitrogen fertilization, nitrogen being the nutrient element with the highest contribution to plant biomass accumulation [5]. Studies show that nitrogen, as a factor that can influence the yield of potato plants, has a percentage contribution of 40 to 50% [28]. Another study carried out on potato crops that aimed to identify the most important factors that can influence the quality of tubers was carried out in the Loess Plateau of China, and the result was that nitrogen was the most important, before phosphorus, potassium and pH in ground [30]. Likewise, the nitrogen content of the plant had an important influence on the total content of soluble sugar, vitamin C, the intensity of browning and the activity of polyphenol oxidase [30]. But for chlorophyll content, the comparison between the `Alouette`, `Productiv`, and `Christian`, `Raclos` varieties shows a slight similarity in results, which may mean that the two `Alouette` and `Productiv` varieties may have genetic potential for adaptability to nutritional stress conditions. For an overview of this research, for which two experimental fields were created, in two different localities, a Duncan test was applied to the obtained results (Table 5).

Table 4. Differences between the results of this experiment and those of Brascu (source: original by own calculation)

Variety	Height of the main stem (cm)	Length of leaf (cm)	No. of principal stems	SPAD index
`Alouette`	64.60^{b}	22.06^{c}	4.33^{b}	37.90^{ab}
`Paradiso`	60.66^{b}	18.26^{de}	3.70^{b}	33.65^{bc}
`Productiv`	60.40^{b}	20.66^{cd}	4.43^{b}	36.31^{abc}
`Salad Blue`	35.90^{c}	16.6^{e}	3.16^{b}	32.78^{c}
`Christian`	82.28^{a}	29.15^{b}	6.08^{a}	41.27^{a}
`Raclos`	84.57^{a}	33.42^{a}	6.32^{a}	39.57^{a}

Note: The means in the column inside the table followed by different letters are significant according to Duncan`s MR test (p<0.05).
Source: Original by own calculation.

Table 5. The results obtained on the experimental fields in Mandra and Rusciori

Variety	Height of the main stem (cm)		No. of principal stems		Leaves no. on the main stem		Length of leaf (cm)		SPAD index	
	Rusciori	Mandra	Rusciori	Mandra	Rusciori	Mandra	Rusciori	Mandra	Rusciori	Mandra
`Alouette`	43.54^{b}	64.60^{a}	6.24^{a}	4.33^{bc}	11.40^{bc}	12.90^{a}	13.90^{c}	22.06^{a}	38.24^{ab}	37.90^{ab}
`Paradiso`	30.24^{c}	60.66^{a}	4.02^{c}	3.70^{cd}	9.38^{d}	12.56^{a}	13.90^{b}	18.26^{b}	36.24^{b}	33.65^{c}
`Productiv`	38.22^{c}	60.40^{a}	5.36^{b}	4.43^{bc}	10.00^{cd}	11.03^{bc}	17.88^{b}	20.66^{a}	36.31^{b}	36.31^{b}
`Salad Blue`	28.64^{d}	35.90^{c}	5.64^{a}	3.16^{d}	9.48^{d}	12.56^{a}	14.24^{c}	16.6^{b}	31.63^{c}	32.78^{c}

Note: The means in the column inside the table followed by different letters are significant according to Duncan`s MR test (p<0.05).
Source: Original by own calculation.

CONCLUSIONS

Considering the results obtained in this experiment, the variety `Alouette` presented the best development among the four varieties of the experiment, with acceptable assimilation of nitrogen from the soil even in the conditions of an unfertilized plot, which can lead, according to the specialized literature and at a high yield of tubers, provided that the other pedoclimatic factors meet the standard vegetation conditions for potato plants. Another argument to determine that the `Alouette` variety has a good ability to adapt to less favorable conditions and to argue that from a physiological point of view it is the variety
with the best results from this experiment, is the statistical comparison with the results of the research done by Barascu and the collaborators, also in Brașov county, with the two local varieties, but who had a part in the application of fertilizers on the experimental plot. The reduced precipitation during the vegetation period did not have such a significant negative influence as on the other varieties in the experiment. Similar to the experiment in the village of Rusciori, Sibiu county, we can consider that the `Alouette` variety could be one of the options for potato growers in the area of Brașov county, showing good adaptability to the pedoclimatic conditions of the region. On the other hand, the variety `Salad Blue`, based on the unsatisfactory results, cannot be considered a good option for cultivation in this area, offering a low yield in terms of nitrogen assimilation from the soil, which leads to a low yield of tubers. Making an overall analysis of the two experiments, the statistical results, according to Table 5, indicate that the best results for chlorophyll content were obtained for the varieties: `Productiv` and `Alouette` in Rusciori locality and `Alouette` in Mandra locality. These claims are supported by the above statistical results of the biometric measurements and readings taken with the SPAD-502PLUS device. We plan to continue the research with the determination of the yield for the two experimental fields and the biochemical analysis of the tubers.

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OBSERVATIONS ON THE PHYTODIVERSITY OF THE SITE OF THE STEPPE ISLANDS OF ȘURA MICĂ - SLIMNIC (SIBIU COUNTY), ROMANIA

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Abstract

Phytodiversity, representing the totality of plant species in a given habitat or territory, plays an essential role in maintaining ecological balance, perpetuating the floristic structure of plant communities and producing phytomass, food for consumers and a source of useful materials for the development of human civilizations. Our research was conducted in the ROSCI0093 site in the period 2011-2024. The aim of the investigations was to assess the diversity of plants in the Peri area, respectively to highlight the flora (elaboration of a floristic list, phytocenological surveys). The results can be used to understand the dynamics of the local ecosystem, to highlight potential threats diminishing phytodiversity, to develop conservation strategies.

Key words: *phytodiversity, Peri-Şura Mare perimeter, Şura Mică-Slimnic steppe islands, Sibiu County, Romania*

INTRODUCTION

The site of the steppe islands Șura Mică - Slimnic was designated for the preservation of wild flora and fauna as well as natural habitats of community interest. The site is fragmented, consisting of islands of steppe vegetation existing, in particular, on the sunny slopes of some hills belonging to the administrative districts of Slimnic, Șura Mare and Șura Mica, located north of Sibiu. It is a Site of Community Importance by Order of the Ministry of the Environment and Sustainable Development No. 1964 of December 13, 2007, being an integral part of the Natura 2000 European ecological network in Romania, with code ROSCI0093. On an area of 367 hectares the site would have had, at its establishment, seven types of community habitats and over 400 plant species (cormophytes). The aim of the investigations was to assess the diversity of plants in the Peri area, respectively to highlight the flora (elaboration of a floristic list, phytocenological surveys).

MATERIALS AND METHODS

Our research at the ROSCI0093 site from 2011-2024 (Fig. 1) involved a complex set of activities, consisting of detailed field observations and identification of plant species using specialized literature [1], [2], [3] [10], together with optical instruments such as magnifying glasses and binoculars, phytocenological surveys in order to highlight the composition, floristic structure and distribution of plant communities in the investigated area, thus contributing to a better understanding of the dynamics of the local ecosystem [4], [5], [6].

Fig.1. The site of the Steppe Islands Șura Mica – Slimnic, the fragment Peri
Source: [9].

Fragments of the ROSCI0093 site have also been studied by other researchers who have emphasized the steppe character of some habitats, the characteristic and rare species of these islands of xerothermophilous vegetation [7], [8], [11-15].

RESULTS AND DISCUSSIONS

The investigations led to the following findings:
1. 168 species were identified (Table 1);
2. The phytodiversity has decreased under the action of several factors among which the decrease of precipitation, intensive grazing with hundreds of cattle and sheep, human activities in the territory;
3. Some rare species and habitats, which were arguments for the site designation, have disappeared or have not been found (e.g. species *Adenophora lilifolia*, *Anacamptis pyramidalis, Angelica palustris* and habitat 6410 Meadows with *Molinia* on carbonaceous, peaty or loamy-clay soils Molinion caeruleae);
4. Zakel Hill Reserve was fenced;
5. The best preserved are the hills of the Sharba Valley;
6. The most degraded is the Peri perimeter (Șura Mare) as a consequence of soil subsidence and erosion, the grass cover having 75% cover, almost one third of the flora being weed species). The species characteristic of the initial grassland, i.e. of the Festuco-Brometea class, are mostly of low abundance-dominance.

In the upper part of the study plot we could identify a phytocenosis belonging to the Festucion valesiacae alliance (Table 2). It has several characteristic species of both habitat 6210 (*Festuca valesiaca*, *Arabis hirsuta*, *Brachypodium p*innatum, *Carex caryophyllea*, *Eryngium campestre*, *Medicago falcata*, *Polygala comosa, Sanguisorba minor, Silene otites*, *Veronica prostrata*, *Leontodon hispidus*) and 6240 (*Festuca valesiaca*, *Teucrium chamaedrys*, *Potentilla arenaria*, *Astragalus austriacus*).

According to its floristic composition, even partially altered, the phytocenosis in question can be classified in the Festucetum valesiacae association. Within it, *Dichantium ischaemum* patches have developed which could also be treated as Dichanthietum ischaemi subas. festucetosum valesiacae.

In the lower part of the plot, the vegetation is difficult to categorize due to the penetration of several weed and shrub species (34 species), sometimes with high abundance and dominance (Table 1).

The information noted in this paper may be useful in the management of this area, which is both agricultural land, grassland and Natura 2000 site.

Table 1. Relevee effectuate

Taxon	Column Number	
	1 Top of the plot (summary) 4 relevee	**2 Lower part of the plot) (summary 2 relevee)**
Festuca valesiaca Schleicher	3-4	2-3
Achillea collina (Becker ex Rchb.f.) Heimerl	+	-
Achillea millefolium L.	+	+
Acinos arvensis (Lam.) Dandy	+	-
Agrimonia eupatoria L.	+	-
Agrostis capillaris L. (*A. tenuis* Sibth.)	+-1	1
Ajuga genevensis L.	+	-
Ajuga reptans L.	-	+
Alyssum alyssoides (L.) L.	+	-
Amaranthus retroflexus L.	-	+
Anthoxanthum odoratum L.	+	-
Arabis hirsuta (L.) Scop.	-	+
Arenaria serpyllifolia L.	+	+
Artemisia campestris L.	+	-
Asperula cynanchica L.	+	-
Astragalus austriacus Jacq.	+	-
Astragalus monspessulanus L.	+	-
Ballota nigra L.	-	+
Bellis perennis L.	-	+
Brachypodium pinnatum (L.) Beauv.	+-1	-
Bupleurum falcatum L.	+	-
Calamintha vulgare L.	1	-
Campanula sibirica L.	+	-
Capsella bursa-pastoris (L.) Medik	-	+
Carduus acanthoides L.	+	+
Carex caryophyllea Latourr	+	-

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Carex tomentosa L.	+	-
Caucalis platycarpos L.	-	+
Centaurea biebersteinii DC. (C. micranthos S.G. Gmelin)	+-1	-
Centaurea scabiosa L.	+	-
Cerastium holosteoides Fries	+	+
Chelidonium majus L.	-	+
Chenopodium album L.	-	+
Cichorium intybus L.	-	+
Cirsium arvense (L.) Scop.	-	+
Convolvulus arvensis L.	-	+
Cornus sanguinea L.	-	+
Coronilla varia L.	-	+
Crataegus monogyna Jacq.	+	1
Crepis tectorum L.	+	-
Dactylis glomerata L.	+	+
Daucus carota L.	+	+
Descurainia sophia (L.) Web.	-	+
Dichantium ischaemum (L.) Roberty	+-1	-
Dipsacus fullonum L. (*D. sylvestris* Hudson)	+	+
Dorycnium pentaphyllum Scop. subsp *herbaceum* (Vill.) Rouy.	+	-
Echium vulgare L.	+	-
Elymus repens (L.) Gould (Agropyron repens (L.) Beauv.)	+	1
Eryngium campestre L.	-	+
Euphorbia cyparissias L.	+-1	+
Erigeron annuus (L.) Pers. (Stenactis annua (L.) Less.)	-	+
Fragaria viridis Weston.	+-1	-
Galium aparine L.	-	+
Galium mollugo L.	+	-
Galium verum L.	+	-
Genista tinctoria L.	+	+
Genistella sagittalis (L.) Gams.	+	+
Geum urbanum L.	-	+
Glechoma hederacea L.	-	+
Helleborus purpurascens Waldst. et Kit.	-	+
Hieracium pilosella L.	+	-
Hypericum elegans Steph.	-	+
Hypochoeris radicata L.	-	+
Hypericum perforatum L.	+	+
Leontodon hispidus L.	+	-
Linaria genistifolia (L.) Miller	-	+
Linum perenne L.	+	-
Luzula campestris (L.) DC	+	-
Medicago falcata L.	+	-
Medicago lupulina L.	+	-

Melilotus officinalis Lam.	-	+
Lactuca serriola Torner	-	+
Lolium perenne L.	-	+
Lepidium campestre (L.)R.Br.	-	+
Lotus corniculatus L.	+	+
Muscari racemosum Mill.	+	-
Nonea pulla DC.	+	-
Onobrychis viciifolia Scop.	+	-
Oxalis stricta L.	-	+
Peucedanum oreoselinum (L.) Moench.	-	+
Pimpinella saxifraga L.	+	-
Plantago lanceolata L.	+	+
Plantago major L.	-	+
Plantago media L.	+	+
Poa annua L.	-	+
Polygala comosa Schkuhr.	+	+
Polygonum aviculare L.	+	+
Potentilla arenaria Borkh.	1-2	-
Potentilla argentea L.	+	-
Potentilla reptans L.	-	+
Primula veris L. em. Huds	-	+
Prunella vulgaris L.	+	+
Prunus spinosa L.	+	1-2
Pyrus pyraster (L.) Burgsd.	+	+
Ranunculus acris L.	-	+
Rhinanthus angustifolius C.C. Gmelin	-	+
Rosa canina L.	+	1
Rubus caesius L.	-	+
Rumex acetosella L.	-	+
Taraxacum officinale Weber	-	+
Salvia nemorosa L.	-	+
Salvia pratensis L.	+	-
Sanguisorba minor Scop.	+	-
Setaria pumila (Poiret) Schultes	-	+
Silene otites (L.) Wib.	+	-
Stellaria media (L.) Vill.	-	+
Teucrium chamaedrys L.	+	-
Thymus pulegioides L.	+	-
Trifolium arvense L.	+	-
Trifolium montanum L.	+	-
Trifolium repens L.	+	+
Urtica dioica L.	-	1
Verbascum phoeniceum L.	+	-
Veronica chamaedrys L.	-	+
Veronica teucrium L.	+	-
Xanthium spinosum L.	+	+

Source: Own calculation.

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Place and date of survey:
Column 1: Șura Mare, In Peri, 29.04.2013, 11.05.2013, 09.08.2013, 19.10.2024 [4], [5], [6].
Column 2: Șura Mare, In Peri, 29.04.2013, 09.08, 2013, 19.10.2024 [4], [5], [6].
For each species in the table, the abundance-dominance was noted according to the Braun-Blanquet scale, where:
+ means abundance-dominance: 0.1%- 1%
1 means abundance-dominance: 1%- 10%
2 means abundance-dominance: 10%- 25%
3 means abundance-dominance: 25%- 50%
4 means abundance-dominance: 50% - 75%
5 means abundance-dominance: 75%- 100%
In addition to the sample areas, the following species were also identified on the site:*Althaea officinalis* L., *Anthyllis vulneraria* L., *Arrhenatherum elatius* (L.) Beauv., *Briza media* L., *Bromus arvensis* L., *Carlina vulgaris* L., *Centaurea apiculata* Ledeb. subsp. *spinulosa* (Rochel) Dostal,*Centaurea phrygia* L., *Cerastium semidecandrum* L., *Conyza canadensis* (L.) Cronq. (Erigeron canadensis L.), *Crepis biennis* L., *Crepis setosa* Haller, *Dianthus carthusianorum* L., *Digitaria sanguinalis* (L.) Scop., *Erigeron acris* L., *Erophila verna* (L.) Chevall., *Euonymus europaeus* L.,*Filipendula vulgaris* Mnch., *Fragaria vesca* L., *Geranium pusillum* Burm.,*Hieracium bauhini* Besser, *Inula ensifolia* L., *Knautia arvensis* (L.) Coulter, *Lathyrus nissolia* L., *Ligustrum vulgare* L., *Linaria vulgaris* Miller, *Linum hirsutum* L., *Melilotus albus* Medik., *Ononis arvensis* L., *Onopordon acanthium* L., *Orchis morio* L.,*Polygala vulgaris* L.,*Ranunculus repens* L., *Reseda lutea* L., *Rumex acetosa* L., *Rumex crispus* L.,*Salvia austriaca* Jacq., *Salvia verticillata* L., *Scabiosa ochroleuca* L., *Sinapis arvensis* L.,*Sisymbrium officinale* (L.) Scop., *Sonchus arvensis* L., *Stachys annua* (L.) L., *Stachys recta* L., *Stellaria graminea* L., *Thalictrum minus* L., *Thlaspi arvense* L., *Tragopogon pratensis* L. subsp. *orientalis* (L.) Celak, *Trifolium pratense* L., *Verbena officinalis* L.,*Veronica arvensis* L., *Veronica prostrata* L.,*Viola ambigua* Wald. et Kit.

CONCLUSIONS

The investigated territory in the Peri area has a high phytodiversity potential, which could be significantly improved by reducing zoo-anthropic influences. In particular, the group of about 400 specimens of *Orchis morio* in the vicinity has the potential to expand in the studied perimeter. This expansion could favor the inclusion of the area in habitat category 6210 - Semi-natural xerophytic meadows of Festuco-Brometalia, a site of major importance for the protection and conservation of orchids. This would help to recognize and protect the site as an area of biodiversity conservation interest.

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PROFITABILITY MANAGEMENT OF ENTERPRISES IN THE AGRICULTURAL SECTOR OF UKRAINE: ANALYSIS OF DEVELOPMENT TRENDS AND MODELLING

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Abstract

The article analyses trends in the formation of profitability of enterprises in the agricultural sector of Ukraine in the studied period, which made it possible to identify certain regularities and outline recommendations. The results of the economic-mathematical modelling of the return on equity of enterprises in the agricultural sector of Ukraine were developed and presented. Based on the evaluation and analysis of the developed models, recommendations are proposed for increasing the profitability of enterprises in the agricultural sector of Ukraine, taking into account modern challenges and prospects. In particular, several measures were proposed to help improve the profitability of Ukrainian farm producers` capital. Among them, it is advisable to highlight the reduction of the financial dependence of agricultural enterprises in terms of reducing the use of credit resources with a simultaneous increase in state support for the farm sector, as well as the further consideration of risk reduction factors during the formation of the commodity policy of agricultural enterprises.

Key words: *agricultural sector, profitability management of farming enterprises, trend analysis, profitability, modelling, economic and mathematical model*

INTRODUCTION

One of the strategic branches of the Ukrainian economy is agriculture. It also belongs to industries that require significant investments and have low returns. That is why the study of profitability for agricultural enterprises is particularly relevant.
Increase management efficiency and use available funds to maximise profitability in limited and exhaustible resource conditions. The company`s profitability is a fundamental indicator that expresses the state and stability of the enterprise and its position on the market, and it is essential for investors.
The problem of assessing the profitability of enterprises was studied by Ukrainian and foreign scientists, particularly N. Antoniuk [1], I. Arakelova [2], I. Artamonov [3], N. Khomiuk [4], Ja. Kostetskyi [5], L. Kozak [6], D. Manole [7], A. Popescu [8-17], T. Shmatkovska [18-23], R. Sodoma [24], A. Verzun [26] and others. Taking into account the significant scientific achievements of these researchers and the peculiarities of the functioning of enterprises in the agricultural sector, we consider it

appropriate to emphasise the need to develop and form economic and mathematical models that will contribute to the identification of factors for increasing the level of profitability of enterprises operating in the agricultural sector of Ukraine.

The analysis of scientific works makes it possible to determine the need for deepening research in the field of study of financial results of the activity of Ukrainian agricultural enterprises as a basis for deciding benchmarks in the evaluation and analysis of reporting data of individual enterprises and selecting resources for internal support of the economy of Ukraine.

MATERIALS AND METHODS

The purpose of the article is an analytical study of the composition, dynamics and structure of financial results and the level of profitability of agricultural enterprises of Ukraine as a factor of increasing economic potential, as well as modelling the profitability of enterprises of the agricultural sector of Ukraine, which will provide an opportunity to identify the main factors that affect profitability, determine the magnitude of this impact and establish possible causes of relationships. It will also make it possible to develop practical recommendations for increasing the profitability of enterprises operating in the agricultural sector of Ukraine in the current economic conditions.

Agriculture is vital because it belongs to the riskiest industries, so the probability of reliable model results for such enterprises is one of the lowest. Therefore, we chose the most famous and common method of profitability analysis, the DuPont factor model [6].

The main task of this model is to determine the factors that affect the enterprise`s efficiency and assess the identified factors [3]. There are many profitability indicators, so DuPont company analysts conducted calculations and found that the most significant is the profitability of equity capital. There are three modifications to this model.

A two-factor model of profitability of assets (ROA).

ROA=Profitability of sales×Asset turnover (1)

$$ROA = \frac{\frac{\text{Net profit}}{\text{Sales revenue}} \times \text{Sales revenue}}{\text{Assets}} \qquad (2)$$

Three-factor model of equity capital (ROE).

ROE=Profitability of sales × Asset turnover × Financial dependence (3)

$$ROE = \frac{\frac{\frac{\text{Net profit}}{\text{Sales revenue}} \times \text{Sales revenue}}{\text{Assets}} \times \text{Assets}}{\text{Own capital}} \qquad (4)$$

Five-factor model of return on equity (ROE).

$$ROE = \frac{\frac{\frac{\frac{\frac{EBIT}{\text{Income}} \times EBT}{EBIT} \times \text{Net profit}}{EBT} \times \text{Income}}{\text{Assets}} \times \text{Assets}}{\text{Own capital}} \qquad (5)$$

RESULTS AND DISCUSSIONS

According to data published by the Ukrainian Statistics Service [25], Ukraine`s agricultural sector produces one of the most significant exports, which indicates that it is strategic for the Ukrainian state.

Ensuring the profitability of agricultural enterprises guarantees the state`s food security and the population`s lives. That is why studying the effectiveness of agricultural sector enterprises` functioning is essential and a priority for any state.

We carried out the general economic characteristics of the indicators of profitability and loss of Ukrainian agricultural enterprises using aggregated statistical data, which are officially listed on the State Statistics Service of Ukraine's website [25].

According to the study`s results, the profitability of Ukrainian agricultural enterprises` operational activities in 2021 was significantly better than in 2010, which indicates an increase in profitability in the analysed period based on operational activity results.

It was also found that the worst profitability indicators of the operational activity of Ukrainian enterprises were observed in 2013 and 2019; in particular, in this period, a decrease in net profit was observed at medium-sized and small-sized agricultural enterprises (Table 1).

Table 1. Profitability of the operational activity of agricultural enterprises in Ukraine for 2010-2021*

Years	The level of profitability (unprofitability) of the operational activities of enterprises				
	Total	including			
		large enterprises	middle enterprises	small enterprises	of them micro-enterprises
2010	22.8	29.7	23.1	17.8	10.3
2011	23.1	30.7	21.1	26.0	23.5
2012	21.6	29.6	19.7	22.8	19.3
2013	11.4	20.1	8.3	12.8	13.1
2014	20.5	23.9	20.9	18.6	14.5
2015	41.6	54.2	37.7	41.3	36.1
2016	32.3	29.4	30.3	37.3	33.1
2017	22.3	24.5	20.9	24.0	24.1
2018	18.2	22.8	17.2	18.7	16.5
2019	19.1	8.4	26.1	13.3	15.4
2020	18.5	16.1	18.6	19.9	18.2
2021	40.2	46.2	37.2	41.3	37.7

Source: S ummarized according to the data of the [25].
*According to the requirements to preserve Ukraine`s national security and territorial integrity, Ukrainian statistical information resources are limited from 2022.

Only large enterprises demonstrated appropriate resistance to changes in the external environment and, even in the most challenging years, showed positive operational profitability. We believe that this is primarily because large enterprises have more economic opportunities to resist negative factors (restrictions due to the coronavirus pandemic, martial law, loss of market share, exchange rate fluctuations, restrictions on turnover, changes in market conditions, etc.) at the expense of own capacities and state economic support provided to large enterprises in Ukraine.

Positive trends in indicators of financial results and profitability of operational activity undoubtedly indicate an increase in the overall profitability of agricultural enterprises. However, an equally important aspect is the quality of these financial results in successfully implementing opportunities to obtain them through cash flows.

According to the results of the analysis of the dynamics of net income from the sale of products of agricultural, forestry and fishery enterprises of Ukraine in 2017–2021, it was established that there are signs of a steady increase in the sales volume of enterprises in the studied industry (Fig. 1).

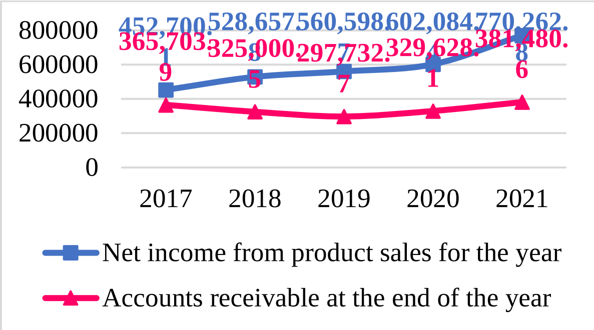

Fig. 1. Dynamics of net income from the sale of products and the balance of receivables of enterprises in the agricultural sector of Ukraine in 2017–2021, UAH million**
Source: Summarized according to the data of the [25].
**Access to Ukrainian statistical information resources will be closed from 2022 to preserve Ukraine`s national security and territorial integrity.

We will use the DuPont three-factor model [5] to calculate the return on equity since we have the necessary data to implement the specified economic-mathematical model.

The main task of this model is to determine the factors affecting the enterprise`s efficiency and assess the determined factors [3]. There are many profitability indicators, so the DuPont company analysts conducted calculations and found that the most significant is the profitability of equity capital.

The economic-mathematical model was developed using annual panel data for eight years, from 2010 to 2021 of four large Ukrainian agricultural enterprises.

In our model, the resulting variable (Y) is the return on equity of enterprises in Ukraine`s agricultural sector.

Based on the results of the research, the following hypotheses were proposed:

1) the level of return on capital is affected by the return on sales (X_1);

2) the level of profitability of capital is affected by the turnover of assets (X_2);

3) the level of capital profitability is affected by financial dependence (X_3).

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Since all the indicators used are relative, we did not standardize the data. Based on the data collection results, 4 large agricultural enterprises were obtained from 2010 to 2021. Since the time series has the minimum number of observations sufficient to build the model, we calculated two regressions: the panel and average values of four enterprises for a more accurate assessment of the econometric model.

The STATA software package was used to analyze panel series data statistically, and the Microsoft Excel package was used to investigate a series of averaged values.

To describe the return on equity, a linear model was used, which takes the form:

$$Y = \beta_0 + \beta_1 \times X_1 + \beta_2 \times X_2 + \beta_3 \times X_3 + E \quad (6)$$

Therefore, the theoretical model (6) was used to test the hypothesis about the influence of factors on the resulting change.

Thus, based on the simulation results, the following econometric models were developed:

$$ROE = 0.27 + 0.8 \times X_1 + 0.23 \times X_2 - 0.27 \times X_3 \quad (7)$$

$$ROE = 0.37 + 0.38 \times X_1 + 0.1 \times X_2 - 0.25 \times X_3 \quad (8)$$

To select the final model, a series of tests were conducted for the model built on average data (8) and the model built on panel data (7). Thus, according to the results of checks of the obtained econometric models for representativeness, it was established:

Table 2. The coefficient of determination R^2 for the conducted economic and mathematical

Indexes	For a model built on the basis of panel data	For a model built on the basis of averaged data
R2	0.8493	0.9791
Normalized R^2	0.8331	0.9068

Source: own calculations.

The calculation results of the coefficient of determination (Table 2) established that the model built based on averaged data is more representative.Therefore, during the analysis of panel data, the significance indicator of the F-statistic during the assessment of the adequacy of the built econometric model is minimal (close to zero).

Table 3. F-statistics for the conducted economic-mathematical modeling

Indexes	For a model built on the basis of panel data	For a model built on the basis of averaged data
F	52.52	23.74
Significance of F	0.0000	0.0053

Source: own calculations.

For the averaged values, the significance indicator of the F-statistic = 0.0052, which is a high-reliability indicator. Therefore, the model (7) gives more reliable results.

Having analyzed the correlation between the factor and result characteristics (Tables 4 and 5), it can be stated that the profitability of sales (X_1) and financial dependence (X_3) have a significant impact on the return on equity (Y). Between asset turnover (X_2) and return on equity (Y), the correlation indicators, depending on the type of data, differ significantly; in particular, for panel data, the correlation is high and positive (39.24%), while for averaged data, the correlation indicator is negative and insignificant (-6.85%).

Table 4. The correlation matrix for the econometric model was built based on averaged data

	Y	X_1	X_2	X_3
Y	1	X	X	X
X_1	0.868728	1	X	X
X_2	-0.06865	0.301677	1	X
X_3	-0.90456	-0.66541	0.386353	1

Source: own calculations.

It should be noted that the correlation indicators between asset turnover (X_2) and sales profitability (X_1), as well as between financial leverage (X_3) and sales profitability (X_1), are high, which provides grounds for asserting the need to check the constructed econometric model for multicollinearity.

Table 5. The correlation matrix for the econometric model is built based on panel data

	Y	X_1	X_2	X_3
Y	Y	1	X	X
X_1	X_1	0.8595	1	X
X_2	X_2	0.3914	0.4359	1
X_3	X_3	-0.6704	-0.4587	0.0455

Source: own calculations.

Based on the results of the calculations, we built regression equations (7) and (8).

According to the results of complex calculations for the econometric model (7) with a significance level of 95%, it can be stated that:

– if the profitability of sales increases by 1%, the level of profitability of own capital will increase by 0.8%;

– with an increase in financial leverage by 1%, the profitability of production will decrease by 0.27%.

We cannot conclude the turnover indicator, as it is statistically insignificant; the Student`s t-statistic is less than the critical value.

For model (8) with a significance level of 95%, a conclusion can be drawn only based on the indicator of financial leverage since the t-statistics of the remaining indicators are less than the critical value, which makes them statistically insignificant. So, with a significance level of 95% based on model (8), it can be stated that if the financial leverage increases by 1%, the return on equity will decrease by 0.26%.

As a result, based on the indicators of model adequacy, we conclude that it is appropriate to study the phenomenon using a model built based on panel data (7); therefore, the following tests will be conducted only for this model.

To test the model for heteroskedasticity, we used the White test. After conducting the White test, we accept the hypothesis of homoscedasticity and the absence of heteroscedasticity.

So, according to the results of the above tests, the model is adequate and describes the phenomenon with high accuracy and reliability. Having developed an econometric model and checked it for adequacy by conducting a series of tests, we can conclude the relationships between the performance indicator and factor characteristics. To reduce the cost of production of agricultural plant products, it is necessary to introduce new technologies for cultivation, grain processing and harvesting, as well as improve logistics systems to optimize transport costs and improve grain storage systems.

The correlation model we developed for estimating the asset turnover rate did not provide statistically reliable results. However, it is logical to claim that an increase in the value of the asset turnover rate will lead to a rise in the profitability of enterprises in the agricultural sector of Ukraine since the asset turnover indicates how finished products were sold during the study period. We note that the following measures are considered standard methods of increasing the turnover of assets: selling a part of unloaded non-current assets provided that there is no plan to increase the workload; reducing the number of stocks, returning receivables, as well as measures to increase the amount of the company`s revenue.

CONCLUSIONS

So, in analyzing the current state of the agricultural industry in Ukraine, we found out that there are positive and negative factors for conducting agricultural activities in Ukraine. First of all, it is appropriate to include the following positive aspects: the presence of significant resource potential for the rapid expansion of production capacities, the presence of a highly qualified and cheap labour force, and the production of mineral fertilizers, machines, and chemical means for plant protection. In addition, the transport infrastructure and grain storage infrastructure are being restored. There is domestic demand for agricultural products, and the world demand for grain is growing. International cooperation also creates conditions and increases the competitiveness of Ukrainian products in foreign markets.

The negative aspects of Ukraine`s agricultural sector`s functioning in the current operating conditions include price uncertainty, lack of market infrastructure, and unattractive investment due to low turnover.

According to the results of the construction and testing of the developed econometric model, the return on equity of enterprises in Ukraine`s agricultural sector is closely correlated with the level of profitability of sales; namely, an increase in the indicator of profitability of sales by 1% was accompanied by an increase in the return on equity of enterprises in the agricultural sector by 0.8%.

Also, according to the study results, the practicality of reducing the financial dependence of enterprises operating in Ukraine`s agricultural sector was revealed since a decrease of this indicator by 1% leads to an increase in the return on equity of the analyzed enterprises by 0.27%.

In DuPont`s model, the turnover of its assets is an essential factor in the positive impact on the return on equity of enterprises in the agricultural sector. However, according to our research and the modelling results, this indicator was statistically insignificant, which is explained by the seasonal nature of farming enterprises` production.

Based on the simulation results we obtained, several measures were proposed to contribute to increasing the profitability of the equity capital of Ukrainian agricultural enterprises. Among them are reducing the financial dependence of farming enterprises in terms of reducing the use of credit resources with a simultaneous increase in state support for the agricultural sector, further consideration of risk reduction factors during the formation of the commodity policy of farming enterprises, etc.

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CHANGE IN PHYSICAL PROPERTIES OF BANANA FRUITS DURING RIPENING STAGE

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Abstract

The aim of this study is measuring the physical properties of banana fruits. In this study we used Dessert bananas (Musa sap.) from local dedicated banana ripening rooms in the city of Santa, Gharbia Governorate in January 2024 was selected for experimental work. Banana ripening starts with a full green fruit, then pale green, then green yellow, then yellow with green tips, then bright yellow, then pale yellow and yellow with brown spots at last. The measurements indicators are physical properties such as length (L), width (W), thickness (T) arithmetic mean diameter (Da), mm, geometric mean diameter (Dg) mm, surface area (As) mm^2, volume (V) mm^3, and sphericity (φ) % of banana fruits. The results recorded that there was a rise in length of 140.97 mm to 151.01 mm, width of 34.06 mm to 38.83 mm, and thickness of 30.67 mm to 35.77 mm, in that order. For the Size and shape index indicators of banana fruits, the results showed that the projected area and shape index increased from 1914.5 to 2259.42 mm^2 and from 3.83 to 4.5, respectively. Also, Elongation and Flakiness for banana fruits increased from 3.64 to 4.39 % and from 0.83 to 0.98 % respectively.

Key words: *banana, ripening rooms, fruit, physical properties*

INTRODUCTION

The banana is a widely grown fruit, for the most part, developed in tropical and subtropical areas of the world. The amount of bananas produced in Egypt in 2022 was 1.21 million tons. Egypt's output of bananas grew at an average yearly rate of 5.52% from 101,000 tons in 1973 to 1.21 million tons in 2022 [6].

The climacteric fruit banana ripens due to continuous ethylene production after harvesting. Ripening is one of the processes controlled by ethylene, a naturally occurring colorless and gaseous plant hormone. Ripening, also known as de-greening, is an organic process devoid of chemicals. Fruits acquire the optimal color, aroma, and texture that are unique to the highest degree of eating quality throughout the ripening process, which involves physiological, biochemical, and organoleptic changes [16].

Bananas are among the most widely consumed and grown fruits in the world. The increasing demand necessitates an increase in supply. A common practice is to harvest bananas while they are still young and consume them once they have fully ripened. Optimizing ripening efficiency is essential to maintaining a stable supply-demand equilibrium. A banana that is immature usually ripens in three to four days. To reduce this time, people commonly use synthetic substances such ethanol, calcium carbide, acetylene, ethylene, propylene, and ethylene (2-chloroethyl phosphoric acid) [4].

Fruit quality is the foundation of fruit marketing and consumer acceptability; although banana cultivars are treated extensively, consumers' awareness of fruit quality is restricted. Customers usually select fruit based on two characteristics: the fruit's flavor and its consistency in terms of size, shape, mass, and color. The grading system is a crucial unit action that influences the fruit's shape, color, size, mass, and texture. Fruits that are identical in shape and size but have different masses have to be manually sorted, which is a time-consuming and complex procedure. Bulk fruit grading is therefore a better choice because it is precise, less expensive than other grading techniques, and permits ideal packing arrangement while saving money on packaging and transportation [3].

Banana fruit is high in carbs, dietary fiber, minerals, and several vitamins. In addition, it contains a sizable number of bioactive substances, which offer health advantages over and above nutrition. These include polyphenols, carotenoids, flavonoids, amines, vitamin C, and vitamin E [15].

Fruit had average measurements of 15.42 cm for length (L), 4.08 cm for width (W), and 3.59 cm for thickness (T). The geometric mean diameter (Dg) and arithmetic mean diameter (Da) were measured to be 6.08 and 7.7 cm, respectively. The results showed that the radius of curvature, aspect ratio, and sphericity were, respectively, 186.49, 0.27, and 39.60%. The flakiness to elongation ratios were found to be 0.88 and 3.77, respectively. The physical characteristics that were measured led to the conclusion that banana fruit was non-spherical and elongated in shape [8].

In 2020, more than 370,000 metric tons of bananas were imported by Egypt. The Philippines, Ecuador, and India supply Egypt with the majority of its banana imports, which are valued at a combined $180 million. Furthermore, Egypt shipped more than 3,000 metric tons of bananas. The estimated value of banana exports was $2.55 million. A number of European nations and Libya are important export destinations [7].

One of the most important and well-known fresh tropical fruits is the banana (Musa spp.). More than 15% of the fresh fruit produced globally comes from there. Bananas are a great source of vitamins C and B6, carbohydrates, antioxidants, minerals (including magnesium and potassium), and dietary fiber. Bananas are also a delicious and healthful fruit that are rich in fructose, sucrose, and glucose, the three main natural sugars. Consuming bananas can instantly and regularly increase one's energy level [17].

Banana fruit is a common crop in global agricultural production and trade. The fruit belongs to the Musaceae family. The most widely consumed tropical fruit in the world, bananas are enjoyed by all age groups and come in both fresh and dried varieties. Bananas account for about 15% of the fresh fruit produced worldwide. The most inexpensive, highly nutritious, easily digested, and high-energy fruit is the banana. It is made up of carbohydrates, dietary fiber, antioxidants, vitamins B6 and C, and minerals including magnesium and potassium [2].

The best temperatures for the banana to produce dry matter were 25/18°C during the day and 33/26°C at night for the best leaf area generation. Heat injury occurred at 37/30°C and chilling injury occurred at 17/10°C [13].

changes in dry weight, protein, phenolics, starch, chlorophyll, and three enzymes—two transaminases and aldolase—from seven days after inflorescence until bunch maturity. The phrase "storage life" is commonly used interchangeably with the preclimacteric period after harvest, also referred to as "green life," because fruit softens and becomes more susceptible to mechanical damage after the climacteric phase begins, resulting in increased loss. Preclimacteric variables include fruit maturity, temperature during transit, humidity, ventilation, mechanical damage, and fungal inocculum [5].

The minimum acceptable maturity for harvesting dessert bananas may be determined by the ratio of edible pulp to peel and the size of fingers that growers and consumers consider acceptable, respectively. Before reaching this stage of growth, the majority of cultivars have the capacity to ripen to good exterior color, high sugar content, and acceptable, if not optimal, flavor. Fruits change in hardness during development, even at the preclimacteric stage [10].

The most common physiological processes that occur when bananas ripen are transpiration and respiration. In terms of transpiration, the green banana shows a brief reduction in rate. The transpiration rate peaks sharply at the banana ripening stage. The ripening and storage processes of banana fruit result in both chemical and physical alterations that greatly affect the skin color. During ripening and storage, banana fruit changes color from green to yellow [1].

When selling bananas, quality is crucial, particularly if they are meant to be consumed fresh. Although a number of factors, including edaphoclimatic conditions, fertilization, cultivar, planting, and harvest time, affect the physical and chemical characteristics of bananas, evaluating the quality of marketed fruits and whether they meet consumer standards is crucial for analyzing them. The taste, shelf life, and appearance (length, diameter, and color) of the fruits are the most crucial characteristics, based on consumer preferences when buying bananas. Thus, it is crucial to do research on the physical and chemical aspects of fruit quality, including length, diameter, weight, pulp and peel color, pulp firmness, soluble solids, and titratable acidity, in order to preserve the desired qualities demanded by market standards [14].

The information provided by the characterisation of the various banana cultivars is also helpful for commercial development and breeding projects that aim to find disease-resistant cultivars with good fruit quality and quantity. As a result, certain characteristics—like plant height, pseudostem diameter, and leaf blade length and width—are crucial data. Plant height is a crucial phytotechnical component in plant breeding, as it affects planting density, harvesting ease, plant damping off, pseudostem breakage by wind or because of its smaller diameter, and huge cluster formation. In addition, sufficient leaf area is necessary for banana plants to grow and, as a result, provide bunches of superior quality [11].

The main objectives of this study was measured the physical properties of banana fruits to know thebanana changes during the ripeningstages

MATERIALS AND METHODS

The experiment was conducted In January 2024, a selection of dessert bananas (Musa sap.) varying in maturity stage were obtained from nearby designated banana ripening rooms located in Santa, Gharbia Governorate, to verify the physical and optical properties of banana fruits. These characteristics were used to study the change resulting from different ripening stages of bananas in banana production refrigerators. Samples were randomly selected and cleaned by hand.

Measurements and determinations.

The physical properties of bananas were determined with 100 repetitions of banana fruits as showed in Photo 1.

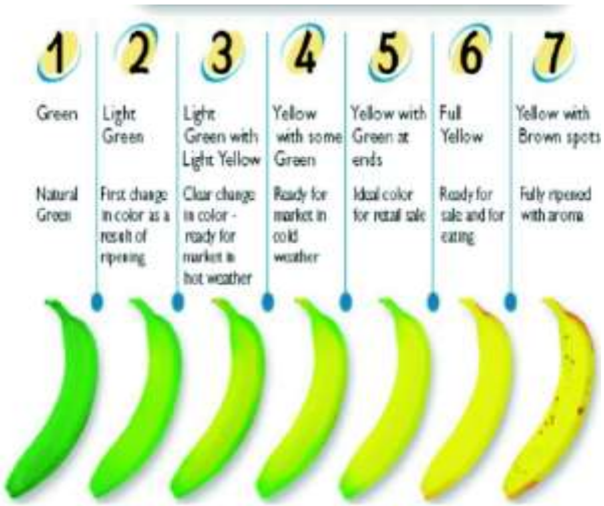

Fig.1 Banana Ripening Chart
Source: Authors' determination.

The different physical properties of plantain banana fruits such as length (L), width (W), and thickness (T) was estimated by digital caliper 150 mm. Average dimensions of banana fruits, arithmetic mean diameter (Da), mm, geometric mean diameter (Dg) mm, surface area (As) mm2, volume (V) mm3, and sphericity (φ) % of banana fruits were calculated as:

-Length (L), (mm): [18]

$L = \frac{(L_o+L_i)}{2}$ …………………….……..…. (1)

-Width (mm): [18]

$W = \frac{(D_3+D_4)}{2}$ …………………...………. (2)

-Thickness (mm)[18]

$T = \frac{(d_3+d_4)}{2}$ ……………………….……..…. (3)

-Geometric mean diameter (Dg), mm: [19]

$Dg = \sqrt[3]{LWT}$…………………….……..…. (4)

-Arithmetic mean diameter (mm): [19]

$Da = \frac{(L+W+T)}{3}$ ……………………….….…. (5)

-Volume standard geometrical shape (mm^3)[19]

$V = \frac{\pi}{6} Dg^3$ ……………………….....…. (6)

-Surface area (mm^2) [19]

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$As = \pi Dg^2$ .... (7)

-Projected area perpendicular to Thickness (mm^2) [19]

$PT = \frac{\pi}{4} TW$ .... (8)

- Projected area perpendicular to length (mm^2) [19]

$PL = \frac{\pi}{4} LW$ .... (9)

-Projected area perpendicular to Width (mm^2) [19]

$PW = \frac{\pi}{4} WW$ .... (10)

-projected area (mm^2) [19]

$PA = \frac{(PT+PL+PW)}{3}$ .... (11)

-Sphericity(φ), %: [19]

$\varphi = \frac{Dg}{L} \times 100$ .... (12)

-aspect ratio [19]

$Ra = \frac{W}{L}$ .... (13)

-Flakiness ratio [12]

$Rf = \frac{T}{W}$ .... (14)

-Elongation ratio [12]

$Re = \frac{W}{L}$ .... (15)

Shape index [9]

$SI = \frac{2 \times L}{W+T}$ .... (16)

Elongation [9]

$E = \frac{X}{Y}$ .... (17)

Circularity index [9]

$CI = \frac{4\pi A}{Perimeter^2}$ .... (18)

Area [9]

$A = \pi xaxb$ .... (19)

Perimeter [9]

$P = \pi\sqrt{2(L+W)}$ .... (20)

RESULTS AND DISCUSSIONS

The primary measurements of banana fruits were computed, along with an examination of their physical properties. Shows the length, width, and thickness frequency distribution curves for seeds; the frequency distribution curve suggests a tendency toward a normal distribution. There was a rise in length of 140.97 mm to 151.01 mm, width of 34.06 mm to 38.83 mm, and thickness of 30.67 mm to 35.77 mm, in that order. The banana fruit's physical characteristics are displayed in Fig. 2, Fig. 3 and Fig. 4 and Table 1, and the curves demonstrate that the measurements are similar in length, width, and thickness by 27%, 34%, and 32%, respectively.

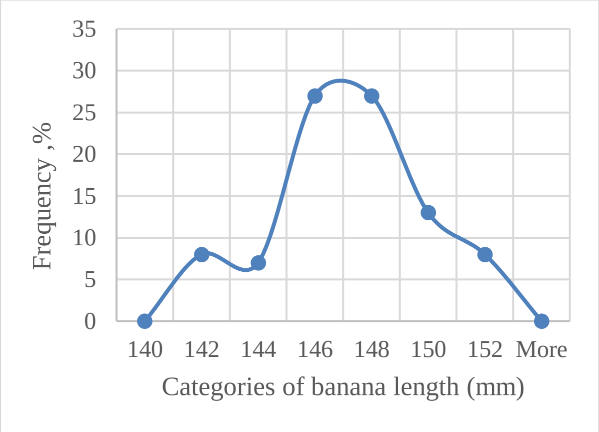

Fig. 2. Frequency distribution curve for Length (mm) of banana fruits.
Source: Authors' determination.

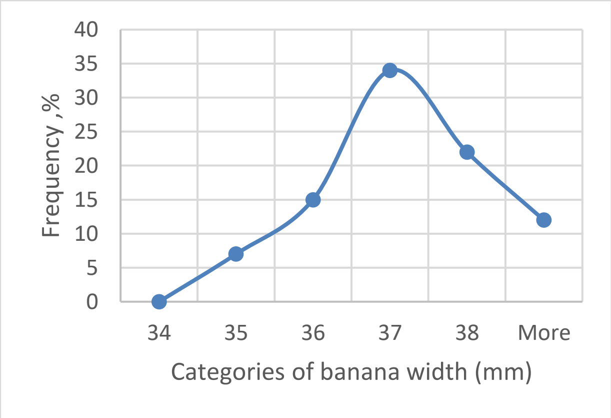

Fig. 3. Frequency distribution curve for Width (mm) of banana fruits.
Source: Authors' determination.

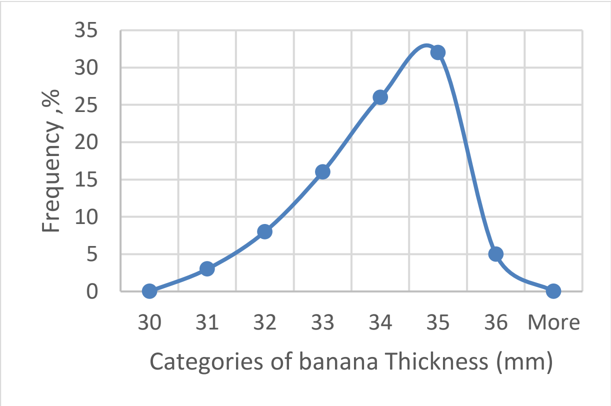

Fig. 4. Frequency distribution curve for thickness (mm) of banana fruits.
Source: Authors' determination.

For the Size and shape index indicators of banana fruits, the results showed that the projected area and shape index increased from

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1,914.5 to 2,259.42 mm^2 and from 3.83 to 4.5, respectively. There was a similarity between banana fruits by 26 and 30 %, respectively. Also, Elongation and Flakiness for banana fruits increased from 3.64 to 4.39 % and from 0.83 to 0.98 % respectively. There was a similarity between banana fruits by 35 % and 19%, respectively as shown in Fig. 5, Fig. 6, Fig. 7 and Fig. 8.

Table 1. Physical properties of banana fruits

Items	Average	Min	Max	Frequency%
Geometric mean diameter, mm	56.50	54.45	58.31	39%
Arithmetic mean diameter, mm	72.19	69.96	74.51	34%
Surface area, mm^2	10,026.71	9,309.96	10,675.64	15%
Volume standard geometrical shape, mm^3	94,466.63	84,490.06	103,746.8	12%
Sphericity, %	38.65	36.64	40.84	44%
Aspect ratio, %	0.25	0.23	0.27	44%

Source: Authors' determination.

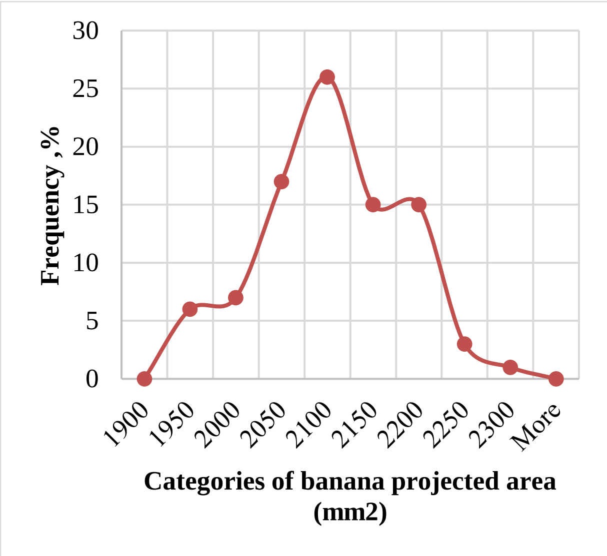

Fig. 5. Frequency distribution curve for projected area (mm^2) of banana fruits
Source: Authors' determination.

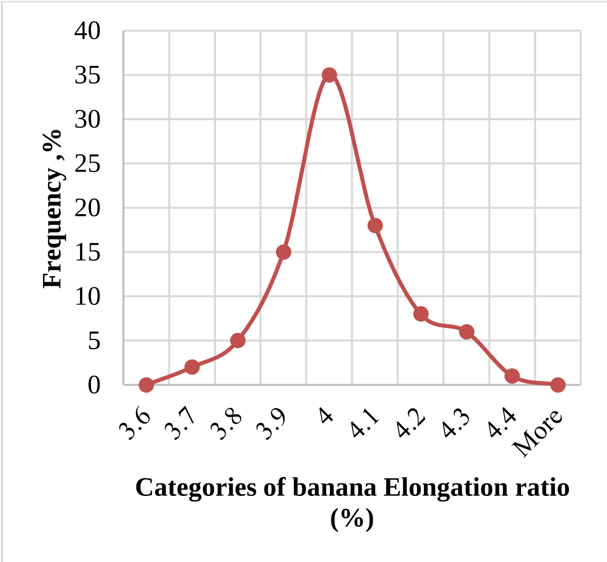

Fig. 7. Frequency distribution curve for Elongation ratio (%) of banana fruits
Source: Authors' determination.

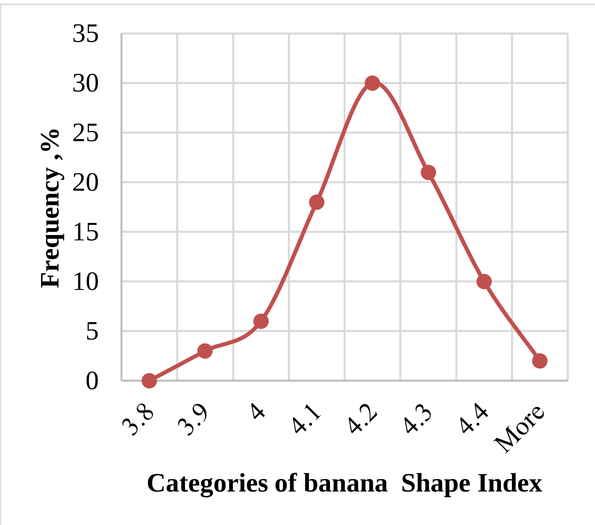

Fig. 6. Frequency distribution curve for shape index of banana fruits
Source: Authors' determination.

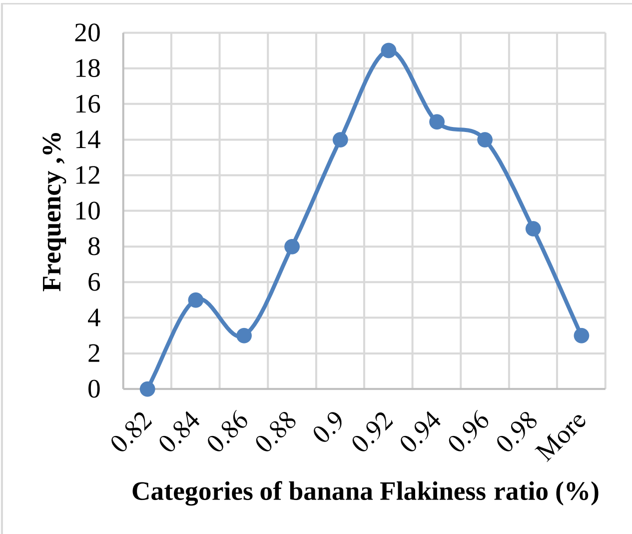

Fig. 8. Frequency distribution curve for Flakiness ratio (%) of banana fruits
Source: Authors' determination.

CONCLUSIONS

The results showed the banana fruit's physical characteristics, and the curves demonstrate that the measurements are similar in length, width, and thickness by 27%, 34%, and 32%, respectively. There was a similarity in the projected area and shape index between banana fruits by 26 and 30 %, respectively. Also, in Elongation and Flakiness There was a similarity between banana fruits by 35 % and 19%, respectively.

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USING THERMAL IMAGES TO MONITOR TEMPERATURE STABILITY IN SALMON SMOKING ROOM

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Abstract

The cold smoking process in a commercial smoke house was used for Salmon fillets were dried for 12 hours at a temperature of about 23°C. It was cold smoked for 12 hours using wood chips. The dry matter and salt content were generally determined. Samples were cooled on slides at 5°C for 6 hours before vacuum packing and then cold stored at approximately 4°C. While inside the freezing room, before smoking the fish sample which ranged from -17.5 to -18 °C. The characterize temperatures of fish smoking house and infrared imagingwith thermal analysis has been used to monitor temperature distribution in those ovens, compare heat transfer and energy efficiency across different ovens, and understand the overall performance of the house, including heating and heating rate. The results recorded the average temperature inside the smoking room, which ranged from 21.34 to 23.34 °C, the temperature stability relies inside the cooling room when the temperature differences between 0 and 1 °C on three dimensions inside the cooling room.

Key words: *cold, smoking, salmon, temperature, infrared thermography*

INTRODUCTION

Smoking is one of the oldest and most widespread post-harvest processing techniques, particularly because it can add value to fish. The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) define fish smoking as the practice of preserving fish or other foods by exposing them to smoke from burning wood or plant material [15].

During produce smoking salmon, the waste was recorded about 20% (skin, viscera, backbone frames and cuts off) of the total mass from salmon slices. Also extract fish oil from this waste by using cold pressing and wet rendering methods provided with 18% of oil productivity[7].

There are multiple subprocesses involved in this process, including as cleaning, drying, heating, fermentation, and smoking. There are four different ways to smoke fish: liquid, hot, cold, or electrostatic. In addition to enhancing the fish's flavor, color, and odor, smoking primarily extends its commercial life [8].

The most widely used and traditional way of processing fish is fish smoking. Fish is an important component of a balanced diet and gives humans the protein they need to rebuild tissues and repair their bodies. Hundreds of people are employed by the fish smoking industry, which also acts as a link to other companies in the fish industry (fish traders, fish smokers, smoked fish merchants, etc.). Because the smoked fish industry has large marginal economic returns, it is tremendously profitable [6].

According to the results of the fuel used in the processing (smoking) of the fish in the earlier experiments, 68 (44.16 %) and 86 (55.84 %) smoked fish using charcoal. implying that the majority of smokers and fish processors utilize firewood for fish processing and smoking [5].

Food preservation and processing through smoking and smoke drying are among the most ancient and customary methods employed by humans for over ten millennia. In rural areas, the smoke-drying method is frequently applied to vegetables like breadfruit (Artocarpusnobilis) and jackfruit (ArtocarpusheierophylIus), as well as to meat and fish. Smoking is accomplished by exposing food to smoke directly, Hang it above a fire source, such as burning wood, or place it on a wooden rack above your kitchen.The technology is really basic, and it is being used today [9].

Protein and nutrition are vital to human and national health. Fish are known for their high content of polyunsaturated fatty acids, minerals such as calcium, phosphorus, salt, potassium and magnesium, and vitamins B and D. They are also considered nutritious, rich in protein, and relatively low in fat, saturated fat and cholesterol. Fish decompose rapidly after death due to a number of physical, chemical and microbiological processes.However, several tactics have been tried to delay spoiling as long as possible due to the rising demand for premium fish products [2].

Fish can be smoked in a number of ways, but the two most common ones are hot and cold smoking. This method of smoking can occasionally be separated into three categories: semi-warm smoking (30–40 °C), hot smoking (70–90 °C), and cold smoking (18–25 °C). But other methods are also employed, like liquid smoke condensate and electrostatic smoking. The product is exposed to at least 80 °C and frequently up to 100 °C when hot smoking. The primary goal of cold smoking, which often involves keeping the product's temperature below 30 °C, is to give it a flavor that consumers will find appealing rather than preserve it [12].

An ancient technique for preserving fish is smoking it. This procedure extends the fish's shelf life while enhancing its flavor, color, and texture. It does this by combining the benefits of an initial salting with the antibacterial properties of certain smoke constituents (phenols, carboxylic acids, and formaldehyde). Because smoked salmon costs far more than fresh or frozen salmon, it is seen as a luxury good [16].

Smoking can be done cold, hot, or liquid. All of these methods provide high-quality items that are well-liked by customers. Cold smoking is most frequently employed in conjunction with dry-salting and is typically carried out at temperatures between 20 and 30 °C for two to twelve hours at a humidity rate of 60 to 75%. For two to four hours, hot smoking is done at temperatures exceeding 60 °C (often between 100 and 120 °C). Smouldering sawdust or shavings of a certain type of wood (beech, hickory, or oak) in the oven just below the fish that is suspended produces the smoke in both methods. Additionally, given regulated temperature and spring conditions, smoke from external smoke generators might be fed to the smoking chamber [4].

Heat is transferred from one thing to another through radiation, a type of infrared radiation, without any physical touch. The measurement of surface temperature can provide information about the physical and health status of humans and other living things. Skin emissivity plays a significant role in identifying the genuine skin temperature [1].

Since many factors may affect thermal imaging, when working at a particular observation scale, it is critical to assess how the measurement environment will probably affect the data to be extracted from the image. Similar to traditional imaging cameras, thermal imaging cameras are constructed using a lens that directs infrared light onto a detector. There are three sources of radiation that hit a thermal camera. Both radiation from the target item, Wobj, and radiation from its surrounds, Wamb, which has been reflected onto the object's surface, are detected by the camera [3].

The invisible radiation patterns of objects are transformed into visual images in thermal remote sensing, It is called a thermogram or thermal image. Thermal sensors combined with optical equipment mounted on aircraft or satellites can be used to obtain thermal images. This technology can be applied in a variety of industries where heat is generated or lost in space and time since it is a non-invasive, non-contact, and non-destructive method for determining the thermal qualities and features of any object of interest [13].

One non-destructive testing method for figuring out an object's surface temperature is infrared thermal imaging. The use of this technology in animal husbandry, namely in the production of chickens, pigs, and dairy products, is growing. Evaluation of sickness, edema, and stress in animals has been aided by the technique, which can distinguish variations in peripheral blood flow from variations in heat loss. additionally identify heat stress in plants [10].

One non-destructive testing technique that can be used to measure an object's surface temperature is infrared thermography (IRT). The surface-emitted infrared radiation is captured by thermal cameras, which then translate it into electrical impulses to produce a thermal image that displays the distribution of surface temperature of an object. Each shade in this technique represents a specific temperature range associated with a given scale [11].

At temperatures higher than absolute zero, the mobility of atoms and molecules on an object's surface releases energy known as infrared radiation. The temperature of the material affects the emittance's strength. Stated differently, the intensity of infrared energy produced increases with temperature. In addition to emitting infrared radiation, materials can also reflect, absorb, and, in certain cases, transfer this energy. The amount of thermal radiation absorbed by the object equals the amount radiated by it when the temperature of the material is equal to that of its surroundings [14].

The main objectives of this study using infrared image to monitor temperatures distribution in fish smoking ovensto optimize the performance of the ovens.

MATERIALS AND METHODS

The experiment was implemented during the year 2024 in one of the fish smoking factories in 10th of Ramadan City, Sharkia Governorate, Egypt. To analyze the thermal performance of fish smoking ovens using thermal imaging. And study the effect of infrared radiation on the performance of ovens. The process of smoking fish includes several stages: 1) Preparation: which includes cleaning the fish and removing the guts. This stage may take a few hours. 2) salting: The salt was covered fish with soaked in a brine solution for phases extending from a few hours to a complete day to add flavor and help in the preservation process. 3) drying: The fish is dried to get rid of excess moisture. This stage take from a few hours to a full day. 4)
cold smoking: Salmon is smoked at low temperatures 20-30°C for a period of time ranging from 12 hours to 24 hours or sometimes longer to achieve a mild flavor and moist texture. Finally, 5) packaging: The fish waspacked and wrapped after smoking, and this process may also take a few hours.

Fig 1 shows the smoking oven with dimensions of length 1.90 m, width 2.15 m, and height 2.80 m and Fig 2 shows the distribution of temperatures over Fish smoking oven.

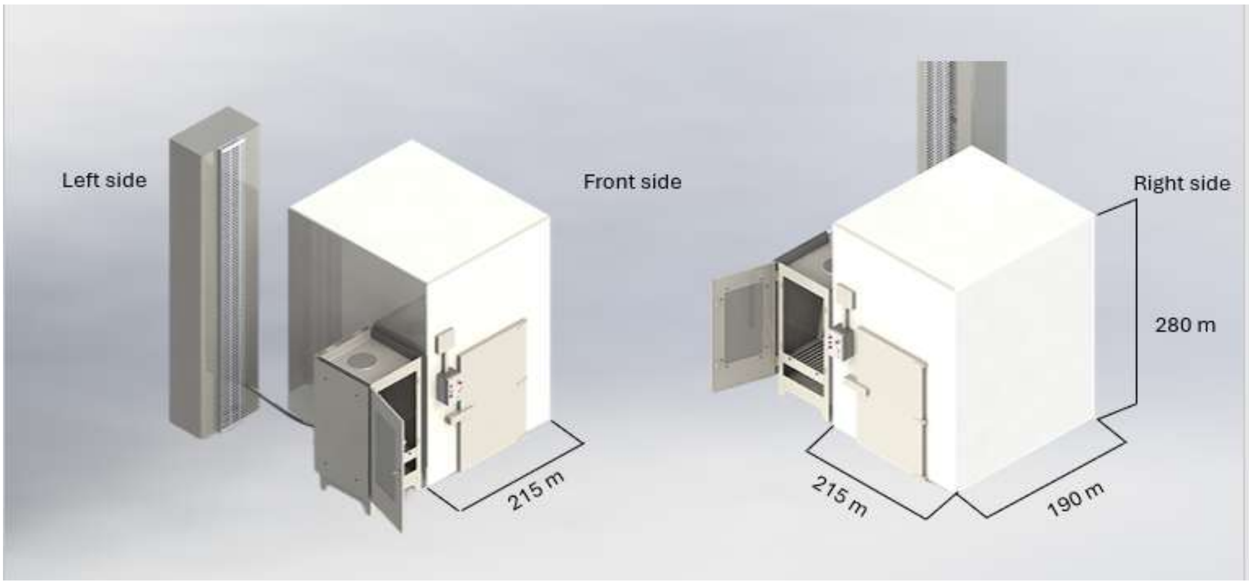

Fig. 1. Fish smoking oven
Source: Author's determination.

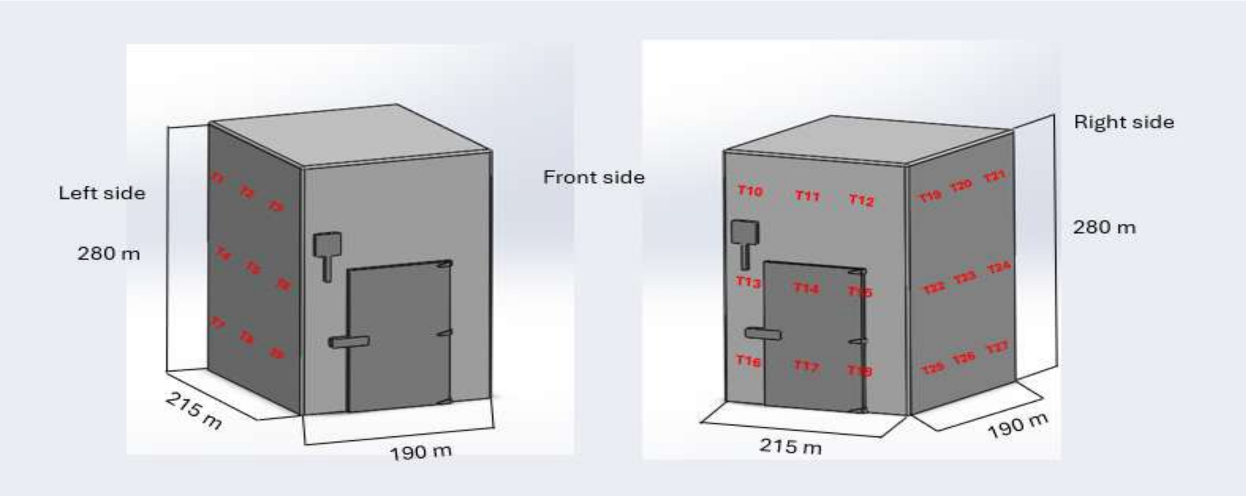

Fig. 2. Distribution of temperatures over Fish smoking oven
Source: Author's determination.

The Thermal camera
With testo Super Resolution technology, the image quality is (320 × 240) pixels with an infrared resolution of (160 x 120) pixels. Features include free analytical software for expert report preparation, automatic hot and cold spot detection, and thermal sensitivity of 0.1 °C. Accurate measurement within ±2 °C and fast with a fixed focus

IRSoft · PC-Software
The IRSoft software was used to process, analyse, and store the images were taken by the testo thermal imager. In addition, integrated reporting was used to provide data in a comprehensible way. The attached thermal imager's parameters can be changed via the instrument control.

MATLAP PC-Software
The Image Analysis system was utilized with the MATLAP program. Samples were taken with digital cameras, and the data was transferred and saved on a PC using a capture card. The MATLAP software was used to analyze the Skillets' pictures. To obtain color indices, three bands—RGB—were obtained for each image.

RESULTS AND DISCUSSIONS

Figures 3 to 7 are shown using MATLAB, where 3D images were extracted from thermal images to measure the effect of temperature on all stages of the fish smoking process.

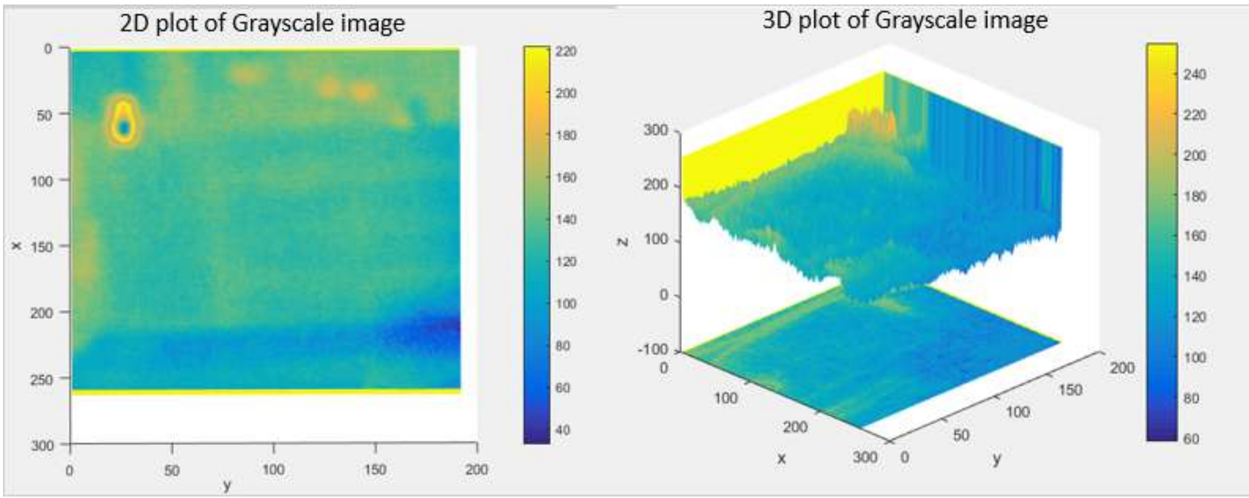

Fig. 3. The profiles of 2D and 3D thermal images for the Smoking-room temperature
Source: Author's determination.

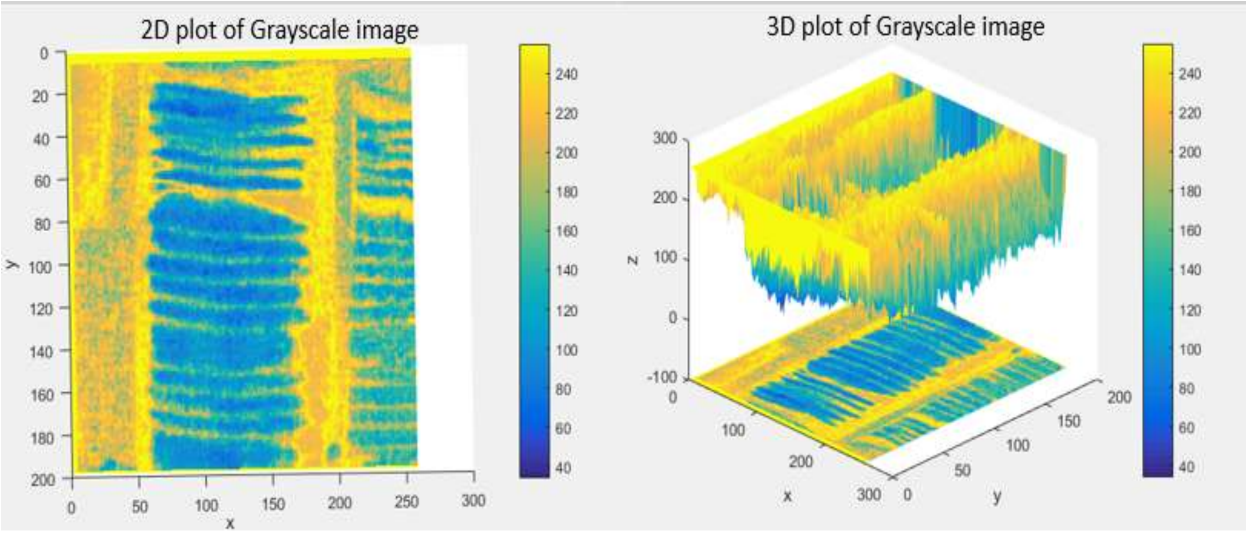

Fig. 4. The profiles of 2D and 3D thermal images for the Salmon slices inside the smoking room
Source: Author's determination.

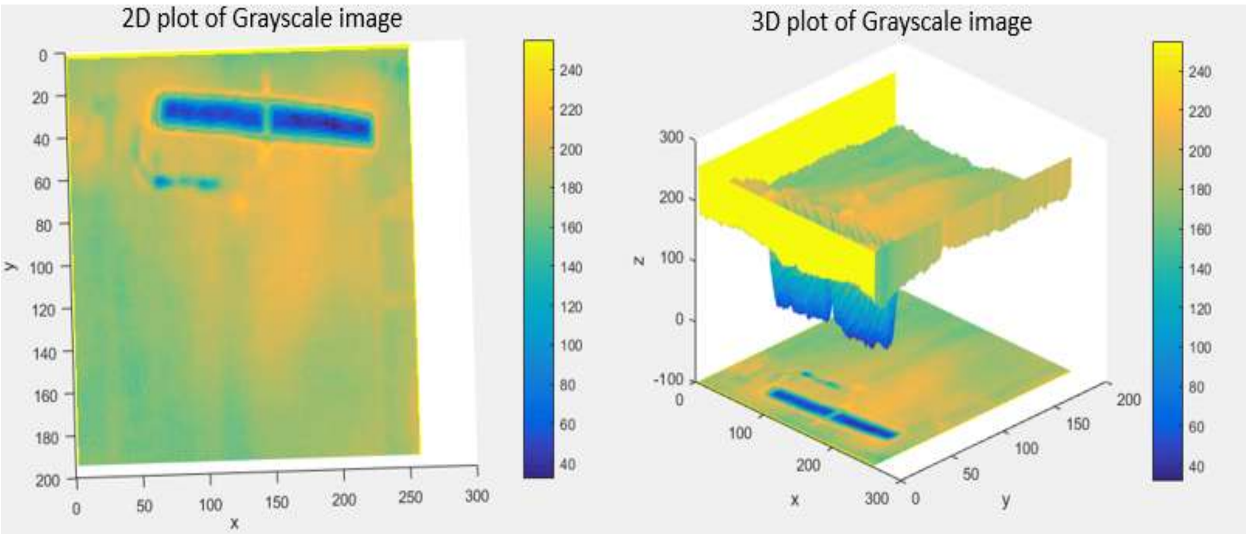

Fig. 5. The profiles of 2D and 3D thermal images for thecooling room.
Source: Author's determination.

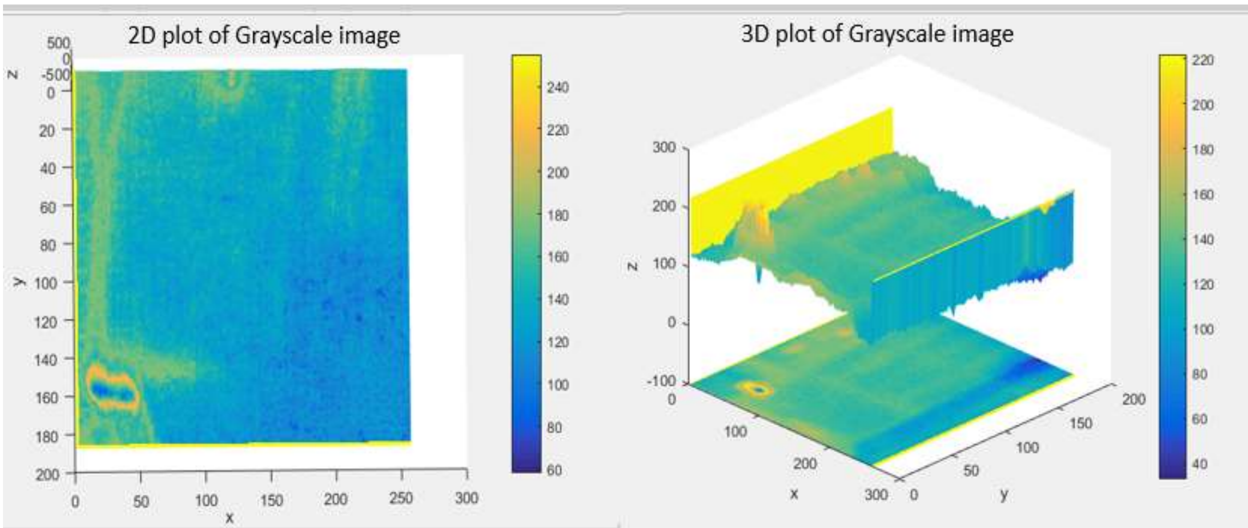

Fig. 6. The profiles of 2D and 3D thermal images for the Freezer room.
Source: Author's determination.

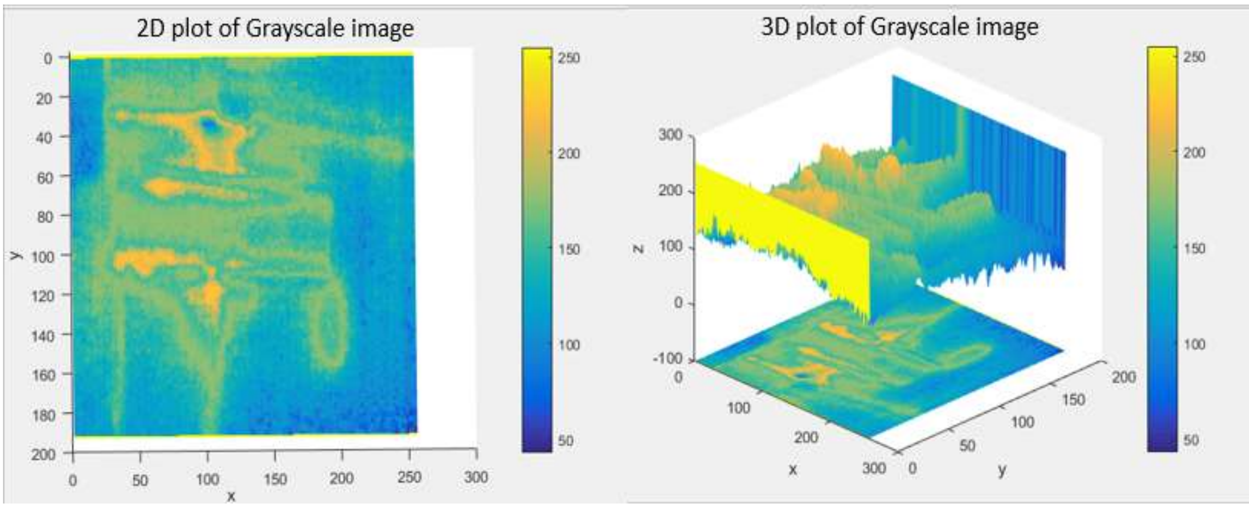

Fig. 7. The profiles of 2D and 3D thermal images for the Frozen salmon fillets inside the freezer room
Source: Author's determination.

Using infrared image to measure the internal temperature of the fish smoking ovens, Salmon slices inside the smoking room in Figures 8, 9, 10, and 11.

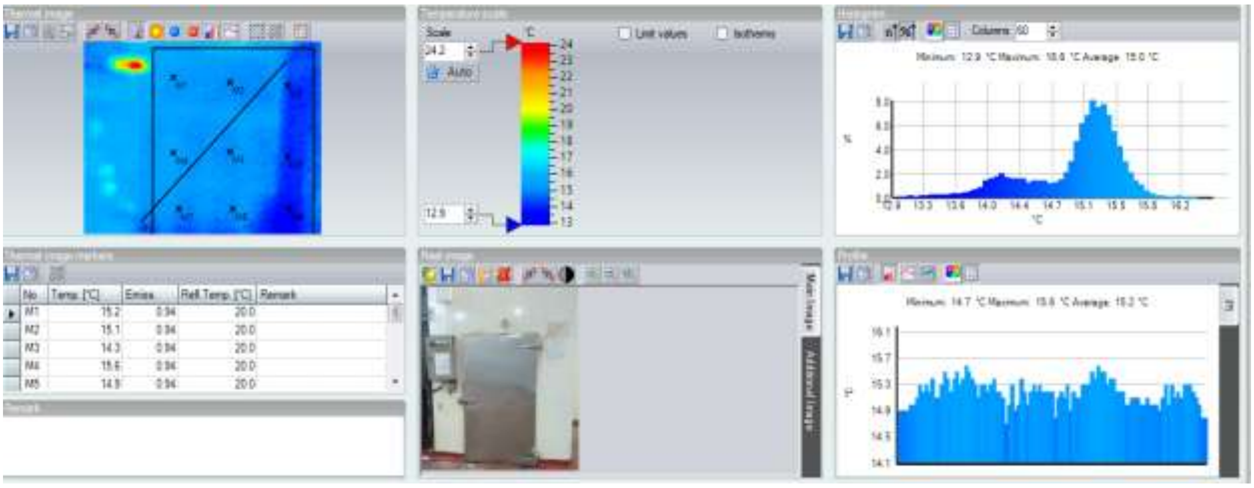

Fig. 8. The internal temperature distribution histogram of the Smoking-room by IRSoft software
Source: Author's determination.

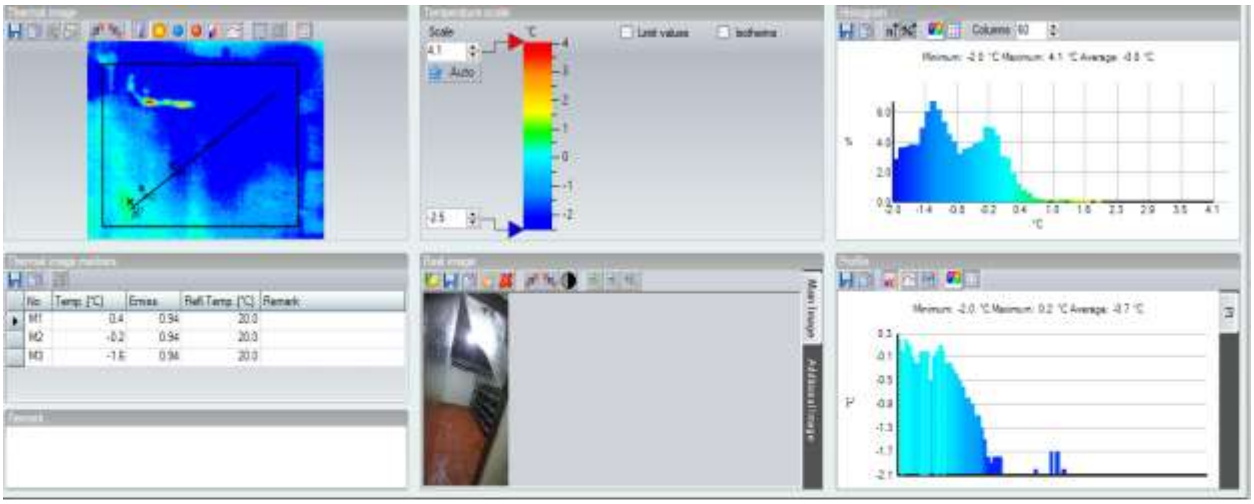

Fig. 9. The internal temperature distribution histogram of the cooling -room by IRSoft software
Source: Author's determination.

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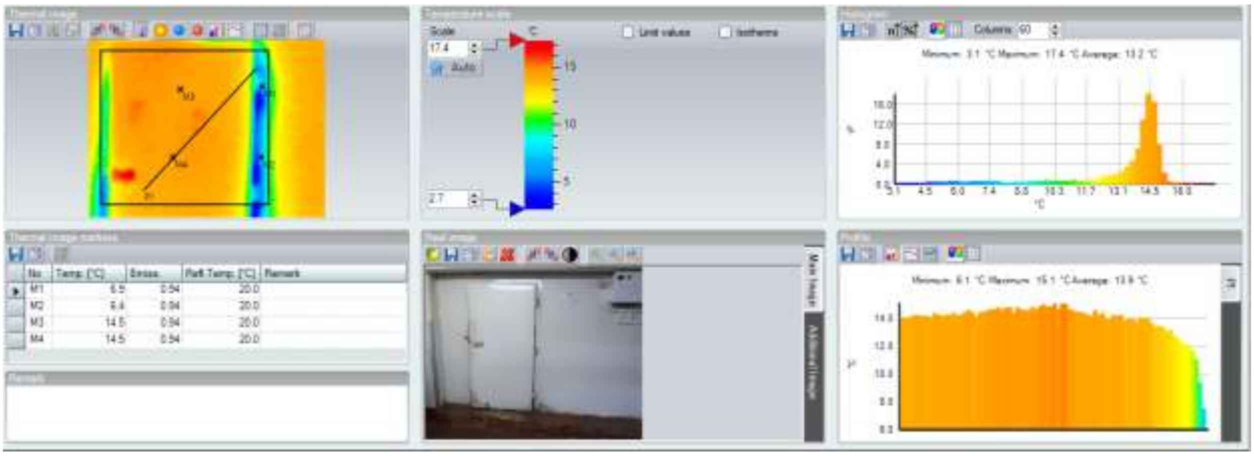

Fig. 10. The internal temperature distribution histogram of the Freezer room by IRSoft software
Source: Author's determination.

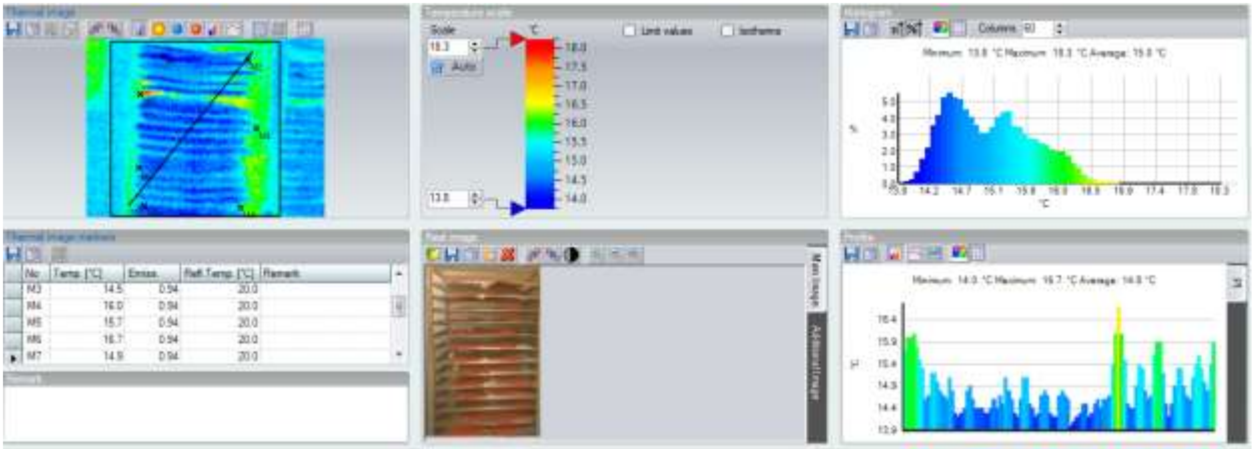

Fig. 11. The internal temperature distribution histogram of the Salmon slices inside the smoking room by IRSoft software
Source: Author's determination.

Figure 12 shows the average temperature inside the smoking room, which ranged from 21.34 to 23.34 ºC during the duration of cold smoking of salmon fillets (12 hours).

Figure 13 shows the average temperature inside the cooling room, which ranged between 0 and 1 ºC during the refrigeration period for the salmon fillets (12 hours).

Figure 14 shows the average temperature inside the freezing room, which ranged between -17.5 to -18 ºC during the freezing period for salmon fillets (12 hours).

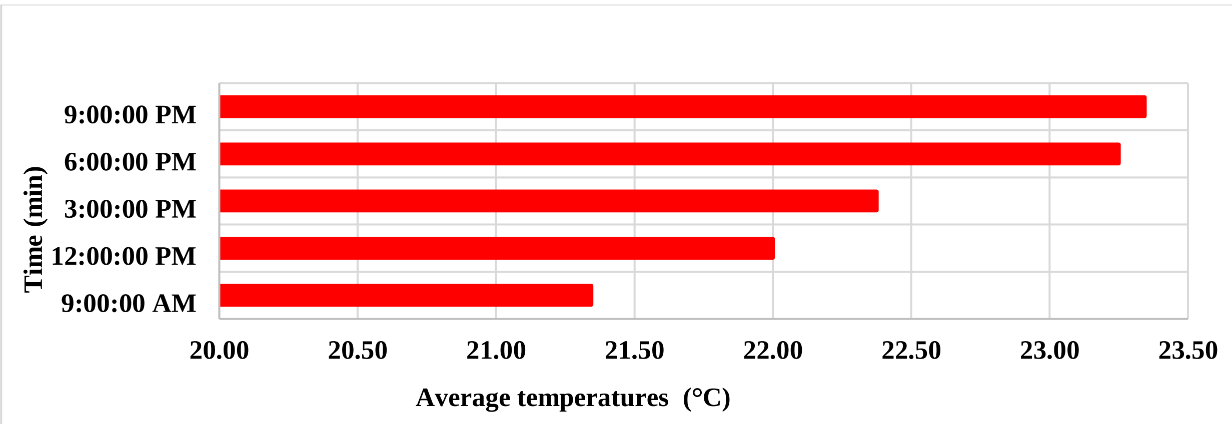

Fig. 12. The relationship between temperature and time in smoking room
Source: Author's determination.

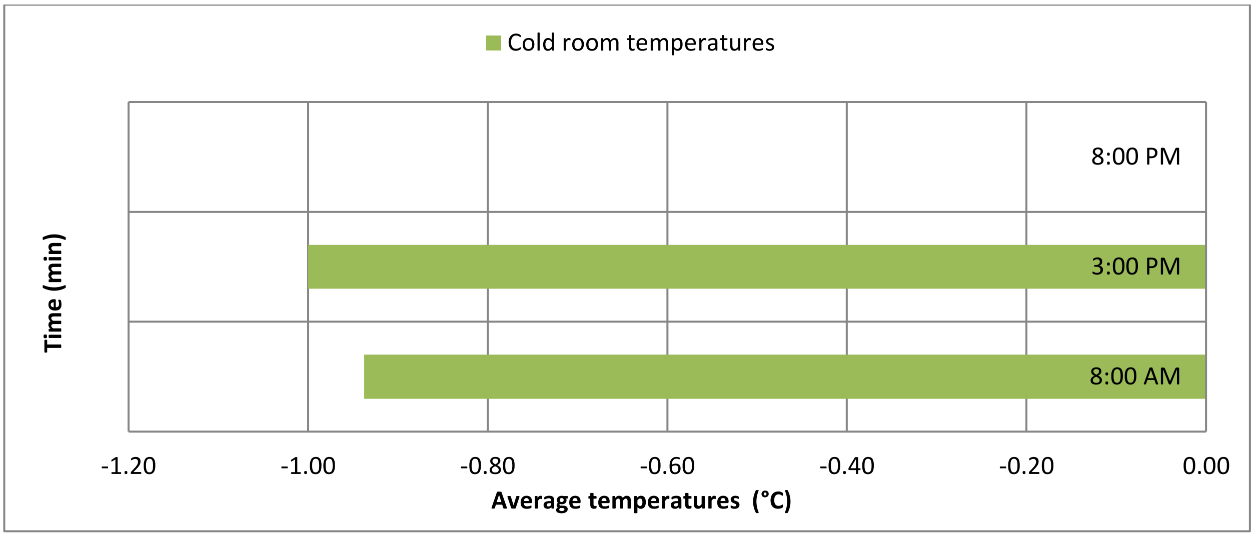

Fig. 13. The relationship between temperature and time in freezer room
Source: Author's determination.

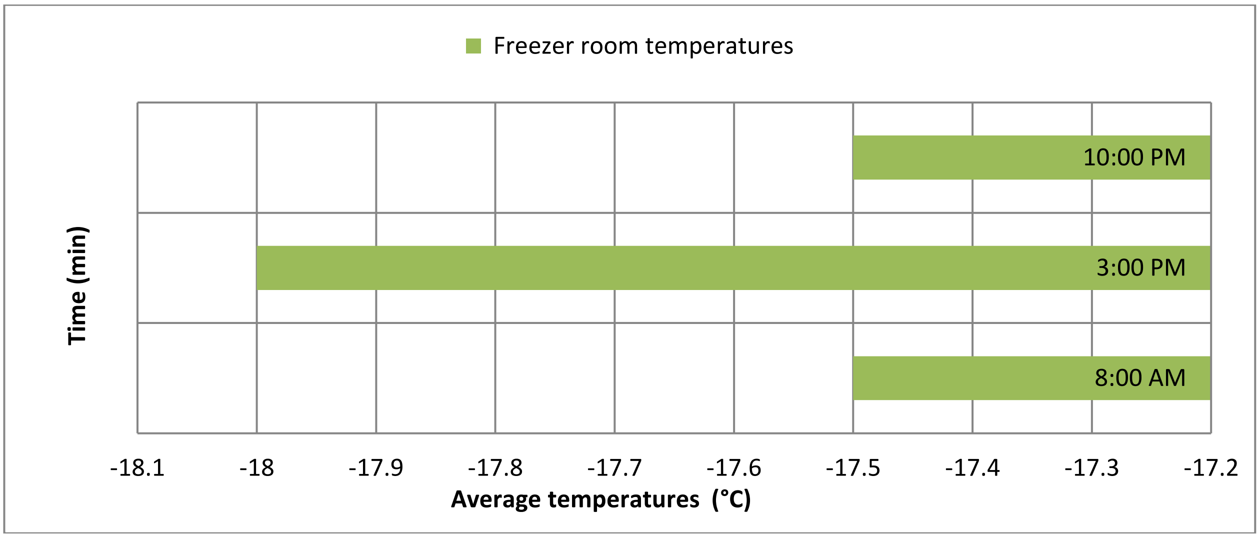

Fig. 14. The relationship between temperature and time in cooling room
Source: Author's determination.

Figure 15 and Table 1 show the average temperature across three sides of the smoking room, which ranged during the left side from 17.42 to 19.62 ºC, ranged during the front side from 16.08 to 17.62 ºC, and ranged during the right sides from 17.62 to 18.12 ºC.

Table 1. Three sides of the Smoking-room temperatures

Lift side		Front side		Right side	
	Average temperature		Average temperature		Average temperature
T1	17.42	T10	16.74	T19	18.12
T2	18.52	T11	16.52	T20	17.82
T3	19.12	T12	16.08	T21	18.02
T4	18.12	T13	17.54	T22	18.12
T5	19.02	T14	16.82	T23	18.12
T6	18.42	T15	16.66	T24	18.12
T7	18.02	T16	16.96	T25	17.82
T8	19.62	T17	17.62	T26	17.72
T9	18.12	T18	16.32	T27	17.62

Source: Author's determination.

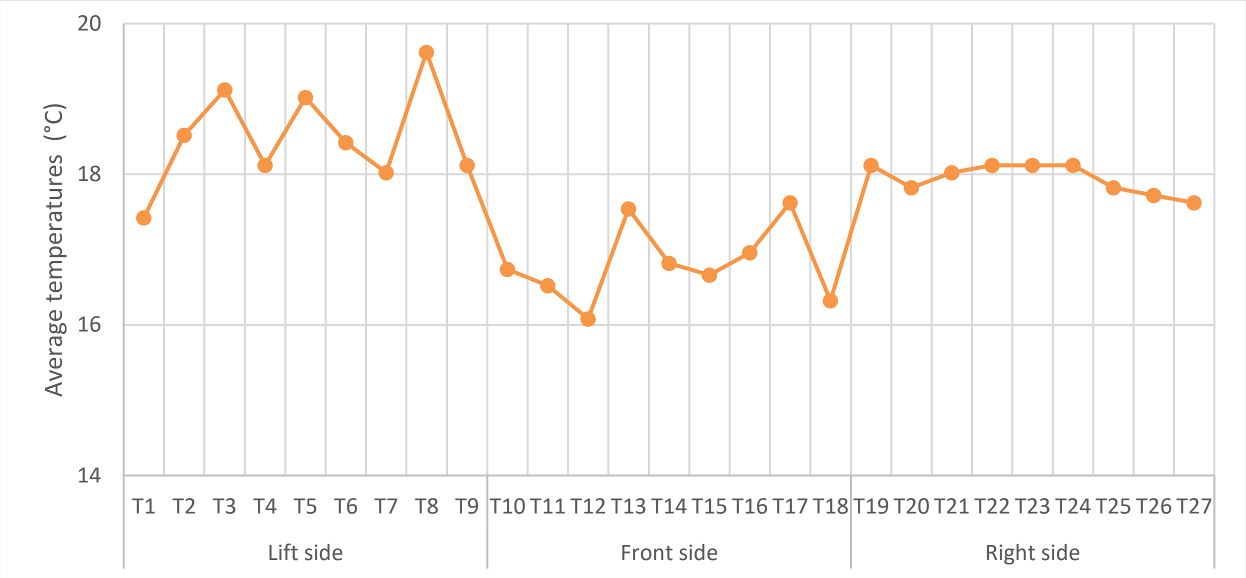

Fig. 15. The relationship between averagetemperature and three sides of the Smoking-room
Source: Author's determination.

CONCLUSIONS

A thermal imaging camera and associated software, which act as non-contact sensors, can be used to perform complete inspections and temperature measurements during salmon smoking operations.The results showed that the average temperature inside the smoking room, which ranged from 21.34 to 23.34 °C, and was between 0 and 1 °C inside the cooling room, while inside the freezing room, which ranged from -17.5 to -18 °C.

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PREDICTING THE AMOUNT OF POLLUTANTS EMITTED OF WOOD BURNED FOR FISH SMOKING

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Abstract

The process of smoking fish uses heat resulting from burning biomass fuel, which is a source of greenhouse gas emissions. There are many ovens that use electricity and firewood as a source for energy. The study aimed to calculate the amount of emissions resulting from burning wood, such as nitrogen oxides, sulphur dioxide, particulate matter, volatile organic compounds, carbon monoxide, carbon dioxide, and carbon dioxide equivalents, and to determine the carbon footprint of fish smoking factories to reduce the negative effects of greenhouse gas emissions. The results showed that the amount of Nitrogen oxides gas produced from the factory per year was 0.007 ton NOx, Sulphur dioxide was 0.0009 ton SO_2, Particulate Matter was 0.0438 ton PM, Volatile Organic Compounds was 0.0876 ton VOCs, Carbon Monoxide was 0.613 ton CO, Carbon dioxide was 6.92 ton CO_2, the emissions from the amount of fuel used was 788 ton CO_2-eq, the emissions of electricity use was equal to 38.3 ton CO_2-eq. In the end, the total amount of emissions produced from the factory is 99.5 ton of CO_2-eq yr^{-1}.

Key words**:** *salmon, carbon footprint, Sulphur dioxide, Nitrogen oxides, Particulate Matter, Volatile Organic Compounds, Carbon Monoxide, Carbon dioxide and carbon dioxide equivalent*

INTRODUCTION

Preliminary forecasts for 2023 show an expected total harvest of 511,000 tonnes of Pacific salmon in the Russian Federation, double compared to 2022, but well below the projected total harvest of 322,000 tonnes. In addition, landings of 375,000 tonnes of pink salmon, 91,000 tonnes of chum salmon, 35,000 tonnes of sockeye salmon, and 9,000 tonnes of coho salmon are expected [5].

Fish has a significant role in the diet of humans. The amount consumed of it globally is steadily rising. Millions of people in Africa depend heavily on fish as a diet, and low-income households use it as a primary source of animal protein. After capture, it is a perishable commodity though. This results in significant post-catch losses and a revenue shortfall for fishermen. Under these circumstances, processing turns becomes a must for maintaining fish quality. To preserve fish, a variety of conventional methods are used, including frying, fermenting, salting, drying, and smoking [16, 6].

A substantial contributor to food security and nutrition, smoked fish accounts for two thirds of the fishery products consumed in the Ivory Coast, and it is still produced using antiquated, traditional smoking techniques. Even if the nation has enhanced ovens known as FTT ovens (FAO-Thiaroye Processing Technique), these methods do not give much thought to the health of the populace or the preservation of the environment [17].

The main processes involved in making smoked fish include brining (either by injecting or bathing in liquid or dry salt combination), chilling, packing (either modified or air/vacuum), and storing. One of the earliest methods of preservation, smoking combines the benefits of heating, drying, salting, and smoking. Fish is usually smoked at 28 to 32°C or at 70 to 80°C. Because cold smoking does not cook the meat, coagulate the proteins, deactivate the enzymes that cause food spoiling, or get rid of food pathogens, the meal must be stored in a refrigerator until it is consumed [1].

Salmon undergoes physicochemical and sensory alterations when it is treated with smoke flavoring. The finished product's qualities may resemble those obtained through the conventional cold smoking process, depending on the makeup of these flavorings. There are several benefits to smoking fish. Fish that has been smoked has a longer shelf life, tastes better, and may be used in more soups and sauces. When there are bumper catches, it minimizes waste and allows for storage during the lean season. It improves people's year-round access to protein and facilitates the packing, transportation, and marketing of fish, particularly in remote areas [13].

One source of polycyclic aromatic hydrocarbons (PAHs) is food. PAHs are produced during the smoking, roasting, barbecuing, or grilling of food, especially meat, meat products, and fish, since the organic elements do not completely burn or decompose thermally. PAH are produced when the fats in the meat or fish undergo pyrolysis and are deposited on the meat or fish. Cooking over charcoal (grilling, barbecuing) produces different amounts of PAH depending on how much fat is in the meat or fish and how close it is to the heat source. Many investigations of typical food products that have been roasted or grilled over charcoal have demonstrated the presence of PAHs like indeno [1, 2, 3-c, d] pyrene, benzo[α]pyrene, anthracene, chrysene, and benzo[α]anthracene [12].

The total amount of greenhouse gases (GHGs) emitted was 30, 279.08 MT CO_2, 131.79 MT CH_4 and 0.91 MT N_2O. The average emissions of GHGs from fish smoking were significantly higher than the usual household biomass cookstoves emission. The findings also show that fish smokers prefer specific fuelwood types to enhance the aesthetics of the fish after smoking, the ability of the fuelwood to last longer in fire, the availability of the fuelwood in the locality and other important factors [4].

Fish has been smoked in traditional smoking ovens for many years, but they have changed over time. These ovens consist of the metal cylinder oven, the metal rectangular mud oven, the metal square oven, and the more modern chorkor smoker. Along the way, more advanced fish smokers have been released, including the FTT-Thiaroye, Abuesi gas fish smoker, and Ahotor Oven. Using incompletely burned wood smoke; fish that has already been salted are treated using traditional fish smoking techniques. The main reason people eat fish is because the process of smoking it, which also requires high temperatures, denatures the proteins in the fish [2].

Determining how smoke-drying temperatures impact the nutritional qualities of the final product is crucial since very high smoking temperatures have the potential to reduce the nutritional value of smoke-dried fish. High concentrations of polycyclic aromatic hydrocarbons (PAHs) have also been seen to be introduced into the final product when fish come into direct contact with combustion fumes [7].

Following harvest, fish losses are classified as follows: physical loss (damage to body parts), quality loss (unacceptability or spoiling), and market force loss (financial). A number of factors, including inadequate road infrastructure, seasonal variations, and inappropriate packing and storage, contribute to the yearly post-harvest losses of landed fish weight, which are estimated to be between 35 and 40 percent locally and 25 percent worldwide. The species, size, and state of cleanliness all affect these losses differently. People were able to overcome the obstacles as a result by creating creative solutions. For instance, it has become more popular to hang fish over a fire to dry, and the smoke enhances the flavor over time. As a result, smoking fish became a common way to preserve fish [11].

Scientists have discovered that a variety of natural phenomena, including shifts in biotic processes, variations in Earth's orbit, variations in solar radiation received by the planet, oceanic, volcanic eruptions, and orogenic changes brought on by plate tectonics, all contribute to the planet's constantly changing climate. Moreover, it has been determined that human activity is the primary cause of the ongoing climate change, also referred to as global warming [14].

A person's contribution to global warming in terms of greenhouse gas emissions is measured and expressed as their "carbon footprint," which is measured in units of carbon dioxide equivalent. It consists of two segments in total: The term "direct footprint," also known as "primary footprint," refers to the amount of carbon dioxide (CO_2) equivalent emissions that result from using fossil fuels at home, in vehicles, on airplanes, and from other activities. The indirect carbon dioxide (CO_2) equivalent emissions from the whole life cycle of the goods and services we use, including those related to their production and ultimate breakdown, are measured by what is known as the "indirect" or "secondary" footprint [10].

The term "carbon dioxide equivalent" (or "CO_2-eq") is used to describe several greenhouse gases in terms of one unit. The amount of CO_2 that, in any quantity and for any sort of greenhouse gas, will have an equivalent greenhouse effect is known as CO_2-eq. The quantity of greenhouse gases can be expressed as CO_2-eq by multiplying it by the potential for global warming. For instance, 25 kilos of carbon dioxide are produced for every kilogram of methane released (1 kg CH_4 * 25 = 25 kg CO_2 equivalent). "CO_2-eq" is an extremely helpful phrase for a number of reasons. It makes it possible to state a "package" of greenhouse gases as a single number and to compare different packages of greenhouse gases easily (in terms of the overall effect of global warming) [3].

Four main steps can be included in the processing of cold-smoked salmon: filleting, salting, drying, and smoking. The drying and smoking processes should be carried out between 20 and 30 degrees Celsius. Filleting can be done mechanically using a machine or by hand. The method and properties of the raw material have an impact on the product yields. When Atlantic salmon is manually trimmed and filed by machine, the overall weight losses fall between 30 and 45 percent [15].

Around 0.49% of greenhouse gas emissions caused by human activity came from aquaculture worldwide in 2017. In order to prevent the worst effects of climate change, the IPCC advises that global greenhouse gas emissions be cut by 45% by roughly 2030 and attain net zero emissions by 2050. But in order to meet these long-term targets, emissions must be drastically reduced over the next several decades, especially in the transportation sector, where emissions are predicted to rise sharply by 2050. The idea of carbon footprinting was created in order to accomplish the objectives. The entire amount of greenhouse gasses, including carbon dioxide (CO_2), released during the production process, from feed preparation to waste disposal, is known as the aquaculture industry's carbon footprint [9].

Fish processing still uses smoking, one of the earliest ways of food preservation. Smoking has antibacterial and antioxidant properties, but it can also produce specific organoleptic traits (taste, color, and scent), as well as texture. A few variables that may affect the quality of smoked fish are the kind of wood used, the temperature, and the length of the smoking process. It should be mentioned that certain carcinogenic substances, like polycyclic aromatic hydrocarbons (PAHs), are present in wood smoke [18].

Since fish meal is an inexpensive source of protein, it is regarded as one of the most significant traditional ingredients in Egyptian cuisine. Fish keeping, recreational fishing, and angling are all significant aspects of fisheries, but fish as food, the fishing business, aquaculture, and fish farming are all commercially significant. When compared to other animal protein sources, fish meals represent a significant and cost-effective supply of protein. In developing nations, fish makes up more than 30% of the total animal protein consumed per person [19].

The aim study was predicted the amount Nitrogen oxides, Sulphur dioxide, Particulate matter, Volatile organic compounds, carbon monoxide, carbon dioxide and carbon dioxide equivalent also determining the carbon footprint of fish smoking factories.

MATERIALS AND METHODS

The experiment was implemented during the year 2024 in one of the fish smoking factories in 10th of Ramadan City, Sharkia Governorate, Egypt. To estimated carbon footprint and other greenhouse gas (GHG) emissions from fish smoking ovens.

The work was carried out in a salmon

smoking plant consisting of: 1) a receiving area of 100-150 square meters which includes an inspection table: 2m x 1m and a cold storage area: 10m x 10m for storing raw fish, with temperature control. 2) Preparation area including washing station: 5m x 2m, including basins and drains. Cutting tables: each table is approximately 3m x 1m. Boning station: 2m x 1m per station. 3) Salting area including salting tanks: each tank is approximately 2m x 1m, with space for multiple tanks. Drainage system: integrated within the salting area to efficiently remove liquids. 4) Smoking rooms consisting of smoke generators: the generator area is typically 1m x 0.5m, the smoking room is 1.90m x 2.15m x 2.80m and accommodates shelves. 5) Cooling area approx. 50-70 square meters. 6) Packaging area approx. 80-120 square meters. Packaging machines: Each machine approx. 2m x 1.5m. Final storage in freezing rooms approx. 100-150 square meters.

A set of mathematical equations was used to calculate the amount of emissions generated from fish smoking factories such as Nitrogen oxides, Sulphur dioxide, Particulate matter, Volatile organic compounds, carbon monoxide, carbon dioxide and carbon dioxide equivalent, according to Inventories (2006) [8].

-Nitrogen oxides (NOx) Emissions:

$$NO_X\ Emissions = \text{Mass of wood} \times \text{EF}_{NO_x}$$

where:

NOx Emissions = Measured in (ton NOx), It is Nitrogen oxides NOx emissions from burning wood.

EF $_{(NOx)}$ = Measured in (1.6 g NOx/ kg of wood), It is emission factor of NOx.

-Sulphur dioxide (SO_2) Emissions:

$$SO_2\ Emissions = \text{Mass of wood} \times \text{EF}_{SO_2}$$

where:

SO_2 Emissions = Measured in (ton SO_2), It is Sulphur dioxide (SO_2) emissions from burning wood.

EF $_{(SO2)}$ = Measured in (0.2 g SO_2/ kg of wood), It is emission factor of SO_2

-Particulate Matter (PM) Emissions:

$$PM\ Emissions = \text{Mass of wood} \times \text{EF}_{\text{PM}}$$

where:

PM Emissions = Measured in (ton PM), It is Particulate Matter PM emissions from burning wood.

EF $_{(PM)}$ = Measured in (10 g PM / kg of wood), It is emission factor of PM

- Volatile Organic Compounds (VOCs) Emissions:

$$VOC_S\ Emissions = \text{Mass of wood} \times \text{EF}_{VOC_S}$$

where:

VOCs Emissions = Measured in (ton VOCs), It is Volatile Organic Compounds (VOCs) emissions from burning wood.

EF $_{(VOCs)}$ = Measured in (20 g VOCs / kg of wood), It is emission factor of VOCs

- Carbon Monoxide (CO)Emissions:

$$CO\ Emissions = \text{Mass of wood} \times \text{EF}_{\text{CO}}$$

where:

CO Emissions = Measured in (ton CO), It is Carbon Monoxide (CO) emissions from burning wood.

EF $_{(CO)}$ = Measured in (140 g CO/ kg of wood), It is emission factor of CO

- Carbon Dioxide (CO_2) Emissions:

$$CO_2\ Emissions = \text{Mass of wood} \times \text{EF}_{CO_2}$$

where:

CO_2 Emissions = Measured in (ton CO_2), It is Carbon Dioxide CO_2 emissions from burning wood.

EF $_{(CO2)}$ = Measured in (1580 g CO_2/ kg of wood), It is emission factor of CO_2

- The emissions from the amount of fuel used

$$\text{E} = \text{FC} \times \text{EF}$$

where:

E = Measured in (ton CO_2-eq), it is the total emissions released.

FC = Measured in (liters), it is the amount of fuel used

EF = Measured in (1.8 kg CO_2-eq per kg of wood burned), it is the amount of pollutants emitted per unit of fuel.

- The emissions from the Electricity used

$$\text{E} = \text{EC} \times \text{EF}$$

where:

E = Measured in (ton CO_2-eq), it is the total emissions released.

EC = Measured in (KWh), it is the amount of electricity used
EF = Measured in (0.45 kg CO_2-eq /KWh), it is the amount of CO_2 emitted per KWh of electricity consumed.

- Carbon dioxide equivalent (CO_2eq):

$$\mathrm{KgCO_2e} = \mathrm{Kg\ NO_X} \times 0.2 + \mathrm{Kg\ CO_2} + \mathrm{E_{fuel}} + \mathrm{E_{electricity}}$$

RESULTS AND DISCUSSIONS

NOx emissions from fish smoking factories by (ton NOx yr^{-1})

Figure 1 depicts the Nitrogen oxides emissions, calculated from fish smoking factories, and estimated at 0.0058 ton of Nitrogen oxides per year for 10 kg burning wood and thus the amount of Nitrogen oxides emitted from fish smoking factory is equal to 0.007 ton of NOx yr^{-1}. The relationship between amount of wood burned and Nitrogen oxides gas emission can be expressed by regression equation as:

y = 0.0006x $\quad$ $R^2 = 1$

NOx emissions from fish smoking factories by (ton CO_2-eq yr^{-1})

Figure 2 depicts the Nitrogen oxides emissions, calculated from fish smoking factories, and estimated at 0.0012 ton of Carbon dioxide equivalent per year for 10 kg burning wood and thus the amount of Nitrogen oxides emitted from fish smoking factory is equal to 0.0236 ton of CO_2eq yr^{-1}. The relationship between amount of wood burned and Nitrogen oxides gas emission can be expressed by regression equation as:

y = 0.0001x-4E-18 $\quad$ $R^2 = 1$

SO_2 emissions from fish smoking factories by (ton SO_2 yr^{-1})

Figure 3 depicts the Sulphur dioxide emissions calculated from fish smoking factories, and estimated at 0.0007 ton of Sulphur dioxide per year for 10 kg burning wood and thus the amount of Sulphur dioxide emitted from fish smoking factory is equal to 0.0009 ton of SO_2 yr^{-1}. The relationship between amount of wood burned and Sulphur dioxide gas emission can be expressed by regression equation as:

y = 7E - 0.5x $\quad$ $R^2 = 1$

PM emissions from fish smoking factories by (ton PM yr^{-1})

Figure 4 depicts the Particulate Matter emissions calculated from fish smoking factories, and estimated at 0.0365 ton of Particulate Matter per year for 10 kg burning wood and thus the amount of Particulate Matter emitted from fish smoking factory is equal to 0.0438 ton of PM yr^{-1}. The relationship between amount of wood burned and Particulate Matter gas emission can be expressed by regression equation as:

y = 0.0037x $\quad$ $R^2 = 1$

VOCs emissions from fish smoking factories by (ton VOCs yr^{-1})

Figure 5 depicts the Volatile Organic Compounds emissions calculated from fish smoking factories, and estimated at 0.073 ton of Volatile Organic Compounds per year for 10 kg burning wood and thus the amount of Volatile Organic Compounds emitted from fish smoking factory is equal to 0.0876 ton of VOCs yr^{-1}. The relationship between amount of wood burned and Volatile Organic Compounds gas emission can be expressed by regression equation as:

y = 0.0073x $\quad$ $R^2 = 1$

CO emissions from fish smoking factories by (ton CO yr^{-1})

Figure 6 depicts the Carbon Monoxide emissions, calculated from fish smoking factories, and estimated at 0.511 ton of Carbon Monoxide per year for 10 kg burning wood and thus the amount of Carbon Monoxide emitted from fish smoking factory is equal to 0.613 ton of CO yr^{-1}. The relationship between amount of wood burned and Carbon Monoxide gas emission can be expressed by regression equation as:

y = 0.0511x $\quad$ $R^2 = 1$

CO_2 emissions from fish smoking factories by (ton CO_2 yr^{-1})

Figure 7 depicts the Carbon Dioxide emissions, calculated from fish smoking factories, and estimated at 5.76 ton of Carbon dioxide per year for 10 kg burning wood and thus the amount of Carbon dioxide emitted from fish smoking factory is equal to 6.92 ton of CO_2 yr^{-1}. The relationship between amount of wood burned and Carbon dioxide gas emission can be expressed by regression equation as:

$y = 0.5767x - 2E\text{-}14 \qquad R^2 = 1$

Fuel emissions from fish smoking factories (ton CO_2-eq yr^{-1})

Figure 8 shows the emissions of use burning wood from the smoke generators in factory and which were estimated at 65.7 ton CO_2-eq for 10 kg burning wood. Thus, the amount of burning wood emissions from the factory is equal to 788 ton CO_2-eq. The relationship between amount of wood burned and Fuel emissions can be expressed by regression equation as:

$y = 6.57x \qquad R^2 = 1$

Electricity emissions from fish smoking factories (ton CO_2-eq yr^{-1})

Figure 9 shows the emissions of electricity use from the amount of electricity used in fish smoking factories, it was estimated at 6.6 ton of **CO_2-eq yr^{-1}** for 40 kWh electricity used and thus the amount of electricity used emitted from fish smoking factory is equal to 38.3 ton of CO_2 yr^{-1}.The relationship between amount of electricity used and electricity emission can be expressed by regression equation as:

$y = 0.1643x - 2E\text{-}14 \qquad R^2 = 1$

Total CO_2-eq Emissions from fish smoking factories (ton CO_2-eq yr^{-1})

Figure 10 depicts Total CO_2-eq emissions were calculated from fish smoking factories, and it was estimated at 78.5ton CO_2-eq for 10 kg burning wood. thus, the amount of Carbon dioxide equivalent emitted from fish smoking factory is equal to 99.5 ton of CO_2-eq yr^{-1}. The relationship between amount of wood burned and Carbon dioxide equivalent gas emission can be expressed by regression equation as:

$y = 7.7918x + 5.9885 \qquad R^2 = 0.9999$

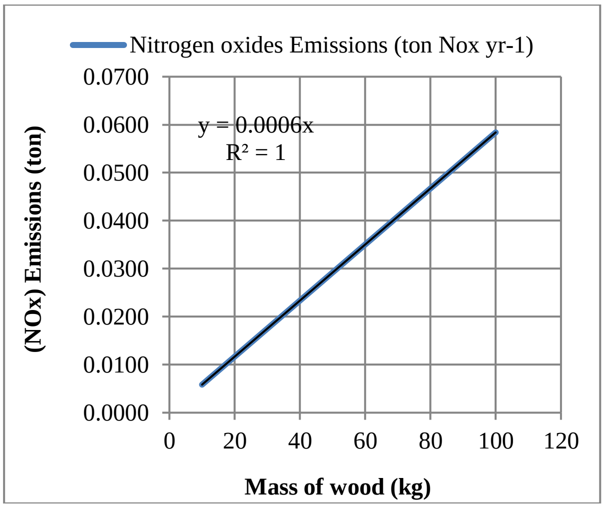

Fig. 1. NO_x emissions from fish smoking factories (ton NOx yr^{-1}) for burning wood.
Source: Author's determination.

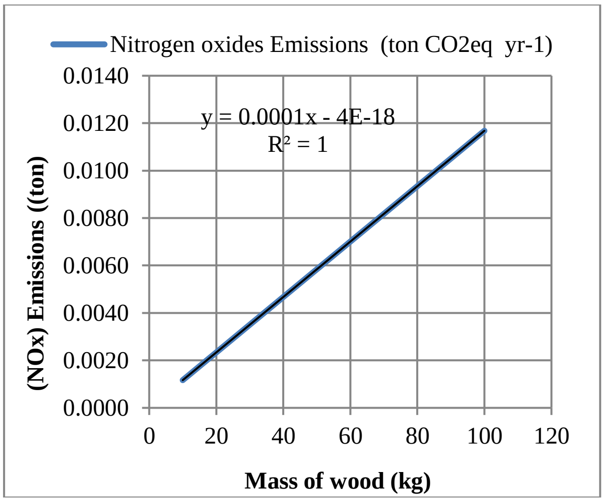

Fig. 2. NO_x emissions from fish smoking factories (ton CO_2-eq yr^{-1}) for burning wood.
Source: Author's determination.

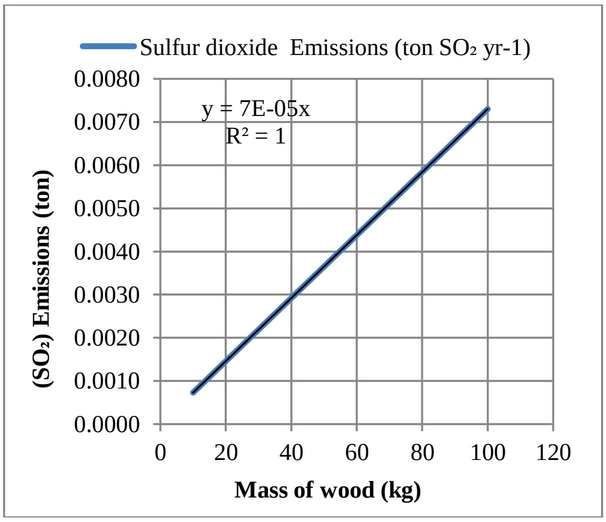

Fig. 3. SO_2 emissions from fish smoking factories (ton SO_2 yr^{-1}) for burning wood.
Source: Author's determination.

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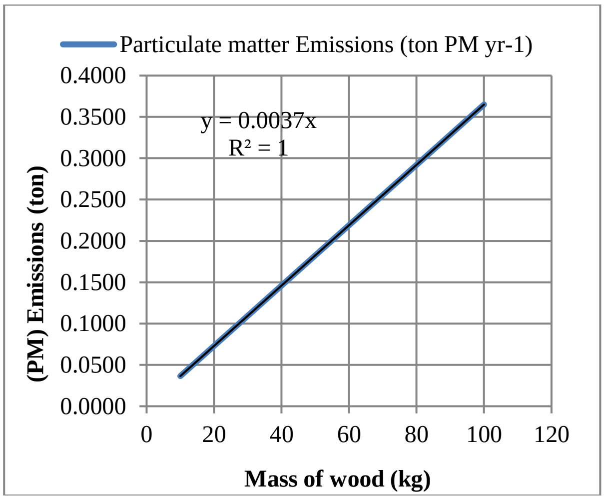

Fig. 4. PM emissions from fish smoking factories (ton PM yr^{-1}) for burning wood.
Source: Author's determination.

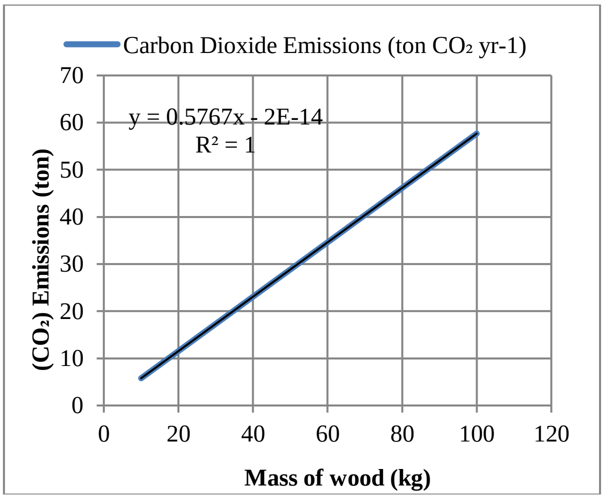

Fig. 7. CO_2 emissions from fish smoking factories (ton CO_2 yr^{-1}) for burning wood.
Source: Author's determination.

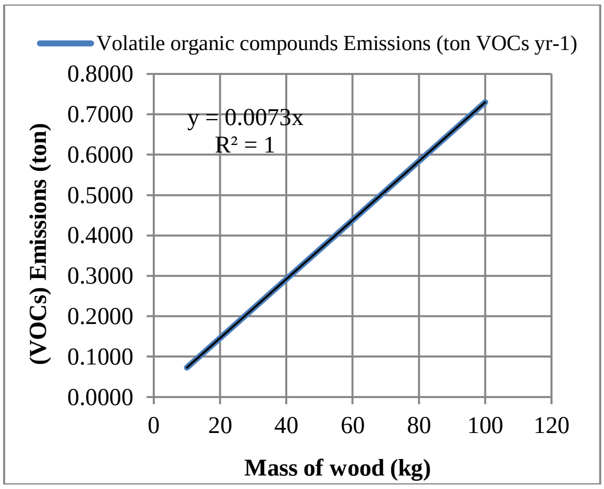

Fig. 5. VOCs emissions from fish smoking factories (ton VOCs yr^{-1}) for burning wood.
Source: Author's determination.

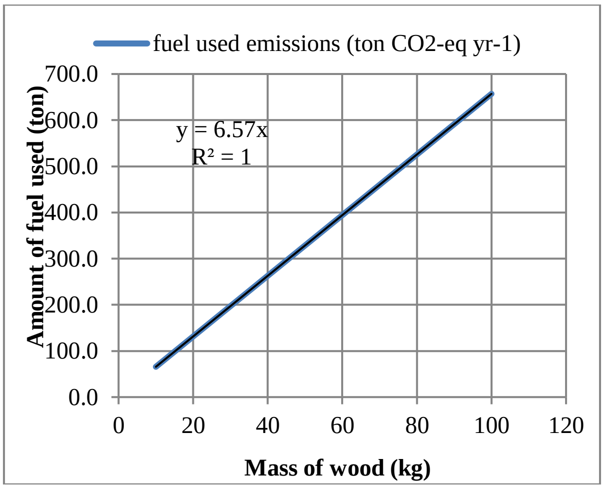

Fig. 8. Fuel emissions from fish smoking factories (ton CO_2-eq yr^{-1}) for burning wood.
Source: Author's determination.

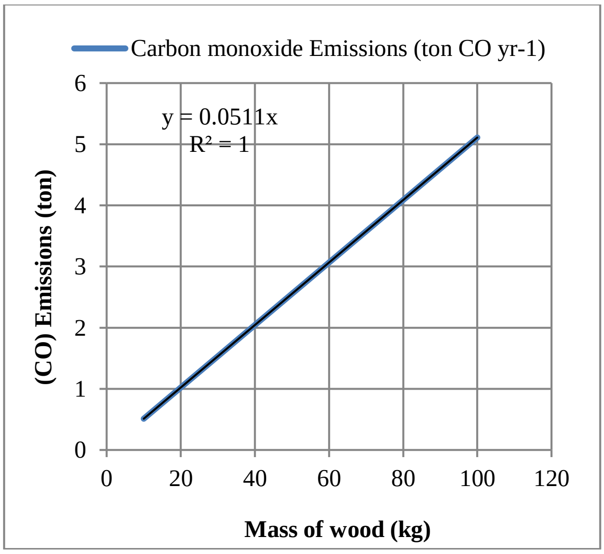

Fig. 6. CO emissions from fish smoking factories (ton CO yr^{-1}) for burning wood.
Source: Author's determination.

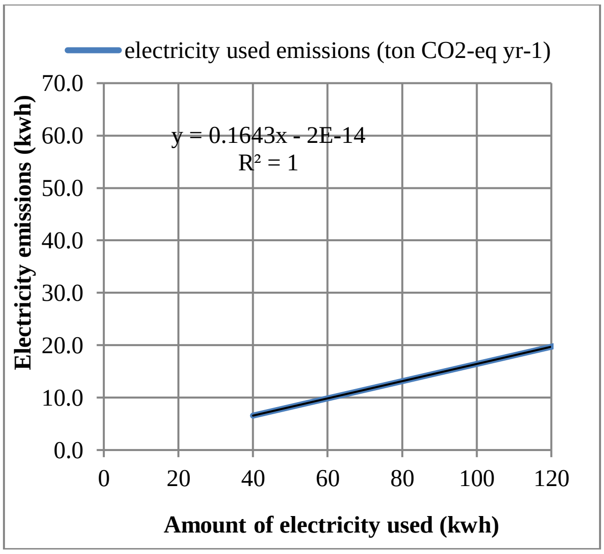

Fig. 9. Electricity emissions from fish smoking factories (ton CO_2-eq yr^{-1}) for burning wood.
Source: Author's determination.

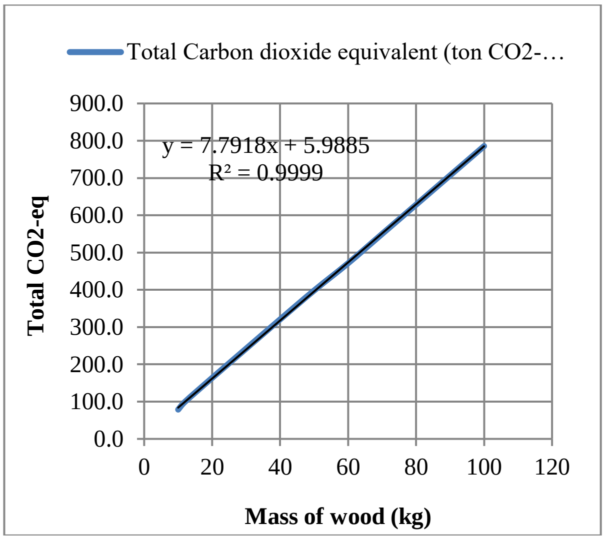

Fig. 10. Total CO_2-eq emissions from fish smoking factories (ton CO_2-eq) for burning wood
Source: Author's determination.

CONCLUSIONS

During the process of salmon smoking, the factory generated the following amounts of pollutants: Nitrogen oxides 0.007 ton NOx, Sulphur dioxide 0.0009 ton SO_2, Particulate Matter 0.0438 ton PM, Volatile Organic Compounds 0.0876 ton VOCs, Carbon Monoxide 0.613 ton CO, Carbon dioxide 6.92 ton CO_2, the emissions from the amount of fuel used was 788 ton CO_2-eq, the emissions of electricity use was equal to 38.3 ton CO_2-eq. In the end, the total amount of emissions produced from the factory is 99.5 ton of CO_2-eq yr^{-1}.

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SIMULATION MODEL TO PERFORM THERMAL ANALYSIS OF VARIOUS PAN MATERIALS DURING REPETITIVE OIL FRYING OPERATIONS

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Abstract

Thermal analysis during frying operations depends on the types of materials, the pans, and the quality of the oil used. Continuous exposure to changing temperatures changes the specifications. The experiment was planned to study the thermal analyse with various pan materials properties and repeated oil frying. The pan was tested and oil frying under steady-state heating conditions. The infrared images extracted with MATLAB, and testo software also Solid Works software were used to determine the material's convection coefficient, and specific heat,. The temperature rise at each point through surface and volume parameters from 0 to 8 minutes at three frying stage of oil and each skillet. The results showing as the frying temperature begins to rise, it rises with heat transfer rate (convective) reached 1,435.32 J/Kg·K during the third stage at 8 minutes. The specific heat capacity peaked at 1,191.37 J/Kg·K during the first stage at 6 minutes. Conversely, the minimum values for these indices were 522.90°C, 1,322.35 J/Kg·K, and 1,006.89 J/Kg·K, observed during the second stage at the beginning, specifically for the wok skillet.

Key words: i*nfrared, pan materials, heating, oil frying*

INTRODUCTION

Solanum tuberosum L., or potatoes, are the first essential non-cereal crop and the fourth most important crop overall. One important source of carbs, which are the main source of energy for a person's daily diet, is potatoes. Not only is it a multinutritional component source of iron, potassium, phosphorus, calcium, and magnesium, but it also contains important antioxidants and phenols. Furthermore, the resistant starch found in potatoes may guard against colon cancer, prevent fat accumulation, and have hypoglycemic and prebiotic effects [4].

One significant non-cereal crop is the potato. It offers carbs, one of the main dietary sources of energy for humans. In order to preserve vegetables and fresh fruits need be blanched before processing them. Pretreating various food materials with high-humidity hot-air impingement blanching (HHAIB) is a potential new method. In order to preserve the nutritional and physical qualities of potatoes while inhibiting the production of browning enzymes, this study sought to determine the ideal hot-water blanching (HHAIB) settings [11].

In the US, more than 17.4 billion pounds of French fries are produced each year, making up almost 44% of the total amount of processed potatoes produced. A French fry consists of two parts: (1) a crispy, oily, and dehydrated outside and (2) a cooked, moist, and oil-free within. The outside crust has a structure that is quite similar to that of a fried potato slice or potato chip. Raw potato strips need to be blanched in hot water and then dried in hot air until they have a moisture level of around 60% (total basis). This is the preparation process for French fry processing. The dried potato strips are cooked in hot oil (160–190C), cooled, then frozen and packaged. To finish the preparation, fry or bake the frozen par-fried potatoes one more time. The ultimate oil and moisture content of French fries are between 15 and 38%, respectively [15].

Cooking is an essential component of daily life for many apparent reasons, such as improving flavor, texture, palatability, digestibility, and shelf life in both domestic and commercial settings, as well as lowering the risk of food-borne infections. Estimates from the FAO indicate that the energy requirement associated with food is 15% for food processing and transportation, 10% for primary production, and 75% for cooking and food preparation [3].

A skillet is a physical delivery device that transfers heat to food's surface by the use of natural gas, induction, or an electrical coil. Food cooks according to the conduction of thermal energy across the food contact surface. Heat travels through the skillet's components and from the cooktop, the heat source, to the skillet's base by a process called conduction of heat. The way that thermal energy is transported from the Skillet to the meal is mainly determined by the materials that were utilized in its construction [9].

Immersion frying is another popular name for deep-fat frying. It is thought to be a food dehydration process, or more precisely, a method of extracting water through convection while undergoing a state shift. During this process, the food is periodically exposed to air and heated to a high temperature (180 C) in an environment of oil. The combined heat and mass transfer between the food and the frying media makes frying a highly complex process. A number of physical and chemical factors, including temperature, warm-up time, kind of oil, food, oil rotation, manipulation, and equipment, affect the amounts. However, when food is fried, a number of chemical processes and changes occur, including the starch gelatinization process, the Maillard reaction, the denaturation of protein, and the reduction of moisture.These alterations result in the food's surface becoming dehydrated, the formation of a crust, and the passage of heat from steam through the product [13].

The homogeneity and quick cooking of the food make frying a desirable method when compared to other methods. Vacuum frying and atmospheric frying are the two types of deep-fat frying methods. In oil mass called convection and within the food named conduction work together to transfer heat during deep-fat frying [10].

The meal has the same heat treatment applied to every surface, giving it a consistent flavor. A fine oil film forms on a product when it cooks in the fryer. The product's internal steam pressure lowers as its temperature naturally convects due to external factors (such as weather) and when it is removed from the fryer. This compels the oil to move within the product's surface. During frying, the product's thermophysical characteristics gradually alter. Both the food's pores and the density of the stuff diminish. When porosity increases, the specific heat falls, humidity content reduces, and oil content increases during frying. The thermal conductivity also decreases when these factors increase [2].

Four stages can be distinguished in immersion frying: (1) preliminary heating; (2) surfaces boiling; (3) dropping rate; and (4) bubble end point. In the initial phase, food immersed in oil has its surface heated to a temperature equal to that of water at its boiling point; heat is transferred between the food and oil through natural convection, with no water evaporating from the food's surface. By evaporating water in the second stage from the surface of the food, forced convection rather than natural convection is the method of heat transfer. This is due to the turbulence in the surrounding oil. At this point, the food's surface starts to take on the appearance of a crust. The food's internal humidity causes the temperature of that portion to gradually rise to boiling point in the third stage. A few physicochemical processes may occur during this time, including the denaturation of proteins and gelation of starches, as well as an decrease in the surface steam transfer rate and increase in the thickness of the superficial crust. The pace at which the humidity is eliminated decreases in the final stage, and the food's surface is free of bubbles. It is possible to classify these four frying states as either boiling phases (stages 2 and 3) or non-boiling phases (stages 1 and 4) [14].

The distinct flavors and crispy textures of potato chips make them very appealing. But because they contain between 35 and 45 percent oil by weight, people have a bad impression of them. Additionally, potato chips seem to contain the highest amounts of acrylamide of all the foods that have been examined up to this point. Demand for premium, health-conscious meals have increased recently as a result of growing consumer knowledge of the connection between nutrition and wellbeing. Therefore, researchers have been very interested in producing potato chips with minimal oil and acrylamide concentration and good sensory quality [8].

One of the most crucial markers of the final product's quality is the distinctive crispy texture of potato chips, which arises from modifications made to the potato tissue's initial structure during heating. The rate at which heat transfers has a direct impact on the development of this crispy texture. This quality can be imparted through deep fat frying since hot frying oil has a high heat transfer rate. The crispy and stretched texture of potato slices is caused by the rapid release of water due to high heat transfer rates during frying [12].

The elevated heat transfer rates that occur during deep-fat frying are primarily responsible for the development of the desired sensory attributes and important structural components of fried potatoes, including density, porosity, and volume. Heat and mass transmission during frying are affected by the shape of the meal, the temperature and pressure of the oil, as well as the thermal and physical-chemical properties of the food and oil. During the frying process, most of the oil does not penetrate the fine structure of the food, so a large part of the oil sticks to the surface of the food after it was on the surface after frying. This occurs in the cooling or post-frying stage [6].

Cooking with fat, often known as oil frying, is a popular technique for food production and preparation. The fat is a crucial component of the fried food and acts as a medium for heat transfer. It is used frequently or constantly at high temperatures, causing a variety of chemical reactions, including oxidation, fission, polymerization, and hydrolysis. This leads to the build-up of breakdown products, which are highly harmful to human health and have an adverse effect on the quality of fried dishes, especially when frying fat or oil is misused [7].

Deep frying is one of the oldest methods of food preparation that basically involves immersing food ingredients in hot oil. The water evaporates because to the high temperature, moving through the surrounding oil and away from the food. Food absorbs oil, which helps to replenish some of the lost water. Immersion frying can also be thought of as a dehydration method since it involves submerging a food product in edible oil or fat that has been heated above the boiling point of water. Too-high drying velocities are a hallmark of frying in hot oil at temperatures between 160 and 180 degrees Celsius.

Improving the final product's mechanical and structural qualities depends on this quick drying. High heat transfer rates, quick cooking, browning, texture development, and taste development are the results of these conditions.

The Maillard reaction, which is influenced by the temperature, frying time, asparagine content, and superficial reducing sugar, produces the color of fried potatoes [1].

An age-old and widely used technique for preparing food, deep-frying is used both in industrial and residential settings.

From a chemical perspective, it suggests a dehydration process marked by a brief cooking period because of the hot transfer, food that is internally heated to less than 100ºC, and the absorption of fat from the frying medium. In order to achieve a quick and even heating, the meal is immersed in very hot fat or oil (160–180ºC) that serves as a heat transmitter. Heat transmission during cooking occurs significantly more quickly when the temperature differential between the meal and the heating medium rises.

Mass is moved from the food to the frying medium and vice versa simultaneously with the transfer of heat [5].

The aim of this study is to perform a thermal analysis with solidworks flow simulation of various pan materials during repetitive oil frying operations.

MATERIALS AND METHODS

Three materials of skillets were used in thermal analysis (Wock, which is made from stainless steel material), (Tefal, which is made from stainless steel +Polytetrafluoroethylene (PTEF)), and (Ramlay which is made from sheet metal (steel material)) as shown in Photo 1, and Table 1 showed the properties of these materials. Also, an infrared camera was used to take pictures of these skillets in the study during 3 stages, for 8 minutes for each one and analysed pictures with Testo, MATLAB software version 2016, then perform the thermal analysis on the SolidWorks software version 2023. Simulation model to determine the thermal indices in surface and volume parameter as shown in Figure 1.

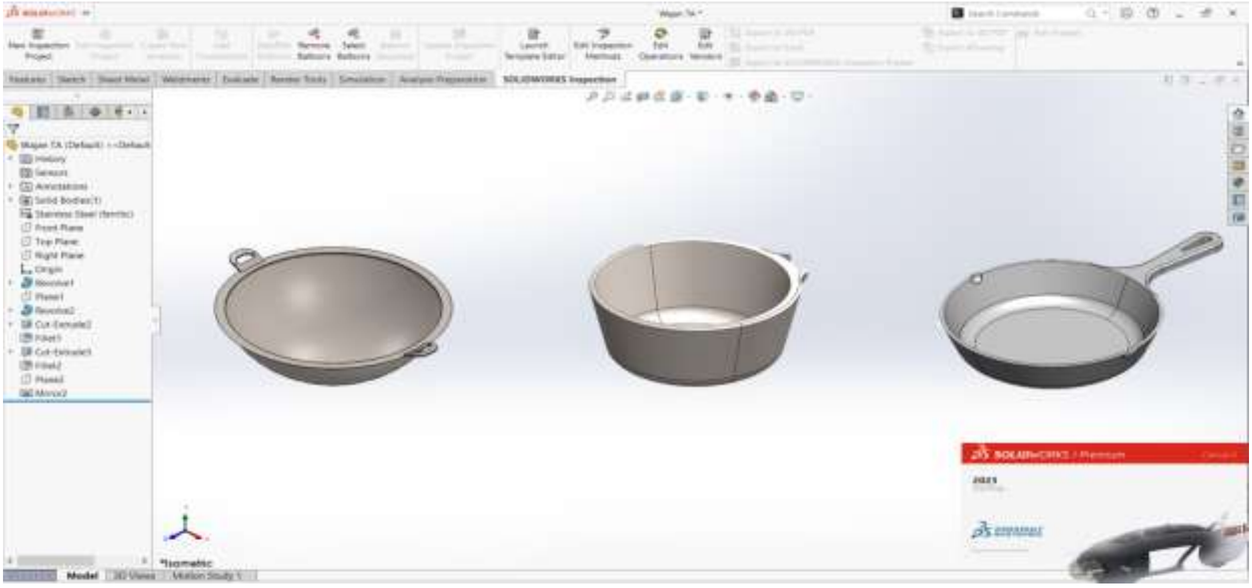

Photo 1. Skellies and their materials
Source: Authors' determination.

Table 1. Skillets materials properies

Stainless steel			Tefal (Stainless steel + PTFE (polytetrafluoroethylene))		Sheet metal (steel)	
Property	Value	Unit	Value	Unit	Value	Unit
Elastic Modulus	2e+11	N/m^2	400	N/m^2	190 to 210	GPa
Poisson's Ratio	0.28	N/A	0.4 to 0.5.	N/A	0.27 to 0.30.	N/A
Shear Modulus	7.7e+10	N/m^2	300 to 500	N/m^2	77 to 82	GPa
Mass Density	7,800	kg/m^3	2,320	kg/m^3	7,750 to 8,050	kg/m^3
Thermal conductivity	18	W/mK	0.25 to 0.35	W/mK	15 to 60	W/mK
Hardness	95	Rockwell	50 to 65	Rockwell	120 to 200	Rockwell
Thermal Expansion Coefficient	1.1e-05	(µm/(m·K))	80 to 135 x 10-6	(µm/(m·K))	10 to 13 x 10-6	(µm/(m·K))
Specific Heat	460	J/(kg·K)	0.5 to 0.55	J/ (Kg. K)	0.46 to 0.51	J/ (Kg. K)

Source: Own results.

Steps of the experiment

-The infrared images extracted for three pans, analyze images using Testo 2016, andMATLAB 2016, adtion to Perform thermal analysis on SolidWorks 2023. To determine thermal indicesduring three frying periods, for 8 minutes each. Calculate internal and external temperatures of pans and air and oil temperatures using Testo. Display thermal images in 2D, 3D format and clarify higher temperatures from Testo.

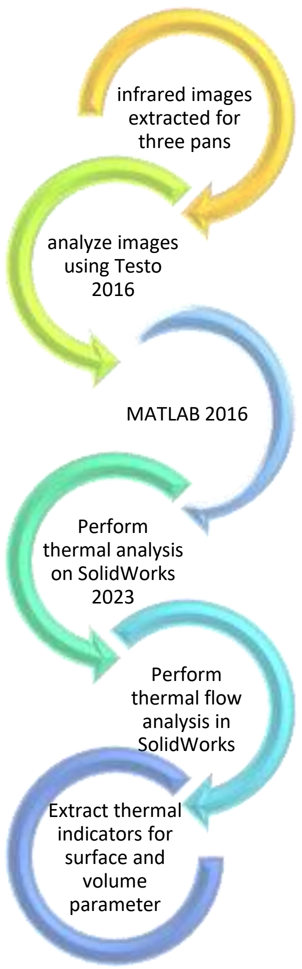

Fig. 1. The steps of the experiment
Source: Authors' drawing.

Surface parameters are focused on the material's exterior and involve properties and reactions occurring at or near the surface, and the importance of this type is surface reactions, corrosion resistance, adhesion properties, and catalytic activity.

Volume parameters encompass the entire material and involve bulk properties and behaviours, and the importance of this type is structural integrity, mechanical strength, thermal expansion, and bulk thermal conductivity.

Thermal indices

According to Zhang et al. (2010) [16]

Thethermal indices were founded as follows:

1- Heat Transfer Rate (Convective), J/Kg. K

$q=\frac{h\cdot A\cdot (Ts-T\infty)}{m}$ ……………………………..…(1)

where:

q is the heat transfer rate (W, or J/s),

h is the convective heat transfer coefficient (W/m²·K),

A is the surface area through which heat is being transferred (m²),

$T_s$the surface temperature (K or °C),

T_∞ is the temperature of the surrounding fluid (K or °C).

m is the mass of the material (kg)

2- Specific Heat, J/kg. K

$C=\frac{q}{m\Delta T}$…………………………………..(2)

where:

c is the specific heat capacity (J/kg·K),

q is the amount of heat absorbed or released (Joules),

mis the mass of the substance (kg),

ΔT is the change in temperature (K or °C).

3-Surface Heat Flux (Convective), W/m²

$q^n=h\cdot(T_s-T_\infty)$……………………………(3)

q+ is the convective heat flux (W/m²),

h is the convective heat transfer coefficient (W/m²·K),

T_s is the surface temperature (K or °C),

T∞ is the temperature of the surrounding fluid (K or °C).

4-Heat Transfer Coefficient (Adiabatic Temperature) (W/m²/K)

$q=h\cdot A\cdot(T_{aw}-T\infty)$……………………….(4)

where:

T_{aw} represents the adiabatic wall temperature,(K or °C).

5-Solid Thermal Conductivity, (W/m·K)

q=-K.

$A.\frac{\Delta T}{\Delta X}$…………………………………….…(5)

where:

q is the heat transfer rate (W),

k is the thermal conductivity of the material (W/m·K),

A is the cross-sectional area through which heat is being conducted (m²),

$\frac{\Delta T}{\Delta X}$is the temperature gradient in the direction of heat flow (K/m). Also, represents the rate of change of temperature with respect to distance within the material.

6-Absolute Total Enthalpy (J/kg)

Absolute total enthalpy, referred to as total enthalpy, is a thermodynamic quantity representing the total energy of a system per unit mass. It includes internal energy, pressure-volume work, and kinetic and potential energy.

$h_t = h + \frac{v^2}{2} + gz$……………………………….(6)

where:

h_t is the total enthalpy per unit mass (J/kg),

$\frac{v^2}{2}$ is the specific kinetic energy (J/kg), with v being the flow velocity (m/s),

h is the static enthalpy per unit mass (J/kg), defined as h=u+pv

where:

u is the internal energy per unit mass (J/kg),

p is the pressure (Pa), and

v is the specific volume (m^3/kg),

gz is the specific potential energy (J/kg),

where:

g is the acceleration due to gravity (m/s^2), and

z is the height above a reference level (m).

7-Stanton number

is a dimensionless number used in fluid dynamics and heat transfer. It measures the ratio of heat transferred to the fluid to the heat capacity of the fluid. It is a key parameter in convective heat transfer, particularly in boundary layer flows.

$St = \frac{h}{\rho c_p u}$…………………………………….(7)

where:

h is the convective heat transfer coefficient ($W/m^2 \cdot K$),

ρ is the density of the fluid (kg/m^3),

c_p is the specific heat capacity of the fluid at constant pressure (J/kg·K),

u is the flow velocity (m/s).

8. Energy balance, (W)

Q_{in} -Q_{out} +Rate of energy generation = Rate of energy accumulation…………………………...(8)

Where:

$Q_{in}= q_x$ is rate of energy in, W

$Q_{out}= q_x + \Delta x$ is rate of energy out, W

rate of energy accumulation= $\rho\ c_p \Delta x\ \frac{dt}{dx}$

final energy balance formula:

$q_x - q_x + \Delta x = \rho\ c_p \Delta x\ \frac{dt}{dx}$……………………..(8.1)

*Using Fourier's law of heat conductivity:

$-KA\frac{dt}{dx} + KA\frac{dt}{dx} = \rho\ c_p \Delta x\ \frac{dt}{dx}$………..……(8.2)

RESULTS AND DISCUSSIONS

Maintaining a constant level, the temperature gradient at each point through surface and volume parameters for 8 minutes at each stage provides significant insights into the overall performance of each skillet. As shown in Fig.2 to Fig 4, in wock skillet the maximum Adiabatic Fluid Temperature was 482.25°C, temperature of the solid was 432.15°C, and the highest heat transfer rate (convective) reached 853.27 W during the third stage at 8 minutes. While Teffal skillet the maximum Adiabatic Fluid Temperature was 479.35°C, temperature of the solid was 387.83°C, and the highest heat transfer rate reached 860.65 W during the third stage. As for Ramlay skillet the Maximum value for the same indicators was 471.25°C, 471.35°C, and 880.26 W during the third stage at 8 minutes, respectively.

Fig. 5 to Fig.7 illustrate the convergence between the values of Heat Transfer Coefficient, and Heat Transfer Coefficient (Adiabatic Temperature) for the wock skillet. The minimum values recorded were 18.06 and 18.11 $W/m^2 \cdot K$, while the maximum values were 23.54, and 23.45 $W/m^2 \cdot K$, corresponding to the The three stages respectively. for The Teffal skillet the minimum values recorded were 22.84 and 25 $W/m^2 \cdot K$, while the maximum values were 25.01, and 29.88 $W/m^2 \cdot K$. The same minimum and maximum values for the same parameters for Ramlayskillet were equal for the three stages 17.93, 18.48, 19.18, 19.90 $W/m^2 \cdot K$. The highest values reached by the Surface Heat Flux were 10.86KW/$m^2$for wock skillet and 12.04 KW/$m^2$for Teffal skillet and 13.73 KW/$m^2$for Ramlay skillet in the last stage for the three skillets respectively.

Fig. 9 to Fig. 11 show that the maximum and minimum values of the thermal indices were recorded as follows: For the wock skillet, The Specific Heat (Cp) ranged from 1,100.94to 1,238.26 J/Kg.K, the Absolute Total Enthalpy varied between 803.9 and 891.13 KJ/kg, These values were observed during the first and third stages, from the beginning to 8 minutes, respectively. For the Teffal skillet, The Specific Heat (Cp) ranged from 1,173.67to 1,423.13 J/Kg.K, the Absolute Total Enthalpy varied between 882.81 and 912.81 KJ/kg, during the first and third stages, respectively.

As the Ramlay skillet, the specific heat (Cp) increases from 1,304.55 to 1,550.21 J/Kg.K, and Absolute Total Enthalpy increases from 909.96 (J/kg*K) to 951.84 KJ/kg, respectively.

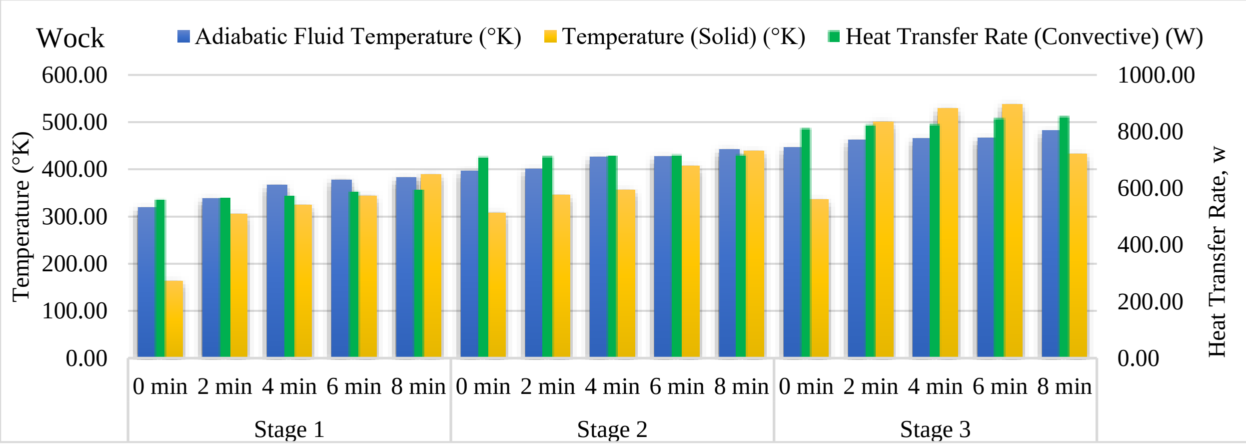

Fig. 2. Changing intemperature, adiabatic fluid temperature and heat transfer rate during frying stages of Wock skillet
Source: Author's determination.

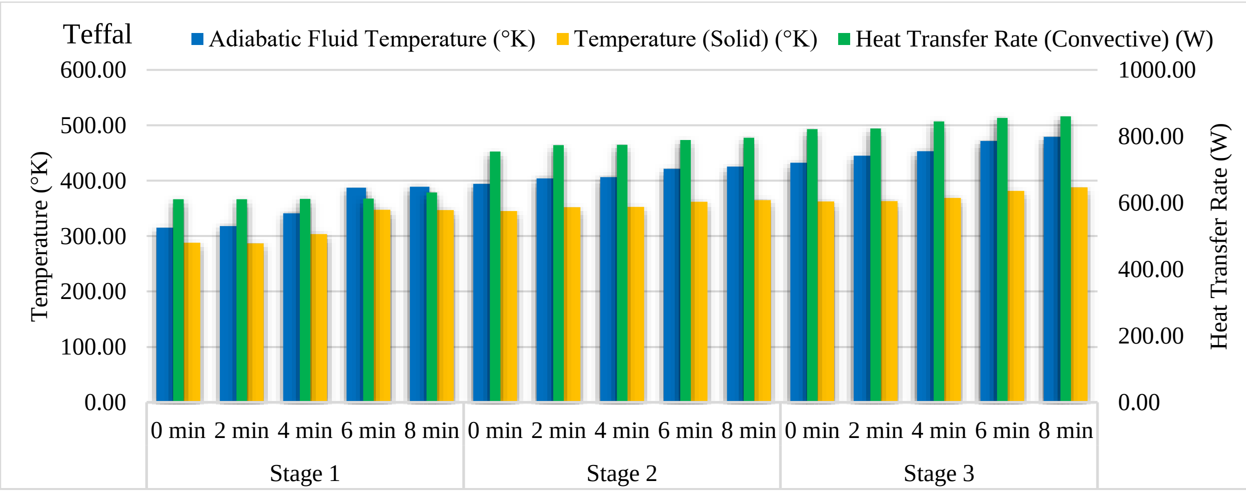

Fig. 3. Changing in temperature, adiabatic fluid temperature and heat transfer rate during frying stages of Teffalskillet
Source: Author's determination.

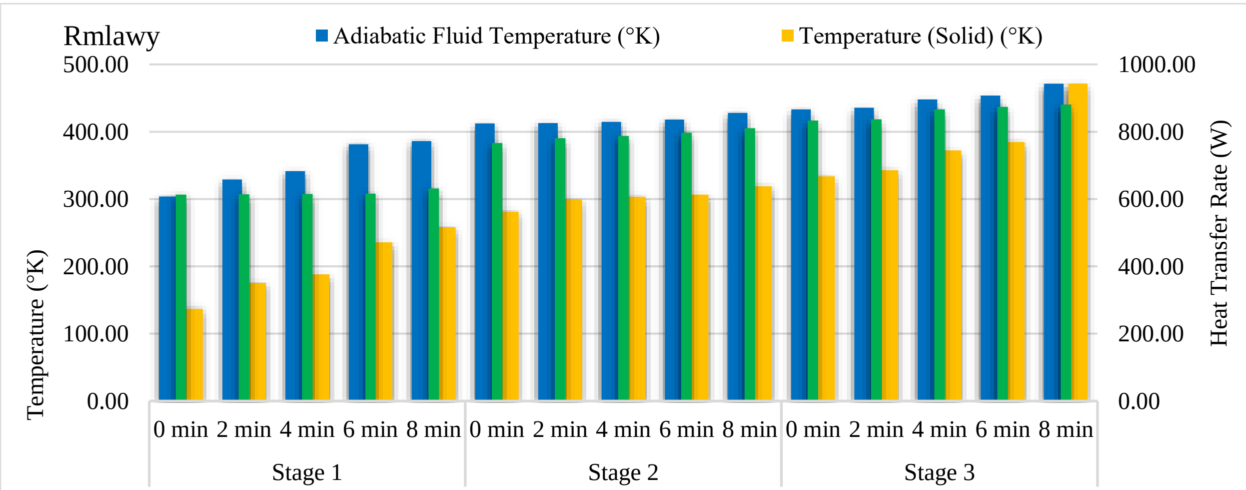

Fig. 4. Changing in temperature, adiabatic fluid temperature and heat transfer rate during frying stages of Rmlawy skillet
Source: Author's determination.

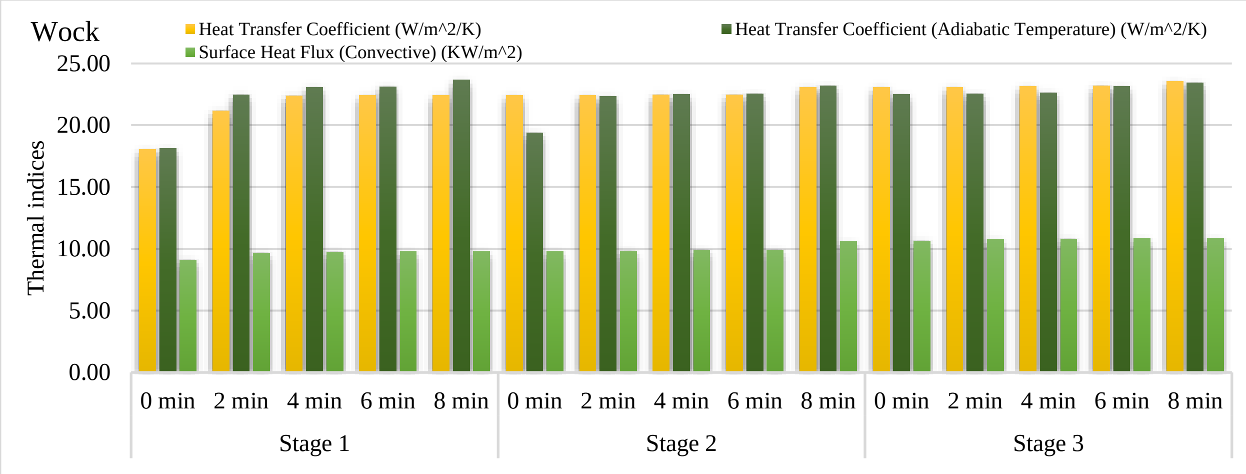

Fig. 5. Changing in heat transfer coefficient, heat transfer coefficient and surface heat flux during frying stages of Wock skillet
Source: Author's determination.

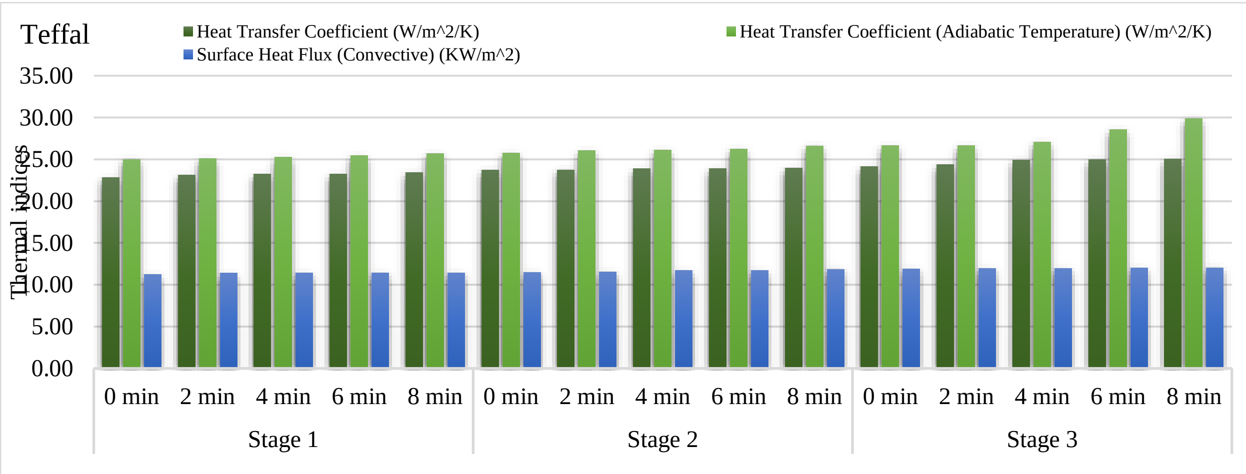

Fig. 6. Changing in Heat Transfer Coefficient, Heat Transfer Coefficient and Surface Heat Flux during frying stages of Teffal skillet
Source: Author's determination.

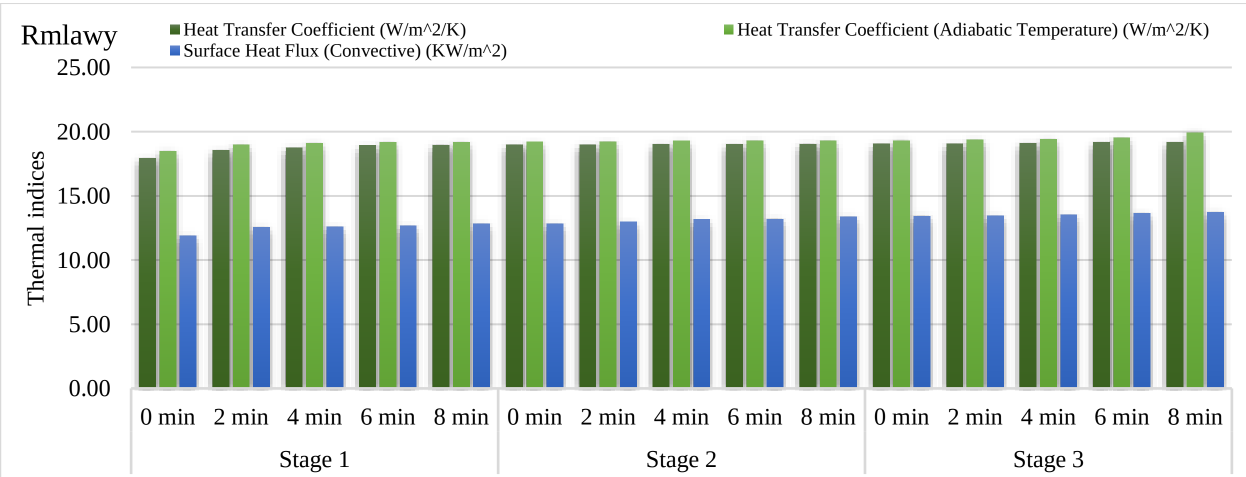

Fig. 7. Changing in heat transfer coefficient, heat transfer coefficient and surface heat flux during frying stages of Rmlawy skillet
Source: Author's determination.

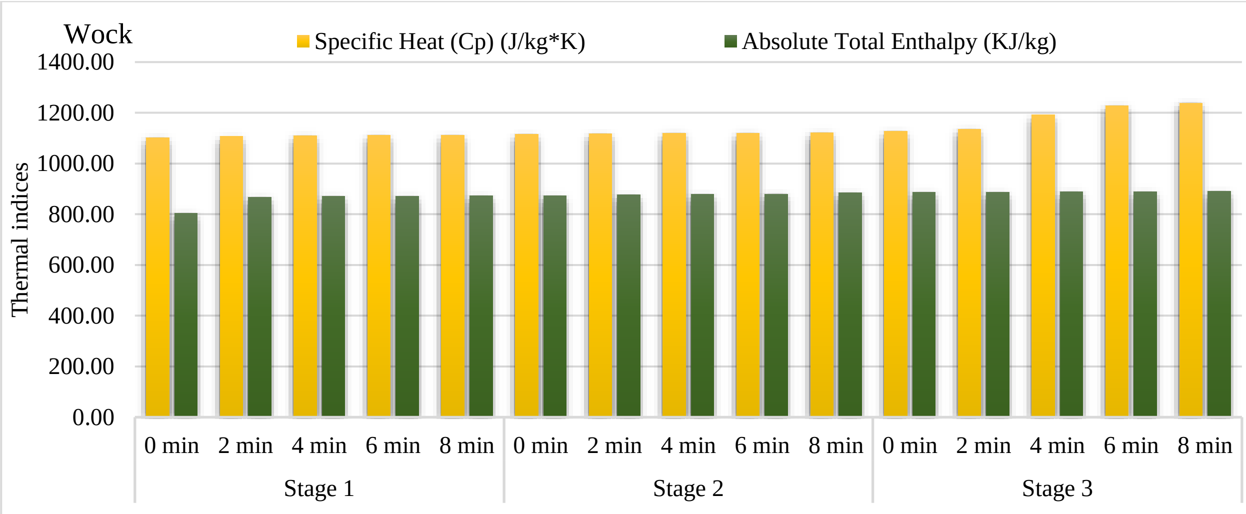

Fig. 8. Changing in Specific Heat and Absolute Total Enthalpy during frying stages of Wock skillet
Source: Author's determination.

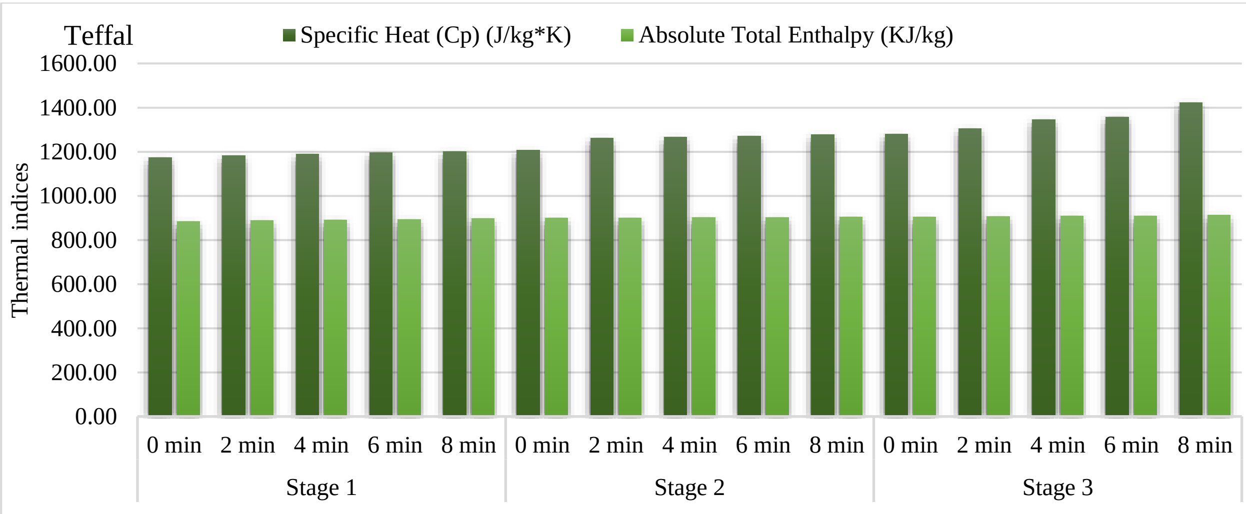

Fig. 9. Changing in specific heat and absolute total enthalpy during frying stages of Teffal skillet
Source: Author's determination.

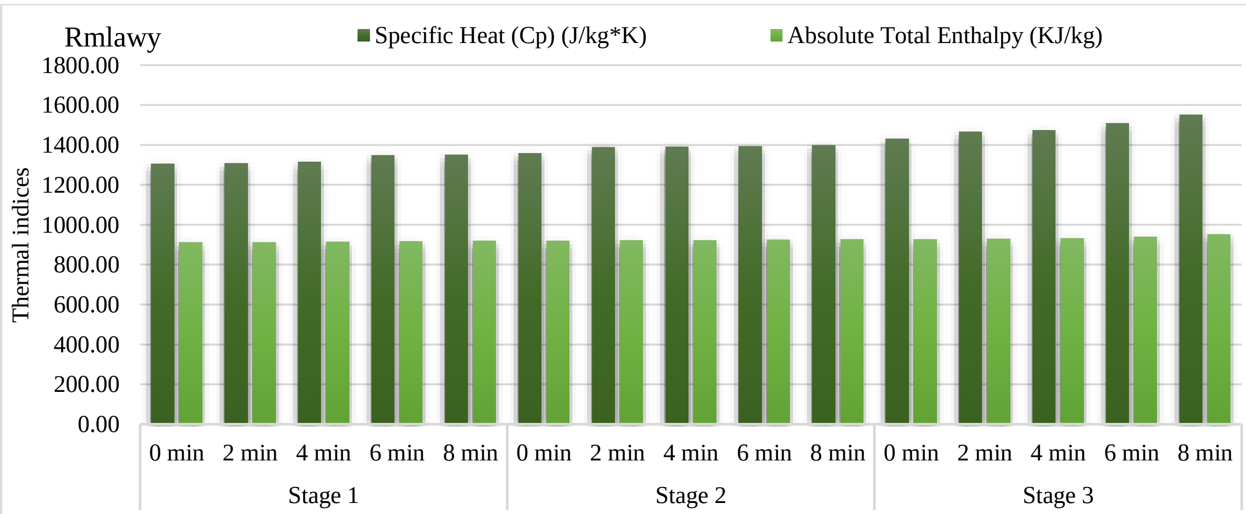

Fig. 10. Changing in specific heat and absolute total enthalpy during frying stages of Rmlawy skillet
Source: Author's determination.

CONCLUSIONS

In a study examining the impact of three types of frying skillets—wok, Tefal, and Rmlawy—on a constant heating process, researchers analysed the physical characteristics of the materials used in each skillet. The findings highlighted significant differences in thermal distribution and energy balance among the skillets. The wok skillet emerged as the most efficient, achieving the best thermal distribution and energy balance, making it an ideal choice for cooking. This efficiency is attributed to the material's superior heat conduction properties, which ensure even heating and optimal energy use. Consequently, the wok skillet's material composition is considered perfect for culinary applications requiring consistent and controlled heating.

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CLIMATE-RELATED RISKS: IMPACT AND CHALLENGES FOR FINANCIAL INSTITUTIONS

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Abstract

Climate change awareness and the necessity of taking steps to lessen its long-term implications on the economy, regions, cities, and population have gained importance in recent years. The transition to a low-carbon economy presents various challenges for governments, organizations, authorities, businesses, and the public. In this context, financial institutions, as key participants in the economic landscape, can and should play a significant role in translating environmental strategies into the real economy. The purpose of the study is to identify and examine how banks are affected by climate change risks and determine the primary mitigation strategies that banks must use to guarantee a sufficient risk management system, control the impact on financial results and maintain the financial stability at country level, while continuing to be a main player in stimulating the global economy in implementing sustainable practices and reducing climate impact. Materials and methods used were driven by collecting statistical data provided by banks and and non-banking financial institutions (IFN) which were analysed in order to come to conclusions as regards changes needed on bank's risk policies, quantification systems and methods (including stress-test. The study main results underline that banks need to continue and intensify incorporating climate risks in the internal risk management policies and risk assessment models (including stress testing) which will support anticipating and managing the impact of future extreme events, potential disruptions in clients' supply chains, interdependencies, and cascading impact potential. Moreover, through financing green investments, banks can contribute to achieving sustainable economic growth and reducing carbon emissions and the impact of climate change.

Key words: *climate risks, transition, low-carbon economy, green investments, risk management, financial stability*

INTRODUCTION

As climate change intensifies and becomes an important topic for international organizations, states, public opinion, mass media, etc., credit institutions, in their capacity as financial intermediaries, respectively financiers of the real economy, are seen more and more than having an essential role in translating environmental strategies into lending policies for corporate and natural customers.

As such, through the lending decisions/orientation of the resources attracted in loans granted to economic sectors, credit institutions contribute, together with states, regulatory and supervisory authorities, to stimulating the global economy in the implementation of sustainable practices and reducing the climate changes impact, by including these items as specific requirements in their own credit policies [2].

The topic of exposure to climate risks must also be addressed at the country level. Countries exposed to climate risks can substantially increase the level of systemic risk of banks operating in that country, mainly due to losses from loans granted (as an effect of the impact of climate risks on customers' ability to repay committed loans) [15].

In this situation, credit institutions have an interest in identifying, assessing, and minimizing exposure to credit risk, specifically the non-payment of loans made to clients who are exposed to the effects of climate change. As a result, they must make investments in risk management strategies and tactics associated with this area.

This is a reason why the authorities have begun to pay more attention to the regulation and supervision of this field, including by carrying out crisis simulations (stress-test) on the impact of financial and capital losses that banks can register in certain negative scenarios. Also, reporting requirements regarding exposure to climate risks and measures taken by financial institutions were implemented [2].

In addition, banks must meet transparency standards regarding internal governance on addressing climate risks (aiming, for example, the senior management involvement, etc.).

For policymakers, the conflict in Ukraine brought to light some medium-term structural concerns, such as the potential for the geopolitics of energy security to endanger the climate transition, and emphasized the urgency of reducing dependence on carbon-intensive energy and accelerating the transition to more renewable resources with reduced impact on the environment [7].

Additional actions are intended to increase funding for the shift to a greener economy and enhance the infrastructure for gathering data on funding in this field.

On the other hand, environmental protection associations and bank shareholders put pressure on them to reduce the carbon footprint of their activities.

The main purpose of the study is, on one hand, to identify and analyse the impact of climate change related risks at the level of individual banks and the systemic risks for financial stability at the level of countries or the EU and to identify the main channels (for example credit risk, market risk, litigation losses etc).

On the other hand, the study is targeting the identification of main mitigating actions needed to align the banks credit risk strategy with environmental objectives, which encourages sustainable economic development but also a healthy loan portfolio.

While supporting the opinion that banks are a main player in stimulating the customers in implementing sustainable practices and reducing climate impact via the loans granted.

MATERIALS AND METHODS

The present study uses an integrative methodology for the assessment of climate risks associated with the credit portfolios of banking institutions, aiming at their alignment with the objectives of sustainability and sustainable development. The methodology involved three main stages: the collection of statistical data, the analysis and assessment of risks and the integration of the results into conclusions regarding possible lending strategies, all carried out with attention to the particularities of each affected economic sector.

The statistical analysis of the data was carried out on the basis of the information provided by banks and non-banking financial institutions (IFN), using the following methodological steps:

Classification and quantification of risks

The data was organized into climate and environmental risk categories with the greatest impact on financial stability, generating an aggregate picture of the perception of physical and transition risks.

Physical risk assessment takes risk assessment into account.

The analysis made it possible to rank the risks based on how frequently banks and IFNs consider them.

Identifying potential risks associated with climate risks

Data were collected on related risks assessed by financial institutions, and responses were averaged in descending order of perceived importance.

Analysis of green products

Information on the adoption of green financial products was evaluated, allowing a classification of institutions according to their involvement in sustainable products.

Data were statistically analyzed to establish general trends, differences between institution types and rank risks and sustainable solutions based on reported frequency.

RESULTS AND DISCUSSIONS

The complexity of climate-related risks implies the use of advanced risk assessment tools/methods and a risk management framework that allows banks to align their credit risk strategy with environmental objectives, which encourages sustainable

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economic development but also a healthy loan portfolio.

A recent development/opportunity is the use of artificial intelligence (AI) and Machine Learning methods, which allow providers of climate risk assessment tools and banks to maximize existing data and information, provide opportunities to identify high-risk areas and even predict natural disasters, such as fires and floods, with a higher degree of accuracy than previous techniques [2].

Purchasing trustworthy instruments to evaluate the effects of climate change and having access to enough climate data for risk models are very important for credit institutions in the process of assessing risks and identifying business opportunities.

This can help them anticipate future extreme events in the localities/sectors of the real economy where they operate and identify potential disruptions to customer supply chains, interdependencies and potential cascading impacts.

Depending on the results, banks can set their lending policy to various customers and adopt proactive strategies such as requiring insurance of fixed assets/products etc.

Their implementation requires appropriate budgets, experience and implementation efforts over time.

Risk models must take into account the challenges given by the specifics of some economic sectors, such as agriculture and the real estate sector (in the latter, for example, data on carbon dioxide emissions, energy consumption, the need to transform into buildings with low/even zero carbon dioxide emissions, etc.).

As part of its annual stress test from 2022, the European Central Bank (ECB) administered a climate risk stress test to 104 major institutions. The test examined the development of the methods banks use to conduct these tests and the primary risks that banks face in terms of transition risks and major physical risk events.

One conclusion is that banks still do not adequately consider climate risks in their internal risk assessment models and stress tests, although the situation has improved since 2020.

At the same time, most banks in the Eurozone do not have a sufficiently developed framework for modeling climate risks and, in general, do not take them sufficiently into account when granting loans.

In Romania, according to a BNR report, the economic sectors considered to be the most exposed to transition risks are the following: agriculture, extractive industry, beverage manufacturing, food industry; manufacture of tobacco products, paper, coke oven products, chemical substances and products, basic pharmaceutical products and pharmaceutical preparations, other products from non-metallic minerals, metallurgical industry, industry of metal constructions and products from metal, production and supply of electricity and thermal energy, gas, hot water and air conditioning, land transport and pipeline transport, air transport, construction, real estate transactions, etc. [11].

The importance of monitoring the exposure to the risks related to these sectors exposed to transition risks also derives from the high weight, respectively between 41% and 60% of interest and commission income for Romanian banks, a similar level being registered at the European level (more than 60 percent of banks' interest and fee income according to the results of the ECB's climate risk stress test in 2022) [11].

In the same context, at the level of the European Union, a high correlation can be observed between the exposure from loans on economic sectors that participate more in the emission of carbon dioxide (for example, banks' exposure to loans in the manufacturing sector is about 20%, which is rather significant given that these sectors contribute over 40% of emissions) [14].

Through conventional channels, such as credit risk and market risk, as well as litigation losses, such as those pertaining to credits that finance polluting activities, the effects of climate change involve risks for financial stability at the national or EU level as well as risks for individual banks [4].

The risks determined by climate change can be classified according to their impact on the sustainability of the business model of credit

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institutions in Romania into two main types, respectively:

a. **physical risks**, caused by extreme weather (storms, hail, tornadoes, floods) and rising temperatures;

b. **issues related to the shift to a carbon dioxide-neutral** economy from the perspective of carbon dioxide emissions (e.g., legislative actions, changing customer preferences) (Figure 1) [11].

The dynamic effects of physical and transition risks on economic sectors should not be understated by climate-related risk analyses. Some of these effects have not yet been demonstrated, but they could materialize in the future in areas like the risk of armed conflicts and social, with associated political and economic ramifications from forced migration brought on by rising temperatures. [2].

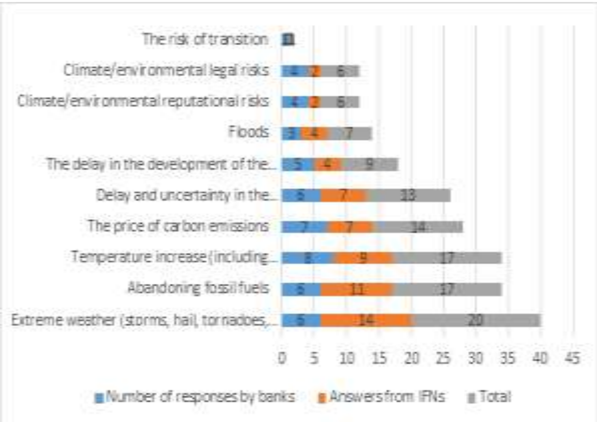

Fig.1. Top of climate and environmental risks for banks and IFNs in Romania
Source: data processing [11].

Another dimension of the problem is that of the possibility of cascading disasters, determined by the impact of some natural disasters on other disasters, such as drought that produces fires, which in turn negatively affect flora and fauna.

The risk categories included in physical risk exposure assessments carried out by banks are usually the most important of those mentioned above, namely floods, extreme weather, drought (Figure 2) [11].

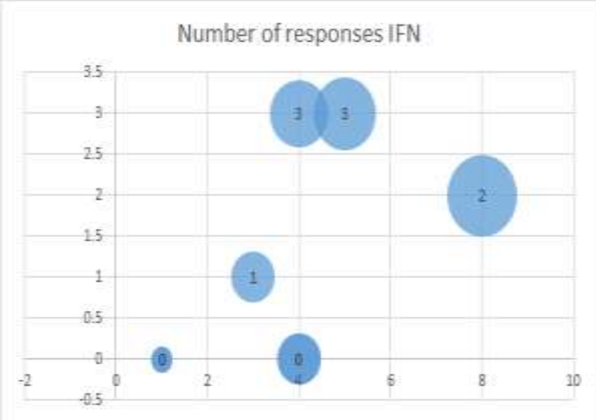

Fig. 2. Top of risks considered by financial institutions when assessing physical risk
Source: data processing [11].

Romanian banks have implemented measures to monitor and mitigate climate risks and have established objectives, targets, limits, climate risk maps or sectoral policies or intend to develop such indicators in the coming period. [11].

The implementation and integration of climate risk assessment systems in the management of the activity of financial institutions is very important for them because it allows them to proactively address potential vulnerabilities/risks that may affect their profitability, strengthening their ability to withstand shocks/crisis and improving the strategic decision-making process.

From the taxonomy of risks specific to the activity of credit institutions, the top risks that can be affected by climate factors are credit risk, reputational risk and operational risk (Figure 3) [8, 9].

At EU level, losses related to credit and market risks resulting from the improper transition to an economy with low carbon dioxide emissions could have the following evolution:

• for legal entities: physical risks could become a major problem in the next 15 years;

• for banks: losses of up to 1.75% of risk-weighted exposures could be recorded until the middle of the current century, concentrated in the electricity and real estate sectors [14].

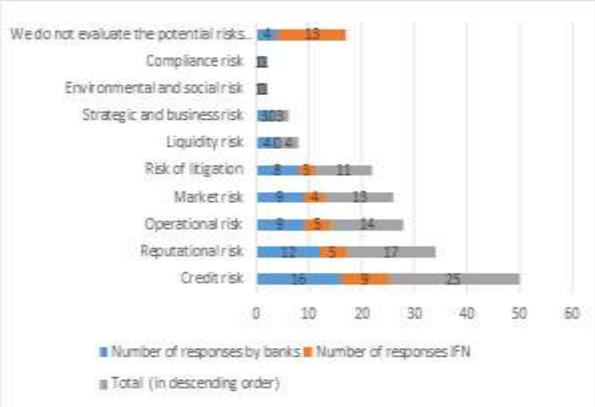

Fig. 3. Types of risks considered by financial institutions
Source: data processing [11].

Romanian financial institutions believe that financing green investments generates opportunities for business development and contributes to achieving sustainable economic growth, reducing carbon emissions and increasing the rate of green assets (including by issuing green bonds or investing in such bonds issued by government institutions or by non-financial corporations) (Figure 4) [11, 13].
The "Other" category refers to the increase in financing in green assets: electric locomotives, electric and hybrid cars, electric or alternative fuel trucks, electric charging stations, photovoltaic panels, etc.

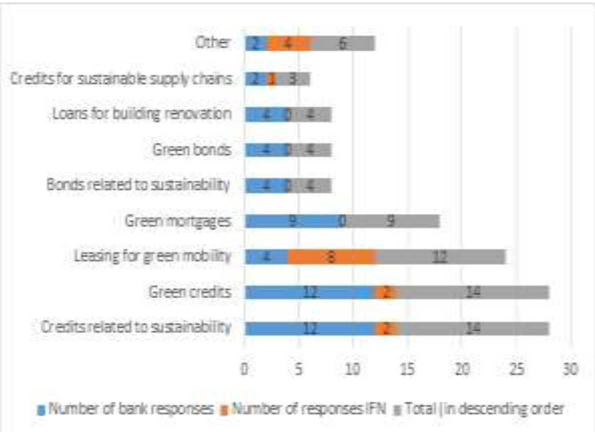

Fig. 4. The main green products granted by credit institutions and IFNs
Source: data processing [11].

Financial institutions can offer green loans as well as financing to help meet other environmental goals aimed at the transition to a circular economy, the sustainable use and protection of water and marine resources, the prevention and control of pollution, and the protection and restoration of biodiversity and ecosystems [1, 3, 5, 6, 10, 12].

CONCLUSIONS

The impact of climate change is felt across many sectors, including credit institutions, which can primarily contribute—through the loans granted to clients—to stimulating the global economy in implementing sustainable practices and reducing climate impact.
As this is a relatively new field, banks need to continue or intensify their investment in methods and techniques for managing the associated risks.
Additionally, they should increasingly incorporate climate risks into their internal risk assessment models (including by setting objectives, targets, limits, climate risk maps, or sector-specific policies) and in stress testing or crisis simulations. Their implementation requires appropriate budgets, experience and implementation efforts over time.
This approach can help them anticipate future extreme events in the regions or sectors of the real economy where they operate and identify potential disruptions in clients' supply chains, interdependencies, and cascading impact potential.
Moreover, by financing green investments, banks create opportunities for business development and contribute to sustainable economic growth and a reduction in carbon emissions and the impact of climate change.
Banks have to align their credit risk strategy/ set their lending policy principles with the environmental objectives.

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COMPARATIVE FORECAST OF ORGANIC EGG PRODUCTION IN ROMANIA AND THE EUROPEAN UNION: INSIGHTS FOR 2014–2030

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Abstract

The study analyses and forecasts organic egg production in Romania and the European Union (EU) from 2014 to 2030, emphasizing significant variations in scale, growth patterns, and market maturity. Data from EUROSTAT (2014–2022) were analyzed utilizing Excel forecasting tools, employing performance metrics including SMAPE, MASE, and RMSE to evaluate model accuracy. In this regard, the EU exhibited consistent growth, with egg production increasing to 4.7 billion by 2022 and anticipated to reach 7.25 billion by 2030. In contrast, Romania's production, although smaller in scale, experienced significant growth of over 250% during the same period and is projected to reach 85 million eggs by 2030. The findings highlight Romania's developing role in the organic sector, the variability of trends, and the potential for targeted interventions to improve its market position.

Key words: *organic egg production, European Union, Romania, agricultural forecasting, sustainable farming*

INTRODUCTION

Organic agriculture is gaining popularity worldwide, reflecting a growing consumer demand for sustainable and ecologically friendly farming practices. This trend is being driven by increased health awareness, environmental concerns, and a desire for high-quality food products. Organic farming emphasises the use of natural processes and materials while avoiding synthetic fertilisers and pesticides, which promotes biodiversity and soil health [2, 15, 23, 25, 26]. The organic industry has grown significantly, with organic egg production emerging as a critical component of this movement, providing not only a premium product but also aligning with consumer ideals such asanimal welfare and environmental sustainability. Organic egg production stands out in the world of organic farming. It is distinguished by greater animal welfare regulations, such as outdoor access and organic diet, which improves the nutritional value of the eggs. Research shows that organic eggs have lower saturated fat levels than conventional eggs [15, 18]. This part of organic farming not only serves to health-conscious consumers[29], but it also contributes significantly to the general sustainability of agricultural operations by encouraging the use of more humane and environmentally sound farming methods [20]. The European Union (EU) has played an important role in boosting organic production by establishing a strong regulatory framework andproviding subsidies[30]. The EU's

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Common Agricultural Policy (CAP) offers financial assistance to farmers who switch to organic practices, encouraging sustainable agriculture [1]. Furthermore, strict restrictions ensure that organic products fulfil high standards, thereby preserving customer trust and market integrity [1, 10].

The EU's commitment to organic farming is evident in its ambitious aims for growing organic land area and production, which aim to improve food security and environmental sustainability across member states [10]. Romania stands out in the European Union's organic agriculture environment. With its rich agricultural history and diversified ecosystems, Romania has the potential to become a major participant in the organic market. Despite its historical dependence on conventional farming methods, the country has shown a growing interest in organic practices, particularly in egg production [1, 11, 24, 31]. The shift to organic farming in Romania is aided by both EU subsidies and rising domestic demand for organic products, allowing the country to capitalise on its agricultural legacy while adopting modern sustainable practices [10].

This contrast of history and innovation makes Romania an appealing subject for studying the growth of organic egg production in the larger context of the EU's organic market from 2014 to 2030.

This paper aims to analyse and forecast organic egg production trends in Romania and the European Union from 2014 to 2030. By comparing historical data and projected growth patterns, the study seeks to identify key factors influencing production dynamics, identify disparities and opportunities between Romania and the larger EU market, and provide insights to inform policy-making, sustainable development, and market strategies in the organic egg sector.

MATERIALS AND METHODS

The data for this study was obtained from EUROSTAT and comprised the annual production of organic eggs for both Romania and the European Union from2014 to 2022. The analysis was carried out using Microsoft Excel, with the built-in forecasting features used to predict production trends from 2022 to 2030.

The forecasting feature was implemented with a 95% confidence interval to determine upper and lower bounds. Missing data points were interpolated, and duplicate entries were aggregated using the average function.

Key performance indicators and metrics, such as Alpha, Beta, Gamma, Mean Absolute Scaled Error (MASE), Symmetric Mean Absolute Percentage Error (SMAPE), Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE), were calculated to ensure the accuracy and reliability of the forecasts. The forecasting model's accuracy and performance were comprehensively assessed using these metrics.

RESULTS AND DISCUSSIONS

The statistical metrics used to evaluate the forecasting model for organic egg production in the European Union provide insights into the model’s accuracy and assumptions. The Alpha value of 0.90 indicates that the model heavily relies on recent data, applying significant smoothing to prioritize recent trends in the production of organic eggs. Both Beta and Gamma values are 0.00, suggesting that the model assumes no adjustments for trend or seasonality. This implies that the forecast is linear and does not account for potential seasonal variations or evolving trends over time.

The performance metrics further confirm the reliability of the forecast. The Mean Absolute Scaled Error (MASE) is 0.59, indicating that the model performs significantly better than a naive forecast. Similarly, the Symmetric Mean Absolute Percentage Error (SMAPE) is 0.06, reflecting an impressive accuracy rate with minimal deviation—only 6%—from actual values.

In terms of absolute errors, the Mean Absolute Error (MAE) of approximately 229,701 (in thousands of eggs) represents the average forecast error, while the RootMean Squared Error (RMSE) of 309,467 (in thousands of eggs) highlights that the forecast errors are relatively consistent, withno significant outliers affecting the projections.

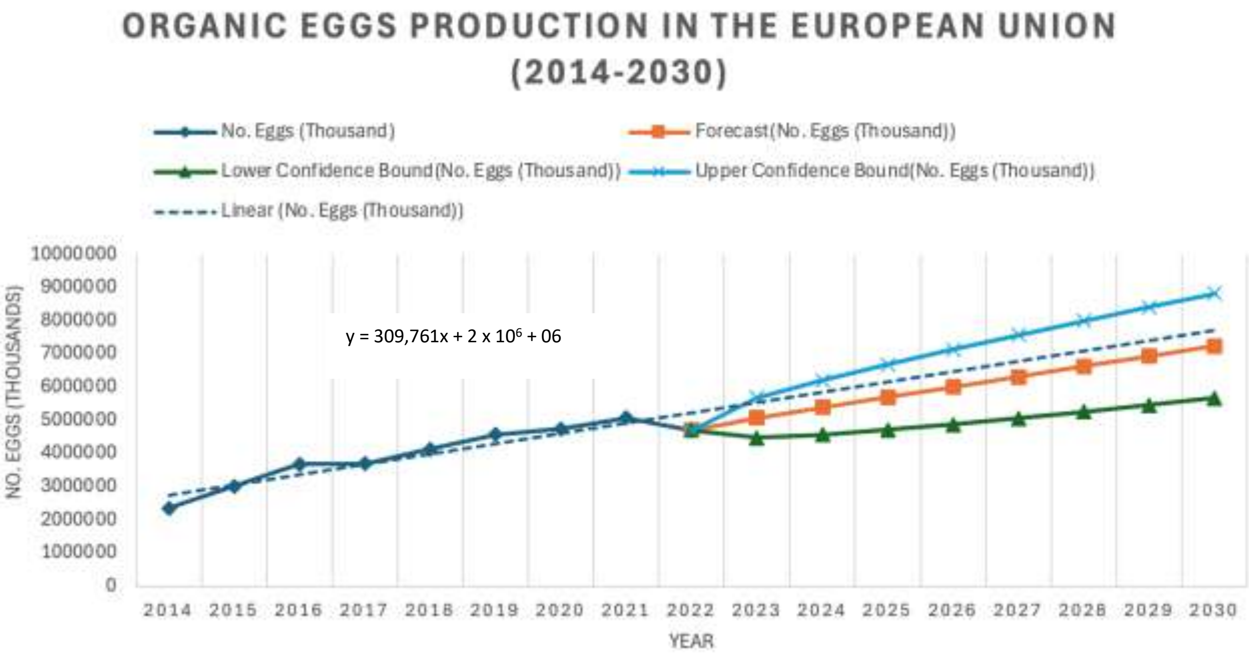

Fig. 1. European Union organic egg production (2014-2030)
Source: Eurostat [8].

Figure 1 indicates that from 2014 to 2022, organic egg production in the European Union demonstrated a consistent increase. In 2014, egg production was approximately 2.3 million thousand eggs, which nearly doubled by 2022, reaching around 4.7 million thousand eggs. This growth indicates a rise in consumer demand for organic products, promoted by supportive EU policies and subsidies designed to enhance organic farming. The annual increase highlights the growing popularity of organic farming practices among member states, influenced by environmental factors and market incentives.

The forecast for 2023 to 2030 indicates a sustained upward trajectory. By 2030, organic egg production in the European Union is projected to reach approximately 7.25 million thousand eggs. This indicates an increase exceeding 54% relative to the levels of 2022. The forecast suggests a steady growth rate, characterised by the absence of significant fluctuations or disruptions throughout the forecast period.

The confidence intervals offer insights into the range of possible outcomes. The lower bound estimates production will reach a minimum of 5.68 million thousand eggs by 2030, whereas the upper bound projections may surpass 8.82 million thousand eggs. This range indicates the strength of the forecast model and the possible impact of external factors, including policy changes, economic conditions, or alterations in consumer behaviour.

While both Romania and the EU show a strong reliance on recent trends (Alpha = 0.90) and do not account for trend or seasonality (Beta and Gamma = 0.00), the forecasts for Romania are less accurate than those for the EU. The higher MASE (0.72) and SMAPE (0.22) values for Romania suggest that its organic egg production is more variable and potentially influenced by external or structural factors not reflected in the linear model. This variability could stem from Romania’s smaller and less developed organic farming sector, which is still in a growth phase compared to the more established markets in the EU.

In contrast, the EU's larger scale of production and more mature organic farming systems result in higher absolute errors (for Romania – MAE = 5,130.38 and RMSE = 6,639.32) but relatively better proportional accuracy (lower SMAPE and MASE). This reflects a more predictable and consistent growth trend across the EU as a whole.

According to Figure 2, between 2014 and 2022, Romania's organic egg production experienced significant growth, reflecting the rapid development of its organic farming sector. Production increased from approximately 14,473 thousand eggs in 2014 to 50,628 thousand eggs in 2022, marking a growth of over 250% in just eight years. This expansion highlights Romania's increasing alignment with EU organic farming standards and growing consumer demand for organic products. Notably, the sharp rise between 2020 and 2021 (+44.5%) indicates the sector's recovery from the COVID-19 pandemic and a heightened interest in sustainable food sources.

The forecast for 2023–2030 projects continued growth, with production expected to reach approximately 85,000 thousand eggs by 2030, an increase of 68% compared to 2022 levels. The lower confidence bound predicts a production of at least 51,266thousand eggs, while the upper bound suggests it could reach as high as 118,734 thousand eggs, reflecting the sector's potential and its sensitivity to external factors such as policy changes, market dynamics, and investments in infrastructure.

The historical data and forecasted trends reveal a developing but still small organic egg market in Romania compared to the broader EU. While the consistent upward trajectory underscores the sector's promise, the variability in annual growth rates and wide confidence intervals highlight its vulnerability to external shocks. These challenges, alongside the relatively modest production scale, suggest a need for targeted interventions to stabilize growth and enhance Romania's role in the EU organic market.

While the EU's organic egg production represents a mature and well-established industry, Romania's sector is in a developmental phase, characterized by rapid growth but greater variability. Romania’s relatively small-scale highlights opportunities for further expansion, but achieving sustained growth will require strategic investments, policy support, and market development.

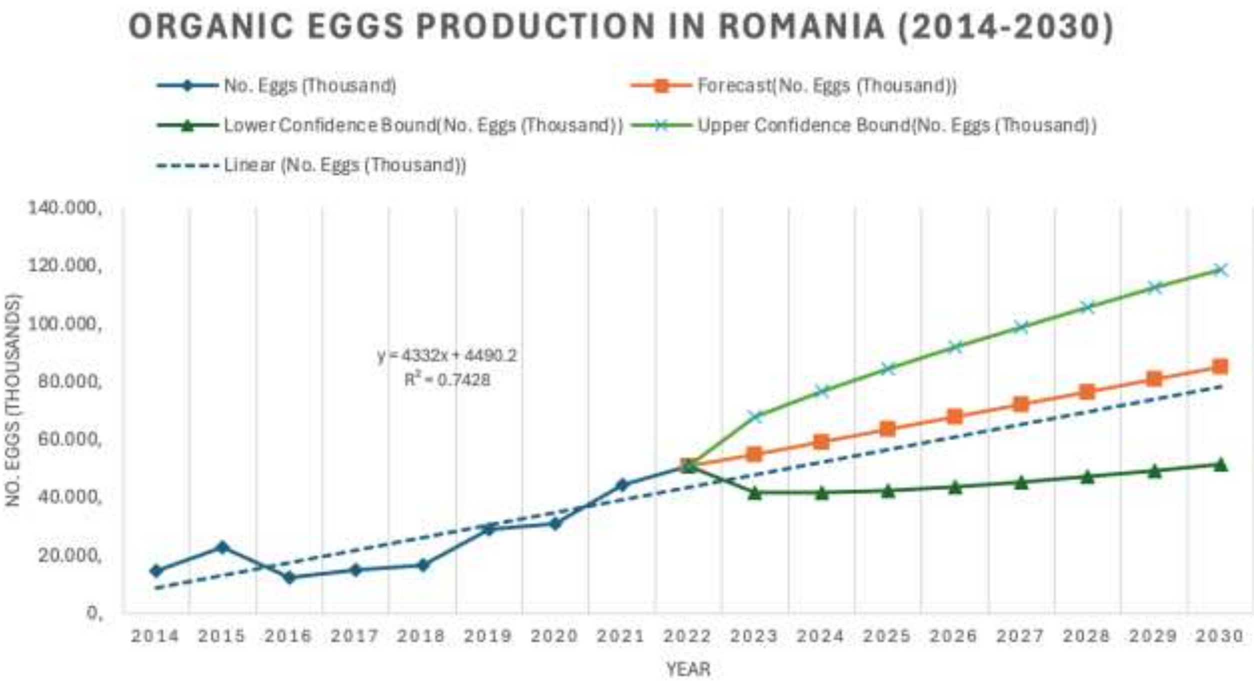

Fig. 2. Organic egg production in Romania (2014-2030)
Source: Eurostat [8].

A variety of variables drives the growth of organic egg production in Romania and the European Union (EU), including consumer preferences, agricultural methods, regulatory frameworks, and market dynamics. Understanding these characteristics is critical for stakeholders looking to improve the organic egg industry, especially in a country where conventional farming methods coexist with increasing organic markets. One of the most important elements driving organic egg production is customer demand for high-quality, ethically produced food. According to research, consumers are increasingly prepared to pay a higher price for organic eggs due to concerns about health, animal welfare, and environmental sustainability [6, 10, 13]. Consumers in Romania and across the EU are becoming more aware of the benefits of organic products, which have resulted in a preference for organic eggs over conventional options [4, 19]. This shift in consumer behaviour is reinforced by research that suggest customers are motivated by the perceived quality and safety of organic eggs, which are frequently associated with higher nutritional profiles and lower levels of pollutants. Another important consideration is the influence of agricultural methods and production systems on egg quality and yield. The choice of housing systems for laying hens, such as free-range or organic systems, has been demonstrated to influence not only the animals' welfare but also the quality of the eggs produced [7, 27]. For example, organic production systems often give hens more opportunity to exhibit natural behaviours, which can contribute to superior egg quality features, such as higher Haugh units, which indicate fresher eggs [21]. Furthermore, the nutritional content of the hens' diets is important in determining egg quality, with research indicating that adding organic minerals and specialised dietary supplements might improve production performance [22,9, 3]. Regulatory structures and financial support from the EU are also important in encouraging organic egg production. The EU's Common Agricultural Policy (CAP) offers subsidies and incentives to farmers shifting to organic approaches, which can help reduce some of the financial challenges associated with organic farming [16]. Furthermore, strict regulations governing organic certification ensure that producers meet high standards, increasing customer trust in organic products [12]. In Romania, aligning national policy with EU standards has supported the growth of the organic industry, allowing local producers to access larger markets and benefit from rising consumer demand [5, 14]. Finally, market variables, such as price changes and competition in the egg market, have a substantial impact on organic eggs production. As the demand for organic eggs grows, producers must balance competitive cost with quality [28]. Consumers' willingness to pay higher prices for organic eggs can encourage producers to invest in improved production practices and technologies, resulting in higher output [17]. However, market saturation and the availability of cheaper conventional eggs might provide hurdles for organic producers, needing effective marketing methods to differentiate their products [6, 19].

CONCLUSIONS

The analysis of organic egg production in the European Union and Romania reveals significant differences in scale, growth trajectories, and market maturity. While the EU represents a global leader in organic farming with a well-established and stable market, Romania's organic egg sector is characterized by rapid growth and untapped potential. From 2014 to 2022, the EU's production more than doubled, reaching 4.7 billion eggs, whereas Romania's output increased over 250% to 50.6 million eggs, underscoring its emerging role in the organic market.

The forecast for 2023–2030 indicates continued growth for both the EU and Romania, with production expected to reach 7.25 billion eggs and 85 million eggs, respectively, by 2030. However, Romania’s smaller scale, higher variability, and less predictable trends reflect the challenges of a developing sector. Factors such as limitedinfrastructure, reliance on external policies, and market volatility contribute to these differences.

Despite these challenges, Romania's rapid growth presents significant opportunities for expansion and development. Targeted interventions, including investments in infrastructure, training, and alignment with EU agricultural policies, could help Romania stabilize its production and strengthen its role in the European organic egg market. Meanwhile, the EU's stable growth reflects its leadership in organic farming, driven by strong consumer demand and well-implemented sustainability policies.

In conclusion, while the EU's organic egg market exemplifies maturity and consistency, Romania's sector is poised for transformation. With the right strategies and support, Romania has the potential to significantly enhance its contribution to the European organic egg market, fostering sustainable agriculture and meeting the growing demand for organic products.

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INFLUENCE ON THE PROTEIN AND STARCH CONTENT OF MAIZE (*Zea Mays* L.) OF INTEGRATED FERTILIZATION WITH GREEN MANURE AND MINERAL FERTILIZERS

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Abstract

Through this study, we aimed to test the variability of protein and starch content of maize when applying an integrated fertilization system using green manure and mineral fertilizer. The research was conducted under specific conditions at the Agricultural Development Research Station of Braila, where a bifactorial experiment was set up to investigate the effects of cultivation and incorporation of green manures and nitrogen fertilizers on the quality traits of maize yield. The green manure species were carefully chosen and were represented by species such as winter pea, rye, white mustard, rapeseed, and control without green manure. Nitrogen fertilizers were applied at rates of 60 kg, 90 kg, and 120 kg nitrogen per hectare. Based on the results obtained in this study, we can state that integrated fertilization with green and mineral fertilizers influences the protein and starch content of maize. The results revealed that the dose of 120 kg/ha nitrogen together with green winter pea fertilizer had the highest influence on protein content, the maximum level being 12.28%, and in the case of starch, the highest content was recorded at the application of 90 kg/ha nitrogen and green winter pea fertilizer with a percentage of 72.83%. The results reported in this study are the average results obtained in two years of research.

Key words: *maize, green manure crops, mineral fertilization, protein content, starch content*

INTRODUCTION

Maize is a nutrient-intensive crop due to its high dry matter and grain production. One of the most important factors contributing to increased production is fertilization. Fertilization influences the morphological and physiological characteristics of maize plants. The application of mineral fertilizers, especially slow-release and organic fertilizers can improve all characteristics and performance of the maize crop [10].

The use of organic and mineral fertilizers aims at sustainable nutrient management, practicing sustainable agriculture all with the aim of meeting human needs and also protecting soil and environmental resources. [9].

The combined use of organic and mineral fertilizers aims to improve the yield and better absorption of nutrients from the soil and also to increase the protein and oil content of maize kernels and basically through this fertilization practice an optimization of maize yield is achieved, with influences on the nutrient composition and levels of protein, total soluble sugars, starch and total carbohydrates in the kernels [6].

Present strategies for global food security are deceiving farmers into utilizing excessive inputs for crop productivity. The indiscriminate application of synthetic fertilizers, herbicides, and insecticides is degrading soil properties and yield-related factors. Green manuring has developed as a cost-effective alternative for farmers to address this issue, replacing artificially synthesized chemical substances. Green manure can fulfil all the requirements (physical, chemical, biological, pathological) of plants from germination to fruiting [3].

Integrated fertility management technologies are effective in increasing maize yield under low rainfall conditions. Higher yields can be obtained if more fertilizer is used, but there is not a directly proportional relationship between fertilization and yield [14].

Fertilization has a significant influence on grain yield and quality, starch and protein content, and the health of the maize crop. Moreover, it maximizes the yield potential of the tested genotypes but in favorable years [2]. A practical strategy for optimizing both yield and quality may be to select hybrids with the best agronomic suitability and then use precise nitrogen management practices to optimize grain yield. Studies are needed to evaluate the potential of variable nitrogen application for corn quality parameters in fields with different soil and field conditions and the potential of variable hybrid selection [12].

Green manuring is a method that can be employed to improve the soil's characteristics, leading to increased productivity. Green manuring is a method used to introduce organic matter into the soil. Recently, it has been hypothesized that the main impact of green manures on improving soil quality is their potential to raise levels of soil organic matter and enhance nutrient availability. Green manuring is an excellent choice for improving soil health and meeting the nutritional requirements of future crops. Integrating green manure crops into the soil can effectively prevent nitrogen loss [8].

Growing green manure is a promising way to protect N in off-seasons and reduce fertilizer input in corn production. Due to high levels of organic and inorganic N dissolved through incorporation and increased nutrient uptake into the soil, recommended fertilizer inputs for corn could be reduced by 15-30%. Green manure-corn rotation could be very promising in replacing some inorganic fertilizers without sacrificing crop yield [17].

Different combinations of green manures with legumes have been shown to influence the chemical composition of maize grains. The nitrogen accumulation capacity of each genotype depends on the efficiency of nitrogen utilization and accumulation by the plant. The application of legume biomass increased the content of most minerals. Fiber and starch showed low values, which were compensated by increased protein content and maize grain quality improve [5].

Another essential role of green manure use is the change in the composition and functionality of soil microbial activity which positively influences nitrogen assimilation by the main crops and increases their yield [11].

The application of N between 50-100 kg N ha has the potential to boost the yield. This suggests that N treatment can result in increased grain yield, as well as higher protein and starch contents. Moreover, by applying an appropriate quantity of nitrogen fertilizer, it is possible to enhance the overall protein and starch levels in maize, hence increasing its nutritional value and elevating its significance in agriculture [13].

Nitrogen fertilizer application increases the protein content of maize seeds. Nitrogen application also increases the crude protein content of maize seeds up to 100 kg N ha. Maize seed protein and starch depend on the conditions of the crop year, which is influenced by weather changes [15].

Széles et al. (2018) [16], through their research carried out between 2011-2016, revealed that different levels of nutrient deficiency or excess nutrient supply, inadequate nitrogen, potassium, and phosphorus balance, and environmental stress factors cause disturbances in nutrient supply in plants. As a result, yield decreases and quality declines. A 73% increase in yield can be obtained with an adequate nutrient supply (120:92:108 kg NPK ha) compared to the non-fertilized variant. Adequate protein content resulted from the 150:115:135 NPK ha treatment, and the growth rate was 17.7% [16].

Research conducted by Chitu et al. from 2018 to 2023 in the field of emerging agro-technical technologies concluded that efficient nitrogen management can significantly improve crop yields. Balancing nitrogen application and actual crop requirements, taking into account soil, weather conditions, and crop variety, is essential to maximize nitrogen use efficiency [4].

Therefore, this study aims to evaluate the efficacy of several types of green manures and nitrogen fertilizer levels on maize yield quality, especially protein and starch content as a result of tests carried out under the conditions at ARDS Braila in the North-East Baragan.

MATERIALS AND METHODS

Field experiment was carried out in the 2022 and 2023 growing seasons on vermic chernozem soil with a medium humus content of 2.4 - 3.1% in the upper horizons and only 1.6% in the transition horizon, 0.14-0.25 % total nitrogen content at the trial site of Agricultural Research and Development Station (ARDS) Braila - Chiscani Experimental Center.

The experiment was designed in fully randomized blocks with 4 replicates.

The experimental factors are as follows:

Factor A- Green manure crops

a_1– control – without green mure crop

a_2 - winter pea (*Pisum sativum* L. var.arvense.)

a_3- white mustard (*Sinapis alba* L)

a_4- winter rye (*Secale cereale* L.)

a_5- white mustard (*Sinapis alba* L) + rapeseed (*Brassica napus* L.)

a_6- rapeseed (*Brassica napus* L.)

Factor B – Mineral fertilization

b_1– N_0 unfertilized

b_2- N_{60} (60 kg/ ha of N)

b_3- N_{90} (90 kg/ ha of N)

b_4- N_{120} (120 kg/ ha of N).

The size of each test plot was 42 m^2 and the total surface area of the research plot was 4,032 m^2.

Green manure cultivation was conducted in early September for both years of study. The green manure was severed and integrated into the soil based on species: mustard before the commencement of winter, and winter pea and rye species were severed and integrated in the spring, approximately one month before corn sowing.

Mineral fertilization involved the application of a 15:15:15 complex NPK fertilizer concurrently with seedbed preparation, while fractional dosages of urea were administered throughout the maize growing season. Consequently, N doses of 60, 90, and 120 kg/ha, along with an agro-foundation of 40 kg/ha of phosphorus and 40 kg/ha of potassium, were administered for all experimental variants.

Maize was planted on May 4, 2022, and May 5, 2023, using the F423 hybrid at a density of 65,000 plants per hectare, with harvesting conducted in the second decade of October in both 2022 and 2023 [7]. Throughout the growing season, treatments for weed and pest management were administered, and the maize was irrigated throughout the two-year experiment..

For this paper, corn yield quality results were followed, and protein and starch contents were evaluated. A granolyser grain analyzer from PFEUFFER was used to determine protein and starch indices. The statistical analyses included analysis of variance and Fisher's least significant differences test (LSD), using the Polifact statistical software [1].

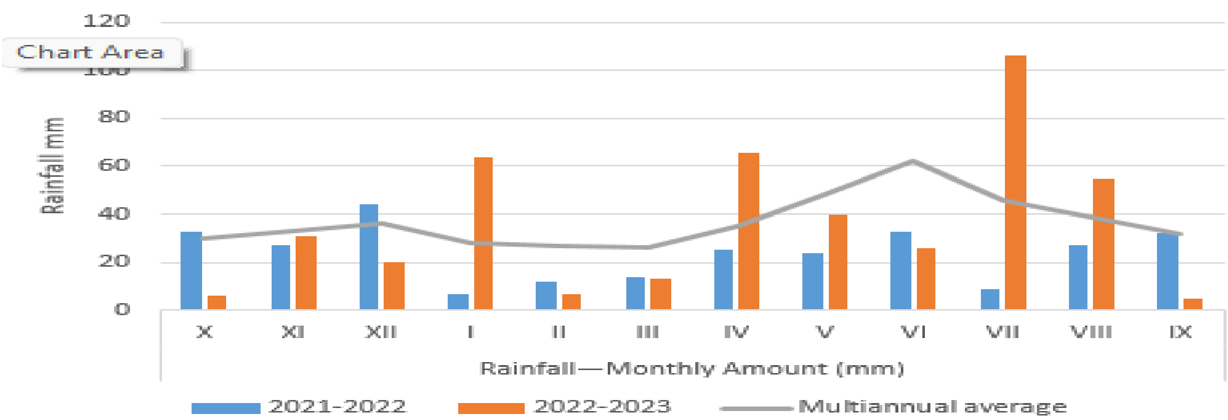

Fig. 1. Rainfall regime from 2021 to 2023 at the ARDS Braila
Source: Meteorological Stations Braila [18].

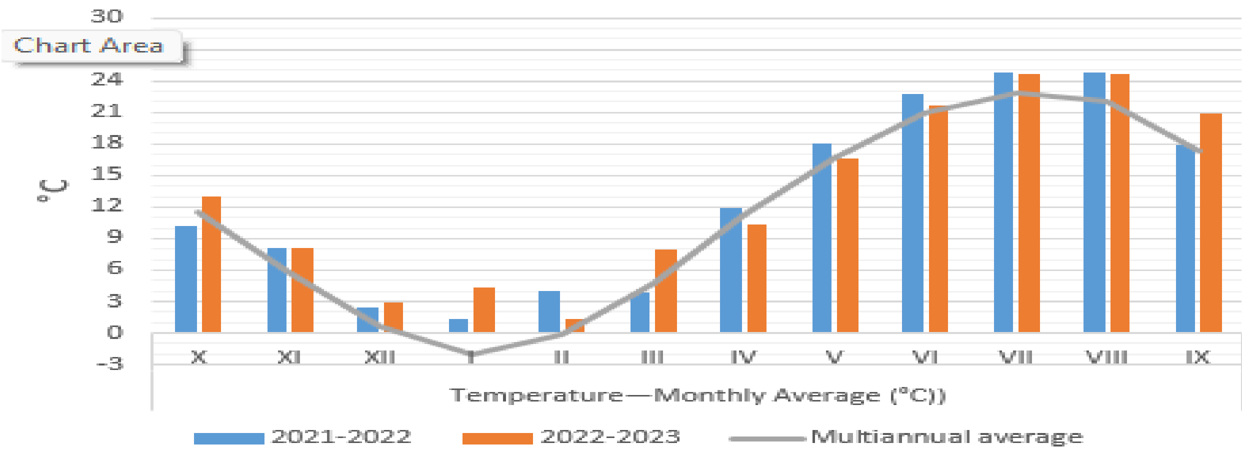

Fig. 2. Thermal regime from 2021 to 2023 at the ARDS Braila
Source: Meteorological Stations Braila [18].

RESULTS AND DISCUSSIONS

ARDS Brăila is situated in the eastern region of Northern Bărăgan, within one of Romania's driest agricultural zones. The region of Northern Bărăganului de Nord, like the entire Romanian Plain, exhibits a temperate continental climate. Summers are characterized by high temperatures and aridity; precipitation is minimal, intense, and irregularly dispersed. The climatic data presented in this research is sourced from the Meteorological Station of Brăila, situated near the Experimental Center Chiscani. The multiannual temperature average is 10.9°C, while the annual precipitation average is 442 mm.

During the agricultural year 2021-2022, the mean temperature documented was 12.5°C. This year experienced a mean annual temperature difference of +1.6°C from the multi-year average. Moreover, it was an extraordinarily arid year, exhibiting a negative divergence of 155 mm from the normative precipitation levels. Summer 2022, with an average temperature of 24.1^{0}C exceeded the multi-seasonal multi-year average by 2.1^{0}C being very warm. June recorded a positive deviation of 1.8^{0}C, July a positive deviation of 1.9^{0}C and August a positive deviation of 2.8^{0}C . In terms of rainfall, summer 2022 started with June providing 33.3 mm of water, 28.7 mm below the multi-year average of 62 mm, July recorded only 8.9 mm with a deficit of 37.1 mm and August recorded 26.9 mm and a deficit of 12.1 mm. September was normally supplied with precipitation (32 mm).

The 2022-2023 crop year experienced elevated temperatures, with an average of 13.1°C, above the multi-year normal by 2.2°C. The rainfall was nearly average, totalling 439 mm, while the distribution of precipitation was varied. The air temperature conditions in the summer of 2023 were quite challenging. The monthly mean temperature values recorded positive deviations from the normal averages for this period, ranging from 0.7 to 2.6 °C. September was also extremely warm, with a positive deviation of 3.6°C.

In terms of precipitation, the summer of 2023 started with a deficit of 36 mm in June but followed a period of good water supply from precipitation, with July providing a water supply of 106 mm, 60 mm above the multi-year monthly average. August provided 55 mm of precipitation.

Protein content

The Romanian maize hybrid Fundulea 423 was the subject of this research, which has very good grain quality, as follows: protein content: 11.0-11.8% and starch content: 70.5-72.0% [16].

Table 1 shows the average results obtained in 2021-2022 and 2022-2023 on the influence of green manure fertilization on protein content. The level of protein content in maize grains ranged from 11.03 to 11.74 % the highest value was recorded by incorporation of mustard as green manure. The differences were statistically ensured against the control for the mustard and winter pea variant..

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Table 1. Protein content under the influence of fertilization with green manure. Average results 2022-2023

Green manure crop	**Protein**		**Differences**		**Significance**
	%	%	%	%	
a1- control	11.03	100.0	Mt.	-	
a2- winter pea	11.71	106.1	0.67	6.1	**
a3- white mustard	11.74	106.4	0.71	6.4	**
a4- winter rye	11.38	103.2	0.35	3.2	-
a5 white mustard + rapeseed	11.31	102.5	0.27	2.5	-
a6- rapeseed	11.36	103.2	0.33	3.0	-
LSD (5%)= 0.45 %; LSD (1%)=0.62 %; LSD (0.1%)=0.85 %					

Source: Results of the own experiments.

The results on mineral fertilization (Table 2) show the influence of nitrogen fertilization on protein content, which increased progressively with increasing nitrogen doses. The highest level of protein content was obtained when applying mineral fertilization with 120 kg/ha nitrogen.

Table 2. Protein content under the influence of fertilization with mineral fertilizers. Average results 2022-2023

Mineral fertilization	**Protein**		**Differences**		**Significance**
	%	%	%	%	
b1– $\boldsymbol{N_0}$ Unfertilized	11.00	100.0	Mt.	-	
b2- $\boldsymbol{N_{60}}$ (60 kg/ ha s.a. N)	11.27	102.5	0.27	2.5	*
b3- $\boldsymbol{N_{90}}$ (90 kg/ ha s.a. N)	11.56	105.0	0.55	5.0	***
b4- $\boldsymbol{N_{120}}$ (120 kg/ ha s.a N)	11.86	107.8	0.86	7.8	***
LSD (5%)= 0.24 %; LSD (1%)=0.32 %; LSD (0.1%)=0.41%					

Source: Results of the own experiments.

From the analysis of the interaction of the two studied factors (Table 3), it can be observed that the interaction of nitrogen dose gradations on green manure agrofounds is not very high.

Table 3. Protein content under the influence of integrated fertilization. Average results 2022-2023

Mineral fertilization	**Green manure crop**								
	a1- control			a2- winter pea			a3- white mustard		
	Prot. %	Diff.	Sign.	Prot. %	Diff.	Sign.	Prot. %	Diff.	Sign.
b1– $\boldsymbol{N_0}$	10.40	Mt.	-	11.38	Mt.	-	11.25	Mt.	-
b2- $\boldsymbol{N_{60}}$	10.93	0.52		11.50	0.13		11.65	0.40	
b3- $\boldsymbol{N_{90}}$	11.03	0.63	*	11.68	0.30		11.78	0.52	
b4- $\boldsymbol{N_{120}}$	11.78	1.38	***	12.28	0.90	**	12.28	1.03	***
	a4- winter rye			a5 white mustard + rapeseed			a6- rapeseed		
	Prot. %	Diff.	Sign.	Prot. %	Diff.	Sign.	Prot. %	Diff.	Sign.
b1– $\boldsymbol{N_0}$	10.80	Mt.	-	11.05	Mt.	-	11.13	Mt.	-
b2- $\boldsymbol{N_{60}}$	11.28	0.48		11.20	0.15		11.08	-0.05	
b3- $\boldsymbol{N_{90}}$	11.50	0.70	*	11.58	0.53		11.78	0.65	*
b4- $\boldsymbol{N_{120}}$	11.95	1.15	***	11.40	0.35		11.48	0.35	
LSD (5%)= 0.59 %; LSD (1%)=0.78 %; LSD (0.1%)=1.02 %									

Source: Results of the own experiments.

For mineral fertilization level b1- N_0 the interaction with the a2- winter pea variant recorded the highest protein content level, 11.38%.For the mineral fertilization level b2- N_{60} the interaction with a3- white mustard had the highest protein content level, 11.65%.

For the mineral fertilization level b3- N_{90} the interaction with a3- white mustard a6- rapeseed had the highest protein content level, 11.78%.

For mineral fertilization level b4- N_{120} the interaction with a2- winter pea and a3- white mustard had the highest protein content level, 12.28%.

Starch content

Table 4 shows the average results recorded in the crop years 2021-2022 and 2022-2023 on the influence of green manure fertilization on starch content. The values of starch content ranged from 70.86% in the control variant to 72.37% in variant a2. Differences from the control were highly significant for variant a2, distinctly significant for variant a4.

Table 4. Starch content under the influence of fertilization with green manure. Average results 2022-2023

Green manure crop	Starch		Differences		Signifiance
	%	%	%	%	
a1- control	70.86	100.0	Mt.	-	-
a2- winter pea	72.37	102.1	1.51	2.1	***
a3- white mustard	71.22	100.5	0.36	0.5	
a4- winter rye	71.95	101.5	1.09	1.5	**
a5 white mustard + rapeseed	71.03	100.2	0.17	0.2	
a6- rapeseed	71.64	101.1	0.79	1.1	*
LSD (5%)= 0.76 %; LSD (1%)=1.05 %; LSD (0.1%)=1.45 %					

Source: Results of the own experiments.

From the analysis of the interaction of the two studied factors (Table 5), it can be observed that the interaction of nitrogen dose gradations on green manure agrofoundations under the conditions of crop years 2021-2022 and 2022-2023 are higher when 120 kg/ha nitrogen dose is used.

Table 5. Starch content under the influence of integrated fertilization. Average results 2022-2023

Mineral fertilization	Green manure crop								
	a1- control			a2- winter pea			a3- white mustard		
	Starch. %	Diff.	Sign.	Starch %	Diff.	Sign.	Starch %	Diff.	Sign.
b1– N_0	70.13	Mt.	-	71.93	Mt.	-	70.77	Mt.	-
b2- N_{60}	70.90	0.78		72.15	0.22		71.03	0.25	
b3- N_{90}	70.85	0.72		72.83	0.90		71.23	0.45	
b4- N_{120}	71.55	1.42	**	72.58	0.65		71.85	1.08	*
	a4- winter rye			a5 white mustard + rapeseed			a6- rapeseed		
	Starch %	Diff.	Sign.	Starch %	Diff.	Sign.	Starch %	Diff.	Sign.
b1– N_0	71.35	Mt.	-	70.50	Mt.	-	70.65	Mt.	-
b2- N_{60}	71.83	0.47		70.98	0.47		71.93	1.28	*
b3- N_{90}	72.33	0.97		71.13	0.63		71.73	1.08	*
b4- N_{120}	72.30	0.95		71.50	1.00		72.25	1.60	***
LSD (5%)= 0.98 %; LSD (1%)=1.31 %; LSD (0.1%)=1.71 %									

Source: Results of the own experiments.

The other gradations influenced less the starch content. For the b1- N_0 mineral fertilization grade the interaction with the a2- green manure variant a2- green manure fall pea had the highest starch content level, 71.93%.
For mineral fertilization level b2 - N_{60} the interaction with a2- green manure variant green manure autumn pea had the highest starch content level, 72.15%.
For the mineral fertilization level b3- N_{90} the interaction with variant a2- green manure green manure autumn pea had the highest starch content level, 72.83%.
For the mineral fertilization level b4- N_{120} the interaction with variant a2- green manure green manure autumn pea had the highest protein content level, 72.58% (Table 5).

Table 6. Starch content under the influence of fertilization with mineral fertilizers. Average results 2022-2023

Mineral fertilization	Starch		Differences		Signifiance
	%	%	%	%	
b1– N_0 nefertilizat mineral	70.89	100.0	Mt.	-	
b2- N_{60} (60 kg/ ha s.a. N)	71.47	100.8	0.58	0.8	**
b3- N_{90} (90 kg/ ha s.a. N)	71.68	101.1	0.79	1.1	***
b4- N_{120} (120 kg/ ha s.a N)	72.00	101.6	1.12	1.6	***
LSD (5%)= 0.40 %; LSD (1%)=0.54 %; LSD (0.1%)=0.70%					

Source: Results of the own experiments.

The results on mineral fertilization (Table 6) attest to the influence of nitrogen fertilization on starch content, which increased progressively with the nitrogen doses. The highest level of starch content was obtained when applying mineral fertilization with 120 kg/ha nitrogen.

CONCLUSIONS

The study conducted and the results obtained confirm that integrated fertilization contributes to the improvement of maize yield quality. Thus in terms of protein content of maize yield it can be concluded that the level of mineral fertilization b4- in interaction with variant a2- winter pea green manure and a3- white mustard green manure recorded the highest level of 12.28%. From the analysis of the influence of integrated fertilization with green and mineral fertilizers on the starch content of maize yield, it can be concluded that the level of mineral fertilization b3- N_{90} interaction with variant a2- green manure winter pea green manure recorded the highest level of starch content, 72.83%.

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HPLC METHOD OPTIMISATION AND APPLICATION FOR THE ANALYSIS OF L(+) AND D(-) LACTIC ACID IN WINE - A WAY FOR ASSESSING WINE QUALITTY

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Abstract

Because of their antioxidant, antimicrobial and anti-inflammatory properties, there is an increasing interest in investigating the presence of organic acids in food. The analysis of organic acids in wine is of great importance, considering their role in organoleptic and aesthetic character. In the present study, a high-performance liquid chromatographic (HPLC) method was optimised and applied for rapid analysis of L-lactic acid and D-lactic acid in wine samples. The enantiomer separation was performed on a chiral column, using an aqueous solution of $CuSO_4$ as the mobile phase. After the optimisation, the method was applied for the quantification of lactic acid enantiomers in several red and white wine samples, collected from two private wineries from Romania. The concentration of L-lactic acid ranged between 0.79 and 1.24 g/l, while D-lactic acid was between 0.17 and 0.29 g/l.

Key words*: *lactic acids, enantiomers separation, wine sample, malolactic fermentation

INTRODUCTION

There are many studies focused on investigating the positive action of organic acids on the human body [15, 8, 14]. It was proven that some organic acids have high antioxidant power (ascorbic acid) [8], antibacterial activity (benzoic and salicylic acids), anti-inflammatory (hydroxycinnamic acids), antimutagenic, anticarcinogenic or anti-inflammatory properties (gallic acid) [15], protective effects on the myocardium (citric acid, malic acid) [17], enhance the iron absorption (succinic acid, acetic acid, citric acid, lactic acid, malic acid, glutamic acid) [1].
The organic acids content of wine is of great interest since these compounds influence the wine's sensory properties, like flavour, taste, colour or aroma [12]. Tartaric and malic acids are the main organic acids found in wine and they originate from the grapes, while other acids like lactic, succinic or acetic, are found in lower concentrations and are formed during the alcoholic and malolactic fermentation. The most important acids present in wine are tartaric acid, malic acid, and lactic acid [2]. Lactic acid is a highly desirable component in some wines because it leads to wine softening, fruity and vegetative aromas. Therefore, many wines undergo a process of malolactic fermentation, where malic acid is decarboxylated into lactic acid, a process commonly found in red wines and some white wines [9, 18].
Lactic acid is present in two enantiomeric forms, which are differently metabolized in the human body. Thus, L(+)-lactic acid is present as a metabolic intermediate, while the isomer D(–)-lactic acid is excreted from the body [10]. Because of their different effects, the two enantiomers have different practical applications, such as: the chemical production of some plasticizers, adhesives or household cleaners for D(–) isomer, while L(+)-lactic acid is used in skin care products, as preservative in food processing, antioxidant, flavouring agent (E270), pH regulator, etc. [10,19]. The predominance of L-lactic acid in

wine is generally associated with malolactic fermentation [9], while the production of D-lactic acid can indicate wine spoilage.

Different methods like spectrophotometric, enzymatic, nonenzymatic, chromatographic and electrophoretic have been developed to quantify the organic acids in wines [12, 3, 13]. A detailed presentation of these techniques can be found in [14]. Considering the high efficiency for enantioselective separation, high-performance liquid chromatography with UV or mass spectrometry detection, using chiral stationary phases, is the most widely used method for lactic acid enantiomers separation [10].

In the present study, a sensitive analytical method by HPLC was optimised for the simultaneous determination of the two enantiomers of lactic acid in wine samples. The method was used to quantify L and D-lactic acid in several wine samples.

MATERIALS AND METHODS

Chemicals and standard solutions

The L-lactic acid standard (100 mg) was purchased from Supelco, while the D-lactic acid standard (250 mg) was purchased from Alfa Aesar.

Mobile phase (aqueous solution of $CuSO_4$, 5 mM) was prepared from $CuSO_4$ anhydrous (10 g), without traces of metals (99.99%) purchased from Sigma-Aldrich.

All the dilutions were made with HPLC pure water (Promochem).

Wine sampling and processing

For this study, wine samples from two private vineyards (Pietroasele – Buzău County and Ștefănești – Argeș County) located in an important Romanian wine region, namely Muntenia region, were analysed (Map 1).

Four samples were tested, consisting of two red wines and two white wines. The wine samples were taken from freshly opened bottles and filtered through Nylon membrane syringe filters of 0.2 µm porosity.

In order to check if the dilution of the wine sample is required before the HPLC analysis, the general physico-chemical parameters (pH, redox potential, electrical conductivity – EC and salinity) were measured by using a multiparameter (WTW 520i).

Following these measurements, it was decided to dilute the wine sample with pure water in a ratio of 1:5 (*v:v*) before HPLC analysis.

Map 1. Location of the two vineyards where the analysed wines come from
Source: Modified map after [20, 21].

HPLC analysis

The HPLC system (Agilent 1200) consisted of a binary pump, a degassing device, a 20 µl injection loop, and a UV-Vis Diode Array Detector. The chromatographic separation was performed on an Astec CLC-D Chiral HPLC Column (Sigma Aldrich), 15 × 0.46 cm ID, 5 µm particle size, 100 Å for pore diameter. According to supplier instructions, the mobile phase consisted of 5mM $CuSO_4$ aqueous solution (pH = 4.2), in isocratic elution at a flow rate of 1 ml/min. The injection volume was 20 µl. The analysis was performed at room temperature.

To optimize the HPLC method, several specific parameters (column separation efficiency, linearity, sensitivity, precision and accuracy) were measured, as presented below.

To establish the optimal conditions for liquid chromatographic separation of the two enantiomers of lactic acid, the *separation efficiency of the column* was tested by calculating the *resolution factor (R_S)* using the formulae [5,16]:

$$R_S = 2 \cdot \frac{t_{R_2} - t_{R_1}}{w_1 + w_2} \quad (1)$$

where:
R_s – resolution factor,
t_{R1} –the time between injection and detection of the first analyte (L-lactic acid),
t_{R2} – time between injection and detection of the second analyte (D-lactic acid), and
w – peak width.

For a satisfactory separation of peaks with different heights, the value RS ≈ 1 is accepted for the resolution factor [5,16].

The *linearity* was tested by an external standard calibration method, by analysing a series of four standard solutions (0.15, 0.6, 0.9, 1.5 g/l) of L-lactic acid and D-lactic acid. The peak areas were plotted versus the concentration to get the regression equation and coefficient of determination (R^2) for the calibration curves. The analyses were performed at five different wavelengths (210, 230, 249, 254 and 259 nm).

Method *sensitivity* was evaluated by calculating the limit of detection (LOD) and limit of quantification (LOQ), according to International Conference on Harmonisation (ICH) guidelines, using the formulae [7, 4]:

$$LOD = 3.3 \cdot \frac{\sigma}{S} \qquad (2)$$

$$LOQ = 10 \cdot \frac{\sigma}{S} \qquad (3)$$

where:
σ – the standard deviation of response (standard deviation of blank response) and
s – the slope of the calibration curve.

The *precision* of the HPLC method was determined by repeatability (intra-day) and intermediate precision (inter-day) [7,11]. The repeatability tests were performed by injecting standard solutions (0.6 and 1.5 g/l) of L and D-lactic acid on the same day and by calculating the relative standard deviation (RSD). The intermediate precision was evaluated by analysing standard solutions (0.6 and 1.5 g/l) on different days, but in identical analytical conditions.

The *accuracy* of the HPLC method was evaluated based on the recovery study. Samples of white wine from Ștefănești, diluted with ultrapure water to 1:1 ratio, were spiked with known amounts of standard solutions of L and D-lactic acid. The recovery was calculated based on the analyte concentrations before and after spiking.

RESULTS AND DISCUSSIONS

HPLC method optimisation

Following the tests, it was observed that the retention of enantiomers L and D on the used column is strong, the *resolution factor* R_s having the value of 1.108, satisfying the optimal conditions for chromatographic separation (RS ≈ 1, for peaks with different heights) [5,16].

The *linearity* data, including the slope, intercept and coefficient of determination, are presented in Table 1. A coefficient of determination (R^2) higher than 0.995 indicates a good linearity for the HPLC method [11]. In the present study, the method proved to be linear, in the range of 0.15 – 1.5 g/l. The best linearity, for both L and D–lactic acid was registered at 254 nm (R^2 = 0.9998 for L–lactic acid, R^2 = 0.9999 for D–lactic acid). Consequently, all the analyses were performed at 254 nm.

Table 1. Linearity regression data depending on wavelength

Analyte	Concen-tration range (g/l)	Wavelength (nm)	Slope	Intercept	R^2
L-lactic acid	0.15 – 1.50	210	774.77	201.88	0.9424
		230	12669	585.3	0.9950
		249	11289	1134	0.9976
		254	11077	99.96	0.9998
		259	5251.5	1475.1	0.932
D-lactic acid		210	767.95	359.6	0.9558
		230	12983	301.43	0.9978
		249	10927	487.77	0.9906
		254	10732	22.86	0.9999
		259	5464.2	976.92	0.9782

Source: Own results.

The HPLC method proved to be *sensitive* to the quantification of L and D-lactic acid. The LOD was 1.17 µg/l for L-lactic acid and 1.21 µg/l for D-lactic acid, while the LOQ was 3.55 µg/l for L-lactic acid and 3.67 µg/l for D-lactic acid. The values for LOD and LOQ were similar to those mentioned in the literature [11].

The results for the repeatability and intermediate *precision* are shown in Table 2. The RSD for repeatability (intra-day) ranged between 0.92 and 1.28%, while the RSD for intermediate precision (inter-day) was between 1.38 and 1.53%. The results showed that the RSD was < 2%, for both L and D–lactic acid, indicating that the HPLC method is precise [11].

Table 2. Method precision

Analyte	Concentration of standard solution (g/l)	Intra-day		Inter-day	
		Measured concen-tration* (g/l)	RSD** (%)	Measured concen-tration* (g/l)	RSD** (%)
L-lactic acid	0.6	0.56	1.28	0.55	1.53
	1.5	1.47	0.92	1.48	1.38
D-lactic acid	0.6	0.57	1.22	0.56	1.48
	1.5	1.48	1.19	1.49	1.52

*average of three measurements, **RSD – Relative Standard Deviation
Source: Own results.

The method *accuracy* was evaluated by recovery tests for the spiked wine samples (wine samples from Ștefănești). All the analyses were performed in triplicates and the average level was calculated. The results indicated high recovery values: 99.89% for L-lactic acid and 102.2% for D-lactic (Table 3). The values were within the acceptable limits (90 – 110%) and were similar to those reported in other studies [11].

Table 3. Method accuracy – recovery test

Analyte	Concentration (g/l)			Recovery (%)
	wine sample	wine sample_spiked		
		expected	observed	
L-lactic acid	0.44	0.97	0.96	98.97
D-lactic acid	0.16	0.72	0.74	102.78

Source: Own results.

Application of the proposed method on real wine samples

The analysed wine samples had a pH between 3.4 and 4.2 (Fig. 1). The tested wines had a pH within the usual range for wines, which is between 3 and 4, with white wines being generally more acidic than red ones. The pH level is an important parameter, which can impact the wine's colour or its taste and smell.
The electrical conductivity of the wine samples ranged between 1,650 and 2,090 µS/cm (Fig. 2). Considering the relatively high conductivity, it was decided to dilute the wine sample with pure water, in a ratio of 1:5 (*v:v*) before HPLC analysis.

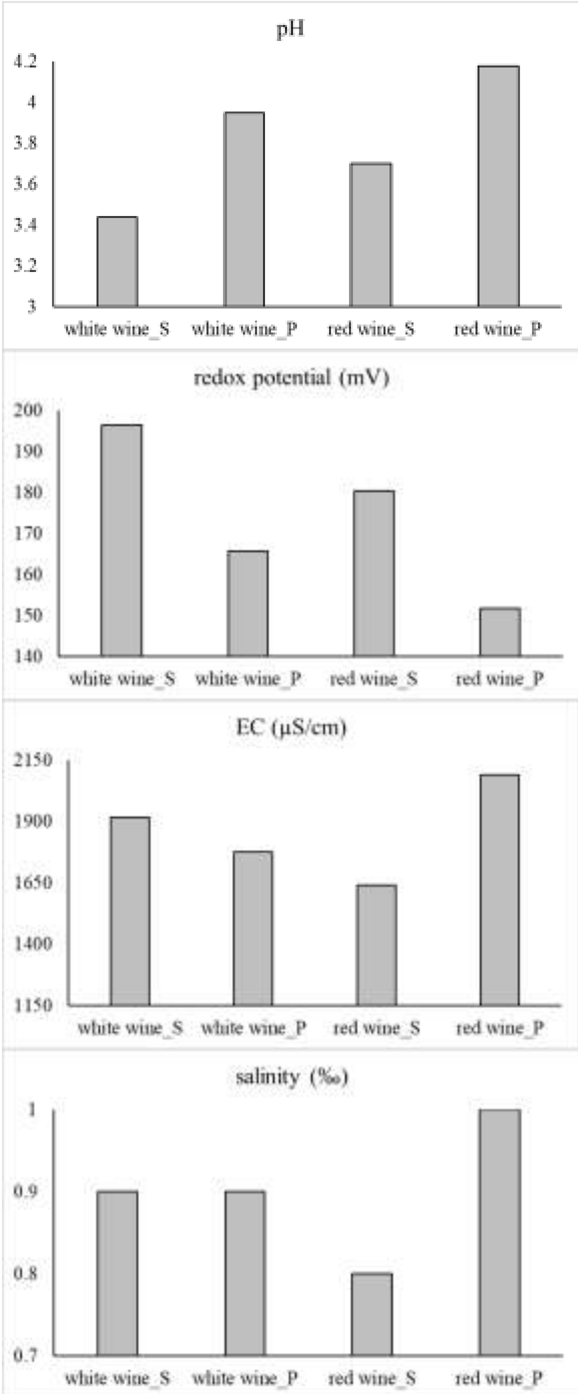

Fig. 1. Physico-chemical parameters of the analysed wine samples
Source: Own results.

Once the chromatographic conditions were established, the proposed method was applied to determine the concentration of L-lactic acid and D-lactic acid in two white wine samples and two red wine samples, from two private wineries from Romania. The amounts of the two enantiomers are presented in Fig. 2.

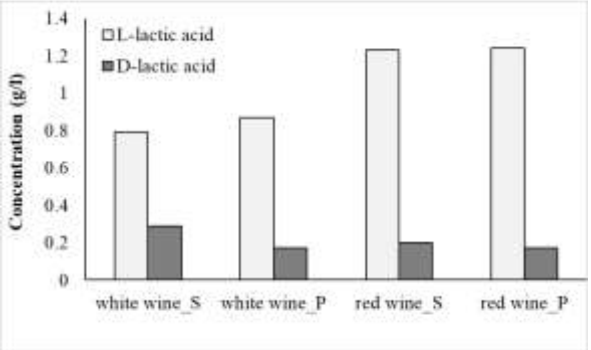

Fig. 2. Concentration of L and D-lactic acid in wine samples from Săndulești (S) and Pietroasele (P) wineries
Source: Own results.

The results showed that the concentration of L-lactic acid (0.79 – 1.24 mg/ml) was higher than D-lactic acid (0.17 – 0.29 mg/ml). The level of L-lactic was higher in red wine than in white wines, while the D-lactic acid was higher in white wines. Considering that the concentration of L-lactic acid is four–five times higher than the level of D-lactic acid, it results that the malolactic fermentation started in the analysed wine samples.
The results obtained in the present study are similar to those reported in other studies. Han et al. [6] investigated the content of several organic acids in 12 wine samples from different regions and reported the following concentrations for L-lactic acid: 0.05 – 2.21 g/l (France region), 0.01 – 0.08 g/l (Germany), 0.01 – 0.07 g/l (Italy), 0.17 g/l (Spain) and 0.39 – 1.57 g/l (USA). According to the same study, the concentration of D-lactic acid ranges between 0.12 – 0.14 g/l (France region), 0.09 – 0.10 g/l (Germany), 0.13 – 0.16 g/l (Italy), 0.10 g/l (New Zealand), 0.12 g/l (Spain) and 0.13 – 0.26 g/l (USA).

CONCLUSIONS

The results of the present study showed that the proposed HPLC method can be successfully used for the quantification of L and D enantiomers of lactic acid in wine samples. The new stationary phase showed good sensitivity and a suitable performance. An advantage of the proposed method is that the sample does not require complex treatment procedures or pre-treatment steps, like solid phase extraction or derivatisation, before HPLC analysis. Sample preparation consisted of dilution and filtration.
Based on the stereoisomer concentration results the malolactic fermentation started in the analysed wine samples.
Optimizing the analysis method of lactic acid enantiomers is of great importance considering his role on defining the wine's sensory properties, being responsible for reducing the acidity of wines and providing a smoother flavour.

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GOOD ORGANIZATIONAL BEHAVIOR MOTIVATIONAL TOOL USED AS A KEY COMPONENT IN VITICULTURE AND WINE RESEARCH AND DEVELOPMENT

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Abstract

The present research proposes to analyze psychological mechanisms involved in making researchers motivated and how good organizational behavior can improve research advances in viticulture and wine science. Organizational behavior implementation was monitored via the use of raw data from human resource department. It is well know that a number of internal and external factors can increase or decrease motivation. Income can be an important instrument used in for the development of a good organization behavior and its significance varies person to person. Economic instruments, the environment, community, exposure to scientific events outside the workplace are also among the important tools used for a motivational boost. This current study identifies the main difficulties present specifically at "Bujoru" Research and Development Station for Viticulture and Winemaking (SCDVV) research facility but the principals can be applied to all types of research facilities and institutes. The present research can conclude that implementation of a good organizational behavior can increase research performance and provides stability from a human resource point of view. A motivated researcher will have a higher level of goal achievement, which will increase the overall scientific standards and productivity.

Key words: *organization behaviour, motivational tool, viticulture and wine research*

INTRODUCTION

Organizational behavior represents how people interact with each other within an organization and explains the dynamics that occur between individuals and groups at their work.

"Organizational behaviour" applies where people interact within groups in companies, so its principles are first applied in an attempt to make businesses work more efficiently and therefore it can be an efficient tool in research and development used as a motivational tool [1]. These behaviours influence how the organization itself behaves in the future and how it functions. In research domains, especially food security and development, organizational behaviour streamlines work, increases productivity whit an added advantage for innovative ideas [4, 23].

A good organizational behavior is necessary in order to maintain and obtain motivated researchers. Motivations defined as an internal process, which works differently for each individual, energizes the person and directs his resources to have a certain behavior and satisfy the tasks he has[13, 2, 4].

The process of motivating researchers has become more and more complex lately and is influenced by several factors - the lifestyle, their needs their career path and non the least difficulties that come naturally whit the innovation process [12, 21, 24].

The present research propose to analyze psychological mechanisms involved in making researchers motivated and how good organizational behavior can improve research advances in viticulture and wine science [22], [15].

Elements of Organizational Behavior

These elements are: People, Structure, Technology, External environment.

People

People are the workforce in any organization because they perform the routine activities required to achieve business goals [20]. People roles, skills, goals, drive and aspirations differ. In addition, the company needs a good reward system to encourage competent staff to stay [12], [2].

It is known that without incentives to motivate high performers, they can feel discouraged over time.

Structure of Organizational Behavior

The structure refers to the formal relationship between the manager, scientific director or project manager and the researchers, from the bottom to the highest level. These types of relationships are structurally classified and are designed to work effectively. Everyone has it role, obligations, responsibilities and duties.

Technology

Technology is one of the important parts of the organization in, because it determines the work process, gathers resources and influences the outcome of most of the innovations in this sector. The current trend in Romanian research and development makes it very difficult to keep up whit research standards. If technology is missing, innovative development in areas such as: food security, precision vineyard practices.

The External Environment

These factors could be social, political, economic, or technological. It is vital that these factors can relate to each other. Anyway, external factors influence individual behavior in their workplace too [9], [10].

By understanding how these elements interact with one another, many improvements can be made.

About motivation, psychologist Abraham Maslow created the best-known theory of it which was adopted by the most companies to obtain from employees a greater desire to perform. Maslow established a pyramid of needs that influence people's behavior and people's unsatisfied needs can be used as motivating factors.

Maslow's pyramid contains 5 categories of needs:

1.Physiological needs - refers to basic needs: food, water, shelter, protection, mobility/transportation;

2.Physical and social security needs - refers to financial security, the security of a job, a salary, a pension, etc.;

3.Social or affiliation needs - they are satisfied in a social context, in relation to those around and belonging to groups;

4.Esteem and social recognition needs - refers to self-esteem, to the respect of people from the same group;

5.Self-actualization and affirmation needs - refers to personal development and the fulfillment of professional potential [14, 7, 25, 24, 11].

Holistic humanist perspective

Moreover, in the study of motivation was also imposed the holistic humanist perspective by Catalin Mamali in the work "Motivational balance and coevolution" - “The holistic humanist perspective was gradually born, some ideas, concepts, techniques belonging to it were shaped in the framework of research carried out under the sign of the physicalist ideal" [8].

He formulates the main characteristics of this perspective:

- Socio-cultural conditioning of human values and motives is a perspective of postulating an evolution of motivation which is distinguished by the conditioning of the transition from one stage of development to another, the higher personality, by the transformations that took place at the level of the individual's motivational structures;
- Another characteristic of this perspective refers to the "reevaluation of the principle of homeostasis [7], [21], and it is a vision that postulates the existence of a motivational structure which belongs to an integrated system so it is not necessary to analyze an isolated reason, but a constellation of reasons;
- It is wrong to make a classification of human reasons because the personality is aware to different degrees of its own motives and the motives of others, the awareness of motives is also accompanied by a structuring of attitudes towards it;
- The motivational structure should relate to the dynamics of social and individual values; there are theories that propose a reevaluation of human needs that are instinctive in nature;

- Another perspective says that the distinction should be between extrinsic means and intrinsic means of stimulating the activity and this highlighted the concept of anticipation, overcoming the vision of the determinism of human actions.

The present research propose to analyze psychological mechanisms involved in making researchers motivated and how good organizational behavior can improve research advances in viticulture and wine science.

MATERIALS AND METHODS

Organizational behaviour implementation was monitored via the use of raw data from Human Resource Deparment of "Bujoru" Research and Development Station for Viticulture and Winemaking, Galati County, Romania.

Sensible resource human data files were censored. Statistical analysis was done using basic Microsoft excel functions.

Organizational behavior evalutation was done whit the help of indices that monitored the following:

-difficulties regarding facility for good organizational system

-motivational opportunities for the success of good organizational implantation

-organizational levers of motivation

-relationship between motivation and organizational behavior

Performance indices for good organizational behavior resulted from ISO 9002 quality management system.

RESULTS AND DISCUSSIONS

Difficulties that Bujoru Viticulture and Wine making Research Station is facing regarding facility for a good organizational system implementation:

Staff employed, statistical analysis based on past and current organizational chart showed the following tendencies:

- young staff fluctuation, due to poor financial remuneration, compared to present expenses and needs; Financial motivation would attract larger numbers of young researchers whit a more select background. This would lead to an increase academic visibility of fundamental and applied research.

Analysis done on raw data from 2015-2023 showed that since 2015 an average number of 5 research assistants were hired. 3 from 5 promoted to researcher and 1 in 5 reached the highest level of their professional career, CS I. On average from research assistant to CS I, it took about 15 years to reach the highest level of professional career.

From all new staff hired an average of 55% left viticulture and wine research, development sector.

The lack of funds necessary for existing equipment the maintenance or the procurement of new up to date equipment;

Equipment maintenance or procurement can be funded through the following financial tools: local budgetary allocations and ADER projects and MADR governmental and EU funds.

Development of the vine plantations

From the development stand of view, there are large areas of aging plantations for which reconversion is mandatory within all the experimental bases. Since 1977 when Bujoru wine and viticulture research station was establish environmental indicators didn't allow vineyard reconversions. Currently 400 acres are occupied by vineyard plantations from a total of 700 acres.

-Although 70% of the costs for vineyard reconversion are allocated through governmental programs, "Bujoru" Research and Development Station for Viticulture and Winemaking is unable to co-finance the remaining 30%;

- Deficient constructive infrastructure and viticulture equipment to ensure the quality of the wine obtained;

Motivational opportunities for the success of a good organizational implementation

Through EU resilience plan, fundamental and applied research infrastructure was updated to modern technological standards used across Europe.

This program was implemented between 2012-2015, and it allows the development of new physico-chemical analytical methods, structural identification of organic and an organic components specific to viticulture, food and pharmaceutical industry. Latest EU environmental directions did not include programs that could be applied for equipment maintenance or procurement.

Modern equipment will always attract eager researches that can build solid databases that can transform into large-scale scientific articles. Analytical range diversification regarding the classes of components identified in wine, by-products and compound extraction for alternative uses in derivative branches. This is a motivational objective for good organizational behavior in research.

Viticulture planting material is an important link on the basis of future development with massive implications on the whole food chain [25], [6]. That’s why “in house” development plays a crucial role in phyto-sanitary security and the human resources involved in this process must be highly trained whit a strong sense of responsibility.

A number of 8 grapevine genotypes: White maiden, Royal maiden, Aligote´, Muscat Ottonel, representing white vine varieties and respectively: Burgund, Cabernet Sauvignon, Merlot, Black maiden, for red grapevine varieties are the main genotypes present in the Bujoru wine area.

Vineyard reconversion for vine varieties that produce high quality wines whit a large basis of requested on the market.

The aim of use of the AI in studies are identifying the existence of new suitable areas for both white and red varieties that can be exploited for the achievement of wines that reach their varietal potential. Another direction is variety diversification by new applied biotechnologies for new wine range development [19], [18]. The extension of the fundamental and applied research systems will have a direct effect in food security domains, development, health, while maintaining and conserving biodiversity. The result will translate to larger and more diverse classes of researchers.

Organizational levers of motivation

As an organization SCDVV is split in research and development sectors. The research sector in divided in two main laboratories:

-laboratory for improvement and viticultural technologies

-wine biotechnologies and wine chemistry laboratory

Each laboratory currently is composed from 4 researchers and 4 laboratory assistants. Every six months mandatory evaluations are implemented for all research staff.

An organization must differentiate between good, average and poor researchers and consequently reward performance and provide opportunities for the advancement of the best researchers and scientific projects in order to achieve the organization's performance.

This reward system must provide competitive compensation. Lawrence and Nohria (2002) show that these reward systems improved employee engagement and satisfaction [5], [7].

The desire to create bonds between colleagues is a vital part of research. Free collaboration and idea swap being one of the fundamental principles of the scientific community.

Good management practices that are implemented at SCDVV Bujoru encourage employee solidarity, whit the sense of taking care of each other, so that a sense of collegiality and belonging is created. Establishing new connections are a fundamental part of research good organizational behavior and often lead to scientific breakthroughs. All research related staff are challenged to use more of their creativity and contribute to make a difference for the organization processes. To achieve these features, performance management and resource allocation processes must be optimized. These stages make the evaluation and decision processes transparent, fair and clear. Management practices regarding personnel are implemented through approved ethics guide regulations. This set of regulations are validated by Academy of Agricultural and Forestry Sciences as a coordinator.

As we know, the four elements of organizational behavior are: people, structure, technology, and the external environment.

Some factors are more easily controlled by the organization like its structure or people hired, but they have to respond to external factors and changes in the economic environment.

So, a productive and efficient workforce is the backbone of success. In order to have decisive influence in the research community, a constant motivational goals must be offered to the research collective.

Motivation in organizational behavior not only creates willingness but also encourages all research related human resource to fully utilize their abilities.

All evidences leads to the fact that motivated researchers have better organizational performance.

For example, some are motivated by rewards, while others focus on promotions or stability. Therefore, it is essential for this organization and its managers to understand what really motivates researchers if they intend to maximize organizational performance.

In order for talented and dedicated researches to develop lengthy careers at this research facility human behavior understanding is a key component for good organizational behavior.

Managers have to recognize how best achieve research engagement, so they can direct their capabilities to obtain the organization's goals and objectives. For example in the last five years 1 in 5 researches were promoted because of meeting all performance requirements.

The Relationship between Motivation and Organizational Behavior

Researchers have to be motivated in order to improve their performance in an organization and to show interest in their jobs using the following strategies:

1. Human resources and its managers should select the appropriate employees of the position and placement according to skills, interest and abilities. Main requirements for research recruitment are detailed by Romanian research legislation and internal regulations.

If employees are recruited and placed based on the mentioned characteristics in a company, it makes the work more interesting and less tedious. This contributes to increase productivity and performance.

2.Salary increases: All employees may be motivated when their salaries are increased, for example, because the wage increase will alleviate the current economic hardships that some of the employees may be facing. Salary increases are stipulated by current legislation and professional advancements as a result of achieving the necessary professional goals.

3.Payment of salaries without delays: Employees can be motivated to perform their tasks more efficiently when the payment of wages is constant.

The situation in which the employee does not know for sure when to receive the next income is the most discouraging for employees.

4. When employees perform spectacularly, they should be appropriately rewarded with bonuses and prizes because if employees are rewarded for excellent performance, they tend to be motivated and perform even better, according to Skinner's theory, which states that employee behaviors that lead to appreciation will be repeated, and behaviors that lead to negative outcomes will not be repeated.

5.Organizing training courses to improve the knowledge and performance of employees in the company: when employees are provided with continuous training, it helps them increase their skills in the workplace, which leads to increased productivity in the organization.

6.Employee participation in the organization's goal-setting and decision-making process enables employees to commit to achieving those goals.

7.Ensuring a favorable working environment: latest technology, tools or supplies.

8.Technology also creates new challenges for managers. Virtual teams and telecommuting require new methods of motivation to ensure employees are creative, flexible and committed.

9.Providing secondary benefits such as:
paying for transport or providing a staff bus

10.Interesting work: employees are motivated with interesting work because this makes them to like doing the job.

When all these strategies are implemented, they will bring about an improvement in employee performance and thus boost organizational behavior and performance.

New trends regarding organic viticulture as a method of reducing climate change and carbon footprint is one of the many strategies that needs to be developed in this [16, 17, 3]. Development of a management tool to indicate the environmental impact of organic viticulture.

From a managerial point of view a good organizational behavior must take in to account carbon footprint management. Recent studies underline the importance of good organizational behavior in carbon footprint reduction. Cartmill et al. (2022), recommend the inclusion of carbon footprint reduction as a fundamental rule in good organizational behavior [5]. Current organizational behavior implemented at SCDVV Bujoru research station takes in to account carbon footprint reduction. These strategies are a part of outgoing climate protection strategies that have an end meaning in human resource protection. Good organizational behavior strategies that include carbon footprint reduction have been implemented in all scientific branches whit the common goal of environmental resource preservation [14].

CONCLUSIONS

Motivation is a key element in organizational behavior because employees must be motivated to exhibit a specific behavior that will lead to the achievement of goals and objectives and that, over time, will help improve research performance.

Motivating people as part of SCDVV Bujoru research facility is a mandatory management function that ensures organizational efficiency. Motivation is person specific and the importance of individual difference recognizes can create a work environment that satisfies research needs, expectations and goals, while keeping sources of dissatisfaction to a minimum.

The field of organizational behavior provides insights which enable managers to increase work quality and efficiency through employee engagement, job design, benefit packages and balancing work-life conflicts.

All being parameters of good organizational behavior that must be taken in to account for wine and viticulture Bujoru research station.

In essence, motivated researchers refers to the integration of individual needs into those of the organization, so that people can best satisfy their own needs and work effectively for common research goals.

The success in wine and viticulture research is based to a large extent on internal strategies for motivating human resources and updating them to current legislation and specific needs. A motivated staff will work efficiently that will bring plus value to the specific wine making and viticulture research sector and none the less improve knowledge regarding viticulture and wine making specific to eastern Europe.

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THE BIOLOGICAL AND AGRICULTURAL POTENTIAL OF SORGHUM CROP IN ROMANIA

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Abstract

Sorghum is the fifth most cultivated cereal in the whole world, after wheat, rice, corn and barley. It is a cereal with a chemical composition, similar to cereals grown in our country, especially corn. This crop must be reconsidered, as a cereal with great potential, to be used for human consumption, not only for animal feed. The sorghum crop is a crop that does not require large production costs, compared to other cereals grown in our country, especially in the context of climate change, in recent times. This research work aimed to present the biological and agricultural potential of Sorghum crop based on statistical data provide online by FAOSTAT, European Union Sorghum Area, Sorghum-id.com și The ARVALIS Technical Institute, France. The analyzed data refer to the period 2010-2022, so to a period of 12 years. The methods used to set up this study have been the comparison and index methods. The main results obtained based on this analysis reflect that, in Romania, where water availability may become a challenge in the future, sorghum can be a valuable crop option. Sorghum is a versatile crop that can adapt to a wide range of soil and climatic conditions. In conclusion, information about the sorghum crop is important for farmers to make the right decisions, because the sorghum crop has a high yield, which could be used in crop rotations or as a complementary crop for maize, being a crop of the future.

Key words: *sorghum, climate change, drought tolerance*, *acceptabile chemical composition*

INTRODUCTION

Based on the characteristics and production potential of different areas agricultural, taking into account the objectives of diversification a energy production, farms face conversion to annual and perennial herbaceous crops: sunflower, canola, sorghum and common cane and with tree crops. Among the different forms of biomass, the energy crops grown able to ensure the production of thermal or electrical energy: stand out: sunflower, rapeseed, artichoke, sorghum, cane, poplar, willow [33, 43, 55].

Biodiesel and bioethanol are obtained from most important agricultural species (wheat, barley, corn, rapeseed, soybean, sunflower, sorghum, sugar beet, etc.) and attract favorable economic implications. Biodiesel, in particular, is considered an excellent contributor to motor vehicles and fuels. It is obtained from vegetable crops to animal fats used in oilseed crops. Biofuels are generally in diester form, a transesterification process [52, 23, 26].

Sorghum (*Sorghum bicolor*) is a monocotyledon belonging to the family Poaceae or Graminaceae, tribe Anthropogoneae. It is believed to have originated in East Central Africa (Sudan, Ethiopia) and then spread to Asia and Europe and later to America and Australia. It was a from the first cultivated species and today it is the fourth most important cereal in the world agricultural economy after wheat, rice and corn [4, 1, 41]. Based on the degree of chromosome pairing, the genus Sorghum would include 6 subgenera that can be classified based on intended use into:

1) broom sorghum or sorghum (*S. bicolor*, var. technicum). It is noted for the very short axis of the panicle, on which long branches are inserted elastic stems that form an umbelous inflorescence. The latter is used in the manufacture of brooms;

2) fiber sorghum (S. bicolor, var. technicum or its hybrids), characterized by a very tall plant, 2-5 m;

3) sugar sorghum (var. saccharatum), a very tall plant, 2-5 m, with a juicy pith, rich in

sucrose (15-20%), is not suitable for sugar production, because in addition to sucrose it has significant amounts of invert sugar that inhibits crystallization. It can be used for the production of syrups and bioethanol;
4) fodder sorghum (varr. sudangrass and saccharatum), with cultivation capacity;
5) cereal sorghum (various hybrids), characterized by low plants (1-1.5 m) with empty grains without tannins, used for human consumption in developing countries and for animal feed in advanced countries [12, 22, 7].
In 2020, the area cultivated with sorghum increased by 18% in the European Union [44]. This increase applies to both grain sorghum (+20%) and forage sorghum (+12%). Of African origin, sorghum is the 5th cereal in the world (with a production of 49 million hectares), after corn, wheat, rice and barley. Globally, 50% of the area under sorghum is in Africa, but it is also grown in the United States, where areas have increased sharply, in Argentina, India, China and Australia. In short, on five continents [12], [22].

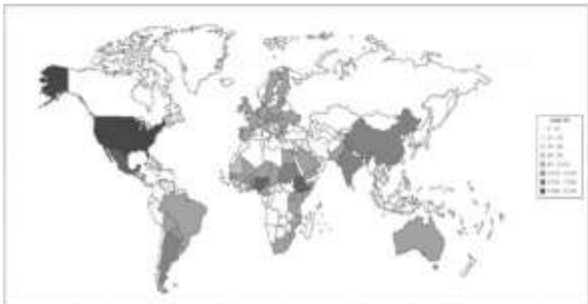

Fig. 1. Global sorghum production
Source: FAOSTAT [19].

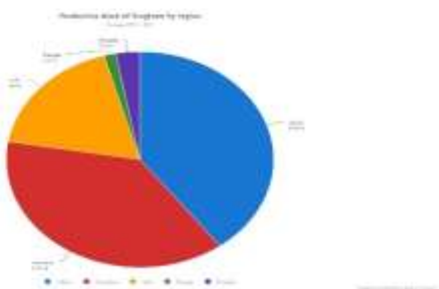

Fig. 2. Production share of Sorghum by region
Source: FAOSTAT [19].

It is mainly used in traditional dishes from Africa, Southern Europe, but also in Central America and Asia. Cultivated grain sorghum, also known by the scientific name Sorghum bicolor, belongs to the family Poaceae (grasses) and the panicoid subfamily. It is a herbaceous plant, widespread in the wild in tropical and subtropical climates. For centuries, the peoples of Africa and Asia have used its seeds for food, its straw for fodder. Sorghum was later introduced to Europe and the United States, but is mainly used for animal feed [7, 56, 28].
In Europe, the sorghum culture was brought in the fifteenth century, but did not know a wide spread.
Sorghum cultivation in Romania is classified in the specialized literature as a technical and fodder crop.
There are over 30 different species of sorghum originating from regions with a tropical and subtropical climate. Most are used as animal feed or are processed to produce alcohol or sorghum syrup. Few varieties are grown for human consumption [41], [25].
For a sustainable production and consumption it is necessary to have a continuous increase of resource productivity, to avoid stagnation and syncope at the macroeconomic level. Should not be lost sight of that increase of resource efficiency in Europe is a means by which the objectives of economic policy, social and environmental development can achieve easier, safer and with lower costs.
Information about the sorghum crop is important for farmers to make the right decisions, because the sorghum crop has a high yield, so it crop rotations, being a crop of the future.
In this context, the aim of this study was to present the biological and agronomical characteristics of sorghum crop, as well as the cultivated areas and production in Romania, EU and at the global level.

MATERIALS AND METHODS

This study was carried out based on based on statistical data provide online by FAOSTAT, European Union Sorghum Area, Sorghum-id.com și The ARVALIS Technical Institute, France.
The analyzed data refer to the period 2010-2022, so to a period of 12 years.

The comparison and index methods were used as analysis methods. Based on these methods, areas and productions were compared worldwide and at the European level.
The indicators (K- FAOSTAT source) as well as the comparative biochemical analysis of sorghum with the main cultivated cereals (data from the Arvalis Institute in France), show the evolution of phenomenon of increasing areas and productions of sorghum culture, but also a favorable chemical composition compared to wheat and especially in relation to corn. That is why the sorghum culture does not compete with that of corn, on the contrary, it contributes to increasing the global grain production, by occupying climatic regions and soils unfavorable for classical cultures [51].

RESULTS AND DISCUSSIONS

Sorghum is a perennial plant that can be harvested several times a year. But in our latitudes, grain sorghum is grown as an annual crop. The stem (stubble) is usually a meter tall, sometimes more, and 1 to 5 cm thick. The leaves, which resemble those of corn, have a flat blade, broadly rounded at the base, 30–100 cm long and 5–100 mm wide [43, 55, 52].
Sorghum is a thermophilic, versatile plant, also called a „camel "plant, because it can be grown on acidic lands and especially on salts, where other plants cannot be grown, having a wide pH range (4.5-8.5).
The plant breeding work shad several objectives: precocity, low content in tannin and hydrocyanic acid, improvement of tolerance to salinity and soil alkalinity [56, 28, 25].
It harnesses low, uneven rainfall, so a sorghum root reaches 4.8 m depth, compared to a maize root, which reaches 2.4 m depth in the soil.
It is an environmentally friendly plant, for example, one ha of sugar sorghum absorbs 50t of carbon dioxide year [41], [13], [46].
The sorghum species is primarily self-pollinated, but wind cross-pollination can occur under certain conditions. For this reason, most local sorghum breeds grown by farmers consist of mixtures of pure and semi-pure lines. Cross-pollination is higher for forage sorghum. Flowering time is extremely variable. Depending on the genotype, depending on the climate, the plant can flower 30 to 100 days after germination. Wet and cold weather causes delayed flowering [23, 26, 4, 5].
The Arvalis Institute in France carries out analyses on sorghum grains every year. The results indicate an advantageous chemical composition because it is comparable to other cereals such as wheat or corn.
The starch content of sorghum represents 74 % of the dry matter; it is equal to that of maize.

Table 1. The chemical composition of Sorghum versus wheat and maize

Dry matter (%)	Wheat	Maize	Sorghum
Starch	69	74	74
Protein	12	9	11
Fat	1.8	4.2	3.5
Sugars	2.9	1.9	1.3

Source: Own conception based on the data from The Arvalis Institute [49].

The protein content of sorghum grains can vary between 10 and 12%, these are values that make sorghum a crop with a favourable chemical composition with a high agricultural potential. It has a wide range of uses.
Sorghum grains do not contain gluten.
Sorghum grains can be included in human food, not only for feeding animals.
Sorghum has an amazing 22 grams of protein in one cup (192 grams) of cooked whole grain. The recommended daily dose of protein for women is 46 grams, and for men, 56 grams. On average, sorghum contains 43% of the daily protein requirement [27, 21, 16].
One portion contains 47% of the required iron and 55% of the recommended value of phosphorus. It is also a good source of magnesium, copper, calcium, zinc and potassium [9, 3, 39].
A portion of sorghum also contains approximately 30% of the recommended amount of niacin and thiamine. These two types of vitamin B are necessary for the correct metabolism of carbohydrates and nutrients.

Sorghum contains a varied range of phytochemicals that act as antioxidants in the body, such as tannins, phenolic acids, anthocyanins, phytosterols and policosanols. In fact, the shell of the sorghum grain has a higher amount of antioxidants than blueberries, strawberries and plums. Antioxidants contribute to slowing down the aging process, and foods rich in antioxidants are associated with a reduced risk of heart disease, diabetes, cancer, type 2 diabetes and some neurological diseases [23, 26, 4].

Many studies confirm that a consumption of whole grains reduces the rate of deaths caused by cardiovascular disease, phytochemicals being considered to be largely responsible for this. It has been proven that they reduce cholesterol and prevent thickening of the arteries. Sorghum is one of the best sources of dietary fiber. One portion contains 48% of the recommended daily dose of fiber [45, 15, 35].

Fibers are vital for the optimal functioning of the digestive system.

Compared to maize, sorghum has a greater number of stomata, but they are smaller in size. This feature, along with the properties of the epidermis and the presence of a waxy layer, offers a strong capacity to save water, thus resisting drought [31, 32, 8]. Practically, the plant is able to reduce transpiration to a minimum until growth is arrested during the driest periods, to then resume vegetation when conditions return to normal humidity [30,11, 29].

Sorghum has a high biological and agricultural potential, which is why it is grown by many farmers, especially in Europe.

Sorghum has a C_4 photosynthetic cycle, meaning high interception efficiency and conversion of light radiation: a quality that is particularly enhanced in environments characterized by high light intensity and high temperature [57, 47, 18].

In Europe, about 80% of agricultural area is not irrigated; this has led to a visibility of sorghum cultivation.

Sorghum is among the most demanding species from a thermal point of view: it requires at least 12- 14°C for germination (2°C more than corn) and 16°C for plant development, while the optimal growth temperatures are 27-28°C. The species has a good adaptation to a wide range of terrains, but the salty ones do not tolerate soils subject to water stagnation. In addition, di- the size of the seed and the lack of vigor of the shoots make the culture very sensitive to the superficial crust in muddy soils [17, 42, 10].

In this sense, as already mentioned, it must be taken into account that biomass production is strongly dependent on the duration of the biological cycle. of the plant which, in a temperate environment, is conditioned by the moment in which it can be found seeding is carried out, which in turn depends on the control of genetic factors germination and development below 16°C. Availability of low grade resistant genotypes if temperatures would allow require early seeding in first two weeks. March of late and more productive types [36, 37, 38 , 40, 2, 20].

At European level, the genetics of sorghum hybrids are constantly being improved as the plant of the future - EUROSORGHO - is the European program for the creation of new sorghum hybrids,

The first European Sorghum Congress was held in Romania in 2016, 3-4 November, in Bucharest, with the theme: Sorghum – the culture of the future. The new varieties, the result of European research, are well adapted to our climate and prove to be much more productive than the first varieties introduced [48, 14, 24, 38].

According to the statistics, the area cultivated with grain sorghum in Europe reached 375.000 ha in 2020 and in 2022, in EU they decreased to 183.000 ha cultivated with sorghum [1, 41]

In the EU in 2022, there were 183,000 ha cultivated with sorghum. From the total EU production, 41% is achieved in France, 34% in Italy, 8% in Hungary and 7% in Romania [44]. In Romania, 5,702 ha were cutivated with sorghum in 2022 [34].

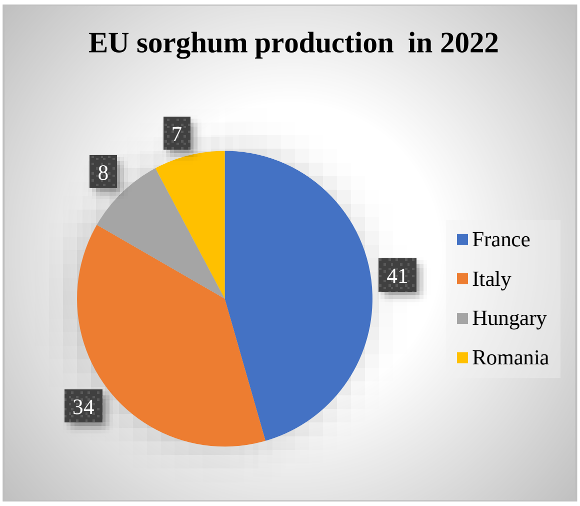

Fig. 3. EU sorghum production 2022
Sou rce: Own conception based on the data from European Union Sorghum Area [44].

Fig. 4. Yield (tones/hectare)
Source: European Union Sorghum Area [44].

In 2023, the largest cultivated areas with sorghum in the EU are in France 51,000 ha and Italy 40,000 ha. The highest production is obtained in Italy, 260,000 tons and France 219,000 tons, while the top yield was registered in Italy 6,500 kg/ha, Greece 5,200 kg/ha and France 4,300 kg/ha [44]. In recent years, sorghum culture has gained momentum in Romania due to its adaptability to semi-arid areas, to soils with low fertility, drought resistance and low production costs compared to corn culture. Sorghum production in Romania, varied as follows, according to FAOSTAT:in the period 2000-2010-25,000 t and in the period 2010-2022-75,000 t [19].
In Romania the cultivated area of sorghum, in the period 2010-2022, registered a significant increase, especially in the year 2013 (Figure 5).

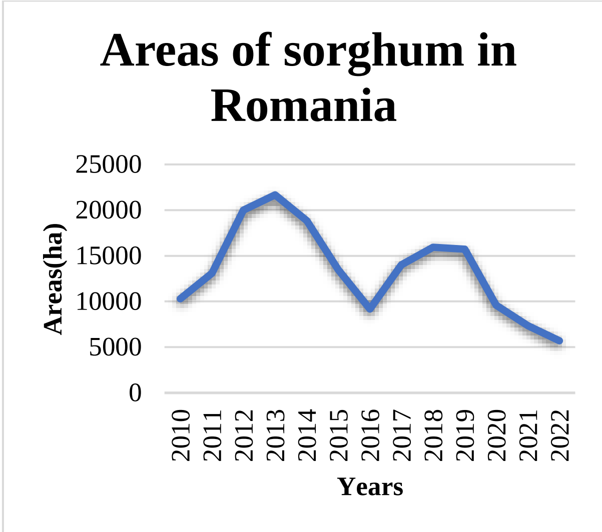

Fig. 5. Romanian sorghum production
Source: Own conception based on teh data from INS-Tempo online [34].

Research and extension services can play a crucial role in helping farmers in Romania understand how to grow and manage sorghum effectively, especially in the context of climate change. Furthermore, policymakers and agricultural organizations can encourage and support the adoption of sorghum through incentives, research funding, and the development of local markets for sorghum-based products. By leveraging the potential of sorghum, Romania can enhance its agricultural resilience in the face of climate change while contributing to food security and sustainable agriculture [33], [50 54, 53, 6].

CONCLUSIONS

The cultivation of sorghum in Europe in recent years, especially due to drought, has attracted the attention of farmers for its adaptability to low rainfall, short growing season, but also its tolerance to pests.
For many farmers, sorghum is a new crop, so information is important in Europe's sorghum development strategy.
Sorghum has a lower consumption of inputs, compared to other crops, by 30%, lower compared to maize, so low costs, but it is also a good precursor plant, it can enter rotations.
This can result in cost savings for farmers and reduce the environmental impact of agriculture.

Sorghum grown in Europe is not used locally, being exported to countries that use it, for example, Spain is the largest consumer of sorghum in Europe.

In Romania, where water availability may become a challenge in the future, sorghum can be a valuable crop option. Sorghum is a versatile crop that can adapt to a wide range of soil and climatic conditions. This adaptability can help farmers in Romania respond to changing climate conditions and shifting weather patterns. Sorghum has a relatively short growing season compared to some other crops, which allows for flexibility in planting and harvesting. Sorghum can be used for biomass production and biofuel feedstock. As the world seeks more sustainable energy sources, Romania can explore the use of sorghum for bioenergy production, which can contribute to reducing greenhouse gas emissions. Sorghum is a valuable source of livestock feed, and its cultivation can support the livestock industry in Romania. It provides an alternative feed source, especially during times of forage scarcity caused by changing weather conditions. Sorghum can be included in crop rotation systems, which can help improve soil health and reduce the risk of diseases and pests, which can become more prevalent in a changing climate.

However, it's important to note that the successful cultivation of sorghum in Romania will depend on several factors, including local climate conditions, soil types, and the availability of appropriate sorghum varieties. Additionally, farmers may need to adapt their farming practices and adopt new techniques to make the most of sorghum's potential.

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GOVERNMENT AGRICULTURAL LENDING FROM THE PERSPECTIVE OF DEVELOPMENTAL INSTITUTIONS OPERATING IN THE PALESTINIAN JORDAN VALLEY

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Abstract

The agricultural sector is a crucial component of Palestine's economy, contributing 6.5% to the GDP. The Jordan Valley, known for its fertile land and underlying eastern groundwater basin, is the focal point of this study. This research assesses governmental support as perceived by civil society organizations (CSOs), with an emphasis on the need for tailored lending programs. The study employs a descriptive-analytical methodology, utilizing questionnaires distributed to 20 CSOs. The findings suggest that effective lending programs should be coupled with agricultural guidance and consider seasonal production and marketing to enhance loan repayment feasibility.

***Key words**: Jordan Valley, agriculture, lending, Civil Society Organizations, farmers, rural development*

INTRODUCTION

The territories, rich in natural resources, have the potential to foster diversified local economies through the optimal utilization of these assets. In Palestine, agriculture is particularly significant, especially in frontier regions that make up many rural areas. Agriculture is not only vital economically but also holds political, social, and symbolic importance. Understanding the dynamic interplay between these aspects is crucial, especially given the ongoing settler-colonial expansion and the ever-changing socio-political landscape of rural Palestine [29].

The economic development of rural areas and the modernization of agriculture are heavily influenced by the availability of adequate financial resources. Experiences from developing countries highlight the centrality of financial systems in meeting farmers' needs and ensuring sustainable development [13, 14]. However, the financing of agriculture has seen inconsistent changes, with debates on the effectiveness of microcredit in combating poverty and promoting rural economies [20, 26]. Peasant farmers typically require both short-term loans for seasonal needs and long-term loans for capital investments. Yet, microfinance institutions predominantly offer short-term loans, limiting their impact on rural development [7].

In the context of the Occupied Palestinian Territories, agricultural finance is under-researched. Existing studies suggest that financial inclusion alone may not overcome the challenges posed by the Israeli occupation, particularly in agricultural development [10]. The COVID-19 pandemic has further complicated agricultural finance strategies, exacerbating the challenges brought on by settler-colonialism [27].

Agricultural finance is not just about future development; it also legitimizes the current operations of institutions like the Palestinian Monetary Authority (PMA,2021) [25] and the Palestinian Capital Market Authority (PCMA, 2021) [24]. Although these institutions have yet to fully realize their mandates, such as facilitating agricultural loans and fostering rural economic growth, their existence is justified by the potential of agricultural finance [11].

Problem statement

Agricultural lending is a crucial tool for achieving sustainability in the agricultural sector, particularly in the Jordan Valley, where financial support is essential for enhancing the resilience of Palestinian farmers.

This study investigates the impact of lending mechanisms employed by civil agricultural and rural institutions on the resilience of these farmers. By analyzing how these practices affect farmers' ability to overcome challenges, the research provides valuable insights into optimizing lending programs to better support long-term agricultural sustainability and livelihood security in the region [28].

Questions of the study

The problem of the study is represented in the following main question:

(1) What are the key characteristics of a potential governmental agricultural lending program for Palestinian farmers in the Jordan Valley?

(2) What are the anticipated effects of such a program on fostering rural agricultural development and enhancing the resilience of farmers in the region?

Objectives of the study

This study aims to achieve several key objectives:

(1) Identify the essential components that should be included in any governmental agricultural lending program to promote integrated agricultural development, thereby enhancing the resilience of Palestinian farmers in the Jordan Valley.

(2) Examine the perspectives of developmental organizations active in the Jordan Valley regarding the impact of governmental agricultural lending programs on both the farmers and the region itself.

Hypothesis of the study

The following hypotheses have been developed for this study:

H1: There is no statistically significant relationship at the level of ($\alpha \leq 0.05$) between the presence of a governmental agricultural lending program—characterized by zero interest, attainable guarantees, and extended repayment periods—and the achievement of rural agricultural development in the Jordan Valley, as perceived by developmental institutions.

H2: There is no statistically significant relationship at the level of ($\alpha \leq 0.05$) between the existence of a governmental agricultural lending program and enhancing farmers' resilience, attracting investments, increasing income, combating Israeli settlement expansion, and expanding agricultural land in the Jordan Valley.

Theoretical framework and Literature Review

Economic Activities in Palestine

The Palestinian economy is predominantly service based, with services contributing about 75% of the GDP, while the production sector contributes only 25% (PMA, 2021) [25]. Table 1 illustrates the GDP components and sector contributions for 2012.

Table 1. GDP and Gross National Income in Palestine (2012):

Economic sector	Million USD
Agriculture, Forestry, and Fishing	977.5
Real GDP at Constant Prices	12,624.1
Real Gross National Income	17,553.1
Real Available National Income	19,342.0

*Base Year: 2015
Source: [25].

The contribution of various economic sectors to the GDP and their growth rates for 2021 is shown in Table 2.

Table 2. Contribution and Growth of Economic Activities to GDP (2021)

Economic Activity	Contribution %	Growth %
Other Services	10.8	1.9
Industry	12.2	4.7
Agriculture	6.5	-2.3
Construction	4.7	10.4

Source: [21].

Labor Force

Palestine has a high population growth rate and a predominantly young population, with 44.2% under the age of 18.

Table 3. Palestinian Labor Force Overview (2023)

Item	No. Thousands	Percentage %
Total Population	5,227.2	100
Out of Labor Age	1,981	37.9
In Labor Age	3,246	62.1
Out of Labor Force	1,838	56.6
In Labor Force	1,408	43.4
- Working	1,036	73.6
- Unemployed	372	26.4

Source: [22].

The labor force participation rate is low, with about 50% of the population not engaged in economic activities, compared to the global average of 34.9% and the regional average of 37.3% [17, 16].

The commerce and services sectors absorb 34.5% of the labor force, while agriculture employs 6.7%. Palestinian labor force distribution includes 630,000 in the West Bank and 260,000 in Gaza, with 140,000 working in Israeli markets, contributing to a high unemployment rate of 26.4% [12, 8].

Lending in Palestine

Lending is crucial for development, with funds provided by commercial and Islamic banks, as well as financial institutions. Agricultural lending is aimed at supporting agricultural projects, but the sector faces significant challenges [31, 3].

Banks

In 2021, the loan-to-deposit ratio in Palestinian banks was 65.1%, with 84.9% of the credit portfolio allocated to loans. Agricultural loans amounted to 128.5 million USD, or 1.2% of total loans [5]. Banks are hesitant to fund agriculture due to its high risk and seasonality [15].

Specialized Lending Sector

By late 2021, eight registered institutions managed a credit portfolio of 274.9 million USD, issuing 64,541 loans. Commercial loans represented 84.8% of the portfolio, with Islamic loans at 15.6%. Agricultural lending constituted 11.3% of the credit [1, 4, 18].

Governmental Lending

The Palestinian Agricultural Lending Institution, part of the Ministry of Agriculture (Palestinian Ministry of agriculture, 2022) [23], provides both Islamic and commercial loans to farmers [19].

The government's policy framework and practical interventions to promote private investment in agriculture for Region (C) with a focus on the Jordan Valley - Palestinian Farmers Union- 2019: Based on the mentioned study, the Jordan Valley and the areas classified as (C) represent the true geographical cohesion of the Palestinian Territory. These areas encompass natural resources and agricultural land. Therefore, achieving real development in Palestine—whether economic, social, or sectoral (primarily agriculture)—is unattainable unless the resources of these areas are utilized [6]. Furthermore, the study highlights the difficulties and challenges faced by residents of the Jordan Valley and the areas classified as (C), which have rendered them a vulnerable social group. These challenges include Israeli occupation practices and policies, as well as the Palestinian government's failure to implement adequate interventions. Therefore, there is a need for tangible governmental intervention that matches the importance of these areas and the potential political and developmental returns from investing in them.

The study by the Palestinian Farmers Union outlines a framework for an achievable developmental process to realize the desired change. However, achieving this change is contingent upon political and administrative will, through bold measures, appropriate decisions, and the allocation of necessary budgets to implement this framework. Despite political and legal challenges and resource scarcity, there are elements that should be considered as effective in achieving change. These elements mainly relate to individual and collective culture and the relationship between people and land. Additionally, there is a need to respect the land and handle it with care, as it is a resource for living and happiness. The value of the land should not be viewed solely from a financial perspective, even though the Jordan Valley represents 50% of the fertilized Palestinian land and produces 60% of the vegetables and fruits consumed in the West Bank. The study emphasized the necessity of ensuring harmony and coordination among active organizations (civil society organizations, cooperatives, local authorities, and educational institutions, particularly applied and vocational educational institutions). It also highlighted the importance of strengthening the governance of these institutions. The study affirmed the need to support entrepreneurial ideas among young farmers and to establish a development fund institution capable of creating a new economic vision.

Economic Policies in the Jordan Valley and Their impact on Farmers [30].

This study by researcher Abdul-Sattar Shreida examines Palestinian economic policies in the Jordan Valley, focusing on governmental, private sector, and civil society interventions. It assesses whether these efforts create real change or merely reinforce economic dependence on occupation. The study highlights the occupation's near-total control over the Jordan Valley and its impact on Palestinian agricultural development and export capacity, noting that some dependence on Israeli resources, including those from illegal settlements, persists. The study is divided into two main sections. The first section details the occupation's strategies to economically dominate the Jordan Valley, including land confiscation for settlements and military bases, the construction of the Annexation Wall, control of water resources, and the imposition of low-wage labor conditions on Palestinians. The second section focuses on Palestinian economic policies, examining government development plans, civil society initiatives, investment in agricultural exports, and support for small-scale farmers. It also explores alternatives to employment in Israeli settlements. The findings reveal that Israel's occupation of the Jordan Valley is primarily driven by economic interests rather than security or political reasons. The study argues that Palestinian efforts should concentrate on diminishing the economic significance of Israeli settlements through sustained boycott campaigns. The declaration of 44% of the Jordan Valley as a military-closed area is viewed as a tactic to expand control and suffocate Palestinian localities, obstructing development in 95% of the region. The study calls for urgent action from Palestinians to address the current situation rather than relying on the 1993 Oslo Accords.

A study about Developing funding for the Entrepreneur Agricultural Projects in Palestine commence by Pro-Active-Solutions for Consultancy and training, for the benefit of the Palestinian Agricultural Relief Committees and Welfare Association (Agricultural Development Association, 2018) [2].**:** The study reveals that financial services for agricultural projects are significantly less developed compared to those for other sectors, limiting the agricultural sector's contribution to Palestine's economic development. Challenges include inadequate financial support, high costs of lending, and restrictive bank conditions. Banks perceive agricultural projects as high-risk, leading to stringent requirements and higher interest rates, which further deter investment.

Key obstacles to agricultural financing identified by the study include:

1. Lack of Trust :Banks' doubts about project success and the high risk of failure.
2. Guarantee Requirements :Difficulty in providing necessary guarantees.
3. Feasibility Studies :Absence of thorough feasibility studies.
4. Revenue Misalignment: Discrepancy between loan amounts and project revenues.
5. Insurance Coverage: Lack of insurance for high-risk agricultural projects.
6. Owner's Financial Capacity: Inability to meet guarantee and funding requirements.
7. High Interest Rates: Elevated costs of loans due to high bank interest.
8. Short-Term Focus: Banks prefer short-term loans over long-term ones, increasing financial strain on borrowers.

Farmers also hesitate to request loans due to:

1. High Lending Costs: Loans are costly compared to early project revenues.
2. Debt vs. Cash Flow: Rising debt compared to available cash flow.
3. Limited Savings: Insufficient personal or family savings.
4. Affordability Issues: Difficulty in managing high interest rates and guarantees.

Additionally, the study conducted by [9] on the "Palestinian Agriculture Clusters Strategy" evaluated the status and potential impact of this plan on the sector. It found that assessing the plan's effectiveness would require 3-5 years. Success depends on collaboration with various stakeholders and overcoming challenges imposed by Israeli occupation policies. Recommendations include involving youth and investors, improving access to technology and resources, expanding cultivated areas, and securing external financing.

MATERIALS AND METHODS

Research Method

The study employs a descriptive analytical approach using a questionnaire to gather data. A total of 20 questionnaires were distributed to employees, with one representative from each of the 20 institutions operating in the Jordan Valley. This comprehensive survey encompasses all institutions within the sector in the region.

Data collection

The best method for gathering data for This study is:

(1) Literature Review: Reviewing academic works, books, articles, and reports on the study.

(2) Questionnaire: distributed among 20 employees (one from each institution) of those working in the Jordan Valley (comprehensive survey, the number of institutions operating in the Jordan Valley in this sector is 20 institutions).

Data Analysis

The study surveyed all 20 civil organizations actively engaged in rural development and agriculture within the Jordan Valley.

(A)Reliability

The study tool's reliability was confirmed through internal consistency, with a Cronbach's Alpha coefficient of 0.95, indicating very high reliability.

(B)Validity

The validity of the study tool was assessed using Pearson Correlation, as shown in Table 4.

The results demonstrate significant internal consistency across most items, affirming the tool’s ability to measure the attributes of a potential governmental agricultural lending program effectively.

RESEARCH RESULTS

(1) What are the key characteristics of a potential governmental agricultural lending program for Palestinian farmers in the Jordan Valley?

The answers are reflected in Table 4.

Table 4. Pearson Correlation for Items in Question 1 (Key Features of a Government Agricultural Credit Program), According to statistical analysis

No.	Item	C C1	S S2	A M3	S D4
1	Agricultural Lending Program bias to small farmers	0.608	0.004	4.40	0.99
2	Islamic Agricultural Lending Program	0.338	0.145	3.80	1.39
3	Commercial Agricultural Lending Program	-0.020	0.932	2.80	1.00
4	Agricultural Lending Program with simple guarantees	0.526	0.017	4.35	1.04
5	Agricultural Lending Program with guidance	0.615	0.004	4.45	0.82
6	Agricultural Lending Program with low interest	0.247	0.294	3.60	1.46
7	Agricultural Lending Program with long payback duration	0.517	0.020	4.25	1.02
8	Agricultural Lending Program with long grace periods	0.454	0.044	4.20	1.15
9	Agricultural Lending Program with low monthly payments	0.457	0.043	4.20	1.10
10	Agricultural Lending Program considering seasonal production	0.660	0.002	4.35	1.04

Source: Statistical analysis.

1C. C: Correlation Coefficient; 2S S: Statistical Significance; 3A M: Arithmetic Mean;4S D: Standard Deviation

The results indicate that most items demonstrate statistical significance, confirming the tool's internal consistency and its effectiveness in measuring the proposed program’s features.

With effectiveness scores of 4.45 and 4.40, respectively, the data indicate that the Agricultural Lending Program with advice and the Program slanted to small farmers are the most successful. Both exhibits extremely low p-values (0.004) and substantial positive correlations (0.615 and 0.608), which show significant statistical significance and reliability.

With effectiveness scores of 4.35, moderate to strong correlations (0.526 and 0.660), and low p-values (0.017 and 0.002), programs that incorporate simple assurances and take seasonal output into account also fare well. These attributes appear to play a major role in the programs' performance.

In contrast, the Commercial Agricultural Lending Program exhibits a low effectiveness score of 2.80, a near-zero correlation (-0.020), a high p-value (0.932), and no statistical significance. Programs with low interest rates and monthly payments have modest correlations (0.247 and 0.457), but they may not be as successful on a consistent basis based on their greater variability and effectiveness scores (3.60 and 4.20).

(2) What are the anticipated effects of such a program on fostering rural agricultural development and enhancing the resilience of farmers in the region?

The answers are reflected in Table 5.

Table 5. Pearson Correlation of Question 5 Paragraphs (Potential Impacts of a Government Agricultural Lending Program)

No.	Item	C C1	S S2	A M3	S D4
1	Increase farmers' income	0.559	0.010	4.35	0.67
2	Enhance farmers' resilience and steadfastness	0.566	0.009	4.55	0.69
3	Increase cultivated area	0.361	0.118	4.25	0.79
4	Transform Jordan Valley into an attractive agricultural area	0.568	0.009	4.40	0.68
5	Transform Jordan Valley into an attractive residential area	0.008	0.973	3.90	0.85
6	Transform Jordan Valley into an attractive investment area	0.193	0.414	4.00	0.73
7	Enhance people's steadfastness on their land	0.507	0.022	4.45	0.69
8	Recession of settlements in Jordan Valley	0.516	0.020	3.70	0.87
9	Minimize occupation's activity in the area	0.571	0.009	3.75	0.85
10	Enrollment of new citizens in agriculture	0.376	0.102	4.20	0.70

Source: Statistical analysis.

Table 5 confirms the internal consistency and highlights the significant impacts of the proposed program on rural development and resilience enhancement.

Ranking of Main Features of a Government Agricultural Lending Program are presented in Table 6.

Table 6 ranks the features of the program based on their perceived importance by organizations, with agricultural guidance and support for small farmers being the top priorities.

With high Pearson correlations (0.566 and 0.568) and statistically significant p-values (0.009 for both), Table 5's results suggest that the two most important expected effects of a government agricultural lending program are strengthening farmers' resilience and steadfastness and turning the Jordan Valley into a desirable agricultural region. Additionally, these items have great effectiveness values of 4.55 and 4.40, indicating a high likelihood of achieving these goals.

Table 6. Ranking of Main Features of a Government Agricultural Lending Program

No.	Item	Arithmetic Mean	Standard Deviation
1	Agricultural lending with guidance	4.45	0.83
2	Program bias towards small farmers	4.40	0.99
3	Considers seasonal production	4.35	1.04
4	Easy guarantees	4.35	1.04
5	Long payback duration	4.25	1.02
6	Long grace period	4.20	1.15
7	Small monthly payments	4.20	1.11
8	Islamic Agricultural Lending Program	3.80	1.40
9	Low interest	3.60	1.47
10	Commercial Agricultural Lending Program	2.80	1.01

Source: Statistical analysis.

Along with a high effectiveness score of 4.35, increasing farmers' income also demonstrates a beneficial impact, with a correlation of 0.559 and a p-value of 0.010. This suggests that the program may significantly increase the financial stability of farmers.

On the other hand, items such as making the Jordan Valley a desirable place to live and reducing the amount of activity related to occupation in the area had smaller correlations (0.008 and 0.571) with higher p-values (0.973 and 0.009), indicating that these effects might not be as direct or substantial. Additionally, these items' effectiveness scores (3.90 and 3.75) are marginally lower, suggesting that these outcomes might have less of an impact or be more difficult to obtain.

In conclusion, the program's most significant effects are probably going to be in strengthening income, boosting resilience, and improving the Jordan Valley's agricultural appeal. These factors are all vital for encouraging rural agricultural development and strengthening the resilience of the area.

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Expected Impacts of a Government Agricultural Lending Program is shown in Table 7.

Table 7. Expected Impacts of a Government Agricultural Lending Program

No.	Item	Arithmetic Mean	Standard Deviation
1	Enhance resilience and farmers' steadfastness	4.55	0.69
2	Contribute to sustaining citizens' presence	4.45	0.69
3	Transform into an attractive agricultural area	4.40	0.68
4	Increase farmers' income	4.35	0.67
5	Increase the agricultural area	4.25	0.79
6	Enrollment of new groups in agriculture	4.20	0.70
7	Attractive area for investment	4.00	0.73
8	Attractive residential area	3.90	0.85
9	Satisfaction with civil society organizations	3.90	0.55
10	Reduce settlement building by occupation	3.70	0.87

Source: Statistical analysis.

Table 7 shows the anticipated impacts of the program on rural development and resilience, highlighting the highest priority impacts such as enhancing resilience and sustaining farmers' presence.

The anticipated effects of a government agricultural loan program are shown in Table 7, which emphasizes several important areas. With great agreement and consistency among respondents, the arithmetic mean of 4.55 and a standard deviation of 0.69 indicate that improving resilience and farmers' steadfastness will have the highest predicted benefit. Contributing to maintaining the presence of citizens (4.45, 0.69) and converting the area into a desirable agricultural region (4.40, 0.68) come next. The program's projected major influence on increasing farmers' income has a mean of 4.35 and a low standard deviation of 0.67, indicating that it is a dependable outcome.

Despite their slightly larger variability, enlarging the agricultural area and promoting the enrollment of new groups in agriculture are deemed significant as well, with corresponding averages of 4.25 and 4.20. Expectations that the program will increase the area's appeal for residential purposes (3.90, 0.85) and investment (4.00, 0.73) are less significant, but they are nonetheless meaningful. The program may have less of an impact on these outcomes since the lowest predicted impacts are on minimizing settlement building by the occupation (3.70, 0.87) and satisfaction with civil society organizations (3.90, 0.55).

Detailed Participant Responses on the main features of a Government Agricultural Lending Program are shown in Table 8.

Table 8. Responses on Main Features of a Government Agricultural Lending Program

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Bias to small farmers	65%	20%	5%	10%	0%
Islamic Lending Program	45%	20%	15%	10%	10%
Commercial Lending Program	5%	15%	45%	25%	10%
Easy guarantees	65%	15%	10%	10%	0%
With agricultural guidance	60%	30%	5%	5%	0%
Transfer to attractive investment area	40%	20%	10%	20%	10%
Long payback duration	55%	25%	10%	10%	0%
Long grace period	60%	15%	10%	15%	0%
Small monthly payments	55%	25%	5%	15%	0%
Considers seasons of production	65%	15%	10%	10%	0%

Source: Statistical analysis.

Table 8 provides a detailed breakdown of participant responses regarding the key components of a government loan program for agriculture. Bias towards small farms and simple promises are the aspects that receive the strongest approval; 20% of respondents agreed with these features and 65% strongly agreed. This overwhelming support implies that participants should give priority to easily accessible programs designed specifically for small-scale farmers, since this could increase their success and involvement.

Long payback periods (55% strongly agree, 25% agree) and agricultural guidance (60% strongly agree, 30% agree) are two more highly accepted elements.

According to these findings, participants place a high importance on financial flexibility and educational support, both of which may strengthen the resilience and sustainability of farming enterprises.

With only 5% strongly approving and 45% remaining neutral, the Commercial Lending Program, on the other hand, garnered the least amount of support.

This answer implies that compared to more specialized or easily available solutions, commercial lending might not be viewed as advantageous or appropriate for farmers' needs.

There is some preference for lending programs that are in line with Islamic principles, as evidenced by the moderate support the Islamic Lending Program has, with 20% strongly agreeing and 45% strongly agreeing.

There is, however, a noteworthy 15% neutrality and 20% disagreement, indicating differing views regarding its efficacy.

The last characteristic that gained less enthusiastic support was turning the area into a desirable investment area, with only 40% strongly agreeing and 10% opposing.

This implies that although investment opportunities are of interest, participants may not find them as important as other qualities that are more closely associated with their farming activity.

The responses on the impacts of a Government Lending Program are given in Table 9.

Table 9. Responses on Impacts of a Government Agricultural Lending Program

Item	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Increase farmers' income	45%	45%	10%	0%	0%
Enhance resilience and farmers' steadfastness	65%	25%	10%		

Source: Statistical analysis.

The participant answers about the effects of a government agricultural financing program are displayed in Table 9. With 45% of respondents strongly agreeing and another 45% agreeing, many respondents think the program will greatly enhance farmers' income. There is a great deal of faith that the initiative will benefit farmers financially, as evidenced by the overwhelming support for it.

Similarly, 65% strongly agree and 25% agree that strengthening farmers' steadfastness and resilience will be a substantial advantage. The initiative appears to be highly valued by participants as a means of enhancing the stability and perseverance of farmers in the area, based on the overwhelming support shown for it.

The lack of disagreement in both instances and the low neutrality percentage (10% for both items) highlight the participants' faith in the program's ability to accomplish these objectives.

CONCLUSIONS

Based on the analysis of the data, the study draws the following **conclusions**:

-Successful Agricultural Lending Programs: Workers in the development field believe that a successful agricultural lending program, which enhances development and strengthens resilience, must include an agricultural guidance component. This feature is most effectively implemented through a government-led initiative, as non-governmental programs may fall short due to high costs and extensive human resource requirements.

-Essential Program Elements: There is a consensus on the key elements needed for a successful government agricultural lending program. These include agricultural guidance, support for small farmers, a repayment system aligned with production and marketing seasons, lenient guarantees, long repayment periods, extended grace periods, and manageable monthly payments. These factors are crucial for achieving the program's developmental goals.

-Program Impacts: Participants from developmental institutions identified two major impacts of a government agricultural lending program: enhancing resilience and ensuring that farmers remain on their land. This supports the study's argument that such programs are pivotal in strengthening farmer resilience.

-Institutional Interventions: The study highlighted that agricultural lending programs and grants are vital for agricultural development. Sixty percent of participants agreed that these interventions are essential for advancing agricultural progress and resilience.

Recommendations:

Comprehensive Program Design: Government agricultural lending programs should be paired with agricultural guidance and focus on supporting small farmers. The repayment schedule should consider agricultural seasons, with easy-to-meet guarantees, long repayment periods, and extended grace periods to meet developmental objectives.

-Enhancing Resilience and Investment: Incorporating these elements into governmental lending programs will significantly improve farmers' resilience and make the Jordan Valley a more attractive area for agricultural investment, thereby increasing income and expanding cultivated areas.

-Prioritizing the Jordan Valley: The Jordan Valley is strategically important for Palestine, serving as a critical economic and agricultural zone. Given its significance and the challenges posed by Israeli occupation policies, it is essential to prioritize its development. Strengthening resilience in this area through government agricultural lending programs is crucial for supporting Palestinian farmers and maintaining the region's agricultural viability.

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SPATIAL VARIABILITY OF WHEAT CROP ASSOCIATED WITH SOME TECHNOLOGICAL PRACTICES DESCRIBED BASED ON REMOTE SENSING

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Abstract

The study analyzed the spatial variability of the autumn wheat crop, based on remote sensing techniques. The RapidEye satellite system was used to retrieve images of the wheat crop. The images were taken during May, when the vegetation was already well represented in relation to the vegetation conditions. Based on the images, the NDVI index was calculated. The map of the NDVI index was reclassified and six classes resulted (C1 to C6). The NDVI raster image was transformed into vector format and the area (Area, ha) was calculated for each class. The area per class varied between 1.873 ha (3.81%) in the case of C1, and 12.659 ha (25.78%) in the case of C4. There were significant differences between sample medians of NDVI on the six identified classes, H (chi^2) = 1.877E04, H_c (tie corrected) = 1.877E04, p = 0. According to the t Test and the Wilcoxon Test, there were significant differences (sig. diff.) between the data series C1 to C6 of the NDVI index, and the mean value, respectively the median, at the wheat crop level. The Area variation in relation to NDVI was described by a 3rd degree polynomial model (R^2 = 0.999, p = 0.00104). The spatial distribution of NDVI values was most likely associated with fertilization works, which generated certain non-uniformity in the distribution of fertilizers.

Key words: *agricultural practices, farm management, field spatial variability, geostatistics, RapidEye, wheat*

INTRODUCTION

Agricultural crops can express spatial and temporal variability in relation to soil conditions (soil genesis, and soil types and quality), with climatic factors, but also with certain agricultural practices, a fact that affects the yield and quality of agricultural production [17, 27]. Agricultural practices can induce variability in the quality of the soil, can alter the ecosystems, and can have a variable impact on the environment [3, 6, 10, 26].

Fanelli (2020) [10] evaluated how certain agricultural practices influenced the variability of agricultural land, and the environment in EU countries. Based on the study, a classification of the considered countries into four classes resulted, in relation to certain considered parameters.

Popescu et al. (2024) [20] carried out an extensive study on land use during the last two decades, globally and at the level of EU countries, which shows the very high importance of agricultural land and soil resources in safety and food security.

In order to achieve an adequate management of nutrients and some technical approaches in relation to the specifics of the location, the spatial variability of the content of nutrients in agricultural lands was analyzed, on a large scale, as well as on a small scale [14]. The authors identified significant spatial variability, in relation to the surface of the plots, and the history of agricultural practices, especially in relation to the applied fertilizers. The yields were in close correlation with the degree of variability recorded, and based on the results, recommendations were formulated for sustainable agricultural practices, in relation to the specifics of the study area.

Kihara et al. (2016) [15] found different sensitivities of corn crops to the application of mineral and organic fertilizers, in relation to soil fertility.

The land of a farm has variable areas in terms of yield, some with better potential and others with lower production potential, in relation to

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various influencing factors, such as the soil, topography of the land, climatic conditions, and management practices [16]. The authors conducted an extensive study (338 crop fields) of different crops (wheat, soybeans, corn, cotton) in conditions specific to the US Midwest, and evaluated how the stability of production is affected by environmental factors.

Studies and experiments at the farm level represent appropriate tools for evaluating variability, in order to improve management decisions and agricultural practices [27]. The authors of the study evaluated the spatial variability of the corn crop in relation to nitrogen and variable seed rates, under the aspect of technological costs.

Spatial variability was analyzed for different agricultural crops through remote sensing techniques (Landsat), and specific indices (e,g, NDVI, EVI, SAVI, GNDVI), in specific Mediterranean climate conditions [2]. The authors recorded variable levels of yield correlation in relation to the indices used, and the location within the crops.

Agroecosystem models are important to estimate crop variability, yields and management of agricultural production systems. Brogi et al. (2020) [5] used simulations to analyze the spatial variability of soil water content and crop dynamics in relation to soil properties. Data from the RapidEye system were used to calculate indices for the purpose of the study. The authors recorded the variation of the LAI index in relation to the water stress in the soil, as well as to the analyzed agricultural soils.

In the context of precision agriculture, the variation of soil properties at the small scale of agricultural land surfaces is important for agricultural practices and crop yields [11]. The authors found a 45-46% explanation of the variation in autumn wheat production in relation to certain soil properties. Significant differences in the yield variation were given by soil organic carbon.

The combined influence of fertilizers with relief on production was studied in different crops [1]. The authors recorded variable yields depending on the relief, and the interaction of the relief with the application of fertilizers to wheat (*Triticum aestivum*) and teff (*Eragrostis tef*).

Crop productivity was analyzed through the appropriate management of nutrients in relation to the spatial variability of soil quality indices [23]. The authors considered certain areas of differentiated soil management necessary in relation to quality indices. The heterogeneity of the soil was assessed based on the values of the coefficient of variation, calculated in relation to the soil quality indices. Based on appropriate methods of analysis, the authors formulated recom-mendations for nutrient management for sustainable yields in the sugar beet and barley crops they studied.

Based on the remote sensing technique, the RapidEye satellite system, the study analyzed the spatial variability of the autumn wheat crop, as a possible effect of some agricultural practices through fertilization, and generated a classification based on NDVI values.

MATERIALS AND METHODS

The study analyzed a wheat crop, to characterize the spatial variability based on satellite images. The field research and the study took place within the DER (Didactic and Experimental Resort), University of Life Scisnces "King Mihai I" from Timisoara (ULST), Figure 1.

The wheat crop was carried out on a plot of 50 ha, with chernozem type soil, medium fertility, and non-irrigated crops system. For the analysis and characterization of the wheat crop, the satellite images were taken in May. The RapidEye satellite system was used to retrieve the images, at a resolution of 5m [19]. Based on the spectral values, the NDVI index was calculated, equation (1) [21].

$$\mathrm{NDVI} = ((\mathrm{NIR} - \mathrm{Red}) / (\mathrm{NIR} + \mathrm{Red})) \quad (1)$$

In relation to the purpose of the study, the map of the NDVI index was analyzed for reclassification [9]. To determine the area on the identified classes, the NDVI raster image was transformed into vector format, and the area of each class was calculated.

For the general characterization of the

recorded data, descriptive statistical analysis was applied. The comparative analysis of the NDVI data series between classes, as well as against the mean value of NDVI at the plot level, was done by specific tests, Several-sample tests (Kruskal-Wallis), and One sample test (t Test, Wilcoxon) [12, 13].

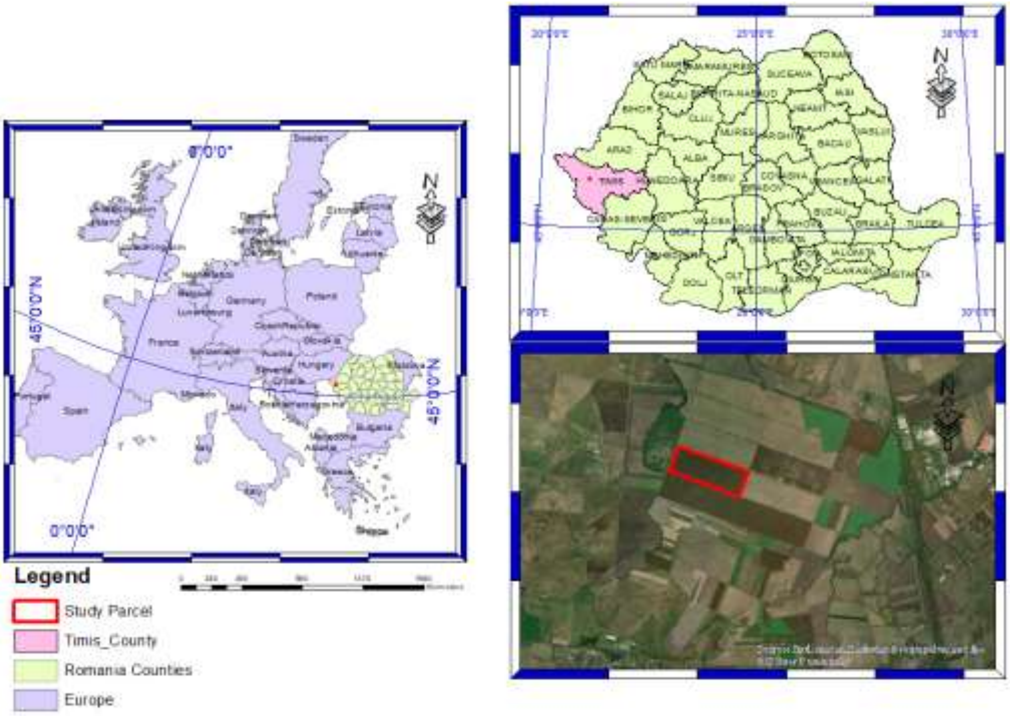

Fig. 1. Study location
Source: Original figure.

RESULTS AND DISCUSSIONS

The satellite images (RapidEye) were analyzed and the spectral values were obtained. Based on the spectral values, and equation (1), the values of the NDVI index were calculated. A series of 19,650 values resulted, which described the wheat crop in the study plot. The NDVI raster image was reclassified and resulted in 6 classes (C1 to C6), depending on the intensity of the pixels. The number of values within the classes was unequal, according to the descriptive statistical analysis presented in Table 1.

Table 1. The statistical data characterizing the NDVI values by class in the wheat crop analysis

Statistical Parameters	C1	C2	C3	C4	C5	C6
Valid	771	2642	4254	5073	4674	2236
Median	0.582	0.603	0.620	0.634	0.647	0.661
Mean	0.578	0.602	0.620	0.634	0.647	0.663
Std. Error of Mean	5.279×10^{-4}	1.131×10^{-4}	6.821×10^{-5}	5.497×10^{-5}	6.050×10^{-5}	1.334×10^{-4}
Coefficient of variation	0.025	0.010	0.007	0.006	0.006	0.010
Variance	2.149×10^{-4}	3.379×10^{-5}	1.979×10^{-5}	1.533×10^{-5}	1.711×10^{-5}	3.981×10^{-5}
Minimum	0.472	0.590	0.611	0.627	0.640	0.655
Maximum	0.590	0.611	0.627	0.640	0.655	0.696
25th percentile	0.573	0.598	0.616	0.630	0.643	0.658
50th percentile	0.582	0.603	0.62	0.634	0.647	0.661
75th percentile	0.587	0.607	0.623	0.637	0.650	0.666

Source: Original data.

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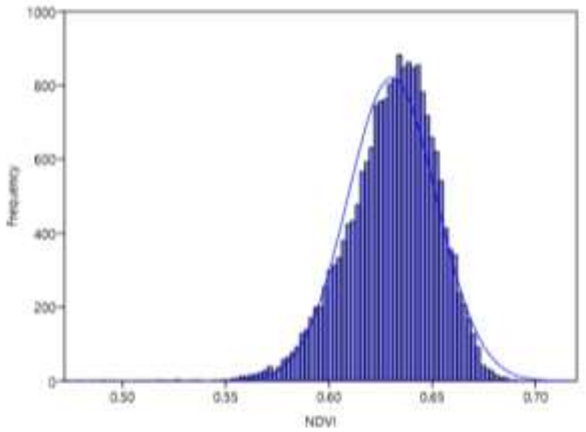
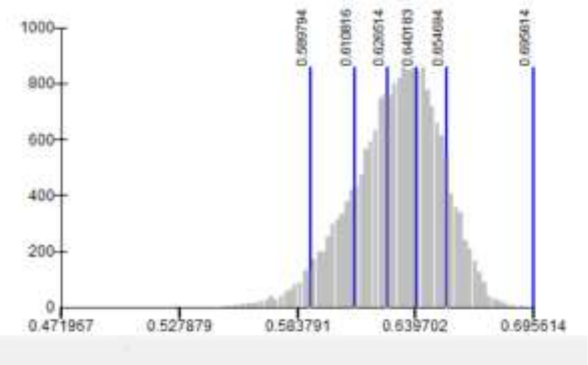
The data series presented a normal distribution, Figure 2. Based on spatial analysis, the raster image of NDVI was transformed into vector format, and it was possible to calculate the area of each class (C1 to C6). The NDVI mean values, and the values areas per class, are presented in table 2. The NDVI values in map format are presented in Figure 3, and the graphic representation of the classes is presented in Figure 4.



(a)



(b)

Fig. 2. Graphic distribution of NDVI values; (a) distribution histogram; (b) the class intervals associated with the histogram
Source: Original figure.

Table 2. Mean values of the NDVI index and of the area per class

Class	NDVI	Area	
		(ha)	(%)
C1	0.5775013	1.873	3.81
C2	0.6021298	6.656	13.55
C3	0.6195131	10.593	21.57
C4	0.6335167	12.659	25.78
C5	0.6468586	11.815	24.06
C6	0.6625326	5.513	11.23
Total		49.109	100.00

Source: Original data.

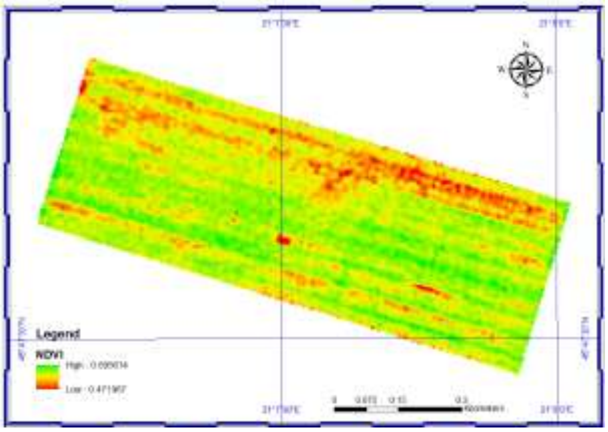


Fig. 3. Map of the NDVI index in the characterization of the wheat crop
Source: Original figure.

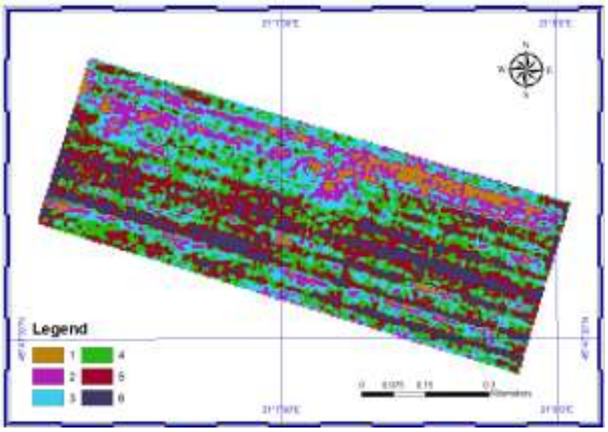


Fig. 4. Map of the resulting classes for the characterization of the wheat crop
Source: Original figure.

According to Several-sample tests, Kruskal-Wallis test for equal medians, it resulted that there are significant differences between sample medians of NDVI on the six identified classes (C1 to C6), H (chi^2) = 1.877E04, H_c (tie corrected) = 1.877E04, p = 0.

The NDVI values expressed the condition of the wheat plants on the crop plot. The distribution of the values was random, depending on the condition of the land, but also with technological works, especially with fertilization.

The comparative analysis was made between each series of NDVI values according to the classification (C1 to C6), with the mean and median value, at the wheat crop level (complete series of data). The results obtained are presented in table 3.

According to the t Test and the Wilcoxon Test, it turned out that there were significant differences (sig. diff.) between the data series

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C1 to C6 of the NDVI index and the mean value, respectively the median, at the level of the wheat crop. The results of the applied tests are presented in Table 3.

Table 3. Test values for NDVI data series by class

Statistical parameter	C1	C2	C3	C4	C5	C6
	t Test					
Given mean:	0.62367535	0.62367535	0.62367535	0.6236753	0.62367535	0.62367535
Sample mean:	0.5775	0.60213	0.61951	0.63352	0.64686	0.66253
95% conf. interval:	(0.57646 0.57854)	(0.60191 0.60235)	(0.61938 0.61965)	(0.63341 0.63362)	(0.64674 0.64698)	(0.66227 0.66279)
Difference:	0.046174	0.021546	0.0041622	0.0098414	0.023183	0.038857
95% conf. interval:	(0.045138 0.04721)	(0.021324 0.021767)	(0.0040285 0.0042959)	(0.0097336 0.0099492)	(0.023065 0.023302)	(0.038596 0.039119)
t :	-87.464	-190.53	-61.02	179.02	383.2	291.21
p (same mean):	0	0	0	0	0	0
Significance of differences for mean	sig. diff.	sig. diff.	sig. diff.	sig. diff.	sig. diff.	sig. diff.
	Wilcoxon Test					
Given median:	0.624285667	0.624285667	0.624285667	0.624285667	0.624285667	0.624285667
Sample median:	0.58181	0.6028	0.61996	0.63352	0.64656	0.66106
W :	2.98E+05	3.49E+06	8.47E+06	1.29E+07	1.09E+07	2.50E+06
Normal appr. z :	24.055	44.518	49.258	61.686	59.21	40.956
p (same median):	7.47E-128	0	0	0	0	0
Significance of differences for median	sig. diff.	sig. diff.	sig. diff.	sig. diff.	sig. diff.	sig. diff.

Source: Original data.

The Area variation in relation to the NDVI values was described by equation (2), R^2 = 0.999, p = 0.00104, figure 5.

$$\text{Area} = -0.693\text{E}04x^3 + 1.577\text{E}05x^2 - 9.515\text{E}04x + 1.909\text{E}04 \quad (2)$$

where: x – NDVI values

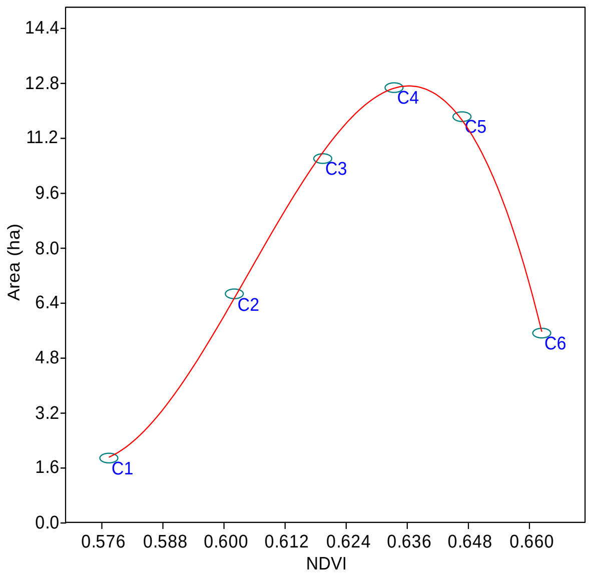

Fig. 5. Graphic distribution of Area in relation to NDVI
Source: Original figure.

The Ranking analysis led to the ranking of the classes identified in the wheat crop, by reclassifying the NDVI raster image, diagram in Figure 6.

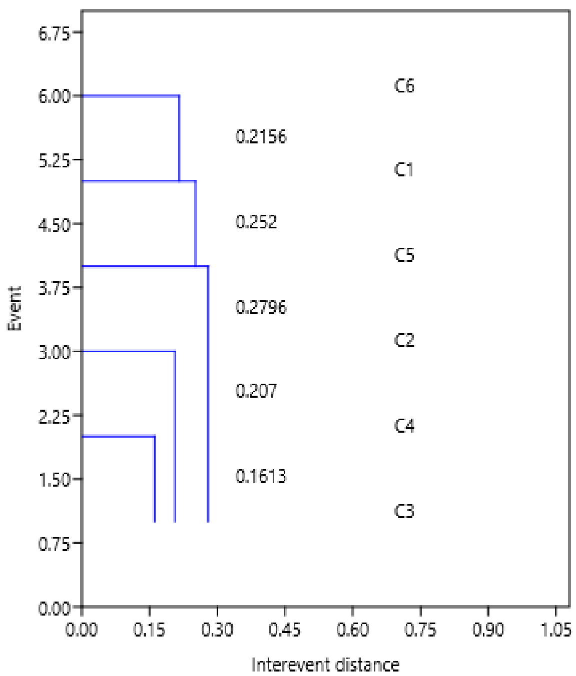

Fig. 6. Hierarchy of wheat crop classes, in relation to mean values
Source: Original figure.

From the analysis of the spatial distribution of the NDVI values (Figure 3), as well as of the resulting classes Ffigure 4), a certain tendency of predominantly longitudinal arrangement of the NDVI values and classes (according to the maps, Figure 3 and Figure 4) was found within the plot of wheat crop.

This layout can be associated with a certain work of agricultural technology, especially with fertilization.

Through the cross-sectional analysis of the values within the study plot, a sinusoidal graphic distribution resulted (Figure 7). In the fertilization work, the administration of fertilizers is done on a variable width of 12m, 24m or 36m. The distribution width of the fertilizers varies depending on the working width of the fertilizer application machine, but also depending on the quality indicators of the mineral fertilizers (e.g. granulometry).

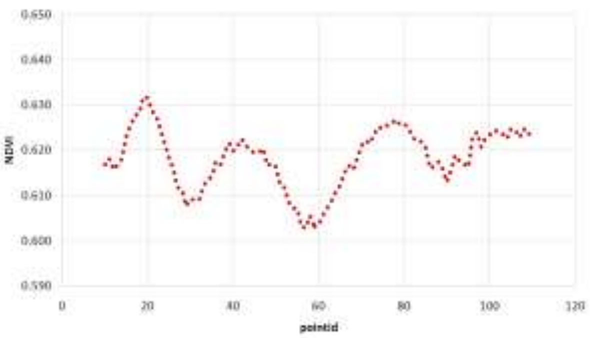

Fig. 7. Transversal distribution profile of NDVI values
Source: Original figure.

The spatial variability of agricultural lands was recorded in relation to natural and anthropogenic factors. The variability of the land induced by agricultural practices was also communicated in different studies [3, 8, 10].

Some studies have recommended certain fertilization systems to control the yield and quality of plant production, for the purpose of sustainable agricultural practices, sustainable agrosystems, and environmental sustainability [7, 18, 24, 28].

The variability of crops in relation to fertilizers was also analyzed in other studies, in order to understand the causes and formulate solutions [15, 22].

The methods based on the remote sensing technique and imaging analysis are very effective in assessing the variability of crops in relation to fertilization, and soil fertility [4, 25], and facilitate yield and quality estimates of agricultural production.

In the present study, certain variability was identified in the winter wheat crop, associated with the land and fertilizer application practices. The non-uniformity of the crop, based on the NDVI values, presented a pronounced longitudinal distribution, expressed by a sinusoidal graphic representation.

This overlaps with the routes of application of mineral fertilizers. Through the partial covering of the fertilization strips, during the mechanized application of fertilizers, associated with the granulometric quality of the fertilizers, it led to an uneven distribution of the fertilizers, and to the generation of spatial non-uniformity in the vegetation state of the plants.

CONCLUSIONS

The analysis based on remote sensing, the RapidEye satellite system, facilitated the analysis and highlighting of the spatial variability of the autumn wheat crop, in an area of 49.109 ha, and the understanding of the significance of the differences.

Through the reclassification analysis of the NDVI map and the transformation of the NDVI raster image into vector format, the classification was made into six classes (C1 to C6) and the land surface was calculated for each class.

The differences between the classes, regarding the mean and median values, calculated on the basis of the NDVI values, showed statistical certainty ($p = 0$), which confirmed the certainty of the classification and the significant difference in the spatial variability of the wheat crop.

The surface of the classes (Area, ha) varied in relation to the NDVI index according to a 3rd degree polynomial model ($R^2 = 0.999$, $p = 0.00104$).

The transversal analysis of the cultivated surface of wheat, based on the NDVI values, led to a sinusoidal graphic distribution, which suggested the association of the recorded variability with the fertilizer application practice.

The recorded results recommend the evaluation of soil quality indices and the adaptation of fertilization works in order to normalize the current situation of the land, sustainable yields of agricultural crops under the study conditions.

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QUALITY INDICES IN SEVERAL WINTER WHEAT GENOTYPES – COMPARATIVE PRESENTATION

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Abstract

The study comparatively analyzed 16 wheat genotypes cultivated in the specific conditions of the Western Plain of Romania, within the ARDS Lovrin. The following genotypes were studied comparatively: Biharia (WG1), Dacic (WG2), Alex (WG3), Ciprian (WG4), Trublion (WG5), Tarroca (WG6), Barbara (WG7), Centurion (WG8), Ultim (WG9), Sphere (WG10), Extrem (WG11), Rubico (WG12), Sacramento (WG13), Vivendo (WG14), Amandus (WG15), and Garavusha (WG16). Compared to the mean values, the genotypes were highlighted: genotype WG9, STARCH = 71.10±0.33% (starch content), genotype WG16, PRO = 15.90±0.26% (protein content), genotype WG4, GLT = 37.80±0.82% (gluten content), genotype WG1, SKHRD = 54.00±0.93 (single kernel hardness), genotype WG6, TKW = 44.00±1.06 g (weight of 1,000 seeds), genotype WG15, HW = 76.00±0.62 kg hl^{-1} (hectoliter weight). A statistically safe correlation was recorded between STARCH and PRO (r = -0.780***), between STARCH and GLT (r = -0.794***), between PRO and GLT (r = 0.868***), between SKHRD and MST (r = 0.812***), between TKW and T (r = 0.807***), between SKHRD and TKW (r = 0.608*), between SKHRD and T (r = -0.538*), and between MST and T (r = -0.587*). Linear and polynomial equations described the variation of quality indices, and the Ranking scaling analysis facilitated the ranking of genotypes based on the recorded quality indices.

Key words: *gluten, hardness, protein, regression analysis, ranking, wheat grains*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a species of the Poaceae family, a family that presents high diversity, important consistency of the included species, and represents the main plant, as a food resource, for most people [10]. The proteins contained in wheat grains play an important role in the quality of bakery products. Based on an extensive review-type study, the authors considered it important to expand the hereditary genetic base, for breeding programs. They considered this possible by reconsidering the genetic resources of the local and wild wheat populations.
A priority problem worldwide is the creation of productive wheat genotypes, with resistance to environmental factors, high production potential, and good quality indices [16]. The reconsideration of ancient wheat genotypes is considered important by the authors of the study. In this sense, the testing of ancient forms of wheat, for the evaluation of protein content, gluten and other quality indices, is of interest and at the same time an opportunity to obtain new genotypes. Based on the results, the authors identified valuable wheat genetic resources for obtaining new genotypes, with good quality indices and adapted to environmental conditions.
The improvement of cereal yield represents a present and perspective challenge, and breeding programs for improvement of yield are based more and more on methods supported by computational analysis and algorithms [6]. The authors considered in the analysis 167 wheat lines (inbred and recombined lines), and based on the analysis methods they succeeded in an efficient classification of the considered lines according to yield, in several categories. Moreover, the authors considered the information useful for farmers, for the

purpose of early estimates of yields, and the establishment of measures to improve yields.

The yield and quality indices in wheat are the result of the interaction "genotype × environment × crop technology" [11]. The authors analyzed 17 quality indices, for 211 varieties of winter wheat, in the specific conditions of the crops in China (period 2006 - 2018), to evaluate the quality variability, and identify the key influencing factors. The authors determined the values of the quality indices, and found out their position relative to the quality standards. Certain levels of correlation were found, statistically assured ($p<0.001$). Certain indices, with importance in wheat quality, were found (e.g. protein). The genetic characteristics, associated with quality indices, were identified, and the authors showed the importance of new varieties in wheat cultivation, and certain appropriate agricultural practices to ensure adequate yields and quality indices.

Bonea (2024) [3] communicated the results of an extensive study on the importance of genomic editing techniques in wheat breeding, in relation to the considered yield objectives and quality indices.

The variation of some wheat quality indices was studied in relation to technology elements, such as sowing date, under conditions specific to the Mediterranean area [5]. The authors studied three varieties of wheat and recorded a different variation of the gluten index depending on the sowing time and environmental conditions. Later sowing influenced a better gluten index, according to the authors. The variation of some quality indices, such as gluten, protein, Zeleny index in wheat, was analyzed depending on certain agricultural practices, such as tillage, fertilization methods [2]. Attafy et al. (2023) [1] reported the influence of irrigation on the yield and quality parameters of wheat, under specific crop conditions in Egypt. The impact of climate change on the yield of the wheat crop, in the crop conditions in Romania, was analyzed over a five-year period, from 2017 to 2021 [15]. The influence of crop technologies on some economic elements of wheat crops was studied in the South-Eastern area of Romania, under the conditions of climate change [12].

The gluten index was studied to differentiate the quality of wheat production, and the quality of flour in relation to the category of final products [4]. Based on the recorded results, the authors considered that the gluten index is important for wheat quality assessment, and can be used together with other indices.

The quality of some types of flour, associated with starch and protein (variable content, by types of flour), was evaluated in relation to the quality of the finished products [19]. It was observed how starch and protein influenced the properties and behaviour of the flour in the preparation process, as well as the quality of the resulting finished products.

Starting from the baking quality indices of wheat grains (e.g. protein content, gluten index, deformation energy, etc.), and grain yield, a synthetic index, "GY parameter", was considered useful, which expresses the relationship between grain yield and quality indices [17]. The authors of the study considered that the “GY parameter” was a tool that facilitated the objective classification of the wheat varieties studied.

The wheat quality indices were considered from a complex perspective, according to which the segments on the agro-food chain, post-harvest (processing industries, and marketing), should maximize their profit, under the conditions of cost minimization [7]. The authors of the study considered wheat quality as a "highly subjective concept" in the value flow of wheat ("milling, processing, end use and nutritional quality"). The authors considered the most important "quality of final use", which was explained by the ability of a wheat genotype to ensure obtaining a certain food, in relation to consumer preferences. The authors analyzed in detail the indices considered important in defining wheat quality (starch, gluten, grain color, and hardness), their genetic control, and the influence of the environment in their manifestation.

The quality indices of grass grain seeds are important for plant breeding programs, but also for the valorisation of grain production, as seed material (establishment of new crops), for bakery, as animal feed, industrialization. Therefore, the quantification of seed quality can be done based on different indices, and it is not always a simple process [14].

For an objective assessment of wheat quality, multivariate analysis was used in a study that analyzed 45 wheat genotypes, based on 13 physico-chemical quality indices, and three finished products [14]. In relation to the considered criteria, the authors of the study classified the varieties studied into three categories, for different bakery and pastry products. The authors considered that wheat quality indices and the obtained results will be of interest to farmers, the industry, and consumers.

An extensive study, based on 13 quality indices, 9 influencing factors and 285 winter wheat varieties, considered the classification of factors in relation to the influence on the quality indices [20]. Based on the recorded results, the authors identified the genotype as the dominant factor, which explained between 28.13% and 38.78% of wheat quality indices. Also, the authors classified the indices in relation to their variation in the "genotype × environment × technology" interaction, and identified the indices with the highest sensitivity to this interaction. The authors concluded by identifying the critical factors, with influence for most of the quality indices, and establishing a strategy for improving wheat quality indices.

In the context of the interest in wheat quality, the present study comparatively analyzed 16 wheat genotypes, based on the quality indices, described the relationship of interdependence and variation of some indices, and made a ranking of the genotypes considered in the study.

MATERIALS AND METHODS

The study made a comparative analysis of the quality indices of 16 wheat genotypes, cultivated under specific ARDS Lovrin conditions.

The following genotypes were cultivated: Biharia (WG1), Dacic (WG2), Alex (WG3), Ciprian (WG4), Trublion (WG5), Tarroca (WG6), Barbara (WG7), Centurion (WG8), Ultim (WG9), Sphere (WG10), Extrem (WG11), Rubico (WG12), Sacramento (WG13), Vivendo (WG14), Amandus (WG15), and Garavusha (WG16). To facilitate analyzes and graphical representations, WG1 to WG16 represent trial code in this study.

The comparative wheat crops were organized in conditions of chernozem soil, medium fertility, and non-irrigated crops system. At physiological maturity, BBCH code 9 [13], mechanized harvesting was done with a combine.

Within the quality indices was determined: starch content (STARCH, %); protein content (PRO, %); gluten content (GLT, %); single kernel hardness (SKHRD); weight of 1,000 grains (TKW, g); hectoliter weight (HW, kg hl^{-1}); moisture (MST, %), and temperature (T, °C).

The mean value for each quality index was calculated, against which the result of each genotype was compared, in order to create a value hierarchy.

Correlation analysis was applied to identify interdependent relationships between indices, and the degree of statistical certainty of these relationships. Regression analysis was used to evaluate the direct relationship and interaction of some indices. Dedicated applications [8, 9, 18] were used for the analysis and processing, mathematics and statistics, of the experimental data.

RESULTS AND DISCUSSIONS

The values of the quality indices resulting from the analysis of grain samples for the 16 studied wheat genotypes are presented in table 1. The starch content (STARCH, %) varied between 66.50±0.33% (WG4) and 71.10±0.33% (WG9). The protein content (PRO, %) varied between 12.20±0.26% (WG5) and 15.90±0.26 (WG16). The gluten content varied between 26.60±0.82% (WG12) and 37.80±0.82% (WG4). Single kernel hardness (SKHRD) varied between 41.00±0.93 (WG16) and 54.00±0.93 (WG1). The weight of 1,000 seeds (TKW, g) varied between 28.80±1.06 g (WG10) and 44.00±1.06 g (WG6). The hectoliter weight

(HW, kg hl^{-1}) varied between 67.60±0.62 kg hl^{-1} (WG16), and 76.00±0.62 kg hl^{-1} (WG15). The moisture of wheat grains, at harvest, varied between 11.30±0.62°C (WG16), and 18.70±0.62°C (WG2, WG3). Higher grain moisture values were recorded in the genotypes in which the plant fall phenomenon was recorded. The temperature of the grains at the time of harvesting varied between 30.30±0.29°C (WG1), and 34.30±0.29°C (WG10). The ANOVA test confirmed the statistical reliability of the results (Table 2).

Table 1. Values of the quality indices of the tested wheat genotypes

Trial code	STARCH	PRO	GLT	SKHRD	TKW	HW	MST	T
	(%)			Index	(g 1,000 $kernel^{-1}$)	(kg hl^{-1})	(%)	(°C)
WG1	68.30	14.30	35.00	54.00	40.80	70.20	18.20	30.30
WG2	67.20	13.90	33.10	49.00	42.40	68.90	18.70	31.50
WG3	67.50	13.80	33.50	51.00	43.20	70.80	18.70	30.70
WG4	66.50	15.70	37.80	52.00	40.80	74.70	16.70	32.70
WG5	70.30	12.20	28.00	50.00	38.80	73.10	16.00	31.90
WG6	69.40	13.80	33.20	52.00	44.00	73.10	15.10	31.00
WG7	69.60	13.90	30.90	49.00	43.20	75.00	14.50	31.30
WG8	69.00	14.20	32.80	47.00	39.60	73.70	13.80	32.50
WG9	71.10	12.30	27.00	48.00	37.60	75.30	14.10	33.00
WG10	67.80	14.70	32.90	43.00	28.80	75.00	13.20	34.30
WG11	70.80	13.10	28.60	48.00	40.40	72.40	12.30	33.20
WG12	70.20	12.80	26.60	44.00	41.20	71.10	12.90	31.40
WG13	68.30	13.50	27.50	46.00	36.80	74.00	12.40	33.70
WG14	68.40	14.60	32.00	44.00	32.00	74.70	12.10	33.30
WG15	68.80	14.50	31.90	44.00	42.40	76.00	12.30	31.10
WG16	67.90	15.90	35.50	41.00	35.60	67.60	11.30	32.70
SE	±0.33	±0.26	±0.82	±0.93	±1.06	±0.62	±0.62	±0.29

Source: Original data.

Table 2. ANOVA Test

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	54839.2	7	7834.2	1062.68	9.6E-105	3.7669
Within Groups	884.645	120	7.3720			
Total	55723.9	127				

Source: Original data.

Within the comparative crops of wheat genotypes, for each quality index the mean value at the level of the experiment was calculated, against which the responses of the genotypes were analyzed and interpreted.

In the case of the starch content (STARCH, %), the mean value was 68.82±0.33%. The cultivated genotypes presented differentiated values, Figure 1.

With values above the recorded average (68.82±0.33%), it was the WG9 genotype (the highest value), followed by WG11, WG5, WG12, WG7, WG6, and WG8.

In the case of the protein content (PRO, %), the mean value calculated at the level of the experiment was 13.95±0.26%, and the studied genotypes presented different values, Figure 2. The WG16 genotype presented the highest value (15.90±0.26%), and other genotypes, WG4, WG10, WG14, WG15, WG1, etc., were also recorded with values above the mean.

In the case of gluten content (GLT, %), the calculated mean was 31.64±0.82%, and the studied genotypes were positioned differently, Figure 3.

The highest gluten content was trial WG4 (37.80±0.82%), followed by WG16, WG1, WG2, WG3, WG6, WG8, WG10.

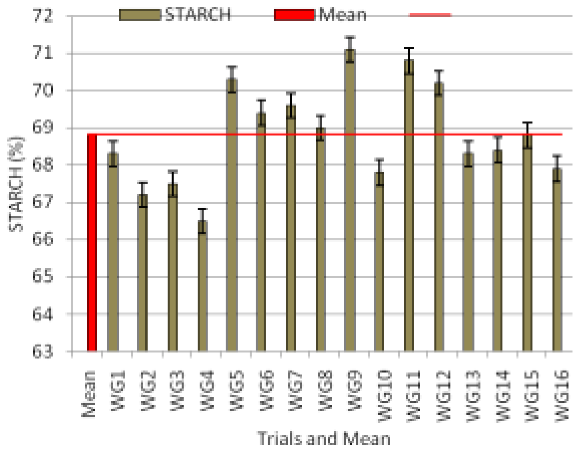


Fig. 1. The graphic representation of the starch content compared to the mean value of the studied wheat genotypes
Source: Original figure.

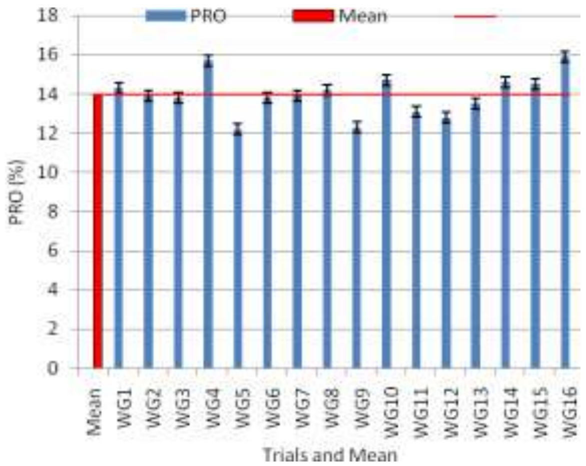


Fig. 2. Graphic representation of the protein content of the wheat genotypes studied, compared to the mean value
Source: Original figure.

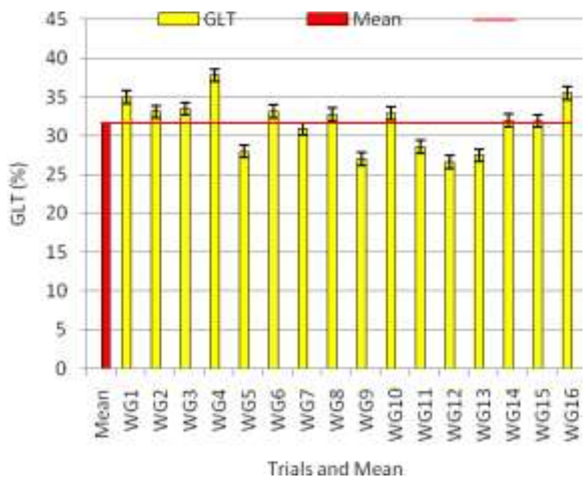


Fig. 3. Graphic representation of the gluten content of the wheat genotypes studied, compared to the mean value
Source: Original figure.

In the case of single kernel hardness (SKHRD), the mean value of the index was 47.63±0.93, and the studied genotypes presented differentiated values, figure 4. With the highest value was positioned WG1 (54.00±0.93), followed by WG4, WG6, WG3, WG5, WG2, WG7.

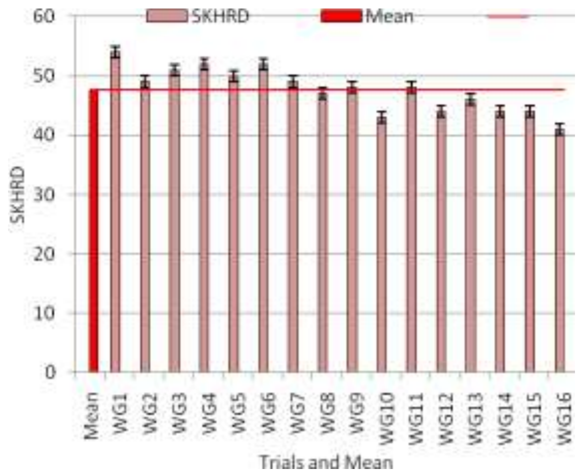


Fig. 4. The graphic representation of the values of the SKHRD index compared to the mean value for the studied wheat genotypes
Source: Original figure.

In the case of the weight of 1,000 grains (TKW), the mean calculated value was 39.23±1.06 g, and the genotypes showed variable values compared to the mean value, Figure 5. The highest value was recorded at WG6 (44.00±1.06 g), followed by WG3 and WG7 (tied), WG2 and WG15 (tied), WG12, WG1 and WG4 (tied), WG11.

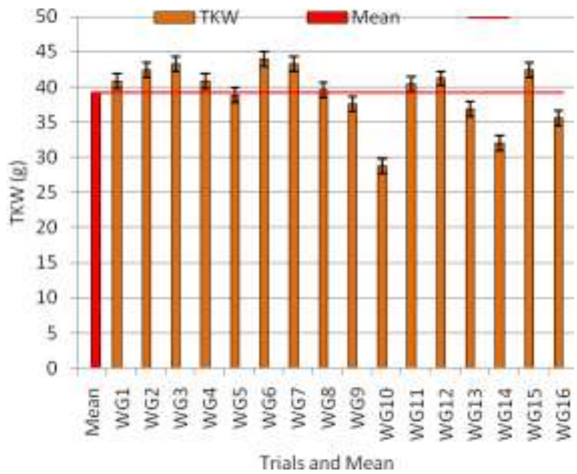


Fig. 5. Graphical representation of the TKW index values compared to the mean value for the studied wheat genotypes
Source: Original figure.

In the case of the hectoliter weight (HW, kg hl^{-1}), the calculated mean value was 72.85±0.62 kg hl^{-1}, and the studied genotypes recorded differentiated values (Figure 6).

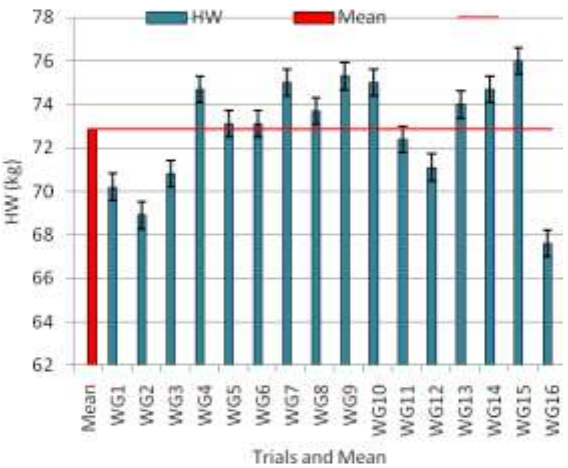


Fig. 6. The graphic representation of the HW index values compared to the mean value for the studied wheat genotypes
Source: Original figure.

The highest value was recorded in trial WG15 (76.00± 0.62 kg hl^{-1}). With values above the calculated mean, in descending order, WG9, WG7 and WG10 (with equal values), WG4 and WG14 (with equal values), WG13, WG8 etc., were positioned.

In the case of moisture (MST, %), the calculated mean value was 14.52±0.62%. Compared to the mean value, high values were recorded in WG1, WG2, WG3, followed by WG4 and WG5. The higher moisture was associated with the phenomenon of plants lodging, a phenomenon recorded in the respective variants. Moisture is a quality index in relation to the preservation of wheat production, so that the respective variants required drying for preservation. The temperature of the grains, at the time of harvesting, was between 30.30 - 34.30 ±0.29°C.

Correlation analysis was applied to identify interdependence between quality indices. The result is table 3, in which the values of the correlation coefficient and the significance of the correlations are presented.

Table 3. Correlation matrix table

Variable		STARCH	PRO	GLT	SKHRD	TKW	HW	MST	T
STARCH	Pearson's r	—							
	p	—							
PRO	Pearson's r	-0.780^{***}	—						
	p	< .001	—						
GLT	Pearson's r	-0.794^{***}	0.868^{***}	—					
	p	< .001	< .001	—					
SKHRD	Pearson's r	-0.044	-0.214	0.226	—				
	p	0.871	0.426	0.399	—				
TKW	Pearson's r	0.119	-0.224	0.042	0.608^{*}	—			
	p	0.662	0.404	0.879	0.012	—			
HW	Pearson's r	0.243	-0.139	-0.247	-0.037	-0.188	—		
	p	0.364	0.607	0.355	0.892	0.485	—		
MST	Pearson's r	-0.365	-0.084	0.365	0.812^{***}	0.491	-0.305	—	
	p	0.164	0.757	0.165	< .001	0.053	0.25	—	
T	Pearson's r	0.001	0.110	-0.192	-0.538^{*}	-0.807^{***}	0.341	-0.587^{*}	—
	p	0.996	0.684	0.476	0.031	< .001	0.196	0.017	—

Source: Original data.

A statistically safe correlation was recorded between STARCH and PRO ($r = -0.780^{***}$), between STARCH and GLT ($r = -0.794^{***}$), between PRO and GLT ($r = 0.868^{***}$), between SKHRD and MST ($r = 0.812^{***}$), between TKW and T ($r = 0.807^{***}$), between SKHRD and TKW ($r = 0.608^{*}$), between SKHRD and T ($r = -0.538^{*}$), and between MST and T ($r = -0.587^{*}$).

Starting from the recorded correlation levels, regression analysis was used to evaluate the variation of some quality indices.

Protein variation in relation to gluten was described by equation (1), under statistical safety conditions (R^2 = 0.753, $p<0.001$), with the graphical distribution in Figure 7.

$$\text{PRO} = 0.276x + 5.218 \qquad (1)$$

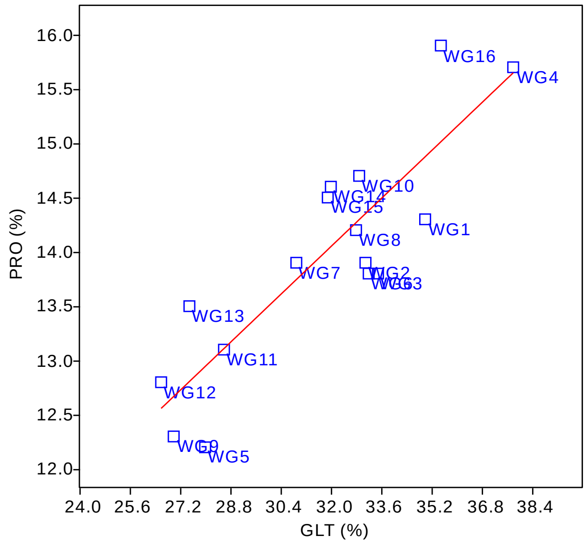


Fig. 7. Graphic variation of PRO according to GLT in the studied wheat genotypes
Source: Original figure.

The variation of the SKHRD index in relation to MST was described by the polynomial equation (2), under conditions of R^2 = 0.760, $p<0.001$, with the graphic distribution in Figure 8.

$$\text{SKHRD} = -0.2439x^2 + 8.637x - 24.97 \qquad (2)$$

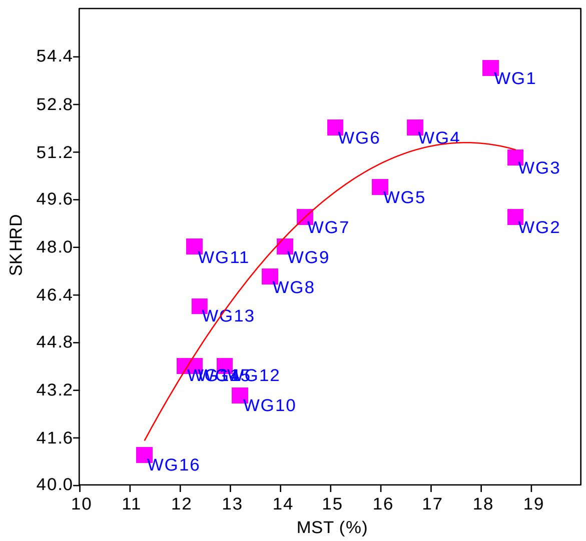
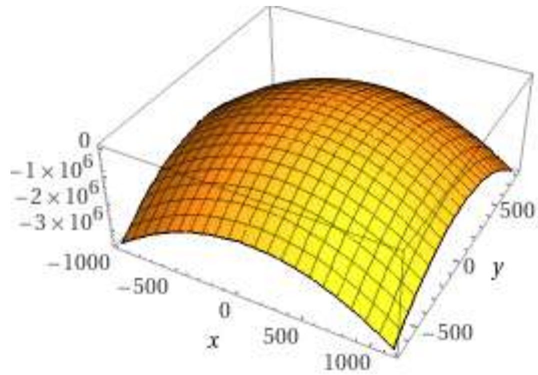


Fig. 8. Graphical distribution of SKHRD in relation to MST in the studied wheat genotypes
Source: Original figure.

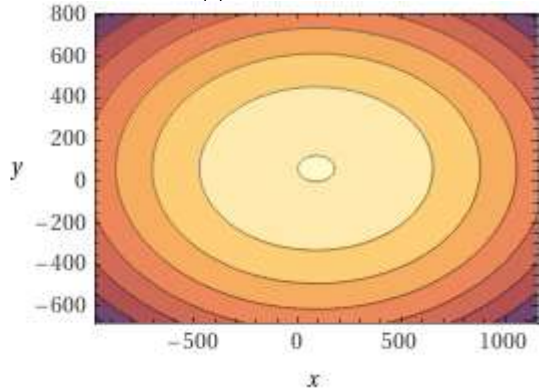
The variation of HW indice, in relation to STARCH and PRO indices, was described by equation (3), in conditions of Multiple R = 0.712, with the graphic representation in Figure 9.

$$HW = ax^2 + by^2 + cx + dy + exy + f \qquad (3)$$

where: HW – hectoliter weight (kg hl^{-1});
x – STARCH (%);
y – PRO (%);
a, b, c, d, e, f – coefficients of the equation (3);
a= -1.61432199;
b= -3.31426973;
c= 286.59803031;
d= 410.56863306;
e= -4.62264263;
f= -12648.259656



(a) 3 D format



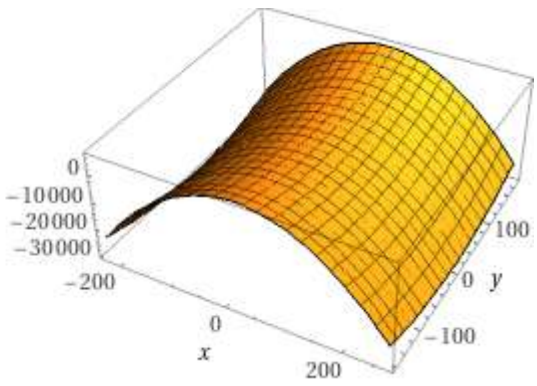
(b) isoquants format

Fig. 9. Representation of HW index variation, according to STARCH and PRO, in wheat grains
Source: Original figure.

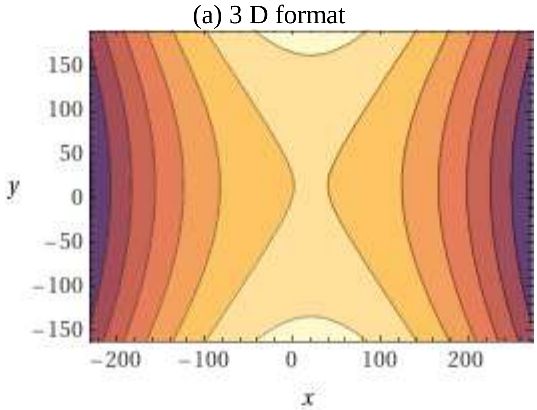
The SKHRD index variation, according to PRO and GLT indices, was described by equation (4), in conditions of R2 = 0.854, $p<0.001$, with graphic distribution presented in Figure 10. Based on the coefficients of equation (4) analysis, as well as the graphic distribution (figures 10 a, b), the differentiated, divergent contribution of the two indices to the variation of the SKHRD index was found.

$$SKHRD = ax^2 + by^2 + cx + dy + exy + f \quad (4)$$

where: SKHRD – index of single kernel hardness;
x – PRO (%);
y – GLT (%);
a, b, c, d, e, f – coefficients of the equation (4);
a= -0.48460726;
b= 0.21856018;
c= 20.25679713;
d= -6.42364576;
e= -0.39564418;
f= 17.80297034



(a) 3 D format



(b) isoquants format

Fig. 10. Graphic representation of the SKHRD index variation in relation to PRO and GLT in wheat grains
Source: Original figure.

Based on the first four wheat grain quality indices (STARCH, PRO, GLT, SKHRD), the studied genotypes were ranked, according to the diagram in Figure 11.

The quality of wheat production is important both for farmers (superior quality means better prices, and facilitates better capitalization on the grain market), as well as for processors, and especially for consumers of finished products [7, 14, 19].

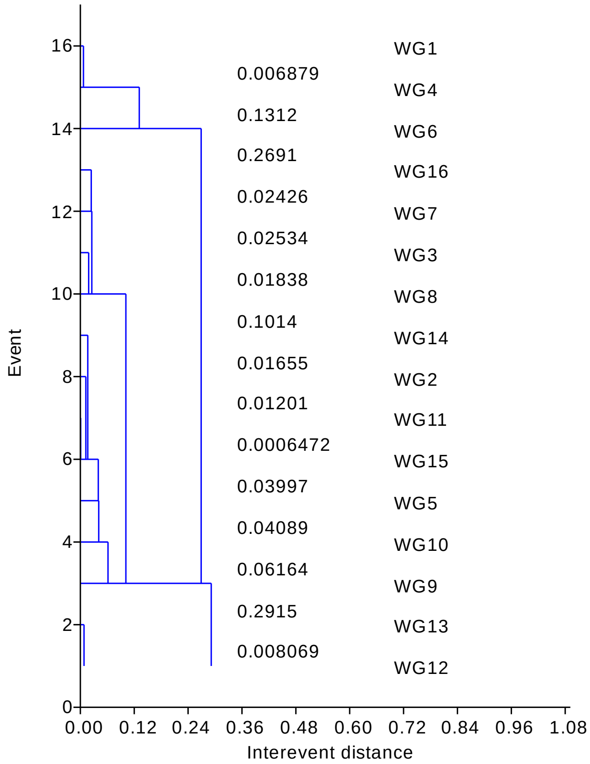


Fig. 11. Hierarchy diagram of the wheat genotypes studied
Source: Original figure.

Quality indices were analyzed individually in relation to different influencing factors, but synthetic quality indices, introduced in some studies, are considered more representative and have been increasingly promoted recently [17].

Quality indices vary in relation to the genotype, but also to the interaction "genotype × technology × environment", so testing wheat genotypes in different agricultural areas is of interest [11, 14, 20].

The classification of genotypes and the wheat genetic base is important for the selection of valuable lines in the breeding process, as well as for agricultural practice [6].

In the conditions of the present study, the quality indices considered showed specific variation for each genotype, in response to the environmental and technological conditions that were uniform for all 16 genotypes.

The recorded information is of interest for the characterization of genotypes, as possible parental forms in breeding programs, as well as for agricultural production, for farmers. The practical applicability, regarding the choice of genotypes in order to be cultivated, has high validity for the study area and neighboring areas, with similar climate and soil conditions. From the aspect of crop technologies, they can differentially influence the yield and quality index values, and can to some extent compensate for the soil and climate conditions, and thus potentiate the genotype towards better quality index values.

CONCLUSIONS

The wheat genotypes generated different values within each quality index, under the study conditions. Based on the obtained results, and the mean values, calculated for each quality indice, one genotype was highlighted, for each index, with the best results; WG9 in the case of starch content (71.10%); WG16 in the case of protein content (15.90%); WG4 genotype in the case of gluten content (37.80%); WG1 genotype in the case of SKHRD (54.00); WG6 genotype in the case of TKW (44.00 g); genotype WG15 in the case of HW (76.00 kg hl^{-1}).

Variable levels of correlation were recorded, under statistical safety conditions, between STARCH and PRO ($r = -0.780^{***}$), between STARCH and GLT ($r = -0.794^{***}$), between PRO and GLT ($r = 0.868^{***}$), between SKHRD and MST ($r = 0.812^{***}$), between TKW and T ($r = 0.807^{***}$), between SKHRD and TKW ($r = 0.608^{*}$), between SKHRD and T ($r = - 0.538^{*}$), and between MST and T ($r = -0.587^{*}$).

The regression analysis led to mathematical models (linear equations, and polynomial equations), that has described of the certain indices variation. Also, some graphical models vas generated.

Based on the coefficients of equation (4) values, and based on graphical distribution (e.g. figure 10, a, and b), it was found varied contribution of the protein and gluten content (PRO, GLT) to the variation of the SKHRD index.

The ranking of the studied genotypes was done by the Ranking analysis, based on the values of the STARCH, PRO, GLI and SKHRD indexes.

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TOURISM DYNAMICS IN BRAȘOV COUNTY DURING THE COVID-19 PANDEMIC (2020-2023)

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Abstract

This study aims to analyse the evolution of tourism in Brașov County during the COVID-19 pandemic, specifically, the 2020-2023 timeframe. The methods used were qualitative and quantitative. The primary data used were obtained from the National Institute of Statistics (NIS) while the qualitative method included a review of relevant literature and analysis of official documents. The purpose was to see if Brasov County tourism sector was heavily affected by Covid-19 pandemic considering the restrictions and blockages that the industry had to face in that period. The study revealed the fact that Brasov County was very resilient and despite the pandemic which affected tourism businesses, increases were registered in accommodations and tourism arrivals. Important growth was observed in hotels, with occupancy rates increasing from 21.63% in 2020 to 37.41% in 2023, agritourism, 14.63% in 2020 to 19.72% in 2023. The domestic tourists played a significant role, dominating the number of overnights spend, respectively, 1.37 million in 2020 to 2.61 million in 2023 while foreign tourists' overnights reached, from 65,122 to 316,772, representing 386% growth. Nature-based and rural tourism is a key attraction with domestic overnights spent in rural related accommodations reaching 553,466 in 2020 to 842,063 in 2023, both domestic and foreign tourists. Regarding the country's foreign tourists came, Germany led the way, 13,220, followed by Israel, 14,095 and Republic of Moldova with 7,268, in 2022. Brasov's ongoing efforts to improve its tourism infrastructure and expand its offerings are essential for sustaining this growth and strengthening its position as a leading destination for cultural and nature-based tourism in the region.

Key words**:** *rural tourism, Brașov County, Covid-19, tourists, Romania*

INTRODUCTION

In January 2020, the World Health Organization (WHO) announced the COVID-19 outbreak as a global public health emergency. By March 2020, the situation was considered a global pandemic. This lasted until May 5, 2023. This was when WHO announced that COVID-19 no longer met the criteria for a global emergency, though the pandemic itself was not officially declared over [1, 20]. In 2020, worldwide tourism experienced a harsh 72% decline, resulting in 1.1 billion less international tourists, bringing the industry back to levels last seen 30 years ago. Governments implemented various strategies to mitigate the impact of COVID-19 on the tourism sector, beginning with widespread border closures and lockdowns to limit virus transmission. As recovery efforts began, policies focused on facilitating safe travel through initiatives like the European Union's Digital COVID Certificate, which standardized health protocols across member states. Countries such as Greece adopted risk-based border management, using targeted testing rather than blanket quarantines. Financial measures, including subsidies, tax relief and liquidity support, were crucial in sustaining tourism businesses. Additionally, governments promoted domestic tourism to compensate for reduced international travel, and introduced worker protection schemes to preserve employment within the sector [21]. By 2022, the industry showed signs of recovery, with 900 million tourists traveling internationally-double the number from 2021-reaching 63% of pre-pandemic levels, whereas Europe and the Middle East led the way with nearly 80% and 83% recovery rates [18]. In Romania, prior to Covid-19, 2019 marked a peak for tourism industry; 13.37

million tourist arrivals and more than 30.08 million overnight stays were recorded [13]. However, by 2020, the pandemic led to a dramatic 53% decline in tourist arrivals, a 51.65% reduction in overnight stays and a significant drop in international tourist flows by 83.2%, forcing the industry to quickly pivot and focus on domestic tourism to mitigate the impacts [12].

In the following years, 2021-2024, Romanian tourism learned to adapt and registered increases in tourism sector. Tourist arrivals, both domestic and international, in Romania showed an optimistic recovery from the impact of COVID-19, increasing from 9.28 million in 2021 to 13.65 million in 2023, with the trend continuing into 2024 as 2.47 million arrivals were recorded in the first quarter alone [16].

In 2020, the same year WHO declared Covid-19 as global pandemic, Romanian tourists rediscovered the beauty of nature and landscapes by spending their leisure escapades at the mountains, in cultural places, rural areas or seaside [12]. In times of crises, nature offers diverse possibilities, providing both material and non-material benefits that enhance endurance and well-being [3].

In this regard, Brașov County, located in the heart of the Carpathian Mountains, has an array of natural attractions. This includes forests, mountains, valleys and other landscapes that represents nature's beauties. Brașov County has 5,363 km² [5] and a population of 641,194 inhabitants as per January, 2024 [9]. It is a county that owns 66 protected areas; two national parks, Piatra Craiului and Bucegi, representing 57% of the county's area [5]. Brașov is a well-known tourist destination in Romania and offers a wide range of touristic activities. For example, Poiana Brașov is the most visited ski resort in the country having a length of 25 km [5].

In 2023, Brașov County ranked third place in Romania, attracting 1.51 million visitors, following Bucharest with 1.8 million and Constanța with 1.57 million visitors [15]. Brașov has also been recognized as a top global tourist destination for 2024 by the British travel platform Tripadvisor. It had wide media exposure, including BBC, as consequence, Brașov had drawn attention from international travellers. It is ranked 21st on Tripadvisor's list and sits near cities like: Tokyo, Nairobi, Casablanca. This position is based on around 1 billion reviews from global travellers. The Tripadvisor award called 'Best of the Best' happens annually [14].

Brasov County offers a large range of accommodation units for tourists: hotels, motels, inns, tourist and agro-tourist guesthouses, apartments, chalets etc [8].

In this context, this study aims to explore the dynamics of tourism in Brașov County during COVID-19 pandemic, precisely on the years 2020-2023 in order to see if the county was affected in terms of accommodations and tourist arrivals. 2020 was the worst year for international tourism with many businesses closing, reducing operations, cutting staff and suffering significant revenue losses [13] while the year 2023 marked the end of Covid-19 as global emergency [20].

The paper seeks to identify key trends and patterns that emerged in response to the challenges posed by the pandemic, based on data related with accommodation facilities, capacity and tourist arrivals within the county. The goal is to provide a comprehensive understanding of how the tourism sector in Brașov evolved during this critical period.

MATERIALS AND METHODS

This study utilized a combination of qualitative and quantitative research methods to explore the dynamics of tourism in Brașov County throughout the COVID-19 pandemic, with a focus on the years 2020 to 2023. The primary data utilized in this analysis were obtained from the National Institute of Statistics (NIS).

A time-series analysis was employed to track and compare key indicators, such as the number of tourist accommodations, changes in lodging capacity and shifts in tourist preferences, between the pre-pandemic period (2020) and the post-pandemic recovery phase (2023). In addition to quantitative analysis, qualitative methods included a review of relevant literature, data collection from accessible studies and analysis of official documents. The data were processed into tables and graphs, which were then interpreted to identify significant trends and patterns that emerged in response to the challenges posed by the pandemic.

RESULTS AND DISCUSSIONS

The varieties of tourism experiences available to visitors in Brașov County:

Mountain tourism. Mountain tourism involves travel and recreational activities within specific geographic areas like hills or mountains, characterized by unique landscapes, topography, climate and biodiversity, as well as distinct local communities. It includes a variety of outdoor leisure and sports pursuits [19].

Brașov County, with its extensive mountainous terrain, is a premier destination for mountain tourism in Romania, offering pristine natural environments and rich biodiversity. The region's major massifs- Piatra Mare, Bucegi and Piatra Craiului- provide diverse outdoor activities such as hiking, skiing and paragliding, complemented by accommodations ranging from rustic cabins to modern guesthouses [7].

Photo 1. Piatra Craiului Region
Source: Butler (2020), https://www.argophilia.com/news/piatra-craiului/293/[6].

Protected areas like Piatra Craiului and Bucegi represents a high factor for sustainable ecotourism and adventure tourism [4].

Cultural tourism. Cultural tourism implies heritage, representing the physical landmarks as well as the cultural traditions of a society [11]. Cultural tourism has gained a lot of attention in the last years. In Romania, Brașov emerged as a prominent destination because of its historic sites, such as: the Black Church, The Council House, medieval fortifications, the Museum of the First Romanian School or St. Nicholas Church. Nearby towns, such as: Făgăraș, with its medieval fortress and Bran, famous for its castle, together with Râșnov, Rupea and Feldioara, known for their peasant fortresses, also draw many visitors. The villages, such as: Viscri, Prejmer, Hărman, added to the region's appeal, especially with Viscri and Prejmer recognized as UNESCO World Heritage sites, along with Sâmbăta de Sus, home to an Orthodox Monastery. Beyond these cultural attractions, there are other cultural sites throughout the county that are to be incorporated into tourist itineraries [2].

As far as ecotourism, this type of tourism puts a focus on responsible exploration of natural areas implying also aspects, such as: protecting the environment, improving the well-being of local communities and providing educational opportunities for both tourists and residents [17]. Brașov County is well-suited for ecotourism because of the diversity of nature landscapes and numerous protected areas. An example is Piatra Craiului National Park, known for rocky formations, karst landscapes and rare species such as the Piatra Craiului carnation and the chamois. Beyond these attractions, Brașov offers a variety of tourism experiences.

Rural tourism. Rural tourism has seen significant growth, particularly in Viscri, a village within the Bunești commune. Over the past decade, Viscri has gained recognition for its rural tourism, largely due to the promotion by HRH Prince Charles and its feature in the documentary "Wild Carpathia," as well as initiatives by the Mihai Eminescu Trust. Today, the fortified church in Viscri draws over 15,000 visitors each year, serving as a gateway to the area's stunning landscapes and rich cultural, historical, and traditional heritage. Visitors are warmly received, offered comfortable accommodations, and treated to genuine hospitality by their hosts [2].

Additionally, Brașov is one of the few regions in Romania where culinary tourism is thriving, particularly through truffle hunting

with dogs, an activity practiced in areas such as Viscri-Bunești and Plaiu Foii near Râșnov.
In Viscri, this activity is often paired with gourmet cooking classes.

Table 1. Distribution and evolution of tourist accommodation structures by type in Brașov County, 2020-2023 (No. units)

Type	2020	2021	2022	2023
Hotels	118	121	120	121
(%)	13.1	10.0	9.8	9.7
Hostels	25	25	23	19
(%)	2.8	2.1	1.9	1.5
Apartments and rooms for rent	:	306	350	398
(%)	0.0	25.4	28.5	31.8
Apartment hotels	3	3	3	2
(%)	0.3	0.2	0.2	0.2
Motels	9	9	9	9
(%)	1.0	0.7	0.7	0.7
Tourist villas	77	69	64	57
(%)	8.5	5.7	5.2	4.5
Tourist cabins	36	33	34	34
(%)	4.0	2.7	2.8	2.7
Bungalows	5	6	6	11
(%)	0.6	0.5	0.5	0.9
Vacation villages	2	1	1	2
(%)	0.2	0.1	0.1	0.2
Campsites	2	2	6	6
(%)	0.2	0.2	0.5	0.5
Tourist cottages	3	4	2	4
(%)	0.3	0.3	0.2	0.3
Student and preschool camps	1	1	1	1
(%)	0.1	0.1	0.1	0.1
Tourist inns	242	240	230	217
(%)	26.8	19.9	18.7	17.3
Agritourism guesthouses	379	387	380	372
(%)	42.0	32.1	30.9	29.7
Total units	902	1,207	1,229	1,253

Source: National Institute of Statistics (NIS), 2020-2023 [10].

Despite its rich culinary heritage, including unique dishes like pumpkin seed soup and soups soured with cabbage juice, these traditions are largely known only to the elderly; *authentic experience tourism* - includes thematic tours, stays at accommodations where guests can participate in preparing traditional dishes and visits to workshops where tourists can interact directly with artisans, such as the blacksmith shop and brickworks in Viscri or the Museum of Textiles and Stories in the village of Mandra and *business tourism* - MICE tourism (meetings, incentives, conferences, and exhibitions) has expanded in mountain resorts like Poiana Brașov and Predeal, which offer large hotels and event spaces ideal for conferences and teambuilding. The Bran-Moieciu-Fundata area is also suitable for such events, with new large accommodations [2].
These diverse options highlight the county's rich natural landscapes, cultural heritage and commitment to sustainable travel.
However, the success and expansion of tourism in Brașov are highly dependent on the infrastructure available, including transportation networks, accommodation options, tourism service quality and hospitality, hygiene and diversity in terms of tourist experiences. The region's ability to support various forms of tourism is closely tied to these factors, which play a crucial role in attracting and accommodating travellers.

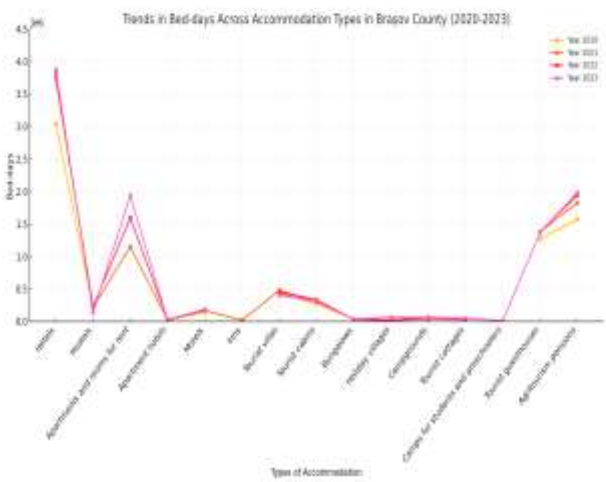

Fig.1. Dynamics of operational tourist lodging capacity by different types of accommodation structures, Brașov County, 2020-2023
Source: Own determination.

Between 2020 and 2023, Agritourism Guesthouses consistently led the accommodation market in Brașov County, although their share decreased from 379 units (42.0%) in 2020 to 372 units (29.7%) in 2023.
Tourist Inns followed, with a decline from 242 units (26.8%) in 2020 to 217 units (17.3%) in 2023.
Conversely, Apartments and Rooms for Rent saw significant growth, rising from 306 units (25.4%) in 2021 to 398 units (31.8%) in 2023.

Hotels remained stable around 120 units, though their share dropped from 13.1% in 2020 to 9.7% in 2023.

Traditional accommodations like Tourist Villas and Hostels declined in both absolute numbers and percentage share over the period.

Table 2. Operational tourist lodging capacity by types of accommodation structure, Braşov County, 2020-2023 (Places days)

	Period			
	2020	2021	2022	2023
Types of tourist reception structures	Places-days	Places-days	Places-days	Palces-days
Hotels	3,046,850	3,726,801	3,806,680	3,869,619
Hostels	212,413	220,563	221,594	140,151
Apartments and rooms for rent	:	1,146,972	1,594,852	1,936,822
Apartment hotels	13,862	28,748	31,012	24,168
Motels	152,039	170,228	178,031	188,170
Inns	:	1,770	:	:
Tourist villas	432,856	477,950	449,243	404,022
Tourist cabins	273,407	310,961	335,054	315,977
Bungalows	33,842	34,190	32,090	36,370
Holiday villages	20,304	16,752	17,520	64,172
Campgrounds	69,344	42,944	64,296	62,667
Tourist cottages	23,540	31,404	33,084	49,110
Camps for students and preschoolers	:	:	:	11,174
Tourist guesthouses	1,267,921	1,375,239	1,376,365	1,368,533
Agritourism pensions	1,574,004	1,825,076	1,945,629	1,980,865

Source: National Institute of Statistics (NIS), 2020-2023 [10].

Between 2020 and 2023, Braşov County's tourism sector exhibited strong growth, particularly in the hotel industry, where bed-days increased by 26.9%, from approximately 3.05 million to nearly 3.87 million (Table 2). This growth highlights the centrality of hotels in the region's accommodation landscape, likely driven by a rebound in travel post-COVID-19.

Hostels and tourist villas showed more volatile trends. Hostel bed-days peaked at 221,594 in 2022, dropped to 140,151 in 2023, reflecting potential shifts in travellers' preferences towards more private or alternative accommodations.

Similarly, tourist villas experienced a decline from 449,243 bed-days in 2022 to 404,022 in 2023. Agritourism pensions, on the other hand, saw a significant rise of 26.11%, growing from 1.57 million bed-days in 2020 to 1.98 million in 2023. This increase suggests a growing interest in rural and experiential tourism, thus aligning with sustainability and local experiences.

Table 3. Arrivals in different accommodation structures in Braşov County, 2020-2023

Types of tourist reception structures	Types of tourists	Periods			
		2020	2021	2022	2023
		No. of people	No. of people	No. of people	No. of people
Hotels	Romanian	378,173	550,370	662,311	676,920
	Foreign	20,492	38,384	78,074	115,532
Hostels	Romanian	11,452	12,501	12,817	13,171
	Foreign	815	961	1,015	1,553
Apartments and rooms for rent	Romanian	:	117,937	193,695	227,564
	Foreign	:	4,760	9,049	20,940
Apartment hotels	Romanian	1,584	3,355	3,283	2,899
	Foreign	6	28	117	36
Motels	Romanian	17,531	11,313	12,549	18,840
	Foreign	312	154	199	694
Inns	Romanian	:	407	:	:
Touristic villas	Romanian	41,756	56,517	54,568	50,202
	Foreign	594	916	1,990	3,680
Tourist cabins	Romanian	21,190	25,925	27,589	35,266
	Foreign	110	423	746	1,612
Bungalows	Romanian	1,804	2,498	2,404	2,848
	Foreign	280	427	505	620
Holiday Villages	Romanian	757	1,145	1,555	15,907
	Foreign	:	:	:	454
Campgrounds	Romanian	638	501	1,436	1,976
	Foreign	:	:	401	309
Tourist cottages	Romanian	182	442	682	2,963
	Foreign	:	46	:	300
Tourist guesthouses	Romanian	104,859	137,422	143,977	156,001
	Foreign	3,255	6,115	11,145	14,741
Agritourism pensions	Romanian	118,860	176,481	180,543	185,495
	Foreign	821	2,185	4,354	6,156

Source: National Institute of Statistics, 2020-2023 [10].

Despite Covid-19 travel restrictions, in the time frame of 2020 and 2023, in Braşov County tourists' arrivals almost doubled, from 725,471 in 2020 to 1,556,679 in 2023, showing 114,57% growth.

This growth was consistent in hotel accommodations, 378,173 in 2020 to 676,920 in 2023 but also in rural related accommodations such as agritourism pensions, where arrivals were 118,860 in 2020 and went up to 185,495 in 2023 (Table 3).

International tourism showed growing by 524.42% (Table 4) where hotel arrivals was 20,492 in 2020 and reached 115,532 in 2023. Tourist villas, 42,350 in 2020 to 53,882 in 2023, domestic and international arrivals along with tourist cabins and even bungalows saw growth thus reflecting the interest of tourists in this type of accommodations.

For tourist arrivals percentage, 2020 versus 2023, it was taken 2020 as the year Covid-19 was declared global pandemic and 2023 as the year Covid-19 no longer qualified as a global emergency.

Table 4. Arrivals in Brasov County in 2020 and 2023

Category	2020	2023	2020 versus 2023 (%)
Romanian tourist arrivals	698,786	1,390,052	98.92%
Foreign tourist arrivals	26,685	166,627	524.42%
Total tourists' arrivals	725,471	1,556,679	114,57%

Source: National Institute of Statistics, 2020 and 2023 [10].

Per all, this trend suggests a growing interest among tourists in rural and experiential travel, likely driven by a desire for more authentic and nature-oriented experiences.

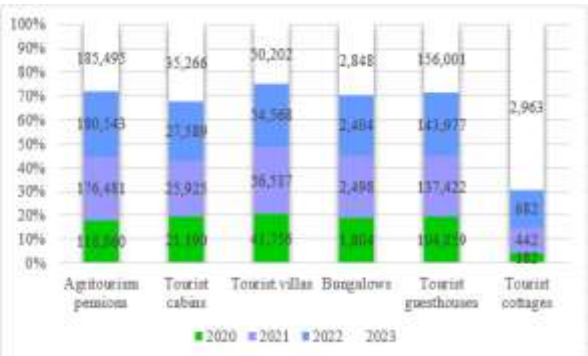

Fig. 2. Romanian tourist arrivals in rural accommodations, Brașov County, 2020-2023
Source: Own determination.

Figure 2 shows a steady increase in Romanian tourist arrivals across various rural accommodations in Brașov County from 2020 to 2023, with agritourism pensions leading at 185,495 arrivals in 2023.

Notably, tourist guesthouses also saw significant growth, reaching 156,001 arrivals by 2023, while smaller categories like cottages, though less popular, demonstrated consistent growth.

Figure 3 shows significant growth in foreign tourist arrivals in Brașov County's rural related accommodations. Tourist guesthouses and agritourism pensions leading the way.

Tourist guesthouses registered 3,255 foreign arrivals in 2020 but in 2023, the numbers went up to 14,741.

Agritourism pensions also experienced notable growth, with arrivals rising from 821 in 2020 to 6,156 in 2023.

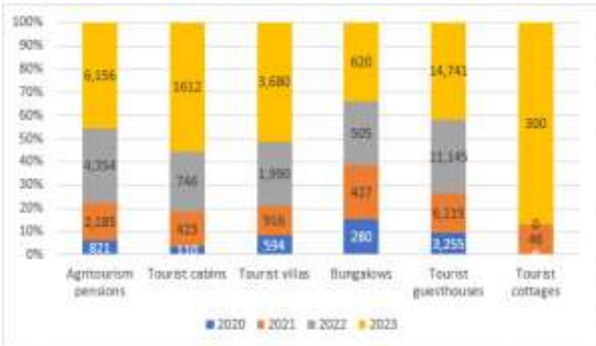

Fig. 3. Foreign tourist arrivals in rural accommodations, Brașov County, 2020-2023
Source: Own determination.

Table 5. Overnights spent in Brașov County, in the timeframe 2020-2023

Year	Romanian	Foreign	Total
2020	1,370,142	65,122	1,435,264
2021	2,111,056	118,279	2,229,335
2022	2,407,697	209,175	2,616,872
2023	2,615,651	316,772	2,932,423

Source: National Institute of Statistics, 2020-2023 [10].

Table 6. Overnights spent in Brasov County in 2020 and 2023

Category	2020	2023	2020 versus 2023 (%)
Romanian overnights	1,370,142	2,615,651	91
Foreign overnights	65,122	316,772	386
Tourists' overnights (total)	1,435,264	2,932,423	104

Source: Own determination.

Though 2020 was a year severely affected by the global travel restrictions, tourist overnights showed resilience, with 1,370,142 in domestic overnights and 65,122 in foreign overnights spent in Brasov County (Table 5). Although foreign tourists made a smaller portion of visitors, their overnight stays represented a 386% growth in 2020 versus 2023 calculation (Table 6). The overall number of overnight stays doubled, rising from 1,435,264 in 2020 to 2,932,423 in 2023, an increase of 104%. These figures demonstrate the robustness of Brașov's tourism sector and its capacity to attract an increasing number of both Romanian and foreign visitors, even in challenging times.

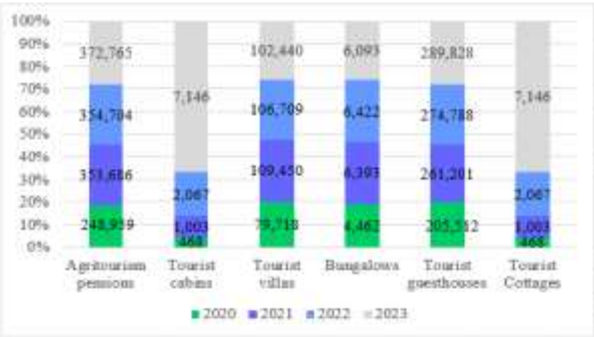

Fig. 4. Overnights in rural accommodations (Romanian tourists), Brașov County, 2020-2023
Source: Own analysis.

Romanian and foreign tourist overnights in rural tourism related accommodations within Brașov County between 2020 and 2023 reveals the dynamics of rural tourism related accommodations in the period 2020-2023, showing a steady increase in overnight stays among Romanian tourists across all types of rural accommodations and a markedly different pattern compared to Romanian tourists.

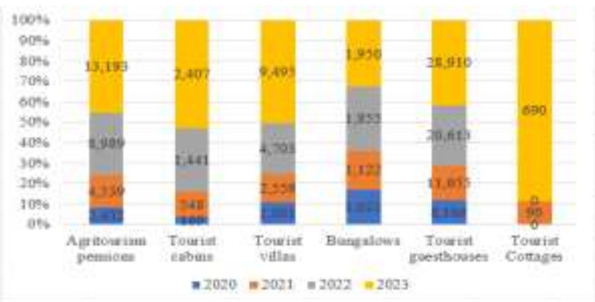

Fig. 5. Overnights in rural accommodations (foreign tourists), Brașov County, 2020-2023
Source: Own analysis.

Agritourism and tourist guesthouses led the way also in the number of overnights stays for both Romanian and foreign tourists. For both types of tourists, tourist guesthouses registered 213,678 overnights in 2020 and 318,738 in 2023 while agritourism pensions registered 251,391 overnights in 2020 and 385,958 in 2023 (Figure 4 and Figure 5).

Table 7. Utilization net index of accommodation capacity in Brașov County, 2020-2023

Structure type	2020	2021	2022	2023
Hotels	21.63	30.27	35.36	37.41
Hostels	9.45	12.03	13.04	21.8
Hotel apartments	23.35	23.62	23.55	29.04
Motels	21.5	12.11	13.68	19.45
Touristic villas	16.99	23.38	25.01	28.09
Tourist cabins	12.76	13.85	13.87	20.06
Bungalows	16.19	21.69	25.93	22.78
Holiday villages	6.72	13.83	17.76	42.1
Campgrounds	2.18	2.18	9.58	7.85
Tourist cottages	2	3.01	5.53	15.53
Tourist guesthouses	15.8	19.83	21.58	23.29
Agritourism pensions	14.63	19.75	18.82	19.72

Source: Own determination.

Accommodation use in Brașov County also grew. Hotel occupancy had an increased from 21.63% in 2020 to 37.41%, in 2023. Other structure types saw important growth, tourist cottages, from 2% in 2020 to 15.53% in 2023, holiday villages, from 6.72% in 2020 to 42.1% in 2023 while tourist guesthouses and agritourism pensions remain at relatively normal values, between around 14% in 2020 to 20% in 2023.

Table 8. Main countries of tourists' origin visiting Brașov County, 2020-2022

Country	2020	2021	2022
Germany	3,745	7,563	13,220
Israel	1,993	4,499	14,095
Moldova	2,396	2,774	7,268
Italy	1,431	3,287	5,258
Ukraine	923	1,799	5,450
France	1,753	3,704	5,168
Poland	1,193	4,378	5,116
Switzerland	203	624	974
Turkey	383	639	1,342
Austria	384	890	1,628

Source: National Institute of Statistics (NIS), Brașov [9].

From 2020 to 2022, thousands of foreign tourists entered and visited Brașov County, Germany led the way with 3,745 in 2020 and grew up to 13,220 in 2023. Israel and Moldova also recorded notable growth, reaching 14,095 and 7,268 visitors respectively, by 2022.

Table 9. National Ranking of Brasov County in the timeframe 2020-2022

Description	2020	2021	2022
Units existing accommodations	1	1	2
Capacity existing accommodations	2	2	2
Capacity accommodations in function	2	2	2
Accommodated tourists	2	2	3
Accommodated Romanian tourists	2	2	2
Overnights stays in accommodations with touristic reception	2	2	3

Source: National Institute of Statistics, Brașov County [10].

Brașov County maintained a strong national ranking in tourism from 2020 to 2022. It consistently held the 2nd position in available and operating lodging capacity, indicating robust infrastructure. While it was the leader in the number of tourist accommodations in 2020 and 2021, it dropped to 2nd place in 2022. The county also saw a decline in overall and domestic visitor rankings in 2022, moving from 2nd to 3rd place, suggesting increasing competition or shifting tourist preferences within Romania. These shifts highlight the need for strategic adjustments to maintain competitiveness.

CONCLUSIONS

The tourism sector in Brașov County demonstrated significant resilience and adaptability during the COVID-19 pandemic, showing strong recovery and growth from 2020 to 2023. The increase in both domestic and international tourist arrivals, along with the notable growth in accommodation capacity utilization, particularly in hotels, holiday villages, reflects a robust resurgence in tourism activity.

Nature-based, cultural and rural tourism continue to be pivotal in attracting visitors, with Brașov’s unique cultural, historical and natural assets drawing significant attention from both national and international tourists. If we refer only to agritourism pensions, domestic tourist arrivals reached 185,495 and foreign tourist arrivals reached 6,156 in 2023. Though the number of foreign tourists seems low compared with Romanian tourists, it grew from year to year in the period 2020-2023. During the challenging times of COVID-19, domestic tourists made a highly significant contribution to the tourism sector in Brașov County. In 2020, tourists’ overnights reached 1,370,142 and continually grew in the following years, 2021 – 2,111,056, 2022 – 2,407,697 and 2023 – 2,615,651.

The county’s ability to sustain high levels of tourism, despite the challenges posed by the pandemic, underscores its importance as a leading tourist destination in Romania.

Brașov's ongoing efforts to enhance its tourism infrastructure and diversify its offerings are crucial for maintaining this growth and further solidifying its status as a premier destination for both cultural and nature-based tourism in the region.

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NEED OF AGRICULTURAL CONSULTANCY PUBLIC SYSTEM FOR FARMERS. CASE STUDY, CĂLĂRAȘI COUNTY, ROMANIA

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Abstract

In the context in which there is talk of "smart agriculture", high precision technique, agriculture with high added value, but also increasingly sophisticated agricultural production marketing schemes, financial instruments available to farmers - the need for them to have access to all these news and innovations. All this is all the more relevant in a country like Romania, whose numerous small and medium-sized farms must produce really intelligently in order to be competitive and to resist the market. The purpose of this study is to identify and analyze the farmers needs regarding agricultural consultancy services, from the point of view of the content of the consultancy but also of the sources they turn to satisfy these needs. In this sense, we initiated a survey based on an interview with 4 questions, on a number of 110 respondents from all categories of existing legal forms in agriculture, with predominant activity - plant growing, and we collected information on the situations in which they appealed to consultancy services, the need for such services, the efficiency of agricultural consultancy services, the sources of information they turn to, etc. The research was based on the method of interview-based survey and χ2 test. Analyzing the answers, it is found that farmers are relatively confused about the source they should turn to for the various types of consultancy regarding their business, the range being heterogeneous in this regard, from Agricultural Chambers, to private consultancy, internet, mass media, etc. These assessments of farmers needs, both in terms of required know-how content and preferred sources of agricultural consultancy, need to be updated and built on. In order to support farmers, it is needed to develop an integrated consultancy system into a regional ecosystem that also includes clusters, universities, information centers, research institutes.

Key words: *agricultural consultancy, farmers, rural area, Common Agricultural Policy, public system*

INTRODUCTION

The agricultural consultancy services represent a vital element in the field of informational and technological transfer in agriculture, providing farmers with information that can contribute to improve their living standard and that of the rural population [4, 20].

The need for farmers to access agricultural consultancy services arises in the context where, in order to run a successful business, they need both knowledge specific to the agricultural field, and skills related to business management, financing, and the implementation of innovations specific to the field [17, 11].

In Romania, agricultural consultancy services were established in the post-communist period and, since then, the system went through countless stages of reform [4, 18]. What it has resulted is a **fragmented system**, with a multitude of institutions offering various atomized services to farmers, **unintegrated**, with institutions that do not communicate with each other and do not coordinate their activities in relation to farmers, and **insufficient** to meet the multiple needs of hundreds of thousands of small and medium farmers, family farms and micro-enterprises they target. At the moment, an agricultural consultant serves more than 4,000 farmers, while the experience of European states shows that an optimal proportion would be one consultant per 65-100 farmers [18, 11].

The public consultancy system consists, at the moment, of only 479 consultants subordinate to the 41 County Agricultural Directorates, that work in the offices in the county residences (about 200 consultants), as well as at the local level, through local centers (about 7-9 municipalities from each county that belong to the local center have agricultural consultants; a total of 279 consultants are distributed at the level of all local centers). [18, 11].

The pace of changes in the economic, technological or social area in which farms operate became, in the 21st century, so fast that farmers and entrepreneurs in the food industry need specialized support to keep up and integrate into their activity all these new technologies, practices and business models [5, 10, 19].

In the specialized literature, the system of knowledge and innovation in agriculture (Agricultural Knowledge and Information Systems - AKIS) is a concept that includes "people, organizations and agricultural institutions involved in the generation, storage, transformation, recovery, integration, dissemination and use of knowledge specific to this field, with the aim of synergistically supporting decision-making, problem-solving and innovation in agriculture" [6].

There is no unified AKIS system in the countries of the European Union. Specifically, each European country has built its own system depending on the institutional structure, the ownership status of research institutions and consultancy organizations, the structure of education, the sources of funding, the characteristics of farms and farmers - their needs and expectations, as well as and the implementation of the Common Agricultural Policy (CAP) and national agricultural policies [1, 3,16].

According to the Ministry of Agriculture and Rural Development (MADR), on the one hand, farmers receive counseling and consultancy services in technical fields - agronomy, animal raising, access to new technologies in the field. On the other hand, consultants provide technical assistance to farmers in order to develop business plans and project proposals to access European funds. [11, 12].

From this last perspective, the consultants provide support to farmers especially in drawing up the necessary files for payments in the case of projects in the financing period. Apart from consultancy and technical assistance services, farmers also benefit from training and professional training courses, adapted to their needs [8, 11].

Some of the stated priorities of the 2014-2020 NRDP was the provision of consultancy and consulting services for farmers, adapted to real market requirements, as well as training, knowledge transfer and innovation in agriculture. This approach also comes against the background of the results of the previous programming period of European funds, 2007-2013, in which the system was considered "insufficiently adapted in terms of CAP requirements, quality and farmers access to agricultural consultancy services [13, 14].

Throughout the 2007-2013 programming period, only 15,717 farmers benefited from support through Measure 143 "Provision of consultancy and consulting services for farmers".

According to SWOT analysis of NRDP 2014-2020, the low rate of achievement recorded at the end of 2013, of only 31.4%, can be attributed to the high degree of complexity of the contracting procedure, as well as to the faulty correlation of the measures whose beneficiaries were those targeted for consultation [14].

Specifically, in the field of agricultural consultancy and counselling, NRDP 2014-2020 aimed at modernizing farms, strengthening competitiveness, sectoral integration, association and short supply chains, innovation, market orientation and promotion of entrepreneurship in rural areas, as well as the implementation of commitments made for environmental and climate measures (agri-environment, ecological agriculture [5,14].

The new framework of public policies and financing of agriculture and rural development through European funds in Romania is the National Strategic Plan (PNS) 2023-2027, which was approved at the end of 2022. According to the PNS, a digital platform will be created, with the role of hub, through which the relevant actors in the field of knowledge and innovation in agriculture are integrated [11,15].

All of these will operate under the MADR umbrella through the AKIS Coordination Unit and there will also be an AKIS Support Unit (which brings together relevant and representative actors for the field from ministries, universities and high schools with an agricultural profile, research institutes, SME- companies with innovative research activities and providers of digital solutions, digital innovation hubs, representative associations of farmers, local action groups, specialized NGOs, etc.) [15].

All this institutional architecture, of programs and funding dedicated to the transfer of knowledge and innovation in agriculture to farmers, can only be evaluated through a juxtaposition with the real needs of farmers in Romania [17, 18].

The purpose of this study is to identify and analyze the farmers' needs regarding agricultural consultancy services, from the point of view of the content of the consultancy but also of the sources they turn to satisfy these requirements.

MATERIALS AND METHODS

The purpose of this study is to identify and analyze the farmers needs regarding agricultural consultancy services, both in terms of the content of the consultancy, respectively, information, training needs, as well as the sources that agricultural entities turn to, respectively, the level of trust granted these sources. The case study was carried out in Călăraşi County, where the public agricultural consultancy service is served by 10 consultants, subordinate to the County Agricultural Directorate. Starting from the reality that farmers need consultancy services for the efficiency on all levels (technical, economic, financial) of the activity carried out, we initiated a survey based on interviews on a number of 110 agricultural entities, with legal forms and different sizes, having in the object of activity also CAEN code 0111 - Growing of cereals (excluding rice), leguminous plants and plants producing oilseeds, located in different areas of Călăraşi county, and we considered the questions: ***Did you use consultancy services for the activity you carry out? In what context, for what problems? What are the main sources you turn to find out about news/changes in the agricultural field? What proposals do you have for making the public agricultural consultancy service more efficient?,*** as edifying to capture the perception of the managers of these agricultural structures on the need and efficiency of the public agricultural consultancy system. Through this approach, we proposed that, in addition to collecting information related to the objective of the study, we would inform the respondents about the role and importance of the activity carried out by these public agricultural consultancy structures. The research was based on the method of questionnaire survey and $\chi2$ test [21].

The questions were structured on 2 levels, respectively, 3 filter questions and 4 questions with open answers, even if the process of completing and analyzing the answers was more difficult, but we aimed for the respondents to answer freely, their answer to reflect the most well the perception of that question, and also to gather other information necessary for the analysis made by this study.

A number of 110 people responded to the interview-based study, applied at the respondents' headquarters, the managers of the agricultural units studied. The age groups were structured in four steps, as follows: up to 30 years, between 31-45 years, between 46-60 years, over 60 years. We have also broken down the size of the farm that they manage in 5 steps, starting with the category of farms that have up to 50 hectares, up to farms/associative structures of over 400 hectares.

In order to evaluate the results of the interview, we used the $\chi2$ ("Chi-square") concordance test, with the aim of determining whether there is a causal relationship between the variables, and then, to take from the $\chi2$ distribution table the value of, theoretical $\chi2$; the obtained results were compared, and it was determined whether or not to reject the null hypothesis [7, 22]. The calculated $\chi2$ was compared with the theoretical $\chi2$ for different probability thresholds.

RESULTS AND DISCUSSIONS

The main natural wealth of Călăraşi county is the agricultural land, in percentage of 84% of the county surface, suitable for the vegetable sector, especially cereal, with very high productions. Through the prism of the comparison between the counties of the South-Muntenia region, Călăraşi county (20.84%) occupies the second place with the most extensive arable surface, after Teleorman (23.10%) [2].

In the rural area of Călărași county, all the agricultural structures that we find at the national level operate, in terms of their legal and associative form. As shown in Table 1, the share is held by the Commercial Companies based on Law 31/1990, followed by small businesses, constituted, from a legal point of view, as Individual Enterprises (I.I.), authorized natural persons (PFA) or family associations.

Table 1. Structure of agricultural entities in Călărași county, in year 2023

Organization form	Number
PFA-Authorized Physical Person, I.I.-Independent Individual/Family associations	537
Agricultural cooperatives	57
Groups of producers	21
Autonomous administrations, jont stock companies	4
Commercial companies base don Law 31/1990	509
Agricultural companies based on Law 36/1991	45
Farmers without legal status	6,458

Source: Călărași County Agricultural Directorate [2].

Among these, as study sample, 110 strucutres were considered, as it is shown in Table 2., most of them being from the caegories that predominate, as organization, at the county level.

Table 2. Structure and share of respondents depending on the juridical form of administered agricultural entity

Juridical form of farm	**No. respondents**	**%**
PFA, I.I., Family association	38	34.5
Commercial company based on Law 31/1990	35	31.8
Agricultural companies based on Law 36/1991	13	11.8
Agricultural cooperative/Group of producers	24	21.9
Total	**110**	**100**

Source: Interview for farmers needs' assessment on public services of agricultural extension in Călărași county [9].

In Table 3, the respondents structure is presented, depending on the farm size they administer. We notice a balanced distribution of the respondents on categories of farms regarding their size, the share is of the farms contained between 100.11 and 200 ha, respectively, 26.37%

Table 3. The structure of the respondents according to the size of the farm

Farm size	UM	Total	
		No.	%
< 50 ha	No	12	*10.91*
	%	100	*X*
50.1 -100 ha	No	26	23.64
	%	100	*X*
100.1 ha-200 ha	No	29	26.37
	%	100	*X*
200.1 ha -400 ha	No	21	19.09
	%	100	*X*
>400 ha	No	22	*19.99*
	%	100	*X*
Total	No	110	*100.0*

Source: Interview regarding the evaluation of farmers needs on public services of agricultural consultancy in Călărași county [9].

Starting from the consideration that the farm manager age has a high influence on accessing consultancy services and different sources of information, we analyzed the sample structure also depending on age, as it is shown in Table 4.

Table 4. Structure and share of respondents according to age

Age group	No respondents	%
< 30 years old	21	19.09
31-45 years old	38	34.55
46-60 years old	33	30.00
>60 years old	18	16.36
Total	**110**	**100**

Source: Interview regarding the evaluation of farmers needs on public services of agricultural consultancy in Călărași county [9].

From the data presented in Table 5., we find that a percentage of 19.09% are under the age of 30 and manage farms of up to 200 ha, and one of them manages an agricultural cooperative that has approximately 400 ha, an encouraging aspect in terms of comparison with the national statistics, according to which the agricultural population is aging. Among those aged between 31-45, a balanced distribution by size category of the farms they manage is found, with the share being in the over 100 ha category. Farms with an area of over 400 ha are mostly owned by those between the ages of 45-60. The $\chi 2$ test, by fitting the value of 20.12 for the calculated Chi, between the values of 17.14 and 20.15 of the theoretical Chi, shows us a significant relationship between the respondents age and farm size they manage.

From the information shown in table 6, we find out that there is a significant correlation between the respondents age, managers of farms and size of farm/associative structure they manage.

Table 5. Analysis of the correlation between the age of the respondents and the size of the farm owned

Age	UM	Farm size (ha)					Total	
		< 50	50.1 -100	100.1 - 200	200.1 - 400	>400	No.	%
< 30 years old	No.	7	6	7	1	0	21	19.09
31-45 years old	No.	3	8	9	9	9	38	34.55
46-60 years old	No.	2	7	8	6	10	33	30.00
>60 years old	No.	0	5	5	5	3	18	16.36
Total	No.	12	26	29	21	22	110	100
	%	10.91	23.64	26.37	19.09	19.99	100	X
Indicators	Test $\chi 2$	Significance threshold						
	≤	0.2	0.1	0.05	0.01	0.001		
Chi theoretical	≥	17.14	20.15	22.16	25.07	28.35	*	
Chi calculated	20,12*							

Source: Own calculations.

Table 6. Analysis of correlations between respondents age and juridical form of farm they manage

Age	UM	The juridical form of the agricultural holding					Total	
		PFA, I.I., family association		Commercial company	Agricultural company	Agricultural cooperative/Group of producers	No.	%
< 30 years old	No.	14		5	1	1	21	19.09
31-45 years old	No.	13		13	5	7	38	34.55
46-60 years old	No.	11		8	3	11	33	30.00
>60 years old	No.	0		9	4	5	18	16.36
Total	No.	38		35	13	24	110	100
	%	34.50		31.80	11.80	21.90	100	X
Indicators	Test $\chi 2$	Significance threshold						
	≤	0.2	0.1	0.05	0.01	0.001		
Chi theoretical	≥	17.14	19.55	23.24	27.19	30.13	**	
Chi calculated	24,31**							

Source: Own calculations.

Thus, the age group of up to 30 years old, manages farms from category PFA, I.I. and family associations in a percentage of about 67% of total respondents of this age category.

Among the 38 respondents in the 31-45 age group, an equal percentage of 34% manage commercial companies and PFA, I.I. and Family Associations and about 18% are chairmen of Agricultural Cooperatives or groups of Producers, which manage large areas of land. The age category 46-60 years, administers in equal percentage both Agricultural Cooperatives or Groups of Producers (having the share in this category) but also companies and PFA, I.I. and family associations. The category of over 60 years old, in percentage of 50% manage commercial companies.

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Test χ2, by fitting the value of de 24.31 for Chi calculated, between values 23.24 and 27.19 of Chi theoretical, show a distinctly significant connection between the respondents age and legal/associative form of the farm they manage.

We mention the fact that we included in the study sample only the respondents who stated that they used consultancy services for the activity they carry out.

In Table 7 we included the problems/situations in which the respondents used consultancy services. The percentage determination was made by relating the number of respondents to the total sample in the respective category. It is found that the majority of farmers, regardless of the form of organization, used consultancy services for the documentation for the establishment of the agricultural structure (84% of the total sample), for accessing European funds and APIA subsidies (79% of respondents), for professional training courses in the field (49%), organized by the County Agricultural Directorates, for the preparation of crop calamity files, etc.

Table 7. Problems/situations in which the respondents used consultancy services, depending on the organization form of the agricultural structure

Crt. No.	Problems/situations mentioned	PFA, I.I., family association		Commercial companies		Agricultural companies		Agricultural cooperative/ Group of producers	
		No.	%	No.	%	No	%	No	%
1	When establishing agricltural entities	35	92.1%	27	77.1%	9	69.2%	21	87.5%
2	Accessin subsidies and European funds	38	100%	31	88.6%	10	76.9%	18	75.0%
3	Professional training courses in the field	19	50.0%	14	40.0%	10	76.9%	11	45.8%
4	Technical information, support in introducing new varieties and hybrids in crop	21	55.3%	7	20.0%	4	30.8%	5	20.8%
5	Informatisation of farm management	7	18.4%	3	8.6%	3	23.1%	7	29.2%
6	Eradication of some diseases and pests of crop	9	23.7%	7	20%	4	30.8%	2	8.3%
7	Purcahse of high performance agricultural equipment and machinery	17	44.7%	13	37.1%	5	38.5%	4	16.6%
8	Preparation of crop calamity files	19	50.0%	9	25.7%	7	53.8%	6	25.0%
9	Other problems/situations	3	7.9%	2	5.7%	1	7.7%	2	8.3%
	TOTAL	38	*	35	*	13	*	24	*

Source: Interview regarding the evaluation of farmers needs on public services of agricultural consultancy, in Călărași county [9].

Regarding the main sources of information that farmers turn to for their activities, as shown in Table 8, the distribution by sources is quite heterogeneous, but most of them mention first the public consultancy service, to which farmers from structures organized in the form by PFA, I.I. and Family Association appeals in 100% percentage, followed by the Internet, the expertise of other farmers and the mass media. Commercial companies call on the public consultancy service (88% of the respondents in this category), participate in trade fairs and profile exhibitions, call on the mass media and use the Internet. And agricultural companies put the public consultancy service first (77% of the group's respondents), followed by mass media and the Internet. Regarding Agricultural Cooperatives/Group of Producers, in the first place in terms of sources of information, they mention participation in fairs and profile exhibitions, the Internet, private consultancy firms and then the public agricultural consultancy service, which they say they receive a lot of or too general and non-specialized information.

Table 8. Main sources used by farmers for information about news/changes in the agricultural field, depending on the organization form of agricultural structure

Crt. No.	Problems/situations mentioned	PFA, I.I., family association		Commercial companies		Agricultural companies		Agricultural cooperative/Group of producers	
		No.	%	No.	%	No	%	No	%
1	Internet	27	71.1%	11	31.4%	8	61.5%	15	62.5%
2	Mass-media	17	44.7%	19	54.3%	9	69.2%	9	37.5%
3	Participation in profile fairs and exhibitions	14	36.8%	25	71.4%	5	38.5%	23	95.8%
4	Firms of private consultancy	2	5.3%	6	17.1%	1	7.7%	11	45.8%
5	Public service of consultancy	38	100%	31	88.6%	10	76.9%	8	33.3%
6	Expertise of other farmers	19	50.0%	4	11.4%	3	23.1%	2	8.3%
7	to experts in profile universities	3	7.9%	3	8.6%	1	7.7%	3	12.5%
8	Other sources	2	5.3%	2	5.7%	1	7.7%	2	8.3%
	TOTAL	38	*	35	*	13	*	24	*

Source: Interview regarding the evaluation of farmers needs on public services of agricultural consultancy, in Călărași county [9].

Table 9. main proposals on efficiency of public service of agricultural consultancy, depending on organization form of agricultural structure

Crt. No.	Problems/situations mentioned	PFA, I.I., family association		Commercial companies		Agricultural companies		Agricultural cooperative/ Group of producers	
		No.	%	No.	%	No	%	No	%
1	Establishing a regional network of physical offices of specialized consultancy	29	76.3%	24	68.6%	10	76.9%	18	75.0%
2	Establishing a network of lots/demonstrative farms	26	68.4%	15	42.9%	8	61.5%	19	79.2%
3	Increasing the number of consultants in the system and increasing their specialization	30	78.9%	19	54.3%	11	84.6%	15	62.5%
4	Organization of round tables, workshops with specialists in the field	21	55.3%	20	57.1%	7	53.8%	20	83.3%
5	Visits of consutants on site	19	50.0%	17	48.6%	7	53.8%	11	45.8%
6	Organization of best practice visists for farmers	21	55.3%	15	42.9%	6	46.2%	5	20.8%
7	Creation of digital platforms, with Access of all farmers	19	50.0%	21	60.0%	4	30.8%	17	70.8%
9	Other proposals	2	5.3%	3	8.6%	1	7.7%	2	8.3%
	TOTAL	38	*	35	*	13	*	24	*

Source: Interview regarding the evaluation of farmers needs on public services of agricultural consultancy, in Călărași county [9].

As shown in Table 9, the farmers have a series of proposals for the efficiency of the public consultancy service, to which approximately 72% of the respondents turn. Among these proposals, the first place is the establishment of a regional network of physical consultancy offices, with 78% of the respondents' opinions, even more so since, from the discussions held with them, they prefer to access the consultancy services individually, on point problems. 75 respondents (68%) mention that it is necessary to increase the number of consultants in the public system but also mention their specialized qualification; 55% of the respondents know the new framework of public policies and financing of agriculture and rural development through European funds, respectively the provisions contained in the National Strategic Plan 2023-2027, according to which a digital platform will be created, with the role of a hub, through which to either integrate the relevant actors in the field of knowledge and innovation in agriculture and support this initiative.

CONCLUSIONS

The research reflects the opinions and experiences of 110 farmers from Călărași county, regarding their assessment of the need and efficiency of the public agricultural consultancy service.

The most important conclusions of the research are:

• All categories of organizational structures in agriculture, and in particular, commercial farms with legal personality, say to a greater extent that they need advice than other forms of organization (agricultural cooperatives/group of producers), the main reason being, the most probably, a better awareness by them of the need for development, which is closely related to access to information and know-how. Most of this category are either young farmers taking over the business from their parents, or farmers who have understood that developing a competitive business in agriculture depends on outside informational support.

• The state consultancy system is requested especially in the field of accessing subsidies and European funds, when setting up the organization, but farmers mention the gaps of this system in the technical field, innovations, marketing, farm management, business or association models.

• About half of the respondents have high and very high trust in the Internet and the media when it comes to information in the agricultural field, but admit that technical information on informal groups on social media can be of questionable quality, as it is not validated by specialists.

• Farmers are dissatisfied that they often receive too general and unspecialized information in a highly fragmented and unmonitored consultancy market in terms of the quality of the services provided.

• In reality small farmers get their information in an ad hoc way from the media, the internet or the community and private providers of consultancy services, provide services on a fee basis especially to large farms and strong agricultural cooperatives

• As the vast majority of farmers prefer to access consultancy services in person, they consider it necessary to strengthen a regional network of physical offices, where farmers can access the widest possible range of information, advice and services. They also support the establishment of a network of demonstration plots/farms, where farmers can practically test various seeds, methods, innovations, etc.

• At the top of farmers' needs in terms of the type of services they need is specific advice on a given problem, being cited by almost three quarters of those who were aware of the need for advice services. Only slightly more than a quarter say they would need vocational training services – short or long courses.

• In reality, the range of DAJ services is less than that presented in official documents by MADR or on DAJ websites. This means qualification courses, grant consultancy, technical monitoring/inspections. Most services are provided in the office, face to face with the applicant, while farm visits are only made in cases of drought or serious crop diseases

•Among the solutions identified by the farmers, in order to make the public agricultural consultancy service more efficient, there are also: increasing the number of consultants, creating regional consultancy centers, but also closer and more homogeneous collaboration with educational and research institutions.

The reality is that small and medium-sized commercial farms need relevant, accessible and easy-to-integrate information in order to survive in the market and grow. And the information, training and consultancy services offered exclusively by the private system (against cost) are physically and financially unavailable for this category of farms, which now get their non-scientifically validated information ad hoc from neighbors, from social media groups or from the press. Many of these farmers still go to county residences and access the few remaining experts within the DAJ for various cases that they sometimes cannot/do not know/do not have the resources to address.

Farmers in Romania need informational support from the state consultancy system, which at the moment is massively under-budgeted and should be invested in - by increasing the number of counselors, but also through their continuous training, to be able to keep up with the rapid developments in the field of contemporary agriculture, strongly digitized.

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DIGITAL MARKETING STRATEGIES BASED ON CONSUMER PERCEPTION OF THE BRAND. *MAGAZIA MORĂRIȚEI* CASE STUDY, IASI, ROMANIA

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Abstract

In the global agricultural landscape, small producers play a crucial role in preserving tradition, fostering resilience, and driving innovation. Despite operating on modest plots of land, they contribute significantly to feeding communities, conserving biodiversity, and sustaining rural economies. This study goes deeper into the world of small producers, focusing on "Magazia Morăriței", a well known brand, renowned for producing ecological bread and other bakery products since the 1990s.Through a mixed-methods approach involving surveys and psychological tests, the study explores consumer perceptions, online engagement, and buying behaviours associated with the brand. The findings reveal that consumers perceive Magazia Morăriței positively, associating it with strong brand personality traits, particularly reflecting the owner's image as a resilient businesswoman. Furthermore, consumers strongly associate the brand with traditional values, quality, and ecological certifications, driving their purchasing decisions. While the brand maintains a significant online presence, there exists a gap between online engagement and physical store visits, suggesting opportunities for improvement in bridging this divide. Moreover, the study unveils the neural networks formed in consumers' minds, highlighting core associations such as good bread, quality, tradition, and yeast bread, which reflect the brand's strong connection with its core products. Additionally, the brand's emphasis on ecological certifications and locally sourced products resonates with consumers, influencing their buying behaviours. Overall, this study underscores the importance of understanding consumer perceptions, leveraging online platforms effectively, and emphasizing brand values to drive consumer engagement and purchasing decisions. By addressing these insights, brands like Magazia Morăriței can enhance their market position and strengthen relationships with consumers, contributing to the sustainable growth of small producers in agriculture.

Key words**:** *consumer behaviour, neural networks, perceptions, small producers, ecological certificate, traditional certificates*

INTRODUCTION

In the sphere of global agriculture, small producers make threads of tradition, resilience, and innovation. These individuals and families, often operating on modest plots of land, play a fundamental role in feeding communities, preserving biodiversity, and sustaining rural economies worldwide. As pillars of agricultural diversity and guardians of traditional farming practices, small producers cultivate crops ranging from heirloom varieties to indigenous staples, enriching the tapestry of our food systems with flavours, textures, and nutritional diversity [12].

Small producers in agriculture are tending to the land with care and respect, mindful of its finite resources and inherent value [11]. Across generations, they have honed their craft, drawing upon traditional knowledge passed down through time-honoured practices. Their intimate connection to the land fosters a deep sense of responsibility, as they navigate the complexities of weather patterns, soil health, and pest management with ingenuity and resourcefulness. Yet, despite their vital contributions to global food security and agricultural sustainability, small producers face a lot of challenges in today's rapidly evolving agricultural landscape [9]. Limited access to resources, including land, capital, and technology, constrains their ability to compete in an increasingly competitive marketplace [4].

In recent years, however, a growing recognition of the unique role and potential of small producers has sparked a renewed focus on empowering and supporting these vital stakeholders. Governments, NGOs, and international organizations are increasingly investing in initiatives aimed at enhancing the resilience, productivity, and market access of small-scale farmers [5]. From sustainable agricultural practices and value-added processing to market linkages and financial services, a lot of interventions seek to unlock the full potential of small producers and foster inclusive agricultural development [15].

Producers could create a coherent value proposition for their agricultural product, having three options for: a producer brand, a geographical brand or a certification brand. All of them are the emblem of quality and encourage consumers to purchase [7].

Nevertheless, the main challenge they all encounter is how to build brand equity and establish a sound positioning strategy.

In this article, we go deeper into the world of small producers in agriculture, by taking an example from Iasi agricultural marketplace and explore their challenges, opportunities, and their marketing strategies. The chosen brand is Magazia Morăriței, a brand which has been on the market since 1990 and it’s a brand which promotes ecological products, also by having ecological certifications for flour and traditional products.

Brand Magazia Morăriței is on the market since the 1990s, and their story starts with an electrician who, unafraid of venturing into unfamiliar territory, decided to explore the world of milling [13]. Residing in the town of Probota, in Iași county, he heeded the encouragement of local residents and embarked on the construction of the commune's first wheat and corn mill with rollers [13]. Over the passage of time, fuelled by diligent labour and unwavering commitment, and happy by the unwavering support of their entire family, the electrician-turned-miller introduced the novelty of cold-pressed sunflower oil to the community [13]. However, his aspirations extended beyond milling alone; a lifelong dream of establishing a bakery lingered in his thoughts. This aspiration was not exclusive to him alone but shared by others as well. Today, it is the daughter of the miller who extends an invitation to savour her dream: an odyssey through childhood. Nowadays, the business has more than just oil and wheat, it extended and today, they produce organically certified flour and also have certified products labelled traditional products [13].

Ecological certificates play a crucial role in giving incentives for sustainable agricultural practices by providing recognition and assurance of environmental trust [8]. These certificates, often issued by third-party organizations or government agencies, certify that agricultural products have been produced using methods that minimize negative environmental impacts and promote biodiversity conservation.

Ecological certificates serve several important functions within the agricultural sector. Firstly, they offer consumers assurance that the products they purchase have been produced in an environmentally responsible manner. This assurance is particularly relevant in today's market, where there is growing consumer demand for sustainably produced goods [1]. Secondly, ecological certificates provide farmers with tangible incentives to adopt and maintain sustainable practices.

By adhering to the standards set forth by certification programs, farmers can access premium markets, command higher prices for their products, and differentiate themselves from competitors [6].

There are various types of ecological certificates tailored to different aspects of agricultural production.

For example, organic certification focuses on the absence of synthetic inputs such as pesticides and fertilizers, as well as the promotion of soil health and biodiversity. Fair trade certification ensures that farmers receive fair prices for their products and adhere to social and labour standards [16].

Despite their benefits, ecological certificates face several challenges and limitations.

One major challenge is the complexity and cost associated with certification processes, which can be prohibitive for small-scale farmers, particularly those in developing countries [3].

Additionally, concerns have been raised regarding the effectiveness of certification programs in achieving meaningful environmental and social outcomes, as well as the potential for greenwashing or certification fraud.

MATERIALS AND METHODS

The research problem is that there is not enough available information regarding how small producers are perceived on the market and whether their marketing is effective.

The scope of this study is to explore the mental connections consumers form by observing the neural networks formed when hearing about a certain brand, in this case, the brand *Magazia Morărișei* and analyse their online presence.

This brand was chosen due to its long living on the market, but also because it promotes a better lifestyle, using ecological products.

The objectives set for this study are:

O1. To identify the brand personality for the brand Magazia Morărișei perceived by consumers.

O2. To identify if social media engagement ends with a visit in the physical store.

O3. To identify the neural networks formed in consumer minds' when faced with the brand Magazia Morărișei.

O4.To identify consumers' buying behaviours for the brand Magazia Morărișei.

In order to find out what was emphasized by the set objectives, a questionnaire was created. This consisted in 13 questions regarding the Magazia Morărișei brand and 5 identifications items.

The questionnaire was distributed on local platforms regarding ecological agriculture like, for example, "Gust de Iași" platform.

There were 123 responses, from which 108 respondents heard of the brand we focus on, and 15 did not hear about it, therefore, leaving our final sample size at 108 respondents.

This study is conducting a quantitative type of study using the survey method. For the interpretations of the results, there were two methods utilized from psychology: the Chinese Portrait method and the Spontaneous Mental Association test.

The Chinese portrait method is a creative exercise where individuals imagine themselves as objects, animals, or characters based on a series of questions. It is often used as a tool for self-reflection and introspection, but it can also be used in marketing, because the method involves answering a set of questions about preferences, personality traits, and characteristics [14]. The answers can be used to construct a portrait of oneself, or as well for a brand. Participants are encouraged to think creatively and metaphorically, drawing parallels between their own attributes and those of the object, animal, or character they choose [2]. Based on the answers given, it is easy to get to know the conscious associations made for certain brands.

The Spontaneous Mental Association test is a psychological tool used to assess unconscious or implicit associations that individuals may have between different concepts or stimuli [17]. It is designed to measure the strength and nature of these associations, which can provide insights into underlying attitudes, beliefs, and biases that may influence behaviour. The test typically involves presenting participants with a series of stimuli, such as words, images, or sounds, and asking them to respond as quickly as possible with the first word or phrase that comes to mind. The respondents were asked to say the first word that comes to their mind when they see the brand Magazia Morărișei.

The spontaneous mental association test is often used in research settings to explore unconscious cognitive processes and attitudes, in order to assess individuals' attitudes and beliefs [10]. It can help researchers and practitioners better understand how individuals perceive and categorize the world around them, and how these perceptions may impact behaviour in various contexts.

RESULTS AND DISCUSSIONS

Findings are going to be displayed based on the objectives set.

O1. To identify the brand personality for the brand Magazia Morărișei perceived by consumers.

Getting to know the brand personality helps because first of all, it humanizes the brand, since our example Magazia Morăriței, already has a human attribute given that it is translated to "Milled Warehouse".

In the constructed questionnaire, there were two questions related to how consumers perceive Magazia Morăriței brand: firstly, they were asked to associate the brand with an important personality, and secondly, they were asked to associate a colour with the brand.

In Figure 1, it is observable the VIPs which had a frequency number higher than 1.

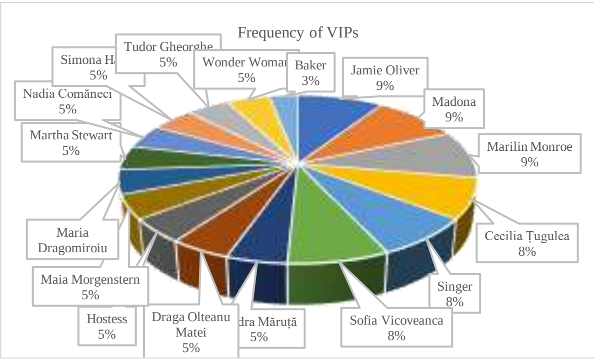

Fig. 1. The VIP distribution for the brand Magazia Morăriței
Source: Own computation in Excel.

The great majority represent names of important people, known in the Romanian actors and singers industry, however, it should highlighted that one of the VIPs which got a high number, is Cecilia Țugulea, which is the actual owner of the business. This shows the fact that consumers know the person behind the brand. Another association made with the owner of the business is the response „Wonder Woman", this shows the fact that consumers perceive Cecilia as being a strong business woman.

There are also some words, which do not necessarily show a VIP, but they mention an occupation, like for example baker, singer and hostess. The words baker and hostess are linked with the area of work, giving the fact that Magazia Morăriței is also baking bread and other types of pastries.

To further interpret the results, the VIPs were taken and divided into grouping fields like gender and occupation.

From Figure 2, it is observable that most of the chosen VIPs are singers or actors, followed by chef, royalty and tennis players. The before mentioned occupations embody one of the most known and popular ones, meaning that the brand is known by the market.

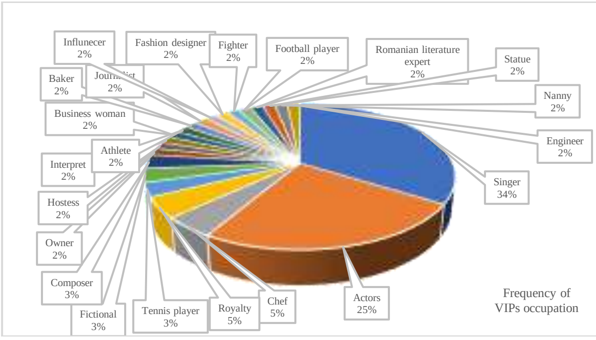

Fig. 2. The VIP's occupation distribution for the brand Magazia Morăriței
Source: Own computation in Excel.

By aligning with singers, the Magazia Morăriței brand is shaping its personality and identity. It may be conveying messages about creativity, passion, or enjoyment by associating with musicians, at the same time, singers often evoke strong emotions and connections with their audience through their music. By associating a brand of traditional products with singers, the brand aims to tap into these emotional connections, hoping that consumers will transfer their positive feelings for the singers onto the bread brand. Since celebrity endorsement is not the case here, an explanation for consumers choosing mostly actors could be that actors often have specific demographics or fan bases that align with certain consumer segments. By selecting actors who appeal to the target audience of the Magazia Morăriței brand, marketers can effectively reach and engage potential customers. For example, if the Magazia Morăriței brand targets families, using actors who are known for their family-oriented roles can resonate with parents and caregivers. The majority of actors are old Romanian actors, which highlights, once more, the Romanian heritage which, the brand wants to portray and deliver to each customer they have.

The majority of mentioned VIPs are women (73%), which can lead to two conclusions: firstly, the brand is perceived as being feminine and secondly, the image of the owner, which is a woman, created a strong association in consumer's minds (Figure 3).

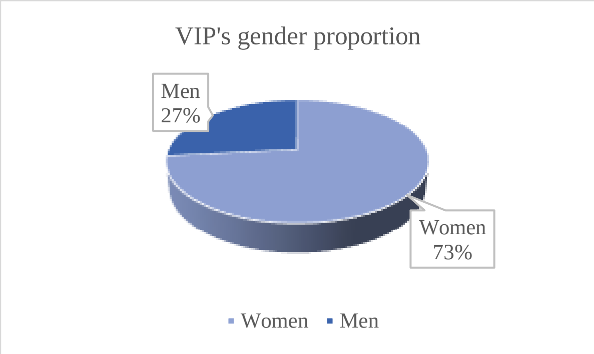

Fig. 3. The VIP's gender distribution for the brand Magazia Morărîței
Source: Own computation in Excel.

When consumers predominantly associate a brand with female characters, it indicates that the brand has successfully positioned itself as a relevant and appealing choice for women, whether through its products, marketing efforts, or brand identity, however, for our brand, its owner is a strong figure, which might influence the perception of the brand.
From Figure 4, it is noticeable the results for the second question asked, regarding consumers perceptions of the brand Magazia Morărîței.
The most mentioned colours are yellow, green and golden.

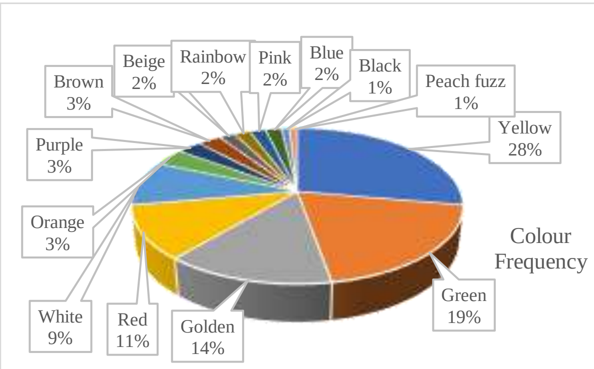

Fig. 4. The colour association distribution for the brand Magazia Morărîței
Source: Own computation in Excel.

The associations with the colours yellow and golden are made, because, the consumers are thinking of the wheat ear and its colours. However, the colour yellow is also linked to creativity, innovation, and originality, which is what its young owner is trying to achieve. The colour green can be associated with nature and environment, it could relate to health and wellness, while also maintaining trust.
Since the brand we investigate has ecological and traditional certifications, the colour green might be chosen because of ecological side of the business, while green is correlated with ecology and fresh products.
The first objective has been met, since consumers perceptions of the brand have been investigated. To conclude, the brand has a strong positioning in the consumers minds', and the owner of the business, is a strong figure, maybe the most important element which makes the consumers buy.

O2. To identify if social media engagement ends with a visit in the physical store.

The brand Magazia Morărîței is present in the online environment. They have a website, a Facebook account, an Instagram account and a TikTok account. Nowadays, it is an opportunity to be present online, since this is increasing the visibility and reachability of the brand.
Consistent and active presence on social media helps businesses build brand awareness and recognition.
By regularly sharing content that reflects their brand identity, values, businesses can establish a distinct personality and image in the minds of consumers, making them more memorable and recognizable.
At the time of creating this research, their online presence is highlighted in Table 1, by showing multiple information regarding the number of followers, how often they post and the number of likes and interactions for their last post.

Table 1. Social media analysis

Social media platform	**Number of followers**	**How often they post**	**Number of likes for the last post**	**Number of comments for the last post**
Facebook	7.8 k	Every two days	7	0
Instagram	1,026	Almost everyday	8	0
TikTok	266	Every six days	16	1

Source: Own processing in Word.

It is evident that even though the brand has an online presence, their customers are not really engaged to reply to posts or like them.

From the questionnaire, we found out that 76% (meaning 82) of respondents follow the brand in the online, while 24% (meaning 26) do not follow the brand in the online environment. From these answers, we wanted to get a more in-depth response, asking them on which social media account they follow the most. From the consumers which responded with yes, we further asked them on which social media platforms they follow the brand the most. In Figure 5, it is visible that most of the people are following the brand on Facebook, followed by Instagram and TikTok. Only one respondent mentioned that they follow the brand on all of the three social media platforms.

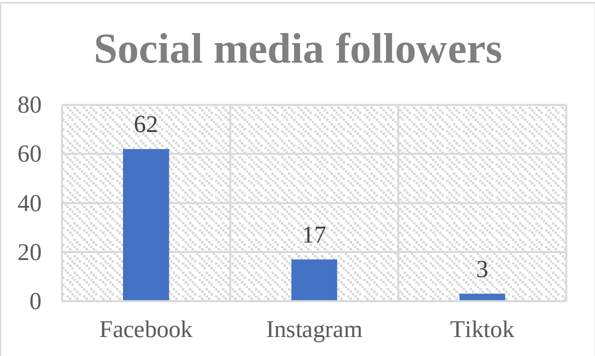

Fig. 5. Social media distribution of followers for the brand Magazia Morăriței
Source: Own computation in Excel.

From those 82 people which responded affirmative to following the brand in the online, 63 also made a visit to the physical store, after seeing a post on the social media. Respectively, 19 of them, did not proceeded with a visit to the physical store.

O3. To identify the neural networks formed in consumer minds' when faced with the brand Magazia Morăriței.

In order to explore the neural networks formed in consumers minds' regarding the brand Magazia Morăriței, the quality of the sample size should be investigated. In table 2, it is observable that the majority of respondents are people working as researchers, in sales, as processors in different products, and as entrepreneurs. The coding for each respondent is done as following: R – comes from respondent, the number after R shows the order of respondents and F or M shows the gender of the respondent.

Table 2. Table showing the quality of the sample size

Respondent no.	**Age Category**	**Gender**	**Occupation**
R1F	45-49	Female	Finance
R2F	35-39	Female	Entrepreneur
R3F	45-49	Female	Medicine
R4F	35-39	Female	Research
R5F	25-29	Female	Economist
R6F	40-44	Female	Art
R7F	40-44	Female	Health
R8F	35-39	Female	Education
R9F	45-49	Female	Research
R10F	40-44	Female	Research
R11F	40-44	Female	Research
R12F	40-44	Female	Research
R13F	40-44	Female	Industry
R14F	35-39	Female	Consultancy
R15F	40-44	Female	Sales
R16F	40-44	Female	Medicine
R17F	40-44	Female	Management
R18F	40-44	Female	Engineering
R19F	45-49	Female	Research
R20F	50-54	Female	Research
R1M	45-49	Male	Research
R2M	40-44	Male	Farmer
R3M	40-44	Male	Research
R4M	40-44	Male	Milk processor
R5M	45-49	Male	Research
R6M	55-59	Male	Research
R7M	35-39	Male	Zootechnics
R8M	50-54	Male	Salesmen
R9M	45-49	Male	Research
R10M	30-34	Male	Meat processor
R11M	30-34	Male	Entrepreneur
R12M	40-44	Male	Academia
R13M	35-39	Male	Economist
R14M	40-44	Male	Salesmen
R15M	45-49	Male	Teacher
R16M	50-54	Male	Agriculturist
R17M	45-49	Male	Economist
R18M	40-44	Male	Pharmacist
R19M	50-54	Male	Public sector
R20M	45-49	Male	Research

Source: Own computation in Excel.

It is observable from Figure 6, that most male respondents thought of quality, tradition, mill, yeast bread and the actual brand when asked about the first word that comes to their mind.

The yeast bread is one of their most known products, while mill and tradition refer to the name of the brand and its time on the market. The word quality shows that this brand is perceived as a very trustworthy one, bringing only high-quality products to their consumers. There were also words related to ecological products, local products, artisanal and certified products, which shows that for the male consumers, the fact that Magazia Morărișei has ecological certifications and traditional certifications, is very important and might be a crucial factor in the buying decision process.

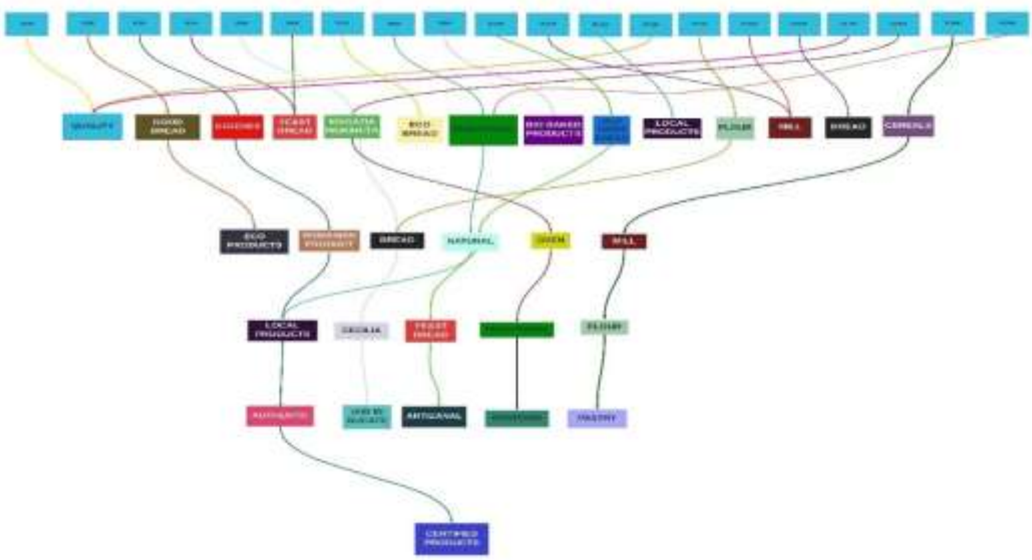

Fig. 6. Neural networks for the brand Magazia Morărișei, men responses
Source: Own computation in Lucidchart.

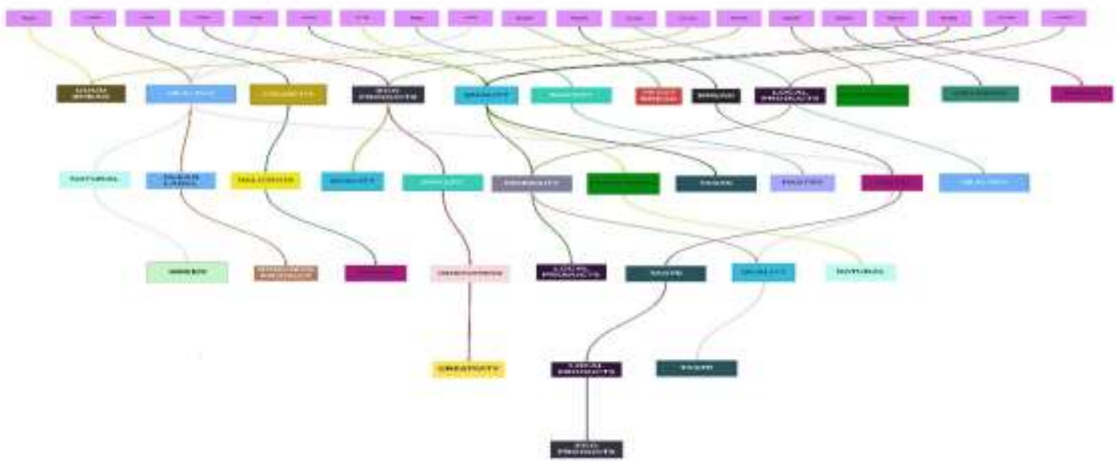

Fig. 7. Neural networks for the brand Magazia Morărișei, female responses
Source: Own computation in Lucidchart

In Figure 7, the neural networks from women responses are highlighted through a visual. The first row of boxes represents the women respondents, this time they are pink. From each respondent, a neural path begins, for each respondent, the lines have a different colour, signifying that each neural path is unique. However, there are some respondents which thought of the same words, like for example good bread, healthy, eco products, quality and local products. These are the strongest associations formed in the sphere of

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consumers which are women. If we were to name the words which have the first position for both men and women, these are good bread, quality, traditional, and yeast bread.

These associations happen, because the consumers think of the main products they buy from the brand Magazia Morăriței.

The next section of findings will sustain this affirmation.

O4. To identify consumers' buying behaviours for the brand Magazia Morăriței.

First of all, the respondents were asked which products they buy most frequently from Magazia Morăriței, and from table 3, it is observable that bread, and yest bread are the on the top of the list.

Table 3. Table showing the most bought item from the store

Most bought item	Frequency
Bread	33
Yeast bread	27
Biscuits	6
Pie	5
Cookies	4
Grandma's bread	3
Crackers	3
Ecological flour	2

Source: Own computation in Excel.

From the associations made before, this step brings more light into the “grandma association”, because first we interpreted it as having a feeling that we would get when we visited our grandparents, but it turns out that this associations is made to a type of bread sold in the store, which is called grandma’s bread.

CONCLUSIONS

In conclusion, this study addresses the lack of available information regarding the perception and effectiveness of marketing strategies employed by small producers in the market, focusing on the case of Magazia Morăriței. Through a comprehensive exploration of consumer mental connections and online presence analysis, the study aimed to achieve specific objectives, including identifying brand personality, assessing social media engagement, exploring neural networks formed in consumers' minds, and understanding buying behaviours.

The findings shed light on several key insights. Firstly, the brand Magazia Morăriței is perceived positively by consumers, with strong associations made between the brand and important personalities, particularly the owner, Cecilia Țugulea, who is seen as a strong businesswoman. Moreover, consumers predominantly associate the brand with traditional values, quality, and ecological certifications, aligning with the brand's positioning as a provider of high-quality, environmentally friendly products.

Regarding social media engagement, while the brand maintains a presence across platforms, there is a disconnect between online interaction and physical store visits. While a significant portion of consumers follow the brand online, a smaller proportion translates this engagement into visiting the physical store. This suggests a potential area for improvement in bridging the gap between online engagement and offline actions.

The study also searches into the neural networks formed in consumers' minds when faced with the brand Magazia Morăriței. Both male and female respondents associate the brand with attributes such as good bread, quality, tradition, and yeast bread, reflecting the strong connection consumers have with the brand's core products. Additionally, the brand's ecological certifications and emphasis on local, artisanal products resonate with consumers and influence their buying behaviors.

Overall, the findings highlight the importance of understanding consumer perceptions, leveraging online platforms effectively, and emphasizing brand values to drive consumer engagement and purchasing decisions. By addressing these insights, brands like Magazia Morăriței can further strengthen their position in the market and enhance their relationships with consumers. The digital strategy approached by the Magazia Morăriței can be an example of success for ecological and traditional certified producers, because consumers trust these certifications.

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YIELD COMPARATIVE ANALYSIS OF SOME WINTER RAPESEED GENOTYPES

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Abstract

The study analyzed the behavior of some rapeseed genotypes, in comparative crops within ARDS Lovrin, Timis County, Romania. Nineteen genotypes were cultivated, in chernozem soil conditions, non-irrigated crop system, agricultural year 2022-2023. The yield (Y) varied between 1,288.24 kg ha^{-1} (Absolute genotype, RCH19 trial code) and 3,703.70 kg ha^{-1} (Excited genotype, RCH2 trial code). The hectoliter weight (HW) varied between 51.60 kg hl^{-1} (Immortal genotype, RCH5 trial code), and 75.00 kg hl^{-1} (Excited genotype, RCH2 trial code). The weight of one thousand seeds (WTS) varied between 3.70 g (Ultimo genotype, RCH17 trial code), and 6.00 g (Umberto genotype, RCH11 trial code). Compared to the mean of the experiment (M_Exp = 2,347.65 kg ha^{-1}), the following genotypes stood out: Excited (RCH2) with ΔY = 1,356.05 kg ha^{-1}, Expectation (RCH3) and P314 (RCH9) with ΔY = 1,195.02 kg ha^{-1}, respectively Momento (RCH14) with ΔY = 1,033.99 kg ha^{-1}. In the case of the hectoliter weight (HW), compared to the mean of the experiment (HW = 62.51 kg hl^{-1}), the Excited genotype (HW = 75.00 kg hl^{-1}) was highlighted, followed by the Vito genotype (HW = 70.50 kg hl^{-1}). In relation to parameters Y, HW and WTS, PC1 explained 53.155% of variance, and PC2 explained 26.458% of variance.

Key words: *comparative crops, multivariate analysis, ranking scaling, rapeseed, yield gap*

INTRODUCTION

Rapeseed (*Brassica napus* L.) is an important crop mainly for oil production, but it has multiple ecosystems, economic, and agronomic valences [11, 15, 16].

Rapeseed is also important for the production of vegetable proteins, as a honey plant, a protective crop for the soil (cover crop), as a green manure, forage crop (biomass production), ornamental attraction in agro tourism (rural tourism), as a resource for natural pollinators, the biomass resource for fuels (biodiesel, pellets), the ingot-cellulosic resource for composite materials, etc. [5, 15, 19].

The nutritional importance of rape was studied in terms of nutritional principles (e.g. fibers, minerals, vitamins, amino acids, etc.) compared to samples of beans [17]. Based on the recorded results, the authors of the study highlighted the nutritional balance of rapeseed sprouts, compared to the other bean samples. The authors concluded the importance of rape seeds, their quality in food, and the obtaining of functional foods, and they considered rape as a "functional vegetable".

Rapeseed is the third crop worldwide, in terms of importance and size of cultivated areas for oil production, and in some countries it is the main plant for oil, e.g. China [17].

Rapeseed is an important crop for Romania, and from this perspective, the concentration of rapeseed crops areas and the dynamics of areas cultivated with oleaginous and protein plants in Romania were analyzed, based on some representative indicators (distribution areas, surfaces, yields, etc.) and were formulated models that expressed trends in the evolution of the respective crops [13, 14].

As a result of the importance of rapeseed, progress has been made to improve cultivated genotypes, seed production, and studies are underway to adapt crop technologies and reduce harvest losses [15].

The production potential and yield of rapeseed crops is considerably affected by climate changes [16]. Also, the depreciation of rapeseed crops and harvests due to diseases and pests, associated with the expansion of cultivated areas, was recorded [16]. In the context of these conditions, it is considered necessary to develop more adapted genotypes, but at the same time it is considered important to preserve gene banks for rape, with natural germplasm (wild relatives of rape) and to preserve the rapeseed genetic biodiversity reserve [16].

Drought, associated with climate change, has become an abiotic stress factor, which seriously affects crops and the yield of rapeseed crops [1].

Various rapeseed genotypes were studied under conditions of water stress, in order to evaluate how seed germination is affected [1]. Based on some biometric parameters of the seedlings, the authors evaluated the behavior of the genotypes in the experimental conditions, and identified genotypes with tolerance to water stress, which represent the germplasm in the improvement of varieties with increased tolerance.

The influence of some agricultural practices, such as the distance between the rows and the density of rapeseed plants, were studied as an effect on the elements of productivity and yield [7]. The authors communicated favorable effects on the productivity elements (e.g. the degree of branching of the plants, the number of pods (elongated siliquae), the number of seeds in the pod, the weight of 1000 seeds, and associated with them, the yield per plant, respectively per surface unit. Also, the authors recorded a better yield with mechanical harvesting, associated with structural changes at the plant level.

Productivity indicators in rapeseed crop were studied in relation to improved rapeseed cultivation techniques [2]. In order to optimize the crop of rapeseed, different interactions of the technological elements, plant density, fertilization, in relation to the nutritional requirements of rapeseed and pedoclimatic conditions were studied [4, 6].

Different techniques were promoted for the study of rapeseed crops, monitoring during the vegetation period and yield estimation [10].

Aspects of the rape crop yield, such as the yield potential, yield constraints and the respective yield gap, were analyzed in different pedoclimatic conditions, in relation to different genotypes and technologies [18]. Through the complex analysis of 118 studies, the authors identified different effects of agronomic practices on rape yield, and reported yields in the range of 37-56% compared to the yield potential in the study area. The authors identified different categories of factors that limited the yield, such as environmental factors, agronomic management, and socioeconomic factors.

Rapeseed crop yield is of high importance in agricultural production, for optimizing technologies and ensuring oil production, important in the agro-food market [8]. For this purpose, the monitoring of rapeseed crops and yield estimation is of high importance [8]. The authors used imaging analysis, based on aerial images (UAV) and satellite images (GF-1, Sentinel 2) for the study of rapeseed crop, and the estimation of the yield. Based on the working methods, the considered parameters and the recorded data, the authors obtained yield estimation models under statistical safety conditions ($R^2 > 0.78$).

Both genetic information and different neural networks were also used to estimate the yield of rape seeds [12]. The authors obtained training models based on information of a physiological and morphological nature, and molecular markers. Based on a considerable number of parameters trained in the study, and an appropriate analysis, the authors detected certain parameters that facilitated models with a high degree of certainty in estimation, for obtaining valuable genotypes.

The development of the rapeseed agricultural industry was designed, and is considered sustainable, by optimizing plant architecture, by improving yields and, respectively, seed quality [9]. The authors analyzed 24 rapeseed genotypes, to evaluate morphological parameters, productivity elements, and yield and seed quality indices. Based on the recorded results, the authors quantified the contribution of the considered parameters to achieving the yields. They also identified genotypes suitable for mechanized harvesting, with high yield potential, and seed quality

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indices.
The present study quantified the yield and certain elements of seed quality in 19 rapeseed genotypes, organized in comparative crops within ARDS Lovrin, Timis County, the representative area within the Western Plain of Romania.

MATERIALS AND METHODS

The study took place within ARDS Lovrin, under conditions specific to the Western Plain of Romania. Rapeseed crops were organized on a chernozem type soil, in a non-irrigated system. Rapeseed genotypes were sown in autumn, in the optimal season.
During the study period, the climatic conditions were characterized by the thermal and precipitation regime presented in Figure 1.

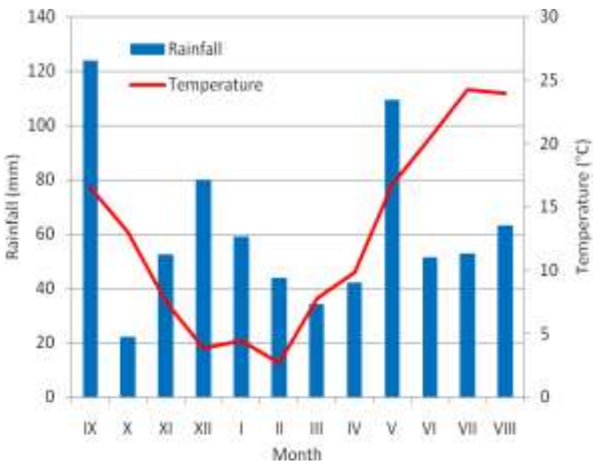

Fig. 1. Climatic conditions during the study period, ARDS Lovrin records
Source: Original figure.

Nineteen rapeseed genotypes from different companies were cultivated. In the study, certain groupings of genotypes were made in relation to companies, and certain experimental codings: RCH - commercial rape hybrids; RG1 – Bayer genotypes group; RG2 – Corteva genotypes group; RG3 – group of KWS genotypes; RG4 – group of Lidea genotypes; RG5 – group of Limagrain genotypes.
The group of RG1 genotypes included the following genotypes: Exbury – RCH1, Excited – RCH2, Expectation – RCH3, Exsun – RCH4, Immortal – RCH5, Inprint – RCH6.
Group RG2 included genotypes: P298 – RCH7, P303 – RCH8, P314 – RCH9, P315 – RCH10.
Group RG3 included the genotypes: Umberto – RCH11, Hilico – RCH12, Granos – RCH13.
Group RG4 included genotypes: Momento – RCH14, Palermo – RCH15, Vito – RCH16, Ultimo – RCH17. The RG5 group included the genotypes: Arhitecto – RCH18, Absolut – RCH19.
The area occupied by each rapeseed genotype was 1,242 m^2. Adequate technology, specific to rapeseed crop, was provided in uniform conditions on the experimental plots.
In relation to the purpose of the study, the yield for each genotype was determined, at mechanically harvesting moment. Samples were taken from seed production to determine moisture (MST, %), Hectoliter weight (HW, kg hl^{-1}), and Weight of thousand seeds (WTS, g).
The mean value of the experiment (M_Exp) was calculated for yield (Y, kg ha^{-1}) and hectoliter weight (HW, kg hl^{-1}), and the mean value for each group of rapeseed genotypes (M_RG1 to M_RG5).
The analysis and processing of the experimental data was done by appropriate methods [3].

RESULTS AND DISCUSSIONS

The harvesting of the 19 rapeseed genotypes was done mechanically, at the time of physiological maturity, on July 10, 2023, on each experimental variant (area of 1,242 m^2).
Based on the primary data recorded, the yield (Y, kg ha^{-1}) was calculated, and the values are presented in Table 1. Seeds samples were taken from each genotype, and determinations were made for moisture (MST, %), hectoliter weight (HW, kg hl^{-1}), and Weight of thousand seeds (WTS, g). The values are presented in Table 1. The ANOVA Test confirmed the reliability of the experimental data (Alpha = 0.001) (Table 2).
In the experimental conditions, rapeseed genotypes behaved differently, in relation to the biological potential, and the "genotype x environment" interaction.

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Table 1. Values of yield and some quality indices for rapeseed

Genotype	Company	Genotype group	Trial code	Yield (Y)	Moisture (MST)	Hectoliter weight (HW)	Weight of thousand seeds (WTS)
				(kg ha^{-1})	(%)	(kg hl^{-1})	(g)
Exbury	BAYER	RG1	RCH1	1,932.36	8.30	56.10	4.20
Excited			RCH2	3,703.70	5.00	75.00	3.80
Expectation			RCH3	3,542.67	5.90	66.10	4.00
Exsun			RCH4	1,610.30	5.70	67.20	4.40
Immortal			RCH5	1,932.36	8.10	51.60	4.60
Inprint			RCH6	1,449.27	5.20	67.50	4.40
P298	CORTEVA	RG2	RCH7	1,610.30	5.80	65.10	4.60
P303			RCH8	2,254.42	6.70	53.10	4.20
P314			RCH9	3,542.67	5.30	62.10	4.20
P315			RCH10	3,220.61	4.10	66.60	4.20
Umberto	KWS	RG3	RCH11	1,932.36	8.20	59.10	6.00
Hilico			RCH12	1,932.36	7.80	61.80	5.10
Granos			RCH13	1,932.36	8.00	60.00	4.80
Momento	LIDEA	RG4	RCH14	3,381.64	5.60	57.90	4.40
Palermo			RCH15	2,737.52	6.30	58.00	4.40
Vito			RCH16	2,737.52	4.30	70.50	4.20
Ultimo			RCH17	1,771.33	5.10	65.70	3.70
Arhitecto	LIMAGRAIN	RG5	RCH18	2,093.39	6.30	58.80	4.40
Absolut			RCH19	1,288.24	4.60	65.40	4.00
SE				±180.28	±0.31	±1.37	±0.12

Source: Original data.

Table 2. ANOVA Test

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	76,959,715	3	25,653,238.26	166.1672	2.78845E-32	6.0377
Within Groups	11,115,512	72	154,382.1045			
Total	88,075,226	75				

Source: Original data, resulted by calculation.

The yield analysis of the genotypes was made compared to the mean of the experiment (M_Exp), in the amount of M_Exp = 2,347.65 kg ha^{-1}. In relation to the mean value, the yield of each genotype was comparatively analysed, and Figure 2 was generated.

Compared to the mean value (M_Exp), seven genotypes had higher values, with increased yield ΔY = 1,356.05 kg ha^{-1} in the case of RCH2 (Excited), ΔY = 1,195.02 kg ha^{-1} in the case of RCH3 (Expectation) and in the case of RCH9 (P314), ΔY = 872.96 kg ha^{-1} in the case of RCH10 (P315), ΔY = 1,033.99 kg ha^{-1} in the case of RCH14 (Momento), ΔY = 389.87 kg ha^{-1} in the case of RCH15 (Palermo) and RCH16 (Vito).

The first three positions, in descending order, were occupied by RCH2 (Excited), RCH3 (Expectation) on par with RCH9 (P314), and RCH14 (Momento).

The yield analysis of the genotypes compared to the mean values within each group (M_RG) was done.

Within the genotypes from the RG1 group, the mean was M_RG1 = 2,361.78 kg ha^{-1}. Within the RG1 group, the RCH2 genotype had a yield increase ΔY = 1,342.92 kg ha^{-1}, and the RCH3 genotype showed a yield increase ΔY = 1,180.89 kg ha^{-1} (Figure 3).

Within the genotypes from the RG2 group, the calculated mean value was M_RG2 = 2,657.00 kg ha^{-1} (Figure 3).

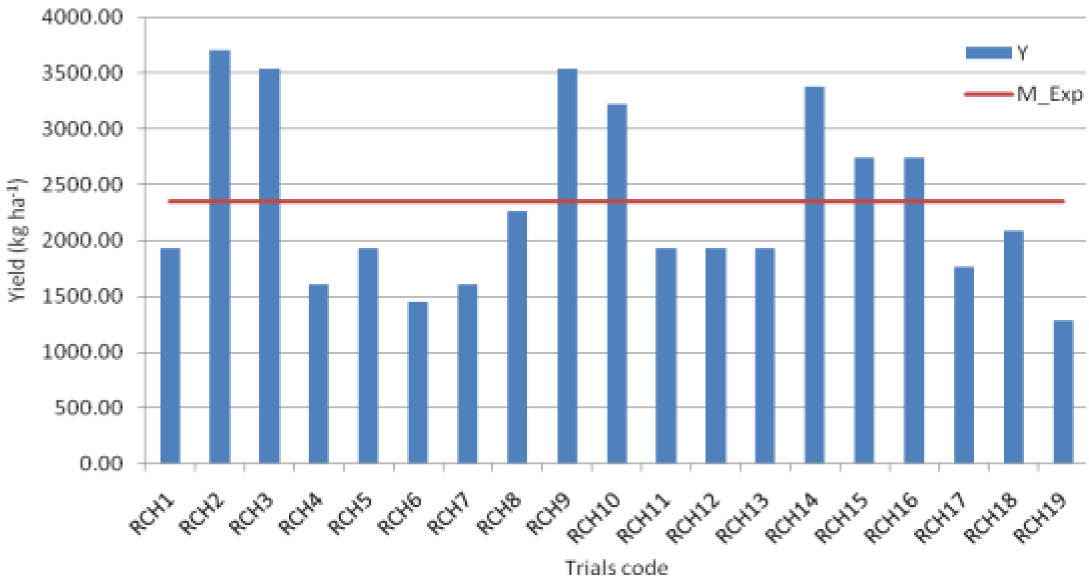

Fig. 2. Graphic representation of the yield of rapeseed genotypes, compared to the mean value of the experiment
Source: Original figure.

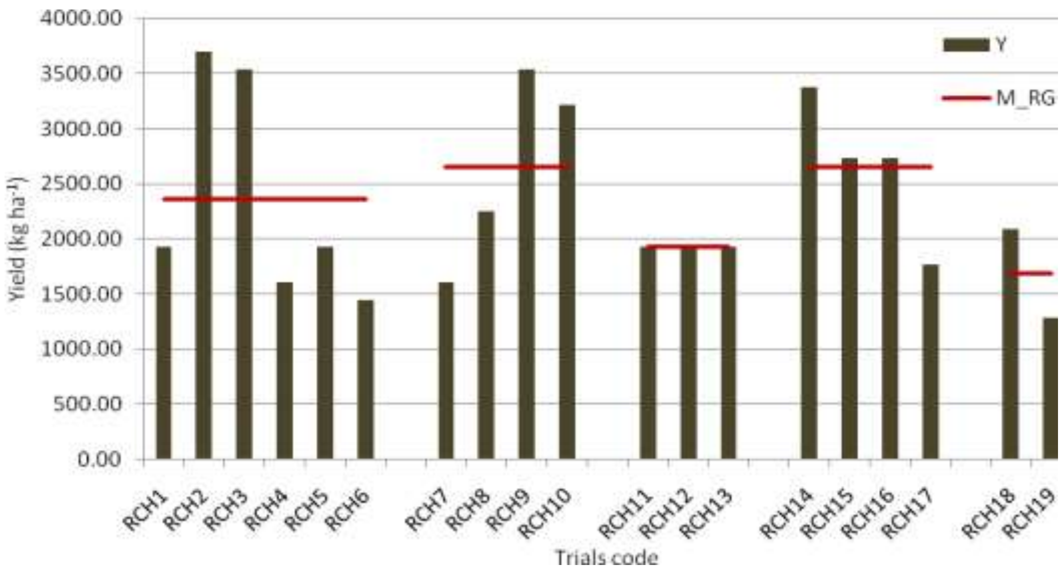

Fig. 3. Graphic representation of the yield, mean value of the genotypes group, and of each rapeseed genotype
Source: Original figure.

Within the RG2 group, the genotype RCH9 showed a yield increase ΔY = 885.67 kg ha^{-1}, and the genotype RCH10, with a yield increase ΔY = 563.61 kg ha^{-1} (Figure 3). Within the genotypes from the RG3 group, the calculated mean value was M_RG3 = 1,932.36 kg ha^{-1}. Within the RG3 group, the cultivated genotypes registered the same yield level, under the study conditions (Figure 3). Within the genotypes from the RG4 group, the calculated mean value was M_RG4 = 2,657.00 kg ha^{-1}. Within the RG4 group, the RCH14 genotype showed a yield increase ΔY = 724.64 kg ha^{-1}, and the RCH15 and RCH16 genotypes showed a yield increase ΔY = 80.52 kg ha^{-1} (Figure 3). Within the genotypes from the RG5 group, the calculated mean value was M_RG5 = 1,690.82 kg ha^{-1}. Within the RG5 group, the RCH18 genotype showed a yield increase ΔY = 402.57 kg ha^{-1} (Figure 3). The comparative presentation of the averages on the five groups of hybrids, and the value of each hybrid compared to the average of the group, is presented in Figure 3.

The mean value for each group of genotypes (M_RG1 to M_RG5) presented differences in relation to the mean value of the experiment (M_Exp) (Figure 4).

The groups of genotypes RG2 and RG4 presented differences for the mean value of the group, M_RG2, M_RG4, at the level of ΔY = 309.35 kg ha^{-1} compared to the mean value of the experiment (M_Exp).

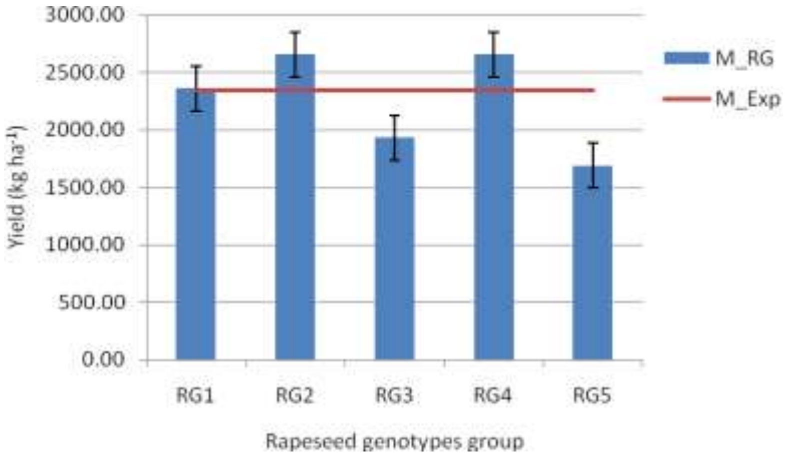

Fig. 4. Mean value of the genotypes groups, compared to the mean of the experiment
Source: Original figure.

In the case of the hectoliter weight index (HW), the mean at the level of the experiment showed the value of HW = 62.51 kg hl^{-1}. The mean value calculated for each genotypes group was HW = 63.92 kg hl^{-1} (RG1), HW = 61.73 kg hl^{-1} (RG2), HW = 60.30 kg hl^{-1} (RG3), HW = 63.03 kg hl^{-1} (RG4), and HW = 62.10 kg hl^{-1} (RG5). The distribution of HW values for the rapeseed genotypes studied in relation to the mean value of the experiment (M_Exp), and the mean value for each group of genotypes (M_RG) is shown graphically in Figure 5.

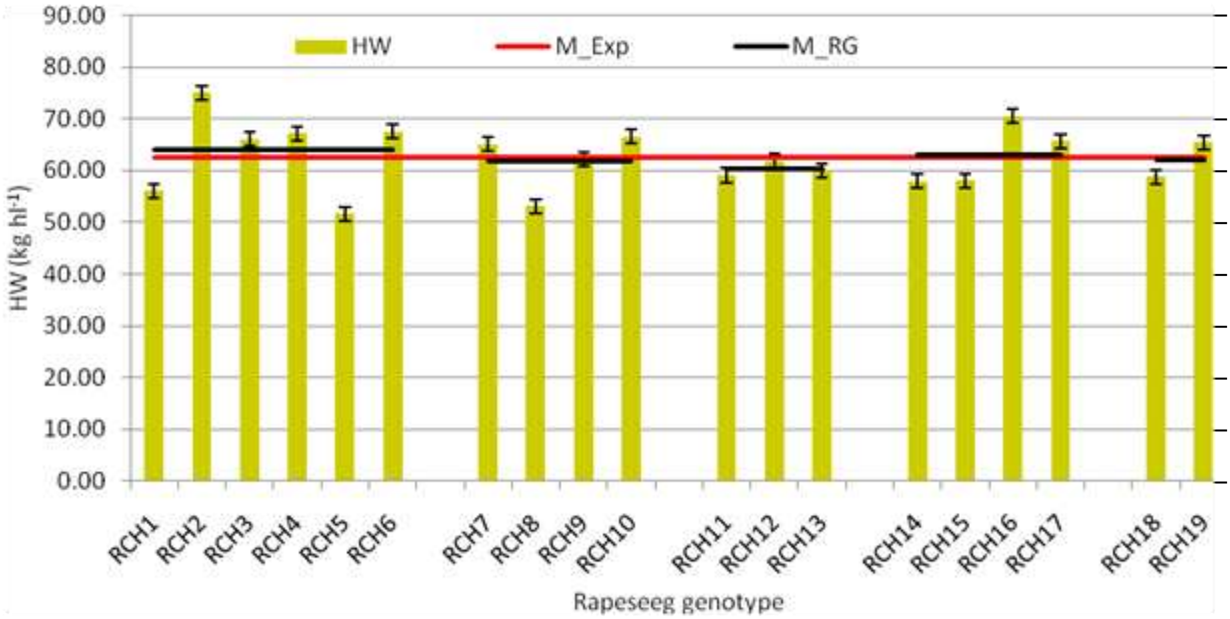

Fig. 5. Graphic distribution of the values of the HW parameter for rapeseed genotypes, in relation to the mean value of the experiment (red line), and the mean value for each group of genotypes (black line)
Source: Original figure.

At the experiment level, the genotype RCH2 with the best value was identified for the HW index (HW = 75.00 kg hl^{-1}), followed by the RCH16 genotype (HW = 70.50 kg hl^{-1}).

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Genotypes with very good HW values were also identified, for each group of genotypes, in relation to the average value at group level.
Multiparameter analysis was applied to obtain the distribution of genotypes in relation to yield (Y), Hectoliter weight (HW, kg hl^{-1}), and Weight of thousand seeds (WTS, g). The PCA diagram in figure 6 resulted, in which PC1 explained 53.155% of variance, and PC2 explained 26.458% of variance.
The RCH2 genotype presented a balanced position between Y and HW. It is the genotype that recorded maximum values for Y and for HW, in the comparative rapeseed crops (Table 1). The RCH3 genotype was positioned towards the Y parameter, and the RCH9 genotype was positioned close to the Y parameter. In relation to the other two components (HW, WTS), genotypes were identified with positioning associated with these indices, as biplot.
The Cluster Analysis was made in relation to Y and HW parameters, considered as important parameters for the commercial characterization of rapeseed production. The result was the dedrogram in Figure 7, in which rapeseed genotypes were grouped based on similarity in relation to the values of the two parameters (Y, HW), under conditions of Coph.corr. = 0.865.

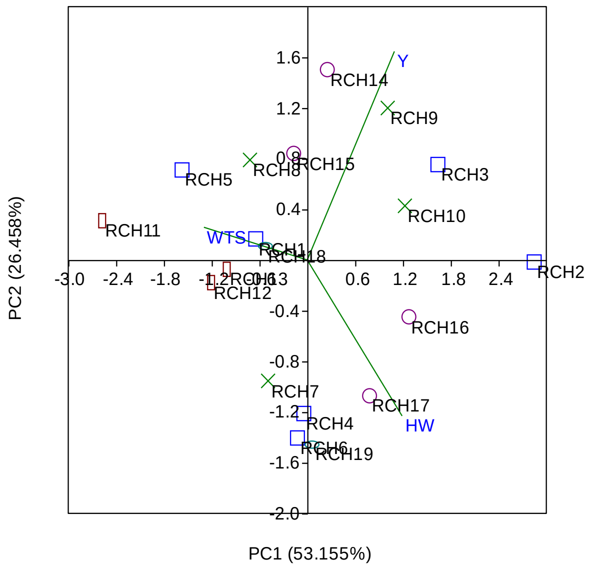

Fig. 6. PCA distribution diagram of rapeseed genotypes in relation to Y, HW and WTS parameters
Source: Original figure.

Two distinct clusters (C1, and C2) resulted, each with several sub-clusters. Cluster C1 included genotypes with high yield values (RCH2, RCH3, RCH9, RCH10, RCH14, RCH15, and RCH16), above the mean of the experiment (M_Exp = 2,347.65 kg ha^{-1}).
Within this cluster, a high level of similarity was recorded between RCH3 and RCH9 (SDI = 4.0) (Table 3).

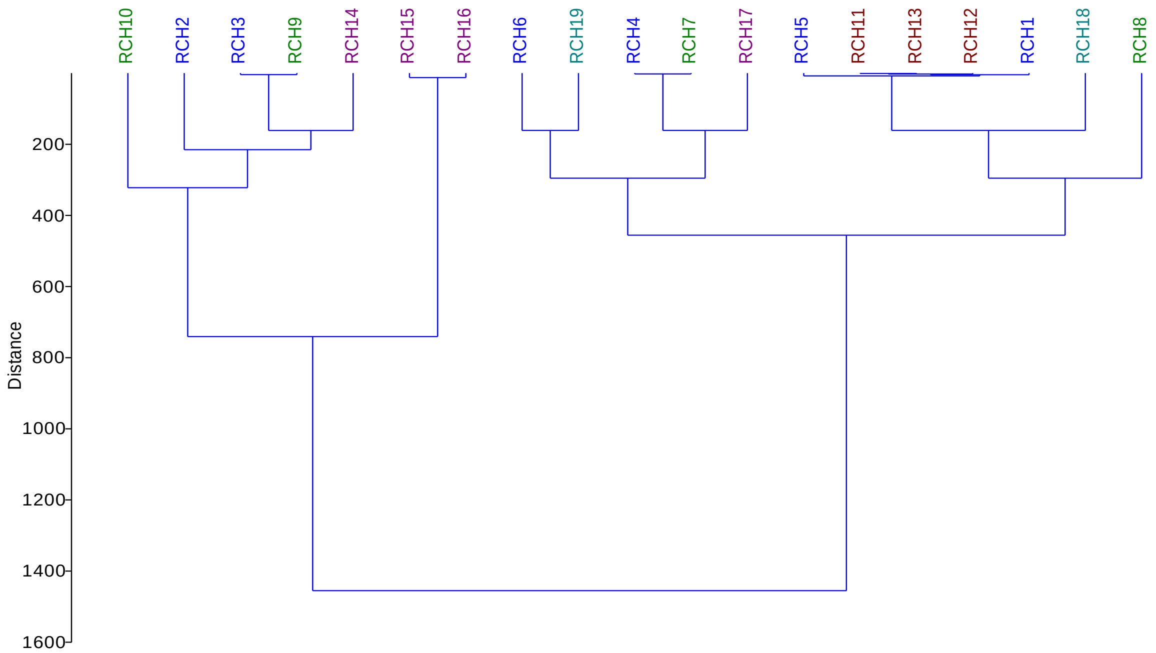

Fig. 7. Dendrogram grouping rapeseed genotypes based on Euclidean distances, in relation to Y, HW parameters
Source: Original dendrogram.

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Cluster C2 included the other genotypes, with yield values below the mean value of the experiment. At the level of cluster C2, a high level of similarity was recorded between RCH11 and RCH13 (SDI = 0.9), which was also the highest level of similarity among the tested rapeseed genotypes (Table 3).

The Ranking scaling analysis led to the diagram in figure 8, in which the rapeseed genotypes were ranked according to the values of the Y and HW parameters.

Table 3. SDI values for describing the similarity of rapeseed genotypes

	RCH1	RCH2	RCH3	RCH4	RCH5	RCH6	RCH7	RCH8	RCH9	RCH10	RCH11	RCH12	RCH13	RCH14	RCH15	RCH16	RCH17	RCH18	RCH19
RCH1		1,771.4	1,610.3	322.3	4.5	483.2	322.2	322.1	1,610.3	1,288.3	3.0	5.7	3.9	1,449.3	805.2	805.3	161.3	161.1	644.2
RCH2	1,771.4		161.3	2,093.4	1,771.5	2,254.4	2,093.4	1,449.4	161.6	483.2	1,771.4	1,771.4	1,771.4	322.5	966.3	966.2	1,932.4	1,610.4	2,415.5
RCH3	1,610.3	161.3		1,932.4	1,610.4	2,093.4	1,932.4	1,288.3	4.0	322.1	1,610.3	1,610.3	1,610.3	161.2	805.2	805.2	1,771.3	1,449.3	2,254.4
RCH4	322.3	2,093.4	1,932.4		322.4	161.0	2.1	644.3	1,932.4	1,610.3	322.2	322.1	322.1	1,771.4	1,127.3	1,127.2	161.0	483.2	322.1
RCH5	4.5	1,771.5	1,610.4	322.4		483.4	322.3	322.1	1,610.3	1,288.3	7.5	10.2	8.4	1,449.3	805.2	805.4	161.7	161.2	644.3
RCH6	483.2	2,254.4	2,093.4	161.0	483.4		161.1	805.3	2,093.4	1,771.3	483.2	483.1	483.2	1,932.4	1,288.3	1,288.3	322.1	644.2	161.0
RCH7	322.2	2,093.4	1,932.4	2.1	322.3	161.1		644.2	1,932.4	1,610.3	322.1	322.1	322.1	1,771.4	1,127.2	1,127.2	161.0	483.1	322.1
RCH8	322.1	1,449.4	1,288.3	644.3	322.1	805.3	644.2		1,288.3	966.3	322.1	322.2	322.1	1,127.2	483.1	483.4	483.3	161.1	966.3
RCH9	1,610.3	161.6	4.0	1,932.4	1,610.3	2,093.4	1,932.4	1,288.3		322.1	1,610.3	1,610.3	1,610.3	161.1	805.2	805.2	1,771.3	1,449.3	2,254.4
RCH10	1,288.3	483.2	322.1	1,610.3	1,288.3	1,771.3	1,610.3	966.3	322.1		1,288.3	1,288.3	1,288.3	161.3	483.2	483.1	1,449.3	1,127.2	1,932.4
RCH11	3.0	1,771.4	1,610.3	322.2	7.5	483.2	322.1	322.1	1,610.3	1,288.3		2.7	0.9	1,449.3	805.2	805.2	161.2	161.0	644.2
RCH12	5.7	1,771.4	1,610.3	322.1	10.2	483.1	322.1	322.2	1,610.3	1,288.3	2.7		1.8	1,449.3	805.2	805.2	161.1	161.1	644.1
RCH13	3.9	1,771.4	1,610.3	322.1	8.4	483.2	322.1	322.1	1,610.3	1,288.3	0.9	1.8		1,449.3	805.2	805.2	161.1	161.0	644.1
RCH14	1,449.3	322.5	161.2	1,771.4	1,449.3	1,932.4	1,771.4	1,127.2	161.1	161.3	1,449.3	1,449.3	1,449.3		644.1	644.2	1,610.3	1,288.3	2,093.4
RCH15	805.2	966.3	805.2	1,127.3	805.2	1,288.3	1,127.2	483.1	805.2	483.2	805.2	805.2	805.2	644.1		12.5	966.2	644.1	1,449.3
RCH16	805.3	966.2	805.2	1,127.2	805.4	1,288.3	1,127.2	483.4	805.2	483.1	805.2	805.2	805.2	644.2	12.5		966.2	644.2	1,449.3
RCH17	161.3	1,932.4	1,771.3	161.0	161.7	322.1	161.0	483.3	1,771.3	1,449.3	161.2	161.1	161.1	1,610.3	966.2	966.2		322.1	483.1
RCH18	161.1	1,610.4	1,449.3	483.2	161.2	644.2	483.1	161.1	1,449.3	1,127.2	161.0	161.1	161.0	1,288.3	644.1	644.2	322.1		805.2
RCH19	644.2	2,415.5	2,254.4	322.1	644.3	161.0	322.1	966.3	2,254.4	1,932.4	644.2	644.1	644.1	2,093.4	1,449.3	1,449.3	483.1	805.2	

Source: Original data.

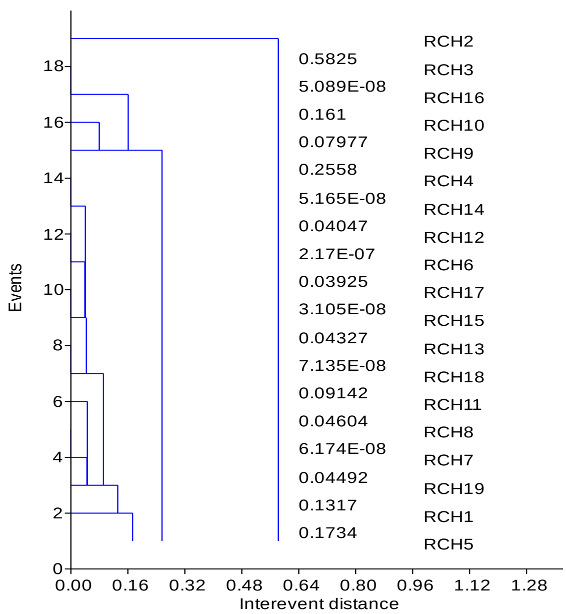

Fig. 8. Scaling dendrogram for the ranking of rapeseed genotypes
Source: Original diagram.

Rapeseed yield is an essential element for the sustainability of this crop at the level of agricultural holdings and farmers. A series of bibliographic sources, based on solid studies [1, 12, 16] evaluated the yield in relation to different influencing factors, and formulated practical recommendations, correlated with the study conditions. Seed quality parameters and indices are also important in relation to the destination of rapeseed production and the capitalization of seed production on the market.

The need to promote new genotypes and to test genotypes has been supported in various studies [12, 18], in relation to climate changes, to pedoclimatic conditions specific to agricultural areas, to the adaptation of crop technologies, and optimizing yields.

The analysis of the results by appropriate methods is also important to objectively detect the genotypes in relation to the yield or quality parameters [8, 12].

In the context of the present study, the genotype Excited (RCH2) presented high values for yield (Y) and hectoliter weight (HW), important parameters for the valorisation of seed production. According to PCA, Figure 6, the Excited genotype was balanced against the two parameters (Y, HW).

According to the Cluster Analysis, the association of the genotypes was found for the considered parameters, values recorded in the study conditions. This ranking of genotypes facilitates the selective choice of certain genotypes, depending on the similarity of response in relation to the best results recorded in the case of each group of genotypes.

CONCLUSIONS

Under the study conditions, the 19 rapeseed genotypes provided different responses in terms of yield and seed quality indices.

Compared to the mean value of the experiment (M_Exp = 2,347.65 kg ha^{-1}), seven genotypes showed higher yield values. Several genotypes were highlighted: Excited (RCH2) with ΔY = 1,356.05 kg ha^{-1}, Expectation (RCH3) and P314 (RCH9) with ΔY = 1,195.02 kg ha^{-1}, and Momento (RCH14), with ΔY = 1,033.99 kg ha^{-1}, respectively.

In the case of hectoliter weight, compared to the mean of the experiment HW = 62.51 kg hl^{-1}, the genotype Excited (RCH2) with HW = 75.00 kg hl^{-1}, and the genotype Vito (RCH16) with HW = 70.50 kg hl^{-1} stood out.

In relation to yield (Y) and seed quality parameters (HW, WTS), the multivariate analysis facilitated the distribution of the genotypes according to the association with considered parameters, and the first two components (PC1, PC2) explained 79.61% of variance. Cluster Analysis facilitated the grouping of genotypes based on similarity, and ranking scaling led to the ranking of rapeseed genotypes in relation to Y and HW parameters.

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ANALYSIS OF SEASONAL FLUCTUATIONS IN CUCUMBER PRICES: THE CASE OF TÜRKİYE

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Abstract

In this study, the development of cucumber production in the world and Türkiye and the changes and seasonal fluctuations in cucumber prices in Türkiye were analyzed. The price data used in this study cover the period 2010-2023 and were obtained from the Antalya Fruit and Vegetable Wholesale Market. Production data covers the period 2000-2022 and was obtained from the Food and Agriculture Organization (FAO). Türkiye ranks 2nd in the world in terms of cucumber production and therefore has significant cucumber production potential. Cucumbers, which are produced both in greenhouses and open fields, are supplied almost every month of the year. In 2023, 57.42% of the total cucumber production in Türkiye came from greenhouses and 42.58% from open fields. In this study, seasonal index values of cucumber prices were calculated and compared in three ways: simple average, moving average, and trend analysis. According to all three methods, cucumber prices increased in December, January, February, and March and decreased in May, June, and July. The reason for this is that field cucumbers are harvested in the summer, which increases their supply and decreases their prices. We also found seasonal fluctuations in cucumber prices throughout the year. This can be explained as follows; since cucumber is a perishable product, its storage period is short, and they should be consumed immediately after harvest. Therefore, the demand for cucumber is high during the harvest season, whereas the demand for cucumber continues throughout the year. In this case, supply is delayed to match demand and causes price fluctuations.

Key words: *vegetables, cucumber prices, price analysis, seasonal fluctuations, Türkiye*

INTRODUCTION

Cucumber is one of the most important vegetables that are grown both in greenhouses and open fields. The total greenhouse vegetable production in Türkiye is approximately 8 million tons, of which 13.5% is cucumber. Cucumber ranks 2nd after tomato in greenhouse vegetable production. Vegetable production in the field is 23.81 million tons, of which 3.4% is cucumber. In field production, cucumber ranks 5th among vegetables. In total 1,871,712 tons of cucumbers were produced, 1,074,796 tons were grown in greenhouses and 796,916 tons in the field. Of the total cucumber production, 57.42% is greenhouse production and 42.58% is field production [9].

Türkiye ranks 2nd in the world in cucumber production [6] and 6th in cucumber exports [7]. Approximately 7% of the vegetables produced in Türkiye are exported [7]. In this regard, producers, consumers, and exporters are affected by seasonal fluctuations in the prices of cucumber, which is one of the most important vegetables for the Turkish agricultural economy.

The reason for seasonal fluctuations in fresh fruits and vegetables is that they are produced in certain seasons of the year, are perishable products, and have short storage times. Fresh fruit and vegetables prices are generally high at the beginning of the harvest period and fall rapidly toward the middle of the harvest period as production increases.

The main factors affecting the prices of agricultural products are farmers' production decisions, market conditions, specific characteristics of agriculture (numerous risks and uncertainties, climatic conditions, diseases and pests, regional differences), and fluctuations in product supply [8].

In this study, seasonal fluctuations in cucumber prices—an important product for producers and consumers—were analyzed. As a result, the reasons for fluctuations in prices were revealed, and a suggestion was developed.

MATERIALS AND METHODS

The primary material of this study was obtained from FAO and statistical data from the Antalya Fruit and Vegetable Wholesale Market. The development of cucumber production in the world, Türkiye and major cucumber-producing countries between 2000 and 2022 was evaluated. These data were analyzed using simple and chained index ratios. Cucumber prices were converted to real prices using the Producer Price Index (PPI) calculated by the Turkish Statistical Institute (TURKSTAT) [10]. Annual and monthly changes in cucumber prices and their causes were analyzed.

Simple ratio, moving ratio, and trend ratio methods were used for seasonal price fluctuations [5].

RESULTS AND DISCUSSIONS

The development of cucumber production in the world

Development of cucumber production

The world cucumber cultivation area changed from 1.9 million hectares in 2000 to 2.1 million hectares in 2022.

The cucumber cultivation area, which was 1 million 978 thousand hectares in the average of 2000-2004, increased by 9.94% in 2022 and reached 2 million 174 thousand hectares. When the change in production areas compared with the previous period is analyzed, the highest increase was realized in the average of 2010-2014 with 8.55%.

As of the same date, global cucumber production has varied between 41 million tons and 95 million tons.

Cucumber production, which was 41 million 319 thousand tons compared to the average of 2000-2004, increased by 129.24% and reached 94 million 718 thousand tons in 2022. When the change in production compared with the previous period is analyzed, the highest increase was realized in the average of 2010-2014 with 30.45%.

Although there is not much change in the world's cucumber production areas, the amount of production is increasing every year. Although the world cucumber yield was 20 930 kg per hectare in 2000-2004, it increased by 108.13% to 43 562 kg per hectare in 2022 (Table 1).

Table 1. The development of cucumber production in the world

Years	1,000 Hectare	A Index*	B Index**	1,000 Tons	A Index*	B Index**	kg/ha	A Index*	B Index**
2000-2004	1,978	100.00	-	41,319	100.00	-	20,930	100.00	-
2005-2009	1,930	97.61	97.61	53,775	130.15	130.15	27,835	132.99	132.99
2010-2014	2,096	105.95	108.55	70,150	169.78	130.45	33,446	159.80	120.16
2015-2019	2,153	108.85	102.73	82,932	200.71	118.22	38,534	184.11	115.21
2020	2,153	108.88	100.03	90,745	219.62	109.42	42,140	201.34	109.36
2021	2,161	109.27	100.37	92,613	224.14	102.06	42,851	204.74	101.69
2022	2,174	109.94	100.60	94,718	229.24	102.27	43,562	208.13	101.66

*(Average of 2000-2004=100), **(Previous year=100)
Source: [2].

In terms of world cucumber production, China ranks first with a share of 81.57%.

China is followed by Türkiye with a share of 2.05% and Russia with a share of 1.73%. It was determined that China's share of global cucumber production increased, and Türkiye's share decreased in the years analyzed (Table 2).

The cucumber cultivation area in Türkiye decreased by 22.42% from 45 476 hectares in 2000-2004 to 35 278 hectares in 2023.

It tended to decrease as of the years analyzed. In 2022, it increased by 36.26% compared with the previous year, and in 2020, it decreased by 29.28% compared with the previous period.

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Cucumber production varied between 1.72 million tons and 1.93 million tons in the years under review.

Table 2. Development of cucumber production in the world's leading producers

Years	China	Türkiye	Russian Fed.	Mexico	Uzbekistan	Other countries	World
	1,000 Tons						
2000-2004	26,000	1,749	972	470	166	11,962	41,319
2005-2009	37,480	1,727	1,060	552	262	12,694	53,775
2010-2014	51,585	1,753	1,588	653	542	14,029	70,150
2015-2019	65,262	1,854	1,628	985	861	12,342	82,932
2020	72,928	1,886	1,687	1,160	813	12,271	90,745
2021	74,815	1,890	1,603	1,039	890	12,376	92,613
2022	77,258	1,939	1,636	1,078	904	11,903	94,718
	%						
2000-2004	62.93	4.23	2.35	1.14	0.40	28.95	100.00
2005-2009	69.70	3.21	1.97	1.03	0.49	23.61	100.00
2010-2014	73.54	2.50	2.26	0.93	0.77	20.00	100.00
2015-2019	78.69	2.24	1.96	1.19	1.04	14.88	100.00
2020	80.37	2.08	1.86	1.28	0.90	13.52	100.00
2021	80.78	2.04	1.73	1.12	0.96	13.36	100.00
2022	81.57	2.05	1.73	1.14	0.95	12.57	100.00

Source: [2].

Cucumber production increased by 7.04% from 1 million 750 thousand tons in 2000-2004 to 1 million 872 thousand tons in 2023. In the same period, cucumber yield per hectare increased by 38.01% from 38,444 kg to 53,056 kg (Table 3).

It is possible to say that there is a decreasing trend in the cucumber cultivation area, an increasing trend in production, and a fluctuating trend in yield in Türkiye. Therefore, increases in yield were effective for increasing production.

In a study, it was determined that Türkiye's comparative advantage in cucumber trade was moderate to high until 2015, but Turkey lost its comparative advantage after this date [1].

Table 3. Development of cucumber production in the Türkiye

Years	Hectare	A Index*	B Index**	Tons	A Index*	B Index**	kg/ha	A Index*	B Index**
2000-2004	45,476	100.00	-	1,748,624	100.00	-	38,444	100.00	-
2005-2009	42,347	93.12	93.12	1,726,572	98.74	98.74	40,859	106.28	106.28
2010-2014	38,593	84.87	91.14	1,753,066	100.25	101.53	45,434	118.18	111.20
2015-2019	36,830	80.99	95.43	1,853,930	106.02	105.75	50,415	131.14	110.96
2020	26,048	57.28	70.72	1,886,239	107.87	101.74	72,414	188.36	143.63
2021	25,930	57.02	99.55	1,890,160	108.09	100.21	72,895	189.61	100.66
2022	35,333	77.70	136.26	1,938,545	110.86	102.56	54,865	142.71	75.27
2023	35,278	77.58	99.84	1,871,712	107.04	96.55	53,056	138.01	96.70

*(Average of 2000-2004=100), **(Previous year=100)
Source: [9].

Cucumber production in Türkiye takes place in two ways: in greenhouses and open fields. Between 2000 and 2023, the share of production in greenhouses changed between 52.71% and 61.90%.

The percentage of production in the open field changed between 38.10% and 47.29% (Fig. 1).

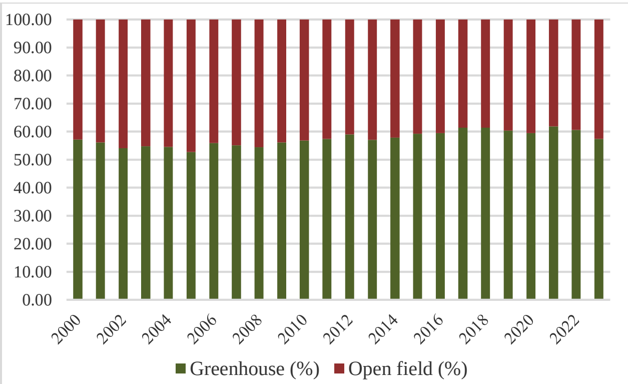

Fig. 1. Shares of cucumber produced in greenhouse and open field in Türkiye

Price analysis

When the monthly real prices of cucumber in Türkiye between 2010 and 2023 were analyzed; it was determined that the highest average prices were in February (841.91 TRY/ton), January (693.89 TRY/ton), and March (553.77 TRY/ton). The lowest average prices were recorded in June (156.86 TRY/ton), May (177.35 TRY/ton), and July (268.95 TRY/ton).

In January, February, and March, the standard deviation values were high, and the fluctuations in cucumber prices were higher in these months than in the other months.

In June and May, the standard deviation values were low and cucumber prices were stable compared with those in other months. The months with high coefficients of variation were October and May.

Real cucumber prices in these months were more variable than average cucumber prices. In February, when the coefficient of variation was low, cucumber prices were less variable than average cucumber prices.

The months with the highest seasonal index values were February, January, March, and December. Cucumber prices during these months were above year averages. The months with the lowest values were June, May, and July. In these months, cucumber prices were well below the yearly average (Table 4).

Seasonal fluctuations in cucumber prices in Türkiye were observed throughout the year. It was determined that cucumber prices increase in the last month of the year and the first month of the year and decrease in the summer months.

The reason for this is that prices for field cucumbers fall in the summer months when they enter the market.

In this case, February had a coefficient of variation below 20% and a seasonal index value above 100.

If farmers can put their products on the market this month, they will be able to sell at higher prices and earn more profit. Therefore, it would be beneficial for them to consider this point in their production strategies.

Table 4. Seasonal fluctuations in cucumber real prices

Months	Arithmetic Mean (TRY, ton)	Standard deviation	Coefficient of variation	Seasonal index
January	693.89	166.64	24.02	171
February	841.91	166.40	19.76	207
March	553.77	134.23	24.24	136
April	322.29	80.45	24.96	79
May	177.35	67.99	38.34	44
June	156.86	40.06	25.54	39
July	268.95	80.64	29.98	66
Augst	352.56	106.85	30.31	87
September	332.88	108.97	32.74	82
October	290.73	125.75	43.25	72
November	348.31	96.62	27.74	86
December	535.75	151.24	28.23	132

Source: Own calculation.

Real cucumber prices per ton in Türkiye varied between 107.33 TRY and 1 140.39 TRY between 2010 and 2014. The average price during this period was 448.34 TRY. In the period 2015-2019, cucumber prices varied between 107.27 TRY and 1 057.16 TRY. In the period 2020-2023, cucumber prices varied between 83.24 TRY and 968.02 TRY. In all years analyzed, real cucumber prices per ton varied between 83.24 TRY and 1 140.39 TRY. Cucumber price volatility was calculated as 51.63%, 54.81%, and 53.79% for these periods and 53.10% for the average of 2010-2023 (Table 5).

Volatility in cucumber prices was very high in all analyzed periods. The reason for this is that cucumber is a perishable product, its storage period is short, and it should be consumed immediately after harvest. Cucumber harvest is performed in certain months, and the product is abundant in these months. Consumer demand for cucumbers continues throughout the year. In this case, cucumber prices fluctuate in months when there is no cucumber harvest.

Table 5. Volatility of annual cucumber price

Years	Average (TRY, ton)	Minimum (TRY, ton)	Maximum (TRY, ton)	Volatile (%)
2010-2014	448.34	107.33	1,140.39	51.63
2015-2019	378.77	107.27	1,057.16	54.81
2020-2023	388.06	83.24	968.02	53.79
2010-2023	406.27	83.24	1,140.39	53.10

Source: Own calculation.

Based on average cucumber prices in Türkiye in 2010, the change in cucumber prices in

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other years was analyzed. Cucumber prices per ton decreased by 1.58% from 430.1 TRY in 2010 to 423.3 TRY in 2023. The highest increase relative to the base year was in 2013. The average cucumber price increased by 12.86% to 485.4 TRY. The largest decrease occurred in 2018 when average cucumber prices fell by 19.88% to 377.4 TRY (Table 6).

In a study examining the developments in cucumber prices in Türkiye using data from 1999-2013, it was determined that the real price index of cucumber increased by 27% in 2013 compared with 1999 [11].

Table 6. Changes in the annual real price of cucumbers

Years	Average (TRY, ton)	Index (2010=100)
2010	430.1	100.00
2011	442.4	102.86
2012	470.6	109.42
2013	485.4	112.86
2014	413.2	96.07
2015	368.3	85.63
2016	362.7	84.33
2017	377.4	87.75
2018	344.6	80.12
2019	440.8	102.49
2020	388.3	90.28
2021	365.4	84.96
2022	375.2	87.24
2023	423.3	98.42

Source: Own calculation.

Seasonal index values for cucumber prices in Türkiye were calculated and compared in three ways: simple average, moving average, and trend analysis. According to all three methods, cucumber prices increased in December, January, February, and March and decreased in May, June, and July. Starting from August, prices started to increase (Table 7). December and March were found to be the most profitable production periods for farmers.

In a study analyzing seasonal fluctuations in cucumber prices in Türkiye using data from 1997 to 2006, it was found that the highest price index occurred in February and the lowest price index occurred in June [4].

In a study analyzing seasonal fluctuations in cucumber prices in Nepal using data from 2013-2022, it was determined that the highest price index occurred from October to March and the lowest price index occurred from April to September [3].

Table 7. Seasonal fluctuations in cucumber real prices using simple average, moving average, and trend ratio methods

Months	Seasonal index with a simple average	Seasonal index with a moving average	Seasonal index with rate on trend
January	171	171	170
February	207	171	206
March	136	141	136
April	79	86	79
May	44	54	43
June	39	49	39
July	66	64	67
August	87	78	87
September	82	80	82
October	72	80	72
November	86	96	86
December	132	129	133

Source: Own calculation.

From January 2010 to December 2023, when monthly cucumber prices were analyzed, the lowest month was May 2022 (83.24 TRY/ton), and the highest month was January 2012 (1,140.39 TRY/ton). It was determined that cucumber prices followed a very fluctuating course throughout the period analyzed. In general, prices peaked in January and February and declined in May and June (Fig. 2).

Fig 2. Cucumber real prices
Source: Own calculation.

From January 2010 to December 2023, monthly cucumber price volatility was calculated as 51.63% in the period 2010-2014, 54.81% in the period 2015-2019, 53.79% in the period 2020-2023 and 53.10% as the average of the period 2010-2023. It was determined that monthly fluctuations and volatility in cucumber prices were high during the analyzed period (Fig. 3).

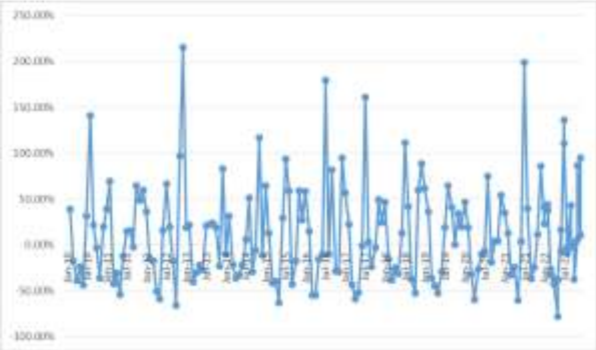

Fig 3. Volatility of cucumber real prices
Source: Own calculation.

CONCLUSIONS

Although cucumber production areas have decreased in Türkiye between the periods examined (2000-2023), production amounts have increased. This shows that cucumber yield has improved. In fact, yield increased by 38.01% due to improvements in agricultural practices during this period. During the period under review (2010-2023), cucumber prices increased in December, January, February, and March and decreased in May, June, and July. Starting in August, prices began to rise again. The seasonal index has its lowest value in June and highest value in February. It was also determined that cucumber prices were highly volatile during all analyzed periods. In general, since cucumber is a perishable and freshly consumed vegetable, its prices decrease during harvest periods. Based on the findings of this study, if farmers can shift their production planning for cucumber production between December and March, their profitability indicators may improve and their incomes may increase.

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ANALYSIS OF LETTUCE PRICES IN TÜRKİYE: SEASONAL FLUCTUATIONS

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Abstract

This study analyzed changes in lettuce prices and seasonal fluctuations in Türkiye. In addition, the development of lettuce production in the world and Türkiye was determined. In this study, world lettuce production data cover the period 2000-2022 and Türkiye lettuce production data cover the period 2000-2023. The Lettuce price data cover the period 2010-2023. Türkiye ranks 8th in the world in terms of lettuce production and 30th in terms of lettuce exports. In 2023, 26.61% of the total lettuce production in Türkiye was achieved in greenhouses and 73.39% in open fields. In this study, seasonal index values of lettuce prices were calculated and compared in three ways: simple average, moving average, and trend analysis. According to all three methods, lettuce prices increased in August and September and decreased in May and June. It was determined that there are seasonal fluctuations in lettuce prices throughout the year. Based on the results of the research, August and September were determined to be the most profitable production periods for lettuce producers. If producers can adjust their production planning according to these months, their earnings will increase.

Key words: *vegetables, lettuce prices, price analysis, seasonal fluctuations, Türkiye*

INTRODUCTION

The vegetable sector is an important sub-sector of agriculture in terms of being directly related to nutrition, providing raw materials to the vegetable processing industry, and contributing to the country's economy through foreign trade [1].

Lettuce production in Türkiye takes place in greenhouses and open fields. Of the 577,773 tons of lettuce produced in 2023, 26.61% was produced in greenhouses and 73.39% was produced in open fields. The total greenhouse vegetable production in Türkiye is approximately 8 million tons, of which 1.93 percent is lettuce production. Vegetable production in the field is 23.81 million tons, of which 5.31% is lettuce [9].

Türkiye ranks 8th in the world in lettuce production [6] and 30th in exports [7]. Revealing seasonal fluctuations in lettuce prices is important for producers, consumers, and exporters.

There is no specific policy on support for fresh vegetable production in Türkiye. Therefore, farmers make their production decisions based on their past experiences and the price of the product in the market during the previous period. The market price intensifies during certain periods of the year. If these fluctuations in prices are upward, consumers suffer, and if they are downward, producers suffer.

Farmers' production decisions, market conditions, specific agricultural characteristics, and fluctuations in product supply are the main factors affecting agricultural product prices [8].

In this study, seasonal fluctuations in lettuce prices—an important product for producers and consumers—are analyzed. The reasons for price fluctuations are revealed, and recommendations are developed.

MATERIALS AND METHODS

The data constituting the main material of the study were obtained from the statistical records of the Food and Agriculture Organization of the United Nations (FAO) and Antalya Fruit and Vegetable Wholesale Market. The development of lettuce production in the world and major lettuce-producing countries between 2000 and 2022 was analyzed. The development of lettuce production in Türkiye between 2000 and 2023 was evaluated. These data were analyzed using simple and chain index ratios. Simple ratio, moving ratio, and trend ratio methods were used to calculate seasonal fluctuations in lettuce prices [5]. Lettuce prices used in this study were converted to real prices using the Producer Price Index (PPI) calculated by the Turkish Statistical Institute (TURKSTAT) [10]. Changes in annual and monthly lettuce prices and their causes were investigated.

RESULTS AND DISCUSSIONS

Development of lettuce production in the world

Development of lettuce production

The world lettuce cultivation area varies between 936 thousand hectares and 1 million 244 thousand hectares between 2000 and 2022. The Lettuce cultivation area, which was 936 thousand hectares in 2000-2004, increased by 32.45% to 1 million 239 thousand hectares in 2022. When the change in production areas compared with the previous period is analyzed, the highest increase was realized in the average of 2005-2009 with 16.84%. As of the same date, global lettuce production has varied between 20.3 million tons and 27.8 million tons. Lettuce production, which was 20 million 303 thousand tons in 2000-2004, increased by 33.72% and reached 27 million 149 thousand tons in 2022. When the change in production compared with the previous period is analyzed, the highest increase was achieved in 2020 (37.10%). While the world lettuce yield was 21 696 kg per hectare in 2000-2004, it increased by 0.96% to 21 904 kg per hectare in 2022 (Table 1). The production of lettuce has also increased due to the increase in global cultivation areas. However, there was no change in world lettuce yield.

Table 1. Development of lettuce production in the world

Years	1,000 Hectare	A Index*	B Index**	1,000 Tons	A Index*	B Index**	kg/ha	A Index*	B Index**
2000-2004	936	100.00		20,303	100.00		21,696	100.00	
2005-2009	1,093	116.84	116.84	23,590	116.18	116.18	21,577	99.45	99.45
2010-2014	1,154	123.34	105.56	25,064	123.45	106.25	21,716	100.09	100.64
2015-2019	1,228	131.21	106.38	26,838	132.18	107.08	21,857	100.74	100.65
2020	1,239	132.42	100.93	27,836	137.10	103.72	22,464	103.54	102.77
2021	1,244	132.91	100.37	27,236	134.15	97.85	21,899	100.93	97.48
2022	1,239	132.45	99.66	27,149	133.72	99.68	21,904	100.96	100.02

*(Average of 2000-2004=100), **(Previous year=100)
Source: [2].

Table 2. Development of letuce production in the world's leading producers

Years	China	USA	India	Spain	Italy	Belgium	Japan	Türkiye	Other countries	World
	1,000 Tons									
2000-2004	8,870	4,553	807	1,028	946	89	542	349	3,121	20,303
2005-2009	11,990	4,260	936	957	940	75	547	434	3,451	23,590
2010-2014	13,562	3,994	1,064	872	758	58	561	430	3,763	25,064
2015-2019	14,549	4,070	1,143	956	725	238	580	481	4,094	26,838
2020	15,121	3,828	1,151	969	735	539	564	520	4,408	27,836
2021	14,851	3,395	1,157	1,066	704	565	547	541	4,410	27,236
2022	14,978	3,299	1,161	969	638	601	563	562	4,378	27,149
	%									
2000-2004	43.69	22.42	3.97	5.06	4.66	0.44	2.67	1.72	15.37	100.00
2005-2009	50.83	18.06	3.97	4.06	3.98	0.32	2.32	1.84	14.63	100.00
2010-2014	54.11	15.94	4.25	3.48	3.02	0.23	2.24	1.72	15.02	100.00
2015-2019	54.21	15.17	4.26	3.56	2.70	0.89	2.16	1.79	15.25	100.00
2020	54.32	13.75	4.14	3.48	2.64	1.94	2.03	1.87	15.84	100.00
2021	54.53	12.47	4.25	3.91	2.58	2.07	2.01	1.98	16.19	100.00
2022	55.17	12.15	4.28	3.57	2.35	2.21	2.07	2.07	16.12	100.00

Source: [2].

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In terms of world lettuce production, China ranks first with a share of 55.17%. China is followed by the United States with a share of 12.15% and India with a share of 4.28%. The total share of these three countries is 71.6%. It was determined that China's share in the world lettuce production increased and that of the USA decreased in the years analyzed. Türkiye's share varies between 1.72-2.07 (Table 2).

The Lettuce cultivation area in Türkiye increased by 4.48% from an average of 2 073 hectares in 2000-2004 to 2,165 hectares in 2023. In 2023, it was 2.5% higher than in the previous year. The amount of lettuce production varied between 349 thousand tons and 577 thousand tons in the years examined. Lettuce production, which was 349 thousand tons in 2000-2004, increased by 65.55% to 577 thousand 773 tons in 2023. In the same period, lettuce yield increased by 58.5% from 16,834 kg/ha to 26,682 kg/ha (Table 3). In Türkiye, lettuce cultivation areas are flat, but production and yields are increasing.

Table 3. Development of lettuce production in the Türkiye

Years	Hectare	A Index*	B Index**	Tons	A Index*	B Index**	kg/ha	A Index*	B Index**
2000-2004	2,073	100.00		349,000	100.00		16,834	100.00	
2005-2009	2,241	108.11	108.11	434,196	124.41	124.41	19,382	115.14	115.14
2010-2014	2,121	102.32	94.64	430,177	123.26	99.07	20,281	120.48	104.64
2015-2019	2,188	105.58	103.19	480,733	137.75	111.75	21,974	130.54	108.35
2020	2,182	105.28	99.71	520,151	149.04	108.20	23,837	141.60	108.48
2021	2,114	101.97	96.86	540,569	154.89	103.93	25,577	151.94	107.30
2022	2,166	104.52	102.50	561,990	161.03	103.96	25,941	154.10	101.42
2023	2,165	104.48	99.95	577,773	165.55	102.81	26,682	158.50	102.86

*(Average of 2000-2004=100), **(Previous year=100)
Source: [3].

The share of greenhouse lettuce production in Türkiye ranged from 10.41% to 27.63% between 2000 and 2023. The share of open field production was between 72.37% and 89.59%. Lettuce production shifted from open-field production to greenhouse production (Fig. 1).

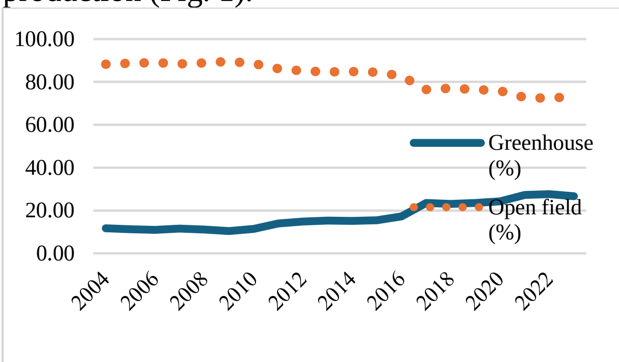

Fig. 1. Shares of lettuce produced in greenhouses and open field in Türkiye
Source: Own calculation from TURKSTAT data [9].

Price analysis of lettuce

When monthly lettuce prices in Türkiye between 2010 and 2023 were analyzed, the highest average prices were in September (490.36 TRY/ton), August (483.17 TRY/ton), and February (407.30 TRY/ton). The lowest average prices were recorded in May (260.36 TRY/ton), June (271.87 TRY/ton), and July (311.07 TRY/ton). In August, September, and December, the standard deviation values were high, and fluctuations in lettuce prices were higher in these months than in the other months. In May-June-July, the standard deviation values were low, and lettuce prices were more stable in these months than in other months. The months with high coefficients of variation were August and September. The lettuce prices in these months were more variable than average lettuce prices. In May, when the coefficient of variation was low, lettuce prices were less variable than average lettuce prices. The months with the highest seasonal index values were February, September, August, and February. Lettuce prices in these months were above the year average. The months with the lowest values were May, June, and July. In these months, lettuce prices were below the year average (Table 4).

Although seasonal fluctuations were observed in lettuce prices in Türkiye throughout the year, prices decreased in May-June-July and increased in August and September.

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Table 4. Seasonal fluctuations in lettuce real prices

Months	Arithmetic Mean (TRY, ton)	Standard deviation	Coefficient of variation	Seasonal index
January	341.48	121.18	35.49	96
February	407.30	193.19	47.43	115
March	337.04	149.07	44.23	95
April	321.40	125.83	39.15	91
May	260.36	56.44	21.68	74
June	271.87	77.50	28.51	77
July	311.07	90.40	29.06	88
August	483.17	574.36	118.87	137
September	490.36	454.57	92.70	139
October	348.11	137.66	39.55	98
November	318.04	159.39	50.12	90
December	356.97	258.37	72.38	101

Source: Own calculation.

Real lettuce prices in Türkiye varied between TRY 152.46/ton and TRY 832.44/ton between 2010 and 2014. The average price per ton during this period was 352.59 TRY. In the period 2015-2019, lettuce prices per ton varied between 177.21 TRY and 642.88 TRY. In the period 2020-2023, lettuce prices varied between 155.63 TRY and 2 468.43 TRY. In all years analyzed, lettuce prices per ton varied between 152.46 TRY and 2 468.43 TRY. Lettuce price volatility was 30.89%, 24.62%, and 54.72% for these periods and 37.57% for the average of 2010-2023 (Table 5).

Lettuce prices were volatile throughout the period. The period with the highest level of price volatility was 2020-2023.

Table 5. Volatility in annual lettuce prices

Years	Average (TRY, ton)	Minimum (TRY, ton)	Maximum (TRY, ton)	Volatile (%)
2010-2014	352.59	152.46	832.44	30.89
2015-2019	312.98	177.21	642.88	24.62
2020-2023	406.79	155.63	2468.43	54.72
2010-2023	353.93	152.46	2468.43	37.57

Source: Own calculation.

Based on the average lettuce real prices in Türkiye in 2010, the change in lettuce prices in other years was analyzed. Although lettuce prices were 464.8 TRY per ton in 2010, they increased by 67.38% to 778 TRY in 2023. Compared with the base year, lettuce real prices decreased in all other years except 2023. The highest decrease in real lettuce prices by base year was realized in 2022. In 2019, average lettuce prices decreased by 47.07% to 246 TRY/ton (Table 6).

In a study examining the developments in lettuce prices in Türkiye using data from 1997 to 2006, it was determined that prices trended downward. In the 10-year period they analyzed, the highest and lowest lettuce prices were in January and November, respectively [4].

Table 6. Changes in the annual real lettuce prices

Years	Average (TRY, ton)	Index (2010=100)
2010	464.8	100.00
2011	322.3	69.34
2012	366.9	78.94
2013	340.3	73.21
2014	268.7	57.81
2015	363.1	78.12
2016	289.3	62.24
2017	287.2	61.79
2018	273.2	58.78
2019	352.1	75.75
2020	306.4	65.92
2021	296.8	63.86
2022	246.0	52.93
2023	778.0	167.38

Source: Own calculation.

Seasonal index values of lettuce prices in Türkiye were calculated and compared in three ways: simple average, moving average, and trend analysis. According to all three methods, lettuce prices increased in August and September and decreased in May and June. It was determined that prices increased starting from August and remained high until April (Table 7). The period from August to April was found to be the most profitable production period for farmers. Therefore, lettuce producers should make production plans considering these periods.

In a study analyzing seasonal fluctuations in lettuce prices in Türkiye using data from 1997 to 2006, it was determined that lettuce prices were high from December to April, while prices were low in June to July and October to November [4].

In a study analyzing seasonal fluctuations in lettuce prices in Brazil using data from 2012 to 2017, it was found that the highest price index occurred in February to March and December, whereas the lowest price index occurred in August and October [3].

Table 7. Seasonal fluctuations in lettuce real prices using simple average, moving average, and trend ratio methods

Months	Seasonal index with simple average	Seasonal index with a moving average	Seasonal index with rate on trend
January	96	96	99
February	115	104	118
March	95	102	97
April	91	88	91
May	74	82	74
June	77	81	77
July	88	102	88
August	137	123	133
September	139	126	136
October	98	111	99
November	90	98	90
December	101	88	100

Source: Own calculation.

From January 2010 to December 2023, monthly real lettuce prices reached their lowest level in April 2011 (152.46 TRY/ton) and their highest level in August 2023 (2 468.43 TRY/ton). Lettuce prices fluctuated considerably during the period analyzed. In August, September, and December 2023, lettuce prices reached their highest levels (Fig. 2).

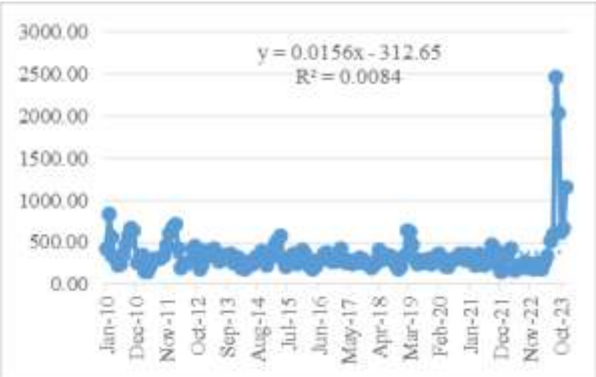

Fig 2. Lettuce real prices
Source: Own calculation.

From January 2010 to December 2023, monthly lettuce price volatility was 30.89% for the period 2010-2014, 24.62% for the period 2015-2019, 54.72% for the period 2020-2023 and 37.57% for the average of 2010-2023. It was determined that there were monthly fluctuations and time volatility in lettuce prices during the period analyzed. Price volatility peaked in August 2023 at 316.38% (Fig. 3).

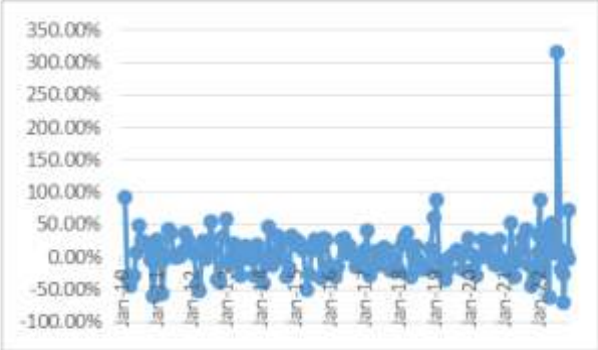

Fig 3. Volatility of lettuce prices
Source: Own calculation.

CONCLUSIONS

Lettuce production increased worldwide between the periods examined (2000-2023), depending on the lettuce production area. There was no change in lettuce yield. In Türkiye, production increased to a greater extent than the production area. The reason for this was the 58.5% increase in lettuce yield due to improvements in agricultural practices during the study period. For the period under review (2010-2023), real lettuce prices increased in August and September and decreased in May, June, and July. The seasonal index was lowest in May and highest in September. It was also calculated that lettuce prices were highly volatile during all analyzed periods. Especially in the 2020-2023 periods, price volatility intensified. The most profitable production periods for lettuce were August and September. If producers adjust their production planning according to these months, they can earn higher profits.

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ANALYZING GLOBAL CROP TRADE PATTERNS AND REGIONAL DIFFERENTIATION IN THE FACE OF CLIMATE CHANGE: A CLUB CONVERGENCE APPROACH

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Abstract

Given the impacts of global climate change, foreign trade in crops is likely to face a number of challenges. It is therefore necessary to assess the foreign trade of crops from a global perspective. This study employs the club convergence analysis by Phillips and Sul to understand the extent to which export markets of crops are differentiated across countries and the differential impact across product groups. The analysis considers codes 6-14 of the 2-digit internationally harmonized system classification, which covers crop exports of countries over the period 1990-2022. The results of the analysis show that crop exports are regionally differentiated between coastal and continental regions, with 10 countries acting distinctively with other country groups in different product groups, clearly demonstrating the differentiation between countries. In addition, the study examines wheat-grain exports as a case study. We observed that most countries with significant shares in wheat-grain production and trade are in the same clubs, that is, they act together.

Key words: *crop export, climate change, club convergence, panel data*

INTRODUCTION

As of 2022, the agricultural sector accounted for 4.3 percent of the world's Gross Domestic Product (GDP) and the value added in agriculture reached 3.8 trillion USD. According to projections, the fact that the human population will reach 9.7 billion by 2050, and that the increasing population will fuel the need for food, draw attention to agricultural food products. On the other hand, the fifth report of the Intergovernmental Panel on Climate Change (IPCC) predicts that people will be under significant risks if climate change continues (IPCC). The report states that people will be exposed more to climate change-induced heat waves, food and water shortages, fires and vector diseases [6].

Potential problems stemming from climate change are expected to affect the foreign trade of crops. Two important events in recent history can serve as a source of inspiration for finding solutions to potential problems in foreign trade markets of crops. The first one is the foreign trade problem of medical products during the Covid-19 pandemic, and the other is the problem of grain shipment during the Ukraine-Russia war. For the former, after Covid-19 was declared as a pandemic, countries quickly banned foreign trade of medical products and tried to stabilize the domestic market by taking specific measures (production of drugs, distribution, price ceilings, etc.) to address the panic-induced increase in demand. The development of the Covid-19 vaccine and the containment of the pandemic enabled the supply of medical products, especially vaccines, to the countries where the pandemic continued. In the second case, the Grain Corridor Agreement was signed to prevent a global food crisis in the wake of the Russian-Ukrainian War. Thanks to the coordination made possible by Türkiye and the United Nations, grain products were made available to international markets, thereby preventing the increase in the prices of agricultural products. In the case of Covid-19, countries initially acted independently, but after their own individual interests were satisfied, they started to act jointly. In the second case, it became necessary for all parties to act in line with their common interests, as the foreign trade of agricultural food products was in question. In this context, considering the inevitable effects of climate change, it may be necessary for countries to act together in line with their common interests in foreign trade of crops.

The purpose of this study is to investigate the extent to which foreign trade markets for crops are differentiated by country and the differential impact across product groups. The Phillips and Sul club convergence analysis is utilized for this purpose. This is the first study to examine countries that exhibit similar trends in exports of crops in terms of sub-clubs by product groups. Such an analysis provides a basis for discussing policy efforts to address the vulnerability of crop exports in extreme circumstances. In this respect, the study stands out from the existing literature. On the other hand, the study employs a new approach to club convergence analysis. In addition, the study analyzes the exports of wheat-grain products as a case study [12; 13].

In the remainder of the study, Section 2 presents the theoretical framework, while Section 3 introduces the dataset and methodology. Section 4 presents the empirical findings and Section 5 provides a visualization of the analysis results. Section 6 concludes the study.

Theoretical framework

The main motivation of the study is the hypothesis of club convergence in exports, that is, whether countries act together in the exports of crop products. The convergence hypothesis is based on Solow's neo-classical growth theory which assumes that capital is subject to diminishing returns [17]. Solow argued that in the initial phase, poor countries will grow faster than rich countries and thus poor countries will converge to rich countries. The key measures in the convergence hypothesis are absolute (unconditional) β-convergence, conditional β-convergence and club convergence. The absolute and conditional convergence emphasize that the per capita income of countries/regions will converge in the long run regardless of initial conditions [17]. However, in the case of club convergence, clubs with a particular equilibrium emerge for country/countries with similar structural characteristics and behaviors [2].

Existing studies in the literature on crop/agricultural convergence focus on agricultural productivity and agricultural income and employ absolute and conditional convergence methods. Among the studies on this subject, Lusigi et al. investigated the convergence of per capita income from agriculture and total factor productivity for thirty-two countries in Africa and concluded that education and investment are the most significant convergence conditions [9]. Rezitis explored whether there is convergence in agricultural total factor productivity between the US and nine European countries and found that convergence is valid [15]. Ghosh studied regional convergence in agricultural development in fifteen major agricultural states in India. According to conditional β-convergence, there are significant differences in land, labor productivity and agricultural output per capita. Factors such as human capital, physical capital, rural infrastructure, and population living in rural areas account for these differences [4]. Galonopoulos et al. examined the convergence of agricultural productivity among a group of thirty-two countries using absolute, conditional β-convergence and club convergence [3]. The club convergence analysis revealed that there are two separate clubs among the countries. In another study using club convergence analysis, Zhan et al. found that the club convergence hypothesis is valid for twenty-nine provinces of China [20].

Barath and Fertöanalyzed agricultural productivity for twenty-three EU Member States with β and σ convergence. The authors found that the convergence hypothesis is valid for agricultural total factor productivity, but the rate of convergence was rather slow [1]. Kijek et al. studied the convergence hypothesis in the old (EU-15) and new (EU-10) EU Member States using agricultural total factor productivity for the period 2004-2016. The researchers found that the convergence

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hypothesis is valid in EU countries except Belgium and the United Kingdom. In addition, the convergence in the agricultural productivity of the new EU member countries was found to be faster than that of the old EU Member States [7]. McCunn and Huffman analyzed the conditional β-convergence in agricultural productivity for 42 US states [10], Mukherjee and Kuroda for 14 major states of India [11], Rezitis for the US and nine European countries [16], and Gong for China [5], but not σ-convergence. Poudel et al. investigated global agricultural convergence for forty-eight states in the US [14] and Yuan et al. found that the convergence hypothesis is not valid [18]. As can be seen from the existing literature, there is no study investigating the convergence of crop exports. It is also worth noting that the studies on club convergence are quite limited [13; 8].

MATERIALS AND METHODS

The crop export data of the countries analyzed in the study cover the period 1995-2022. These data are codes 6, 7, 8, 9, 10, 11, 12, 13 and 14 in the 2-digit internationally harmonized system (HS-2) classification and were retrieved from the COMTRADE database. Table 1 shows the descriptive information of the data.

Table 1. Descriptive Information of the Data

HS Code	Description	Countries
6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage.	89
7	Edible vegetables and certain roots and tubers.	95
8	Edible fruit and nuts; peel of citrus fruit or melons.	96
9	Coffee, tea, maté and spices.	97
10	Cereals	86
11	Products of the milling industry; malt; starches; inulin; wheat gluten.	92
12	Oilseeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder.	93
13	Lac, gums, resins and other vegetables aps and extracts	73
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included.	67

Source: World Customs Organization, 2024, Hs Nomenclature 2007 Edition [19].

The methodology proposed by Phillips and Sul was employed to analyze the convergence of crop exports [12]. The methodology proposed by Phillips and Sul is based on a non-linear transition model and explores convergence with respect to idiosyncratic time varying components:

$$Y_{it} = \partial_{it}\mu_t \qquad (1)$$

In Model 1, Y_{it} represents the crop exports of countries by HS-2 code, ∂_{it} represents the components of time varying units, and μ_t represents the time varying common factor in the data. ∂_{it} cannot be estimated directly through Model 1.

Therefore, the components of the units are defined as in Model 2:

$$\partial_{it} = \partial_i + \sigma_i v_{it} L(t)^{-1} t^{-a} \qquad (2)$$

In Model 2, ∂_i is the constant, v_{it} iid(0,1) is the weak dependence on t along i, σ_i is the measurement parameter, a is the convergence rate, and L(t) is the slowly varying penalty function. In this model, ∂_{it}, converges to ∂_i for a ≥ 0. Therefore, the hypothesis H_0 ($H_0 = \partial_i = \partial$ and a ≥ 0) indicating whether there is convergence in the panel is tested against the alternative hypothesis H_1 ($H_1 = \partial_i \neq \partial$ and a < 0). To test the hypothesis H_0 in the panel, Phillips and Sul show the relative transition parameter as in Model 3 [12]:

$$h_{it} = \frac{Y_{it}}{\frac{1}{N}\sum_{i=1}^{N} Y_{it}} = \frac{\partial_{it}}{\frac{1}{N}\sum_{i=1}^{N} \partial_{it}} \qquad (3)$$

In Model 3, h_{it} is the transition parameter of country ‘i’ relative to the panel average at time t. The convergence t → ∞ occurs as h_{it} moves to 1 for all ‘i’s. The convergence concept defined in the model can be expressed as h_{it} , where H_t represents the horizontal cross-section variance:

$$H_t = \frac{1}{N}\sum_{i=1}^{N} (h_{it} - 1)^2 \qquad (4)$$

In Model 4, if the cross-sectional distribution of h_{it} or ∂_{it} decreases, the inverse variance ratio (H_1/H_t) will increase over time. For this reason, Phillips and Sul proposed the logt convergence test [12]:

$$\log\left(\frac{H_1}{H_t}\right) - 2logL(t) = \hat{a} + \hat{b}log(t) + \hat{\varepsilon}_t, for\ t = [rT], [rT] + 1, \ldots, with\ r > 0 \qquad (5)$$

In Model 5, H_1/H_t is the horizontal cross-section variance ratio, $\hat{b} = 2\hat{a}$ is the speed of convergence parameter, -2log L(t) is the penalty function that improves the performance of the test, r is the parameter that removes a certain number of initial observations, and the choice of r directly affects the results. Based on Monte Carlo simulation experiments in the log-t test, Phillips and Sul states that taking r as 1/3=0.33 for small samples (T≤50) and 1/5=0.2 for large samples would yield better results [12]. However, Kwak found that 1/10 = 0.1 for small samples outperforms the 0.33 suggested by PS at p = 0.05 significance level [8]. In addition, when T is very small in the log t test, the size of Y_{it} is distorted if r is taken as 0.33, but the size of Y_{it} is not distorted if r is taken as 0.1 [8]. To test the hypothesis of convergence H_0, the one-sided t-statistic using standard errors consistent with changing variance and autocorrelation is utilized. The hypothesis H_0 is rejected if the one-sided t statistic is less than -1.65.

RESULTS AND DISCUSSIONS

According to the 2-digit Harmonized System classification, codes HS-06 to HS-14 correspond to crop products. Table 2 shows the log t results for the whole panel for these crop products.

Table 2. Crop Export Club Log t Results

HS Code	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Coefficient	-1.242	-1.211	-1.178	-1.038	-1.205	-1.143	-1.245	-1.133	-1.345
T statistics	-4.941	-3.983	-4.205	-3.116	-4.161	-4.206	-4.467	-4.343	-6.113

Source: Own calculation.

As the log t values calculated for the 9 product groups in Table 2 are smaller than the critical the combined final club results at the last phase.

An analysis of Table 3 reveals that exports of HS-06 to HS-10 are divided into 12, 9, 8, 5 and 6 sub-clubs, respectively. In 5 product groups, Italy and Germany stand out as being in the first club. Subsequently, the Netherlands, South Africa and Belgium act together in club 1 with 4 product groups. On the other hand, Ecuador, Tunisia and Saint Vincent and the Grenadines are in the last club in all 5 product groups and have the same transition paths. It can also be observed that there are diverging countries that do not belong to any club in the exports of crop products; namely Chile and Poland for HS-6; the Netherlands for HS-07; Barbados, Estonia, Jordan and El Salvador for HS-08; and Austria, Barbados, Canada and Denmark for HS-10.

Table 3. Crop Export Club Convergence (6-10)

CLUB/HS	**6**	**7**	**8**	**9**	**10**
C1	BFA CYP DEU DNK GBR ITA JPN NLD PRT ZA1	AUS, BEL, BGR, DEU, DNK, EGY, ITA, NZL, PRT, ZA1	AUS, BEL, BFA, CHL, DEU, EGY, GRC, GRD, HKG, ITA, NLD, NZL, PRT, SVK, TGO, TTO, ZA1, ZMB	BEL, BGR, BRA, CAN CHE, CHN, COL, CZ DEU, FRA, GBR, GTM IDN, IND, ITA, JOR, JPN, LTU, MD MEX, MUS, NIC, NLD, PER, POL, RU SVK, SVN, TUR, USA	BEL, BGR, DEU, GRC, ITA, LVA, NLD, SEN, SVK, SWE, ZA1
C2	EGY GRC IRL MAR NZL	CHL, CYP, IRL, JPN, LVA, MWI, OMN, SVK, SWE	BLZ, DNK, FIN, GBR, IRL, SVN, SWE, USA	ARG, AUS, AUT, AZE, BOL, CHL, CRI, DNK, EGY, EST, FIN, GEO, GRC, GRD, HKG, HRV,	ARG, BFA, BRA, CHE, CHL, CYP, CZE, EGY, EST, FIN, GBR, GUY, HKG, HUN, IRL, JPN, LTU,

				HUN, IRL, ISR, LVA, MAR, MDA, MKD, MOZ, MWI, MYS, NOR, NZL, PRT, PRY, SAU, SEN, SGP, SLV, SWE, THA, UKR, ZA1	MEX, MLT, MWI, NOR, NZL, OMN, POL, PRT, PRY, ROU, SVN, THA, TTO, UKR, URY, USA, ZMB
C3	BEL CAN FIN SEN SVK	GRC, SVN	AZE, BDI, BOL, BRA, CHE, CYP, CZE, GEO, GTM, HRV, ISL, ISR, LTU, MDA, MEX, MOZ, MUS, MWI, NOR, PER, POL, PRY, SYC, TUR, UKR	CYP, PYF	BOL, HRV, MDA, MUS, TGO, TUR
C4	AUS MKD NOR PER SVN	FIN, HKG, MEX	CAN, JPN	BLZ, GUY, ISL, URY	COL, GEO, GTM, ISR, MKD, MOZ, NIC, PHL, SLV
C5	CHE ETH LVA SGP SWE	CAN, CHE	BGR, HUN	BDI, CIV, COM, ECU, ETH, JAM, KAZ, KOR, LCA, MAC, MLT, NER, OMN, PAN, PHL, ROU, SYC, TGO, TTO, TUN, UGA, VCT, ZMB	AUS, CHN, CIV, CRI, ECU, ETH, FRA, IDN, IND, KAZ, KOR, MAR, MDG, MYS, NER, PER, RUS, SAU, SGP, TUN, UGA, VCT
C6	CRI CZE GTM HKG HUN ISR KAZ LTU MEX MWI PYF SLV SUR TUR USA	ARG, AZE, BLZ, BOL, BRA, CRI, CZE, EST, GEO, GTM, GUY, HRV, HUN, ISL, ISR, JOR, KOR, LTU, MDA, MKD, MOZ, MUS, NIC, NOR, PER, POL, ROU, SLV, SUR, TGO, TUR, UKR, USA	MKD, NIC, PAN, ROU, URY		Not Convergent AUT, BRB, CAN, DNK
C7	BRA GEO HND HRV ISL KOR MDA NIC PHL PRY UKR	PRY, URY	ARG, AUT, CHN, CIV, COL, CRI, ECU, ETH, FRA, GMB, IDN, IND, JAM, KAZ, KOR, LCA, LVA, MAR, MDG, MLT, MYS, NER, OMN, PHL, RUS, SAU, SEN, SGP, THA, TUN, UGA, VCT		
C8	COL EST JOR	CIV, GBR	Not Convergent BRB, EST, JOR, SLV		
C9	MUS URY	AUT, BDI, BFA, CHN, COL, ECU, ETH, FRA, IDN, IND, JAM, KAZ, LCA, MAC, MAR, MDG, MLT, MYS, NER, PAN, PHL, RUS, SAU, SEN, SGP, THA, TTO, TUN, UGA, VCT, ZMB			
C10	BGR BRB UGA	Not Convergent NLD			
C11	ARG AUT BDI CHN CIV ECU FRA IDN IND JAM LCA MDG MYS OMN PAN ROU RUS SAU THA TTO TUN VCT ZMB				
C12	Not Convergent CHL POL				

Source: Constructed by the authors using club convergence methodology.

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Table 4. Crop Export Club Convergence (11-14)

CLUB NO/HS	11	12	13	14
C1	AUS, BEL, BGR, CAN, CHE, CYP, DEU, DNK, EGY, FIN, GBR, GRC, GRD, GUY, HKG, IRL, ITA, JOR, JPN, LVA, MUS, NLD, NOR, NZL, PRT, SEN, SUR, SVK, SWE, ZA1	AUS, AUT, BEL, BGR, CAN, CYP, DEU, DNK, EGY, GBR, HKG, IRL, ITA, NZL, OMN, PRT, SEN, SVK, ZA1	BEL, BGR, CAN, CHE, CYP, DEU, DNK, EGY, FIN, GBR, GRC, HKG, IRL, ITA, JPN, MDG, MYS, NLD, NZL, PRT, SGP, SVK, ZA1	BEL, BGR, CAN, CHE, DEU, EGY, GBR, GRC, HKG, IRL, ITA, JPN, NZL, PRT, SWE, ZA1
C2	BFA, BRA, CZE, EST, GTM, HRV, HUN, ISL, KOR, LTU, MDG, MEX, MOZ, MWI, PRY, SLV, TTO, TUR, UKR, URY, USA	BRA, FIN, GRC, ISL, JPN, MUS, NOR, SVN, SWE, UKR, USA	BRA, CHL, CIV, CZE, GTM, HRV, ISR, JOR, KOR, LTU, MEX, MKD, MLT, NOR, PHL, POL, SVN, TTO, TUR, USA	AUS, SVK
C3	BRB, CRI, GEO, ISR, MDA, NIC, TUN	CHL, CZE, GUY, HRV, HUN, LTU, MDA, MOZ, POL, PRY, TTO, TUR, URY, VCT	AUS, SWE	MEX, SVN
C4	BOL, MKD	ISR, KAZ, MEX, NIC, PER	COL, EST, ETH, GEO, HUN, SLV, UKR, URY	DNK, NLD
C5	ARG, AUT, CHN, CIV, COL, ECU, ETH, FRA, IDN, IND, JAM, KAZ, LCA, MAR, MLT, MYS, NER, OMN, PER, PHL, ROU, RUS, SAU, SGP, TGO, THA, UGA, VCT, ZMB	BLZ, BOL, GTM, UGA	ARG, AUT, BOL, CHN, CRI, ECU, FRA, IDN, IND, KAZ, LVA, MAR, PER, ROU, RUS, SAU, SEN, THA, TUN, UGA	AZE, BRA, CHL, CZE, GTM, HUN, JOR, LTU, MDA, NOR, POL, TUR, UKR, USA
C6	Not Convergent CHL, POL, SVN	CHE, EST, JOR		BOL, EST, ETH, GEO, HRV, NIC, SLV
C7		AZE, GEO, MKD, PAN, SLV		FIN, KAZ
C8		ARG, BDI, BFA, CHN, CIV, COL, CRI, ECU, ETH, FRA, GMB, IDN, IND, JAM, KOR, LVA, MAR, MDG, MLT, MWI, MYS, NER, PHL, ROU, RUS, SAU, SGP, TGO, THA, TUN, ZMB		AUT, CHN, CIV, COL, CRI, ECU, FRA, IDN, IND, KOR, LVA, MAR, MDG, MYS, PER, PHL, ROU, RUS, SGP, THA, TUN, UGA
C9		Not Convergent NLD		

Source: Constructed by the authors using club convergence methodology.

The results of the export analysis of products from HS-11 to HS-14 are presented in Table 4. An analysis of Table 4reveals that countries are divided into 6, 9, 5 and 8 sub-clubs in the exports of products from HS-11 to HS-14, respectively. Countries with different geographical regions such as Belgium, Bulgaria, Germany, United Kingdom, Portugal, Ireland, Italy, Canada, South Africa, Hong Kong, New Zealand and Egypt are in club 1 in all 4 product groups and have the same transition paths. It is noteworthy that the majority of these countries are located in the European continent. In addition, China, Indonesia, India, Thailand, Thailand, Russia, Romania, Morocco, Ecuador and France act together in the last club. As in Table 3, Table 4 shows that there are countries that do not belong to any club in crop exports including Chile, Poland and Slovenia for code 11 and the Netherlands for code 12.

Visualization of the results

The present study employs Gephi 0.10, a network analysis application, to visualize the results. Gephi 0.10 is an open source network analysis application that can be used to reveal complex network relationships. The reason for choosing Gephi 0.10 is that it is more adaptable and has better visualization features than other available network software packages. Each country is defined as a "node" in the graphs, and countries in a common club are defined as "edges". Since countries are not in the same club, the links are weighted and directed. Direction-weighted graphs are generated using the club as convergence speed weights. The geography-based network is spatialized in the visualization using Geo-Layout, a geographic layout method. The geographic coordinates (latitude and longitude) of each country were placed in the Gephi.

Figure 1 includes 4 graphs: Panel A, Panel B, Panel C and Panel D. In Panel A, each color indicates a sub-club, while in Panel B each sub-club is shown as a single club. The red club in Panel B, which is clearly shown in Panel C, represents the countries that do not belong to any club in exports of crop products. The lines in panels A, B and C show the social networks linking countries and the sub-clubs they belong to. The countries that do not belong to any club are marked on the world map in Panel D, which shows that non-converging countries located on three continents.

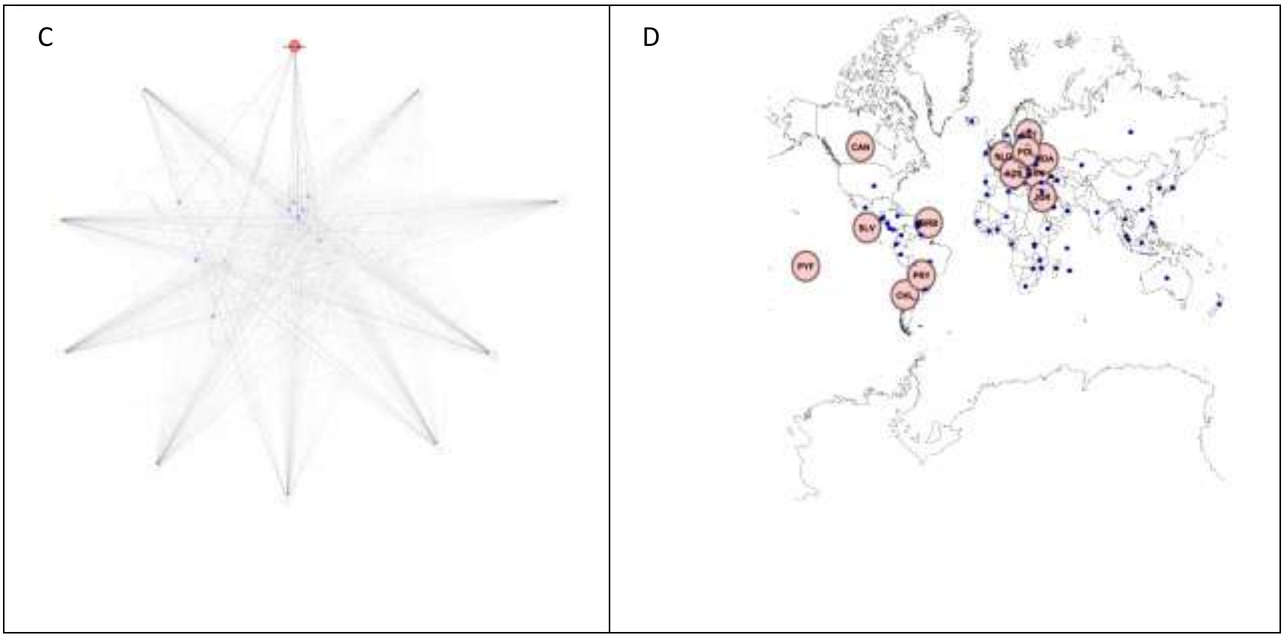


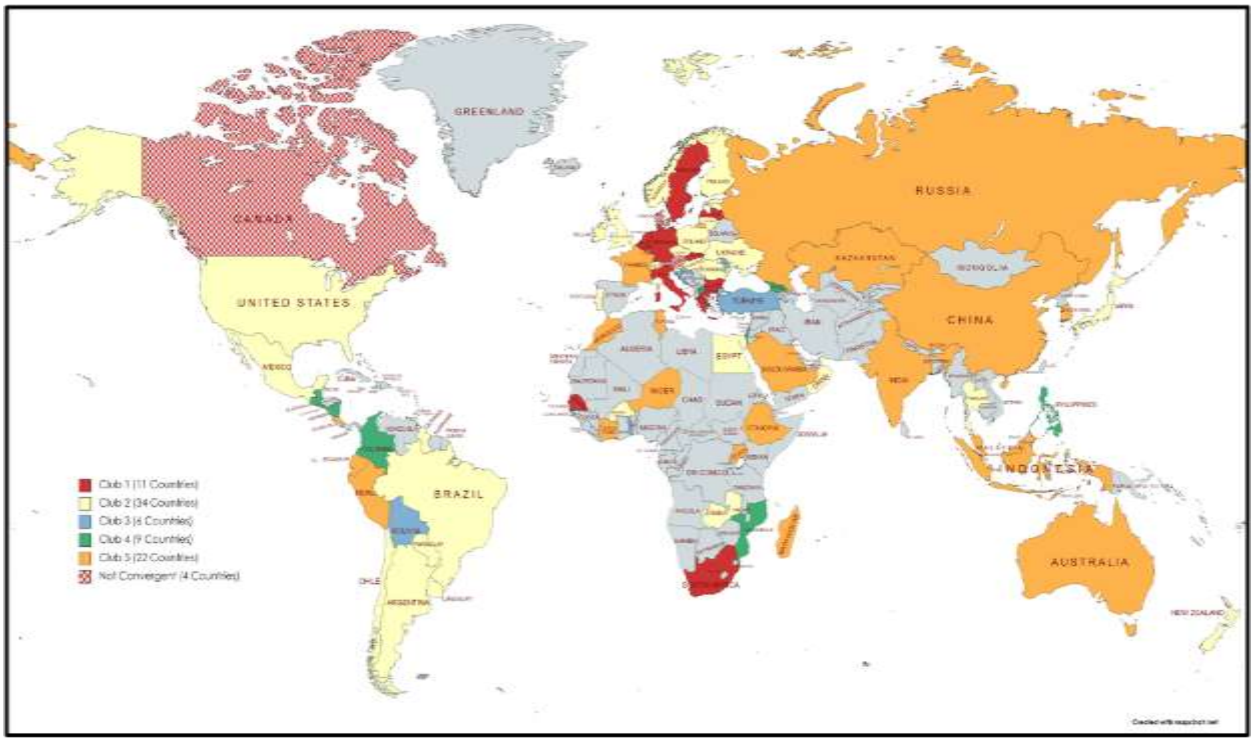
Fig. 1. Countries Not Included in Convergence
Source: Generated by the authors.

Case study

The Covid-19 pandemic, which broke out at the end of 2019, spread across the world in 2020 and started to show its impacts. As of 2020, the demand for grain and grain products increased due to their ability to be stored and preserved for extended periods of time, leading to a significant increase in world grain use and stocks. Before the world could fully recover from the Covid-19 pandemic, the war between Russia and Ukraine which started on 24 February 2022 negatively affected the whole world in terms of agricultural products supply.

On the one hand, due to the prolonged war between Russia and Ukraine, which has an important position in the world grain supply, and the economic sanctions imposed on Russia due to the war, and on the other hand, due to the Covid-19 outbreak, prices, which had been on an upward trend, increased further and reached record levels. Russia and Ukraine, which are considered to be the granaries of the world, are among the most active countries in the world grain trade. These countries are net exporters of several grain products. Both the impact of Covid-19 and the Russian-Ukrainian war forced countries to act together to solve the problems caused by the excessive increases in the prices of commodity-energy-grain products as well as challenges in their supply. It will be important to know which countries or groups of countries can or cannot come together in the face of the circumstances that have occurred or are likely to occur. For the common interests of producer-exporter or importer countries in the trade of grain products, countries can be expected to act together rather than individually. The analysis included data from 86 countries in the trade of grain products.

According to the results in Table 2, the countries that export Wheat-Grain in HS-10 are divided into 5 clubs and there are 4 countries (Austria, Barbados, Canada and Denmark) that are not members of any club. It is seen that the top 10 countries in the world wheat-grain exports are included in two different groups. Map 1 was generated by utilizing Table 2.



Map 1. Visualization of the Clubs for Grain Exports
Source: Visualized by the author.

Map 1 shows that the countries that are not in the top 10 in world wheat and grain production are mainly gathered in clubs 1, 3 and 4, while the countries that have an influence in the production and trade of wheat and grain products are in clubs 2 and 5. Countries in Club 2 (with the exception of Russia) are known to have an influence in the production of grain products and it is known that the majority of the production is consumed domestically. The countries in Club 2 (Russia, China, India and France) have been interpreted as countries that act independently by prioritizing their own national interests in order to maintain their strategic advantages and achieve new ones. In addition, the majority of the countries that have a significant share in world wheat-grain production and trade are gathered in club 5.

CONCLUSIONS

After 2000, structural transformations in the global agricultural sector, such as higher yields, relatively lower costs, a shift from staple food products to intermediate inputs, and a shift in production from low value-added to high value-added products, have created a more favorable market for international trade in agricultural products. This market needs to be stable on both the supply and demand sides to be sustainable. However, the impacts of global climate change, which have become more pronounced in recent years, are likely to cause a number of problems in the foreign trade of crops, primarily on the supply side. The PS (2007, 2009) club convergence analysis was employed in this study in order to identify the countries that may stand out in the vulnerability of crop exports in the event of possible extraordinary circumstances. The reason behind the choice of Phillips and Sul analysis was to identify whether countries act together in foreign trade of crops. The results of the analysis show that ten countries (Chile, Poland, the Netherlands, Barbados, Estonia, Jordan, El Salvador, Austria, Canada, Denmark, Slovenia) act separately from other country groups and clearly reveal the differentiation between countries. Of these countries, Barbados, Jordan, Estonia, Slovenia and El Salvador have low export volumes, while Poland, the Netherlands, Austria, Canada and Denmark have high exports of certain product groups [12].

The literature review reveals that there are numerous studies investigating the convergence of macroeconomic indicators, but there is no convergence/divergence study examining crop exports. The focus of the present study is to investigate the convergence in the transfer of countries' exports to the world economy through their export volumes instead of their production volumes. In terms of methodology, the study employs a panel convergence methodology instead of examining annual changes in exports or other similar measures of distribution. While it is known that the market for crop products is heterogeneous across the world, given the large differences in the capacity of countries to produce crop products, it is highly unlikely that countries can act together in export markets. However, considering the results of the analysis performed in this study, it can be interpreted that countries can act jointly. This suggests that countries should consider establishing crisis management mechanisms to respond to future shocks such as climate change in a coordinated manner.

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EVALUATION OF LINEAR TYPE CLASSIFICATION BASED ON THE EXTERIOR CHARACTERISTICS OF THE BROWN CATTLE COWS OF DIFFERENT ORIGIN IN UKRAINE

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Abstract

The research was conducted in the aspect of preserving the gene pool of Brown cattle with the perspective of breeding animals with the desired conformation type, characteristic to the original Brown Swiss. In the Sumy region of Ukraine, a linear assessment of first-born cows of Brown cattle of different origin - Lebedyn, Ukrainian Brown dairy and Swiss breeds – was carried out. The level of interbreed variability in the development of linear type traits has been established. Results of the linear estimation revealed better indicators of the conformation type in cows of the Swiss breed, which characterize it as a specialized dairy. Lebedyn cattle correspond to the combined type by the linear type traits of linear classification. Ukrainian Brown dairy occupies an intermediate place between Lebedyn and Brown Swiss breeds. Linear assessment indicators confirmed the better development of limbs and body growth in the Lebedyn cattle compared to animals of the Brown Swiss and Ukrainian Brown dairy breeds. However, they were inferior in the development of technological features of the udder.

Key words*: *Lebedyn, Ukrainian Brown dairy, Brown Swiss, conformation type, linear classification

INTRODUCTION

The task of the world's dairy cattle industry is to constantly improve the economically useful traits of cows and to select the best by breeding value ones for reproduction. The accuracy of the selection is ensured both with the help of direct breeding information and indirect information obtained using linear type traits of the conformation, which are quite important for the dairy cattle improvement [1, 2, 3, 4, 5, 7].

The world breeding practice shows that in order to promote the health of dairy cows, increase the productive longevity and milk productivity, more attention should be paid to the enhancement of the conformation of cattle [13, 14, 16, 6, 32]. To achieve this, the conformation of cows is evaluated with the help of the linear evaluation technique. According to ICAR guidelines, the system of linear evaluation of dairy cows by the type includes the confirmative features of economic and functional value, or directly or indirectly related to breeding goals, including those ones aimed to improve the characteristics of the productive longevity [12, 15].

The brown cattle are presently known all over the world as one of the extremely hardy, highly adaptable breeds with a high performance potential. Being in extreme conditions, from tropical heat to changing weather conditions of highland climate with a scanty feeding level, cows of this breed are beyond compare in achieving high performance and trouble-free adaptation to various housing systems. Under optimal conditions brown cows are able to realize their high performance potential to the greatest possible extent. At the same time, the brown cattle are notable for a long period of being kept, which, in turn, has a very positive effect on their economic performance. Brown cows give high-quality, pleasant-tasting milk with a high capacity for cheese making due to the content of kappa-casein BB [4, 21, 24, 25].

Overall, such breeds as the Brown Swiss, Lebedyn, Brown Carpathian, Ukrainian Brown Dairy are bred from among the brown cattle in Ukraine. In the Sumy region, the most common is the Ukrainian Brown Dairy, and the less common Lebedyn and Brown Swiss.

The Lebedyn (or Lebedynska) breed has been bred in Sumy region as a result of the restoration breeding of cows of local breeds (mainly, the Ukrainian Grey breed) with bulls of the Brown Swiss breed with the subsequent inter se breeding (from the second-third generation) of the best crossbreeds while improving the conditions of feeding and keeping animals.

The use of sires of the Brown Swiss breed of foreign breeding in the reproductive crossing with the Lebedyn cattle has resulted in the creation of the new Ukrainian brown dairy breed, officially approved as the breeding achievement in 2009 (the Order of the Ministry of Agrarian Policy and the National Academy of Agrarian Sciences of Ukraine No. 386/59 dated June 03, 2009)[3].

The concept of development of a new Ukrainian brown dairy cattle has provided for obtaining an animal type intermediate between parental breeds, which would be characterized by high yields and performance of the Swiss breed, with objective advantages of the mother one concerning the quality of milk, high adaptive capacity, constitutional strength and productive longevity [19, 20, 22].

Brown Swiss breed is spreading all over the world, especially it is very popular in Europe. There are reports about between 7 and 10 million Brown Swiss animals in the world [27]. However, against this background, the number of Brown Swiss of combined type, which at one time were used as parental stock in the creation of the Lebedyn breed, is currently quite small and they are kept as gene pool herds.

Similar types of Brown cattle have been preserved in some farms of the Sumy region since then, taking into account their original hereditary qualities, which are appreciated by the owners of Brown cattle in foreign countries - the best ratio of protein and fat in milk and a small number of somatic cells, high adaptability, excellent reproductive qualities, strong limbs and hoof horn, balanced, obedient temperament, long-term productive use [9, 10, 11, 27], need protection, preservation and improvement. World and domestic experience shows that the loss of breed diversity is not only the loss of unique and invaluable genetic diversity, but also the narrowing of genetic potential, which fundamentally limits the possibilities of breeding work in the present and the future [20].

Taking into account the importance of preserving Brown cattle in the original type, the purpose of our research was to conduct a comparative characterization of the body structure of animals of maternal, paternal and intermediate form, evaluated by conformation type, and to determine the variability of the assessed linear type traits.

MATERIALS AND METHODS

The conformation type was assessed in first-born cows of Brown cattle of various origins in the leading farms of the Sumy region according to the method of linear classification [17] by the latest recommendations of ICAR [12] at the age of 2-4 months after calving. Research indicators were worked out by biometric methods on a PC in the Microsoft Office Excel environment using the software according to the formulas described by Ladyka et al., 2023 [26].

RESULTS AND DISCUSSIONS

The linear evaluation of the firstlings of brown cattle of different origin, as estimated by the 100-point system of linear classification, showed the significant variability of its indicators within the control breeds (Table 1).

According to the results of linear classification of firstlings of brown cows of different origin, within 100-point estimation, a mongrel variability by its indicators is established. The firstlings of the Schwyz brown breed cows, with a score of 83.6 points, exceeding the cows of the same age of Lebedyn and Ukrainian brown dairy breeds with a significant difference of 2.4 and 1.1 points respectively ($P < 0.001$), are considered to be the best in terms of the dairy type. By the confirmative traits that evaluate the development of the barrel as “very good”, the experimental groups of animals are almost indistinguishable.

The average grade for group characteristics of the barrel indicates a good overall strength of the animals of the brown breeds, the ability to consume roughage in large amounts, and the animals of the Ukrainian brown dairy and Schwyz breeds have good inclinations for high milk productivity.

The assessment of the linear traits that characterize the state of the legs is also important, because the current conditions of milk complexes with a firm flooring and excess moisture lead to severe complications and pathology of the legs of animals. There is some information that, being tied up, 40% of cows suffer of leg diseases, and when cows are kept in mono-block sheds, this figure reaches almost 90%. On dairy complexes, we can trace from 60 to 80% of leg diseases of cows, mainly of the hooves, among all the mechanical damages [30]. Therefore, the task of breeding is to minimize the negative impact of the harmful conditions of dairy complexes on the legs of animals by breeding and selecting animals that have strong legs.

Table 1. The results of the evaluation of the experimental breeds of brown cows by the type of conformation (points)

Conformation traits		**Breed**					
		Lebedyn breed		Ukrainian brown dairy breed		Schwyz breed	
		x ± S.E.	Cv,%	x ± S.E.	Cv,%	x ± S.E.	Cv,%
Quantity of animals		284		306		275	
Group of traits to characterize: dairy type		81.2±0.14	1.4	82.5±0.16	1.1	83.6±0.12	1.0
Barrel		83.8±0.16	1.3	83.2±0.13	1.2	83.8±0.18	1.2
Legs		82.8±0.17	1.5	81.4±0.12	1.4	81.8±0.12	1.3
Udder		81.4±0.15	1.2	82.9±0.13	1.5	83.5±0.15	1.4
Final evaluation		82.2±0.14	1.4	82.5±0.12	1.4	83.2±0.12	1.2
Descriptive traits: Height		6.2±0.18	18.2	6.5±0.15	15.3	6.8±0.19	12.4
Chest breadth		7.5±0.15	11.2	7.1±0.18	12.3	7.3±0.17	11.4
Depth of barrel		7.7±0.16	10.2	7.8±0.12	11.2	7.9±0.19	10.8
Angularity		5.2±0.17	12.4	6.3±0.10	11.2	7.2±0.15	9.7
Position of hindquarters		5.5±0.09	14.6	5.2±0.07	13.2	5.1±0.06	11.3
Width of hindquarters		5.2±0.13	13.7	5.4±0.11	12.5	5.6±0.15	10.4
Angle of ligament		5.3±0.11	12.1	5.1±0.12	17.4	4.9±0.12	14.2
Position of hind legs		6.9±0.18	12.3	6.2±0.15	15.3	7.1±0.10	14.4
Angle of hoof		5.5±0.10	12.7	4.6±0.09	14.3	4.9±0.15	15.0
Udder parts attachment	fore	6.4±0.18	20.4	7.2±0.14	16.1	7.6±0.15	14.9
	hind	5.2±0.17	18.4	5.9±0.13	17.3	6.3±0.17	15.8
Central arch		5.7±0.15	21.6	6.8±0.19	20.1	7.2±0.13	17.3
Depth of udder		5.8±0.16	21.1	6.5±0.14	21.8	7.1±0.18	17.2
Teats location	fore	4.6±0.21	24.3	5.8±0.17	22.8	6.2±0.28	20.5
	hind	5.1±0.21	22.1	6.2±0.17	21.4	6.5±0.28	17.6
Length of teats		6.8±0.11	14.4	5.6±0.14	14.2	5.4±0.11	12.1
Mobility		7.5±0.12	12.5	7.1±0.13	16.2	7.3±0.18	14.4
Fattening		7.8±0.13	14.3	6.5±0.11	13.6	5.7±0.15	12.5

Source: Own calculations.

The state of the legs of the Lebedyn breed cows, characterized by the development of its traits, is better revealed with an average score of 82.8 points. exceeding the cows of the same age of the Ukrainian brown dairy and Schwyz breeds with the difference of 1.4 and 1.0 points, respectively ($P < 0.001$).

The group of linear traits that characterize the dairy system is, at this stage of selection and retention conditions, the most important among the others, since their development depends not only on the productivity of the cows, but also on the adaptability and productive longevity, as evidenced by the research conducted in this aspect [8, 14, 18, 28, 29, 31].

The Schwyz breed cattle is characterized by the best development of linear features used to evaluate the milk system, as evidenced by an average score of 83.8 points. The difference between the Schwyz brown breed and Lebedyn maternal lineage cattle by the group of udder traits is 2.1 points (P <0.001), and 0.6 points (P <0.01) compared to the Ukrainian brown dairy bred. That is, the use of the gene pool of the Schwyz breed made it possible to significantly improve the morphological characteristics of the udder in the breeding process of its transformation into Ukrainian brown dairy breed.

According to the final evaluation, which summarizes the estimates of the four group complexes, obtained by the weight coefficients, the Schwyz breed has got the highest value of 83.2 points, which testifies the best conformation traits of the dairy cows. The cows of the same age of the Lebedyn breed are far behind them by the total evaluation of the type by 1.0 point (P <0.001), and the Ukrainian brown dairy - 0.7 points (P <0.001).

The descriptive traits, unlike the group ones, differ in variability significantly, regardless of the breed being evaluated, with coefficients of variation within the range of 10.2-24.3% of the Lebedyn cattle, 11.2-22.8% of the Ukrainian brown dairy and 9.7 -20.5% of the Schwyz breeds. The slightly lower variability of the descriptive features of the Schwyz breeds indicates that they are more consolidated in type, and higher estimates indicate the enhancement of the conformation development.

In general, the high phenotypic variability of the assessment indicators for the development of the descriptive traits, especially concerning the height, attachment of the fore and hind parts of the udder, the depth of the udder and the location of the teats, indicates the need for systematic selection for the use of linear evaluation of the breeds studied according to the traits of conformation.

The Schwyz breed cows exceed the ones of the same age of the Lebedyn breed significantly by the following descriptive features, namely: height - by 0.6 points (P <0.05), angularity - by 2.0 points (P <0.001), width of hindquarters - by 0.4 points (P <0.05), attachment of the fore teats - by 1.2 points (P <0.001) and the hind teats of the udder - by 1.1 points (P <0.001), the central arch - by 1.5 points (P < 0.001), the depth of the udder - 1.3 points (P <0.001), the location of the fore and hind teats - 1.6 and 1.4 points (P <0.001) respectively, being far behind in fattening by 2.1 points (P <0.001). In compliance with the descriptive traits, the Ukrainian brown dairy breed cattle are located between the Lebedyn and Schwyz breeds.

Using the method of linear classification, we evaluated cows of leading herds of brown cattle of different origin applying the nine-point scale with the conformation profile diagram in the comparative analysis of such breeds as Lebedyn, Ukrainian brown dairy and Schwyz evaluated (Fig. 1, 2, 3). The level of evaluation of the development of the 18 descriptive traits of the cow's conformation, given in the diagram according to the linear classification method, indicates their specific intragroup variability.

The firstlings of the Lebedyn breed cows (Fig. 1) are slightly higher than the average ones (6.2 points), with good development of the chest width (7.5 points) with a deep barrel (7.7 points). Among the animals evaluated there are individuals with slightly flattened hindquarters, as evidenced by the assessment of the character of its position (5.5 points), and by the development in width, the assessment is closer to the average level (5.2 points).

It is well-known that the productive longevity of the dairy cattle in the conditions of the industrial complexes often depends on the strength of the hind legs, which is determined by the assessment of the angle and location of the ligament and hooves. The angle of the ligament of the Lebedyn breed cows is also at an almost optimal level (5.3 points). The state of the hind legs is characterized mostly as parallel one (6.9 points). The firstlings of the Lebedyn breed cows are considered to be better when characterized by the angle of hooves (5.5 points), with a significant superiority of the cows of the same age of the

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Ukrainian brown dairy (4.6 points) and the Schwyz (4.9 points) breeds by 0.9 and 0.6, (P < 0.001) points respectively.

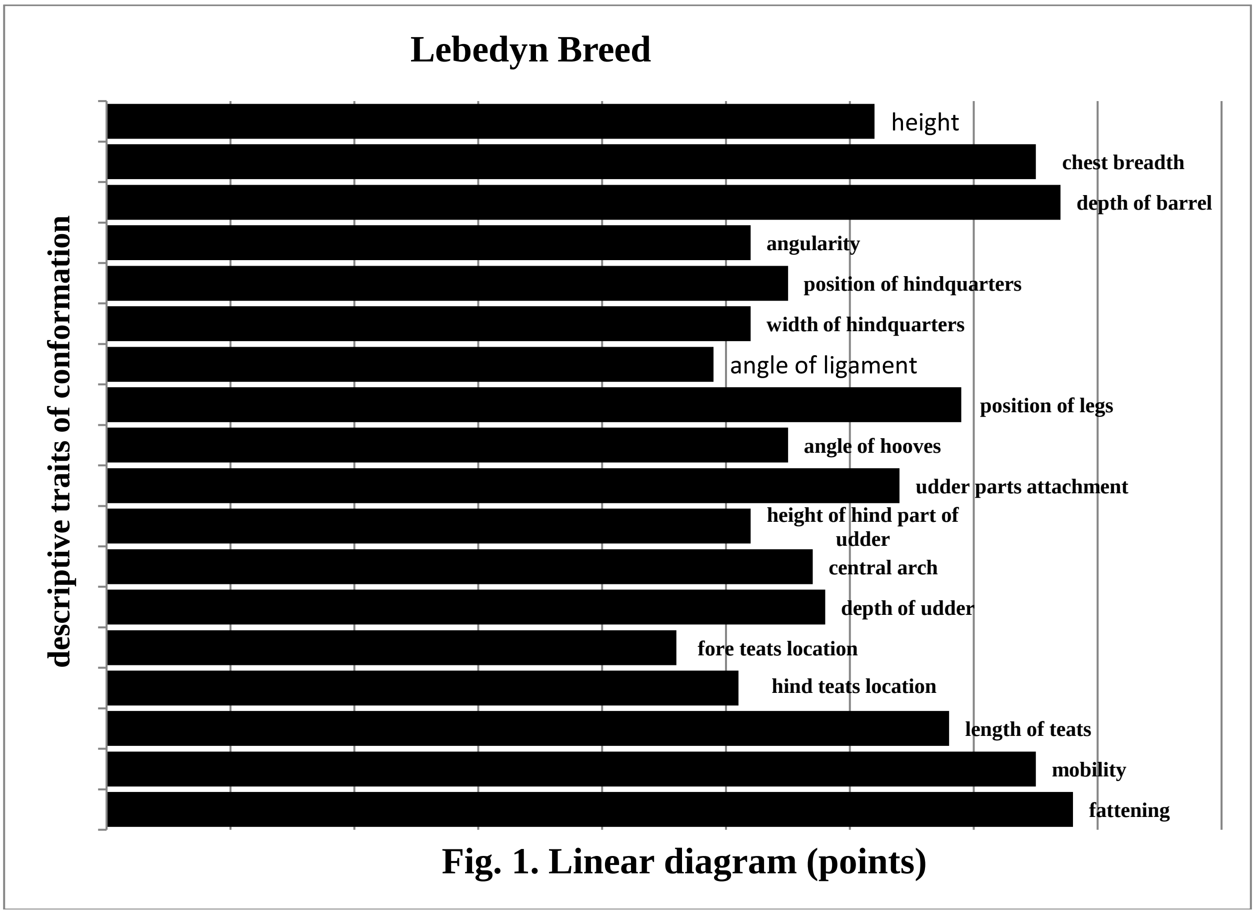

Fig. 1. Linear diagram for Lebedyn Breed (points)
Source: Own calculations.

The most important element of the linear evaluation is the characteristics of the dairy system. In all countries of the world, in the complex classification of the dairy cows by four groups of conformation traits with their independent assessment of the 100-point system, the largest proportion (40%) is occupied by the complex traits that characterize the udder, and six major morphologically important selective traits of udder are evaluated.

The attachment of the fore part of the udder is evaluated by the angle formed at the junction of the udder with the abdomen. Strong attachment of the udder is the most demanded trait highly appreciated. The best development of this type is characterized by the gradual transition of the glandular tissue of the udder into the abdomen through the suspensory lateral ligament to form a blunt angle. The rigid attachment of the udder does not allow it to sag with age. According to this trait, the Lebedyn breed cattle (6.4 points) are significantly far behind the cows of the same age of the Ukrainian brown dairy (7.2 points) and Schwyz (7.6 points) breeds by 0.8 and 1.2 (P <0.001) points, respectively.

The height of the attachment of the hind part of the udder also performs a restraining function and indicates the high level of potential yields. According to this trait, the Lebedyn cows (5.2 points) are also far behind the cows of the same age of the Ukrainian brown dairy (5.9 points) and Schwyz (6.3 points) breeds by 0.7 and 1.1 (P <0.001) points, respectively.

Similarly, the Lebedyn breed cows are far behind the rest of the morphological traits of the cows of the same age of the Ukrainian brown dairy and Schwyz breeds. Their central arch (5.7 points) is slightly shaped and udder (5.8 points) is more drooped, the teats (4.6

and 5.1 points) are located more closely to each other, and the length indicator (6.8 points) is far behind the optimum. This proves the necessity to enhance their morphological traits of udder by the rational selection of the herd bulls, evaluated by the conformation type of their breed.

The Schwyz breed, which was used as a maternal lineage in the process of breeding of the Ukrainian brown dairy breed when crossing it with the Lebedyn breed cattle and, being used to improve the breed recently bred, has been characterized by the best descriptive traits of linear evaluation(Fig. 2).

Having the height in sacrum of 6.8 points, the firstlings of the Brown Swiss breed cows were slightly superior to the Lebedyn and Ukrainian brown dairy breed ones of the same age by 0.6 and 0.3 points, respectively.

The desirable development of angularity trait, used to characterize high yields of animals, the firstlings of the Brown Swiss breed cows are considered to be the best in this respect, which is confirmed by their high evaluation (7.2 points). They have the best sacrum position (5.1 points) and well-developed width of hindquarters (5.6 points). The assessment of the angle of ligament (4.9 points) indicates that there are some animals with elephant position of the hind legs, and the assessment of the angle of hooves (4.9 points) is used to show the average level of the trait.

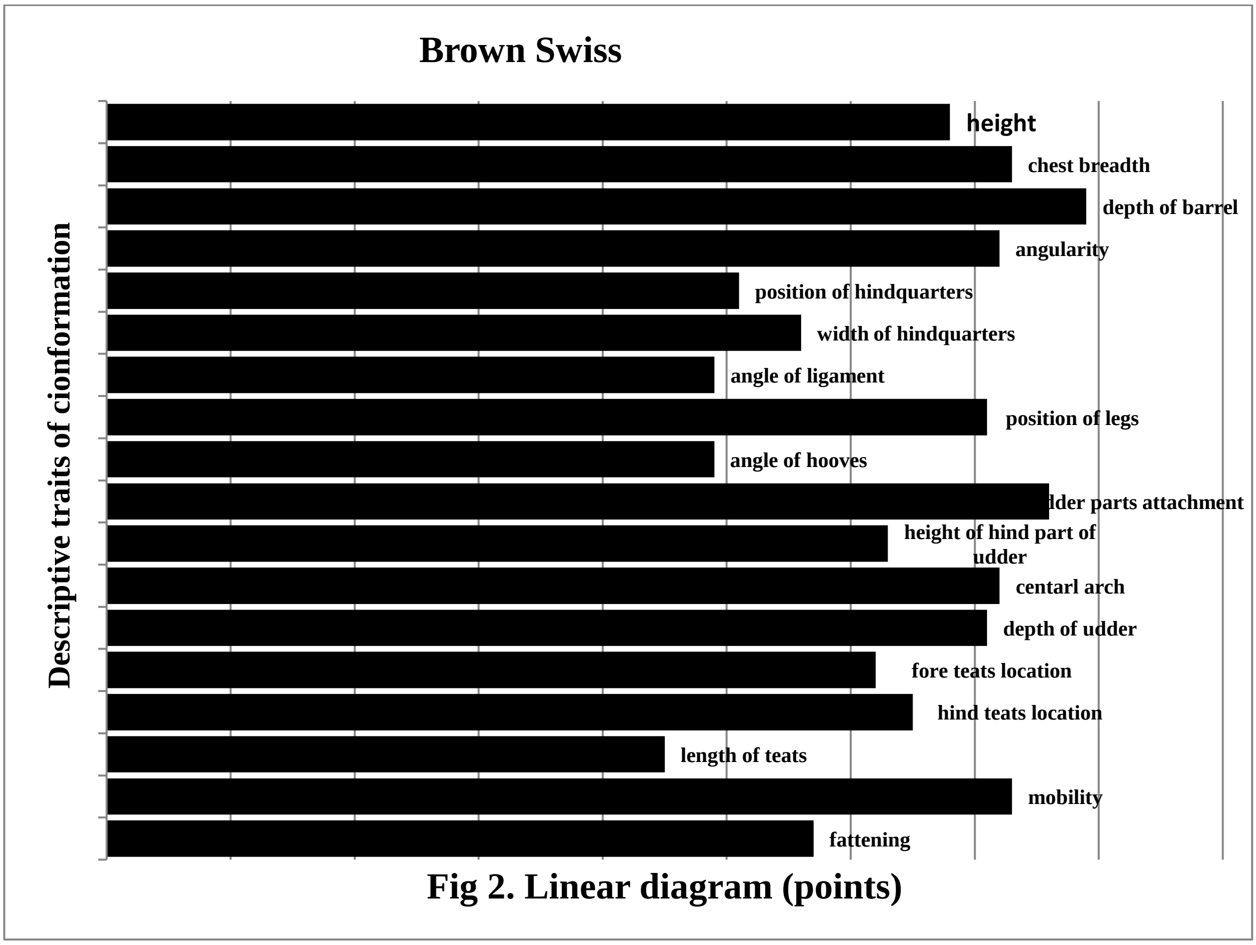

Fig. 2. Linear diagram for Brown Swiss Breed (points)
Source: Own calculations.

According to the linear evaluation of morphological characteristics, the udder of the Brown Swiss breed cow is vastly different from the Ukrainian brown dairy and Brown Swiss breeds. They have the highest assessment of the fore teats attachment (7.6 points), the hind teats attachment (6.3 points), their central arch (7.2 points), which performs a holding function, is sharply shaped, the udder is located high enough from the angle

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of ligament (7.1 points). Taking into account all the traits of udder assessment, the difference in comparison with the Lebedyn breed cattle is vivid.

According to the estimation of the mobility trait (7.3 points), the firstlings of the Schwyzbreed cows are not far behind the Ukrainian brown dairy and Lebedyn breed ones, but by the fattening trait (5.7 points) they are significantly worse (1.3 and 2.1 points respectively).

According to the diagram, the level of estimation of the Ukrainian brown dairy breed in most cases is between the Lebedyn and Brown Swiss breeds.

Thus, the results of the linear evaluation of cows of brown breeds of Sumy region revealed the best efficiency of the conformation type of the Brown Swiss breed cows, which characterizes it as specialized dairy one. According to the linear classification, the Lebedyn breed cattle can almost be characterized as the combined type of productivity, and the Ukrainian dairy breed is between the maternal and paternal lineage (Fig. 3).

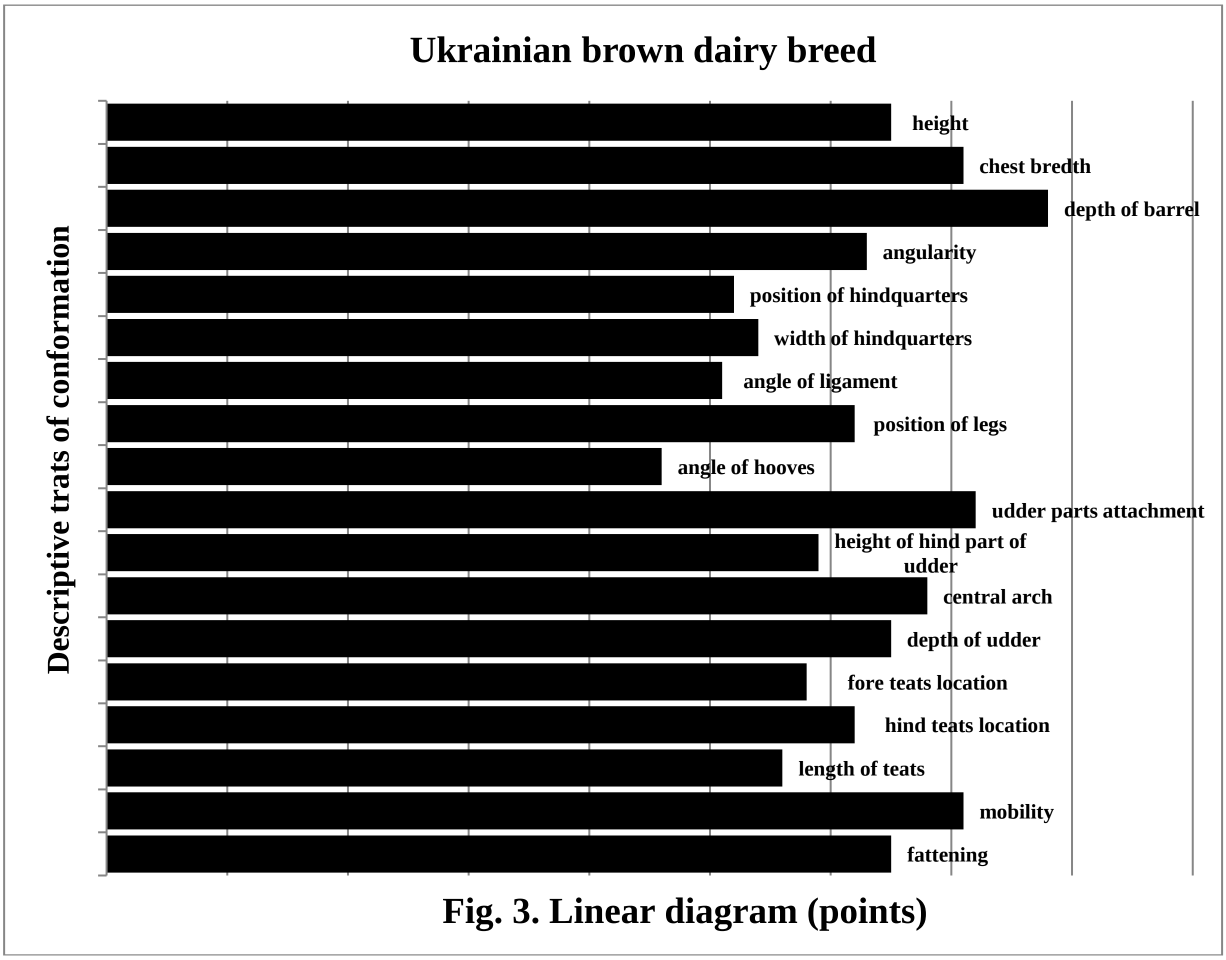

Fig. 3. Linear diagram for Ukrainian Brown Dairy Breed (points)
Source: Own calculations.

At the same time, the assessment of linear type traits characterizing the conformation of created Ukrainian Brown dairy breed indicates that it belongs to the dairy type productivity. Animals of established breed are distinguished by pronounced angularity inherent in specialized dairy breeds, strong limbs and, especially, technological udder. According to the traits of the fore udder parts attachment, central ligament, depth, teats position and length, animals of Ukrainian Brown dairy breed are approaching to those of the Brown Swiss breed. Further careful selection based on linear type traits of the conformation will only allow us to improve this created breed in the dairy type direction.

CONCLUSIONS

The results of linear assessment of Brown cows in the Sumy Oblast revealed better indicators of the conformation type in cows of the Swiss breed, which characterize it as a specialized dairy. By the traits of linear classification, the Lebedyn cattle are approaching the combined type of productivity, and the Ukrainian Brown dairy cattle occupy an intermediate place between the maternal and paternal breeds.

Indicators of linear evaluation of the type of Brown cattle cows of different origins confirmed the better development of limb traits and body development in Lebedyn cattle compared to animals of Brown Swiss and Ukrainian Brown dairy breeds. At the same time, they were inferior in the development of technological features of the udder.

Therefore, in order to improve the morphological qualities of the udder, the breeding stock of the original Brown breed of breeding have been selected for the preservation of the Lebedyn cattle, assessed by the conformation type of daughters with excellent indicators of the dairy system linear type traits.

Further scientific research, will be aimed at carefully evaluating the progeny obtained from the Lebedyn cows and the original Brown Swiss bulls, with the selection of animals of the desired type for breeding. This will preserve valuable maternal properties and improve the technological qualities of the udder.

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COMPARATIVE ADVANTAGES OF APPLYING AN INNOVATIVE SUBSURFACE IRRIGATION SYSTEM IN AGRICULTURE OF THE REPUBLIC OF SERBIA–ECONOMIC ASPECTS

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Abstract

The aim of the research in this paper is to confirm the economic justification of the application of innovative subsurface irrigation "Agrokapilaris". In the introduction, an overview of irrigated areas in the Republic of Serbia is given, from which it is clear that irrigation was applied in 2022 by 4.6% more compared to the previous year and that this is a small but at least some progress, with a tendency to further increase areas with irrigation systems. Also, the key features of the innovative subsurface irrigation are given. The innovative subsurface irrigation has been used for some time on plots in Serbia. In this paper authors examine further development and economic profitability of this irrigation model, on the example of its application in the plastic greenhouse production of vegetables on the agricultural property of the Secondary Agricultural and Chemical School in Obrenovac, Serbia. The assessments of the economic effectiveness of investments in this type of irrigation system in plastic greenhouse vegetable production, on an area of 0.5 ha, showed, based on static calculations that the investment will succeed in 4.02 years. According to the dynamic calculation, the investment project will succeed in 4.26 years, which clearly shows the quick return of the invested funds in this type of irrigation system, that is, justified investments.

Key words: *subsurface irrigation, vegetable, investment, evaluation, static and dynamic methods, return, profit*

INTRODUCTION

In order to achieve sustainable development, agricultural production must not have a negative impact on the environment or degrade its resources, but should be designed in a way that it is technically applicable, economically profitable and socially acceptable [19]. Accordingly, the concept of development based on the principles of using new technologies and renewable energy sources, which imply minimal use of water resources with their optimization and preservation of ecological status, is imposed on agriculture.

According to [1], predicted climate changes and the progressive pressure of the human population on nature and resources will contribute to the reduction of water resources.

According to [2], the frequency of 100-year droughts will increase at least 10 times. Due to the upcoming changes, efficient, controlled management of water resources is necessary.

Irrigation has a strategic role in the process of agricultural production and agricultural development in general [8] and the management of water resources and management of systems for the use and protection of water is gaining more and more importance [3]. Along with that, the intensification of irrigation could lead to a positive restructuring of agricultural production both in the field of vegetable growing, cattle breeding and in the field of industrial plants. In the conditions of intense climate changes, when rainfall isn't enough for cultivated plants either in terms of intensity/quantity or schedule, during their vegetation cycle, it is impossible to imagine agricultural production without the use of irrigation, as well as the achievement of quality yields in satisfactory quantities, with all that, economically justified. With the intensive application of irrigation, with the use of all the necessary agro technical measures that accompany production, the

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genetic potential of the cultivated calves can be reached and developed [11, 13].

In the Republic of Serbia, a total of 54,639 ha of agricultural land were irrigated in 2022, which is 4.6% more than in 2021 [14].

Irrigation research includes business entities and agricultural cooperatives engaged in agricultural production and services in agriculture and/or managing irrigation systems.

In the total irrigated areas, arable land and gardens have a dominant share of 51,008 ha (93.4%). They are followed by orchards (2,943 ha) with 5.4%, while other agricultural areas participate in irrigation with only 1.3% or 688 ha (Figure 1/a).

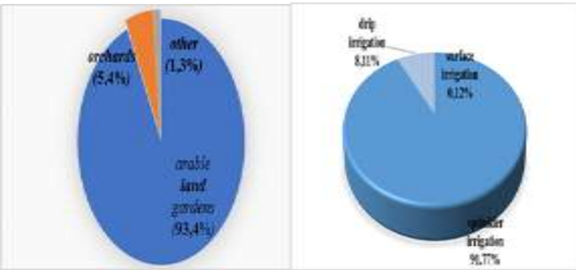

Fig. 1. Irrigated areas under crops (a) and by type of irrigation (b) in the Republic of Serbia, 2022, %
Source: Statistical Office of the Republic of Serbia [14].

The most common type of irrigation in 2022 was sprinkling, applied by 91.8% (on 50,143 ha). Drip irrigation was applied to 8.1% of the area or 4,433 ha), while only 0.1% of the area or 63 ha was surface irrigated (Figure 1/b).

According to the same data source, for irrigation in 2022, most of the water was drawn from watercourses (89.8%), while the remaining amounts were taken from groundwater, lakes, reservoirs and water supply networks.

Irrigation as an old ameliorative measure has existed almost as long as human civilization and it has improved and intensified over time. Its representation in the world is not equal and is conditioned by the natural features of the area, the water needs of the cultivated plants and many other economic, social and natural factors. There are several methods of irrigation, but the research in this paper refers to underground/subsurface irrigation or sub-irrigation.

Subsurface irrigation is irrigation below the surface of the soil, at a certain depth, which is generally aligned with the depth of the rhizosphere of the cultivated plant. It is a relatively recent method of irrigation, since its beginnings date back to the sixties of the last century, and it was first used in America.

The principle of subsurface irrigation involves bringing water to the surface intended for irrigation through canals, i.e. through pipes and distributing water below the surface of the soil into the rhizosphere zone, through a system of laterals with water emitters [5]. A pictorial representation can be seen in the Figure 2.

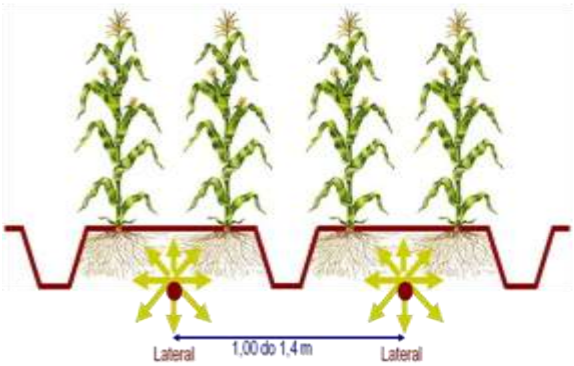

Fig. 2. Subsurface irrigation - installation of laterals with water emitters
Source: Zloh Zdenko, internal documentation [20].

When it is about Republic of Serbia, subsurface irrigation is mainly applied on plots of larger areas, from 1 to 130 ha. The total areas covered with subsurface irrigation systems range from 15,000 to 20,000 ha, and about 80% are present in the area of AP Vojvodina [10].

As all types of irrigation, subsurface irrigation has a number of advantages and a number of disadvantages. The potential advantages are mainly reflected in lower water consumption, providing the possibility of automation and remote control of the system, not disturbing the movement of agricultural mechanization on the irrigated surface, greater water application uniformity and others [9]. The main limiting factors of subsurface irrigation are clogging of drippers, soil salinization and damage caused by rodents. The solution for this could be regular flushing of pipelines and laterals, use of herbicides and acids that prevent root growth and treatment against

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rodents. If all these factors were harmonized, the lifetime span of the subsurface irrigation system would be about 20 years [6].

The implementation of innovations and new technologies through applying new technical solutions for optimizing water consumption in the irrigation process, opportunities are created for improving agricultural production and sustainable rural development. Unlike Serbia, in economically developed countries, there are precise and official data on the application and justified use of new technologies and renewable energy sources in agriculture [17, 16]. One of the most considerable problems worldwide is water shortage. Regarding agriculture is a sector with high water needs through the use of irrigation systems, "smart systems" that use water wisely are priceless [4]. In order to promote the use of new technologies and renewable energy sources in agriculture in Serbia, the research in this paper is focused on the comparative advantages and economic effects of using an innovative subsurface irrigation system with solar panels. The innovative solution "Agrokapilaris" was created as a result of many years of research and experimental work on monitoring the water-physical properties of the soil on test fields with different agricultural crops. One of the several locations where this system was installed is the sample location "Grabovac" at the Secondary Agricultural and Chemical School in Obrenovac, on the production area of the plastic greenhouse of 5 acres which will be shown in this paper.

Agrokapilaris represents an innovation in irrigation that could overcome the problems related to extreme droughts in the long term. Structurally, this system is very precise because it strictly controls optimal water consumption and has a self-regulating mechanism for giving water to plants. This system is placed below the depth of tillage, at a parallel distance that depends on the plant being grown. Certainly, in vegetable growing, these distances are shorter, while in fruit production they are longer.

The Agrokapilaris innovation is a specific construction, it is a small dimensions underground channels network made of non-degradable plastic foil, in the shape of the letter "V", within which there are hoses for water transport with built-in elements for turn on water into the system (Figure 3). The plastic foil enables capillary moisture to rise laterally and ascendingly, preventing water from flowing into the deeper layers of the soil, which prevents loss of water. Every drop of water goes to the root system in the form of capillary moisture. Droppers are not used as water emitters, so there is no clogging of them, which makes this system different from other existing and so far applicable systems for subsurface irrigation in practice.

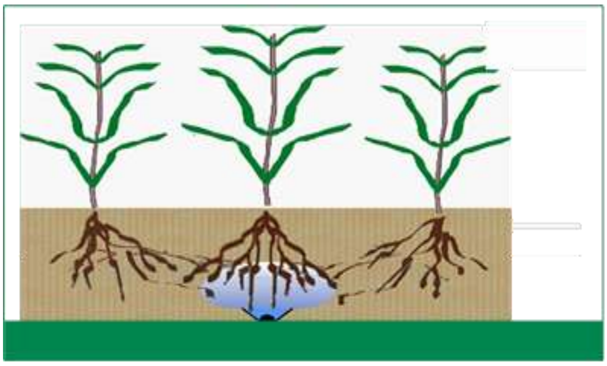

Fig. 3. “Agrokapilaris” working concept
Source: Zloh Zdenko, internal documentation [20].

The main differences between this system and conventional irrigation systems are as follows:
-Long lifespan (possible service life is 70 years);
-Good working system under extremely low pressures (for using this system, a pressure of 0.2 bar is enough, which means watering several times the area with the same energy consumption compared to the drip irrigation system);
-Self-regulation when giving water to the soil, i.e. plants, without clogging the drippers [20].

MATERIALS AND METHODS

For the purposes of research, the data of the Statistical Office of the Republic of Serbia, the results of previous research related to the issue of subsurface irrigation by local and foreign authors, previous research related to innovative subsurface irrigation and data collected from the plastic greenhouse of the Secondary Agricultural and Chemical School in Obrenovac were used.

The methods used to evaluate the economic effectiveness of investments in agriculture are significant not only in the field of application of new technologies and renewable energy sources in agriculture, but in general in the application of the concept of sustainable development on agricultural holdings. Consequently, this part of the research represents an important segment of the overall presentation when it is about the evaluation of the economic effects both of applying the innovative subsurface irrigation system and solar panels in agriculture, in which the important role of the economic effectiveness of investments for sustainable development on the agricultural holdings is underlined. In this research, the authors emphasize the methods for evaluating the economic effectiveness of investments in agriculture, such as [15]:

- Static methods for evaluating the economic effectiveness of investments;
- Dynamic methods for evaluating the economic effectiveness of investments;
- Methods for evaluating the economic effectiveness of investments in conditions of uncertainty and risk.

The research results are presented in tables and graphs.

RESULTS AND DISCUSSIONS

By implementing investments in the irrigation system, the positive effects of sustainable use of natural resources are realized, the quality of the environment and the general, socio-social and economic development of society are improved [7].

The evaluation of the economic effectiveness of investments in agriculture is based on the foundations that will ensure maximum economic effects during the period of exploitation of the investment object, that is, on the highest possible level of obtained effects per unit of invested funds. Accordingly, the evaluation of the economic effects of the application of the innovative system of subsurface irrigation and solar panels in agriculture, regardless of the conditions in which the production process takes place, should be based on quantitative and qualitative provisions, which will ensure the direction of cash flows, that is, investment in the most profitable business activities on the agricultural holding [12].

Investments in the irrigation system depend on the type of mobile equipment, the location of captured water, the distance of the energy source, the terrain configuration, etc.

In the plastic greenhouse of the Secondary Agricultural and Chemical School in Obrenovac, on the agricultural sample location “Grabovac”, an experiment was conducted in order to monitor the results achieved by the introduction of the innovative method of subsurface capillary irrigation. Three crops were observed: red pepper (first and second category), radish and onion.

The values obtained during the calculation are shown per acre, in euros.

With the introduction of an innovative subsurface irrigation system in the plastic greenhouse, a change occurred:

-in the amount of income (increase in yield and prices),

-and in terms of costs (reduction in water consumption for irrigation, reduced use of fertilizers and plant protection products) for all crops. In the process of evaluating the economic effects of the application of subsurface irrigation and solar panels on the agricultural holding, we started from assumptions that are reflected in: investments in fixed assets (Table 1), total investments (Table 2), sources of financing (Table 3), formation of total income (Table 4), total expenses (Table 5), income statement (Table 6) and economic flow (Table 7).

Investments in fixed assets refer to the purchase and installation of an innovative subsurface irrigation system, the purchase and installation of solar panels, the purchase and installation of a digital weather station, and the purchase and installation of soil and air sensors. All investments refer to the acquisition of new fixed assets, and the investment is shown in total amount (purchase price + VAT). The total income is formed from income from the sale of products and income from subventions.

Direct material includes: onion bulbs; radish seeds, pepper seedlings, fertilizers, pesticides, packaging, binder and foil.

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Table 1. Investment in fixed assets (EUR)

Ord. No.	Description	Value (with VAT)
I	**Constructions and buildings**	**6,925.17**
1.	Irrigation system "Agrokapilaris"	6,925.17
II	**Equipment and mechanization**	**2,311.79**
1.	Weather station with software	1,020.66
2.	Solar energy power system, electric valves and i electric motor	1,015.55
3.	Soil and air sensors	275.58
TOTAL		**9,236.96**

Source: Author's calculation based on [18].

The calculation of depreciation (amortization) refers only to the basic price (purchase value without VAT). The value of investments in fixed assets accounted for Euro 9,236.96, VAT included (Table 1).

The value of total investments is Euro 10,160.65 as shown in Table 2.

Table 2. Total investments (EUR)

Ord. No.	Description	Existing funds	New investments	Total investments	Participation in total investments (%)
I	**Fixed assets**	**0.00**	**9,236.96**	**9,236.96**	**90.91**
1.	Constructions and buildings	0.00	6,925.17	6,925.17	68.16
1.	Equipment and mechanization	0.00	2,311.79	2,311.79	22.75
II	**Current assets**	**0.00**	**923.70**	**923.70**	**9.09**
TOTAL		**0.00**	**10,160.65**	**10,160.65**	**100.00**

Source: Author's calculation based on [18].

Table 3. Financial resources (EUR)

Ord. No.	Description	Existing funds	New investments	Total investments	Participation in total investments (%)
I	**Own resources**	**0.00**	**10,160.65**	**10,160.65**	**100.00**
1.	Fixed assets	0.00	9,236.96	9,236.96	90.91
2.	Current assets	0.00	923.70	923.70	9.09
II	**Other sources**	**0.00**	**0.00**	**0.00**	**0.00**
1.	Fixed assets	0.00	0.00	0.00	0.00
TOTAL (I+II)		**0.00**	**10,160.65**	**10,160.65**	**100.00**

Source: Author's calculation based on [18].

Table 4. Total income formation (EUR)

Ord. No.	Product/subventions/Services	Unit of Measure (UM)	Years of the project: I – Price per UM	I – Quantity in UM	I – Total	II – Price per UM	II – Quantity in UM	II – Total	III - X – Price per UM	III - X – Quantity in UM	III - X – Total
0	1	2	3	4	5=3x4	6	7	8=6x7	9	10	11=9x10
1	Income from product sales				4,790.62			5,554.97			6,323.61
1.1.	Onion	bunch	0.31	1,970	603.12	0.31	2,280	698.13	0.31	2,600	796.11
1.2.	Radish	bunch	0.23	5,114	1,196.08	0.23	5,930	1,387.03	0.23	6,750	1,578.83
1.3.	Red pepper 1st category	kg	1.06	2,500	2,657.96	1.06	2,900	3,083.24	1.06	3,300	3,508.51
1.4.	Red pepper 2nd category	kg	0.77	436	333.45	0.77	505	386.57	0.77	575	440.16
2	Revenues from subventions				3,462.58						
2.1.	Subventions for the purchase of irrigation systems (50% of the purchase price	piece	3,462.58	1.00	3,462.58						
TOTAL					**8,253.20**			**5,554.97**			**6,323.61**

Source: Author's calculation based on [18].

The total financial resources accounted for 10,160.65, of which 90.91% fixed assets and the remaining of 9.09 representing current assets (Table 3).

Table 5. Total costs (EUR)

Ord. No.	Costs	Years of the project				
		I	II	III	IV	V
I	**Material costs**	**1,988.46**	**2,042.98**	**2,097.48**	**2,097.48**	**2,097.48**
1.	Direct material	1,938.46	1,992.98	2,047.48	2,047.48	2,047.48
2.	Energy and fuel	50.00	50.00	50.00	50.00	50.00
II	**Non material costs**	**1,677.28**	**1,677.28**	**1,677.28**	**1,677.28**	**1,677.28**
1.	Amortization	462.10	462.10	462.10	462.10	462.10
2.	Labour	987.74	987.74	987.74	987.74	987.74
3.	Interest on the loan	0.00	0.00	0.00	0.00	0.00
4.	Costs of production services	136.00	136.00	136.00	136.00	136.00
5.	Non material costs	91.43	91.43	91.43	91.43	91.43
TOTAL (I+II)		**3,665.74**	**3,720.26**	**3,774.76**	**3,774.76**	**3,774.76**

Source: Author's calculation based on [18]

Table 6. Profit and loss statement (EUR)

Ord. No.	Description	Years of the project				
		I	II	III	IV	V
I	**TOTAL INCOME**	**4,790.62**	**5,554.97**	**6,323.61**	**0.00**	**0.00**
1.	Income from product sales	4,790.62	5,554.97	6,323.61	0.00	0.00
2.	Other income	0.00	0.00	0.00	0.00	0.00
II	**TOTAL EXPENDITURES(1+2+3)**	**3,665.74**	**3,720.26**	**3,774.76**	**3,774.76**	**3,774.76**
1.	Business expenses	3,665.74	3,720.26	3,774.76	3,774.76	3,774.76
1.1.	Material costs	1,988.46	2,042.98	2,097.48	2,097.48	2,097.48
1.2.	Non material costs without amortization and interest on the loan	1,215.18	1,215.18	1,215.18	1,215.18	1,215.18
1.3.	Amortization	462.10	462.10	462.10	462.10	462.10
2.	Financial expenses	0.00	0.00	0.00	0.00	0.00
2.1.	Interest on the loan	0.00	0.00	0.00	0.00	0.00
III	**GROSS PROFIT (I-II)**	**1,124.88**	**1,834.72**	**2,548.85**	**-3,774.76**	**-3,774.76**
IV	**PROFIT/INCOME TAX**	0.00	0.00	0.00	0.00	0.00
V	**NET PROFIT (III-IV)**	**1,124.88**	**1,834.72**	**2,548.85**	**-3,774.76**	**-3,774.76**

Source: Author's calculation based on [18].

Table 7. Economic flow (EUR)

Ord. No.	Name	Zero moment	Year				
			1	2	3	4	5
I	**TOTAL INCOME (1+2)**	**0.00**	**4,790.62**	**5,554.97**	**6,323.61**	**6,323.61**	**13,788.45**
1.	Total income	0.00	4,790.62	5,554.97	6,323.61	6,323.61	6,323.61
2.	The rest of the project value	0.00	0.00	0.00	0.00	0.00	7,464.84
	2.1. Fixed assets	0.00					6,541.14
	2.2. Permanent current assets	0.00					923.70

II	**TOTAL ISSUANCE (3+4)**	**10,160.65**	**3,203.64**	**3,258.15**	**3,312.66**	**3,312.66**	**3,312.66**
3.	Investment value	10,160.65					
	3.1. In fixed assets	9,236.96					
	3.2. In permanent current assets	923.70					
4.	Costs without amortization and interest	0.00	3,203.64	3,258.15	3,312.66	3,312.66	3,312.66
5.	Income tax	0.00	0.00	0.00	0.00	0.00	0.00
III	**NET INCOME (I-II)**	**-10,160.65**	**1,586.98**	**2,296.82**	**3,010.95**	**3,010.95**	**10,475.79**

Source: Author's calculation based on [18].

Table 8. Economical-efficiency coefficient, (Ee>1) (EUR)

Year of investment life cycle	Total output (market value of production)	Total input (costs of production)	Ee
0	**1**	**2**	**3 = 1/2**
I	4,790.62	3,665.74	1.31
II	5,554.97	3,720.26	1.49
III	6,323.61	3,774.76	1.68
IV	6,323.61	3,774.76	1.68
V*	6,323.61	3,774.76	1.68

Source: Author's calculation based on [18].
*Representative year (full capacity)

Table 8 regards the economic efficiency in terms of the ratio between the total output at market price and total input expressed in costs of production. The value of economic efficiency is higher than 1, Ee>1, reflecting an increasing trends from the 1st year of investments to the 5th year.

Table 9 reflects net profit margin ratio (NPMR), calculated as the relative ratio between profit and total output (income).

The NPMR values had an increasing trend in the 2st and 2nd year of investments, and then, in the 4th, 5th and 6th years, they remained at the level of 40.31%.

Table 9. Net profit margin ratio, (NPM > i) /EUR/

Year of investment life cycle	Profit	Total output (income)	NPMR
0	**1**	**2**	**3 = 1/2*100**
I	1,124.88	4,790.62	23.48
II	1,834.72	5,554.97	33.03
III	2,548.85	6,323.61	40.31
IV	2,548.85	6,323.61	40.31
V*	2,548.85	6,323.61	40.31

Source: Author's calculation based on [18].
*Representative year (full capacity)
Symbol meaning: i - assumed weighted cost of capital (discount rate = 7.00%)

Table 10 presents he accounting rate of return (ARR), whose value increased from 11.07% in the 1st year of investment to 18.96% in the 2nd year, and then it remained at the constant level of 25.09%.

Table 10. Accounting rate of return, (ARR > i) (EUR)

Year of investment life cycle	Profit	Initial outlay	ARR
0	**1**	**2**	**3 = 1/2*100**
I	1,124.88	10,160.65	11.07
II	1,834.72	10,160.65	18.06
III	2,548.85	10,160.65	25.09
IV	2,548.85	10,160.65	25.09
V*	2,548.85	10,160.65	25.09

Source: Author's calculation based on [18].
*Representative year (full capacity)
Symbol meaning: i - assumed weighted cost of capital (discount rate = 7.00%)

Table 11 shows the payback period which reflects that in the 5th year the investment value is recovered.

Table 11. Simple payback period, (SPP<n) (EUR)

Year of investment life cycle	Net cash flow from economic flow	Cumulative net cash flow
0	-10,160.65	-10,160.65
I	1,586.98	-8,573.67
II	2,296.82	-6,276.85
III	3,010.95	-3,265.90
IV	3,010.95	-254.94
V	10,475.79	10,220.85

Source: Author's calculation based on [18].
Symbol meaning: T - investment payback time; n - years of the project

Table 12 regards Net present value (NPV) and internal rate of return (IRR), the last accounting for 20.54%.

Table 12. Net present value (NPV) and internal rate of return (IRR)

No.	Description	Zero moment	Year of investment life cycle					Cumulative
			I	II	III	IV	V	
0	1	2	3	4	5	6	7	8
1.	Net income from the economic flow (column 3 to column 7)	-10,160.65	1,586.98	2,296.82	3,010.95	3,010.95	10,475.79	***20,381.50***
2.	Discount rate (%)	7.00	7.00	7.00	7.00	7.00	7.00	
3.	Discount factor $(1+i)^{-n}$ or $1/(1+i)$^^{n}, where is i = discount rate; n = years of the project	1.0000	0.9346	0. 8734	0.8163	0.7629	0.7130	
4.	Net present value of project (column from 3 to column 7)	-10,160.65	1,483.16	2,006.13	2,457.84	2,297.04	7,469.09	***15,713.26***
5.	Net present value of project (column from 2 to column 7)	5,552.61						
6.	Relative net present value of project: [(column from 2 to column 7) / |column 2|] > i	0,55						
7.	Internal rate of return: (ISR > i)	20,54%						

Source: Author's calculation based on [18].

Table 13. Dynamic payback period, (DPP < n) (EUR)

Year of investment life cycle	Present value of net cash flow from economic flow	Cumulative net cash flow
0	-10,160.65	-10,160.65
I	1,483.16	-8,677.49
II	2,006.13	-6,671.36
III	2,457.84	-4,213.52
IV	2,297.04	-1,916.48
V	7,469.09	5,552.61

Source: Author's calculation based on [18].

Table 13 and 14 present the dynamics of payback period and the breakeven point of the investment exploitation.

Table 14. Break-even point of investment exploitation (EUR)

No	Description	Year of investment life cycle				
		I	II	III	VI	V
1.	Incomes (I)	4,790.62	5,554.97	6,323.61	6,323.61	6,323.61
2.	Variable costs (VC)	2,976.20	3,030.72	3,085.22	3,085.22	3,085.22
3.	Fixed costs (FC)	227.44	227.44	227.44	227.44	227.44
4.	Gross margin (GM = I - VC)	1,814.42	2,524.26	3,238.39	3,238.39	3,238.39
5.	Break-even point (relative) (BEPr = (FC / GM) * 100), in %	12.53	9.01	7.02	7.02	7.02
6.	Break-even point (value) (BEPv = (I * BEPr) / 100), in EUR	600.50	500.51	444.12	444.12	444.12
7.	Margin of safety (MS = ((1 - (BEPv / I)) * 100), in %	87.47	90.99	92.98	92.98	92.98
8.	Incomes (I)	4,190.12	5,054.47	5,879.50	5,879.50	5,879.50

Source: Author's calculation based on [18].

CONCLUSIONS

The irrigation in the Republic of Serbia has been a sporadic measure in plant production for a long time. In last few years, it has been more intensive, but despite of it still inadequately represented. Innovative subsurface capillary irrigation, as a subject of the study, compared to classical approaches i.e. the scientifically recognized methods of irrigation, has numerous environmental and economic advantages. It was found that its application in plastic greenhouses is economically justified, because it leads to an increase in the production value of all analysed vegetable crops, as well as to a reduction of the most important groups of variable costs (fertilizer costs, plant protection products, energy costs, etc.).

Observing the years of full capacity i.e. from the third year of the project, the static evaluation of the project's effects points the following conclusions: that coefficient of economy is greater than one, which indicates the fact that the total income is greater than the total expenditure. It can be stated that the investment project is economical, which means that the investment is profitable. Accumulation rate is higher than 7.00% (assumed weighted cost of capital), which shows that the investment project is accumulative. During the exploitation of the project, the cost of the source of financing is covered and through this "earnings" are made. Based on the static calculation, it is clear that the investment project will pay off in 4.02 years. The investment payback time is, therefore, 4 years and 0.29 months (0.02 x 12 months).

According to the dynamic assessment of the project's effects, the following can be concluded: the investment in a period of five years of use (years of the project's lifetime span) would enable the investor to increase the total profit, calculated using the discount rate (i = 7.00%) at the initial moment of exploitation (n = 0), in the amount of RSD 5,552.61. The investment is profitable because the project's internal rate of return is higher than the discount/weighted rate (20.54% > 7.00%). Also, according to the dynamic calculation, the investment project will pay off in 4.26 years.

Therefore, the investment payback time is 4 years and 3.08 months (0.26 x 12 months).

Regarding the assessment of the effects of the project under conditions of risk and uncertainty, with an emphasis on the bottom point of profitability in the years of full capacity (from the third year of the project), we come to the following conclusions:

-the volume of production must not fall below 7.02%;

-the realized income from sales must not be below 444.12 euro;

-a decline in production volume by 92.98% is allowed;

-a decrease in sales revenue of 5,879.50 euro is allowed.

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EFFICIENCY OF BREEDING OF PUREBRED CROSSBRED AND HYBRID PIGLETS OF THE ENGLISH BREED

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Abstract

The study examined the performance of purebred, crossbred, and hybrid piglets during their rearing period and the efficiency of their results under a liquid feeding system. It was found that during rearing, purebred piglets of the Large White and Landrace breeds were inferior to their counterparts of the synthetic sire line PIC–337 in intra–line breeding by 29.2% and 24.1% in terms of average daily and absolute gains. They had a 29.4% and 24.3% higher mass at the end of this period but were inferior to them by 2.7% and 2.0% in terms of survivability. There was a trend towards a 4.1% improvement in average daily and absolute gains and a significant 4.0% difference in the mass of weaners at the end of rearing in favor of the Landrace breed. Hybrid piglets obtained from crossbred sows of maternal breeds in direct and reverse crossing with boars of the synthetic sire line PIC–337 outperformed their crossbred peers from direct and reciprocal crossing of these two maternal breeds by 8.0–15.7% in average daily and absolute gains, by 9.5–15.3% in live weight at the end of rearing, and by 0.7–1.3% in survivability during rearing. Crossbred animals from direct and reverse crossing of maternal breeds did not have significant differences in reproductive performance indicators. Hybrid piglets consumed and utilized 5.5–14.0% more feed daily and throughout the rearing period compared to their crossbred peers and 9.1–17.0% more compared to purebred animals of the maternal line. They also had better feed conversion by 0.6–2.8% compared to crossbreeds and by 3.8–5.0% compared to purebred peers of the maternal breeds. In turn, crossbred piglets consumed 0.7–4.8% more feed daily and throughout the rearing period and had 2.2–5.3% better feed conversion compared to the original maternal breeds. Piglets of the synthetic sire line consumed feed at the same level as their hybrid peers, 6.3–7.7% more than crossbreeds, and 9.1–11.2% more than purebred animals of the maternal breeds.

Key words: *breed, breeding method, feed payment, maternal line, rearing, growth, terminal line*

INTRODUCTION

It is a well-known fact that crossbreeding often yields better results in animal husbandry compared to purebred breeding. According to [2, 38, 43] an important aspect of crossbreeding is hybrid vigor or heterosis, which enhances offspring performance above the average performance of the parent breeds. In pig farming, this usually results in a higher number of piglets born, faster growth rates, better survival rates, and improved feed conversion efficiency, especially when the breeds involved have high genetic diversity. According to [9], hybrid vigor is due to the collective effect of many genes that individually have a small impact but together produce a significant effect. This has led to the widespread use of industrial crossbreeding in commercial pig production over the past centuries to fully exploit this phenomenon. In recent decades, this phenomenon has been extensively studied by both domestic and foreign scientists [3, 6, 10, 12, 15, 19, 21, 22, 24, 28, 31, 33, 35, 39, 45]. According to [13, 18, 23], genotype is a determining factor in the growth and development of pigs due to its influence on a number of physiological and biochemical processes. As stated by [16], the genotype of pigs affects their growth rate, and therefore different breeds and lines of pigs have different growth intensities. In modern pig farming, separate selection is conducted for maternal and paternal lines, where the latter are selected for growth rate, feed efficiency, and carcass quality [38]. According to [11], fattening qualities of pigs are closely related to their genotype, which determines the potential for growth rate, feed efficiency, meat quality, and disease resistance. The use of modern genetic technologies and selection methods allows for significant improvement of these characteristics, ensuring more efficient production and better product quality. According to [4, 21], genomic selection reveals genes and alleles responsible for growth hormones, which can accelerate this process and significantly impact its intensity in pigs. Additionally, according to [17], feed efficiency also depends on genotype and breeding method, manifested in the genetic predisposition to feed utilization. According to [7], some pig genotypes have a better ability to convert feed into muscle mass due to differences in their digestive efficiency and metabolic pathways, while others do not. This opinion is supported by [21], who believe that genetic predisposition to feed utilization is determined by genes regulating appetite and metabolism, affecting appetite, nutrient absorption, and utilization. Specifically, genetic variations in genes regulating protein, fat, and carbohydrate metabolism can influence feed efficiency, significantly affecting the efficiency of pig farming. According to [1], modern selection programs use genetic data to improve fattening qualities, thereby enhancing economic performance in pig production. Studies by [8, 37] report integrating economic parameters into genetic selection to utilize economically important genes to improve fattening qualities, and consequently, the efficiency and competitiveness of pig production. According to [34], genotype affects the immune system of pigs, determining their disease resistance and better feed utilization, thereby improving fattening performance. Therefore, selection based on genes for disease resistance can reduce treatment losses and improve overall fattening qualities. According to [5], extensive use of crossbreeding in pig farming is due to the benefits of hybrid vigor and breed compatibility. However, as noted by [36], such improvements are usually not observed in subsequent generations of crossbreeding, making it important to maintain purebred forms for crossbreeding and their continuous improvement. At the same time, due to the differing inheritance of reproductive and fattening traits, the full effect of heterosis cannot be fully utilized. Therefore, a more advanced form of breeding – intra-breed or breed-line hybridization is used in modern pig farming [25]. In this form of breeding, maternal breeds and lines, mainly represented by Yorkshire and Landrace breeds, and paternal (terminal) lines, usually represented by Duroc and Pietrain breeds or their crosses, are selected separately and continuously tested for their combinatory ability [2, 6, 14, 42], not all performance parameters achieved in nucleus herds are fully realized in commercial herds of hybrid offspring due to different management conditions. Some papers [29] reported that hybrid pigs had 40% lower growth efficiency and 18% lower feed utilization compared to purebred Duroc pigs, with a 2.7% lower meat yield in crossbred Landrace × Yorkshire × Duroc pigs compared to purebred Duroc pigs. According to [27], using different paternal breeds and synthetic lines for hybridization results in varying growth and feed conversion efficiency. Their data show that Landrace × Yorkshire × Duroc crosses had 142 g higher daily gains, 0.14 FEsv/kg better feed conversion, but 2.0% lower meat content in the carcass. Similar conclusions were drawn by [29], reporting that feed conversion and meat content in Duroc (LY) crosses were worse than in purebred Duroc pigs, but the incidence of diseases and mortality were significantly lower. At the same time, it was reported [5] uneven growth in purebred and crossbred pigs during different production cycles, stating that high growth intensity during the suckling period does not always translate to similar trends in subsequent production periods. In Ukrainian industrial enterprises, according to [44], foreign breeds and lines of pigs are predominantly used, making it essential to test their productivity and combinatory ability under specific Ukrainian conditions. This is especially important for such a sensitive technological group of pigs as those in the rearing period, during which, according to [26, 40, 32, 41], a significant number of stressful events occur. Therefore, it is crucial to have information on the rearing efficiency of maternal, paternal forms, and their hybrids of foreign origin under industrial pig production conditions, which is the goal of our study.

MATERIALS AND METHODS

For conducting research at the breeding reducer of the limited liability company "Globinsky Pig Complex," seven groups of 10 sows each were selected using the group analogy method according to the scheme presented in Table 1.

The first and fourth groups included purebred sows of the Large White breed, the second and fifth groups included purebred animals of the Landrace breed, the sixth group consisted of crossbred animals from Large White sows and Landrace boars, and the seventh group included animals from the reciprocal crossing of these breeds.

The third group comprised sows of the synthetic PIC-337 line.

The sows in the first and fifth groups were inseminated with the semen of Large White boars, their analogues from the second and fourth groups were inseminated with the semen of Landrace boars.

The sows in the third, sixth, and seventh groups were inseminated with the semen of boars from the synthetic terminal line PIC-337.

Table 1. Scheme of the experiment

A group of animals	I	II	III	IV	V	VI	VII
Maternal genotype	LW	L	PIC337	LW	L	♀ LW ×♂ L	♀L×♂ LW
Number of sows, head	10	10	5	10	10	10	10
Genotype of boars	LW	L	PIC337	L	LW	PIC337	PIC337
Number of boars, head	3	3	3	3	3	3	3
Genotype of offspring	LW	L	PIC337	½LW½ L	½ L ½LW	¼ LW ¼ L ½ PIC337	¼ L ¼ LW ½ PIC337
The number of piglets at the beginning of the experiment, head	75	75	50	75	75	75	75
Age of piglets at the beginning of the experiment, days	28	28	28	28	28	28	28
Duration of growing, days	49	49	49	49	49	49	49
Combination of genotypes	♀LW×♂LW	♀L×♂L	♀PIC337×♂PIC337	♀LW×♂L	♀L×♂LW	(♀LW×♂L)×♂PIC337	(♀L×♂LW×♂PIC337

Source: own calculations.

During the dry and conditionally gestational periods, all experimental sows were kept in identical conditions in individual stall boxes with regulated feeding of complete feed mixtures according to specific recipes. On the 33rd–35th day of pregnancy, after echoscanning, they were transferred to the gestation house where they were kept under identical conditions in stable groups with regulated feeding using Velos feeding stations from the Dutch company Nedap. On the 110th–112th day of pregnancy, the animals from all experimental groups were moved to the farrowing section of the same facility, where they were kept in individual pens with diagonal fixation of the sow (Photo 1). The sows were fed ad libitum using continuous feed dispensers with complete balanced feeds.

Photo 1. Conditions for keeping piglets during the suckling period
Source: own calculations.

Supplementary feeding of the piglets began on the 14th day after birth with dry pre-starter compound feeds.

At weaning, experimental groups of piglets were formed from each experimental group by the method of analogous groups, each consisting of 75 heads, and were transferred to Growing Unit No. 4. For this purpose, all weaned piglets from each experimental group were subjected to group weighing, after which the average weight for each group was calculated. The next step in our research was the individual weighing of all experimental piglets, during which their weight and order number in the litter were marked on their backs with a chemical marker. During the weighing, the piglets were sorted within each group by weight, which was closest to the average weight of the group, taking into account the sex of the animals.

Upon completion of the formation of all seven experimental groups, the average weight of the formed groups was adjusted to match the average weight of the piglets determined by group weighing in each group by replacing piglets of varying weights of the same sex. All experimental piglets were then tagged with numbered ear tags of different colors or shapes on their right ears, and were transported, considering their groups, to the rearing section of Growing Unit No. 4 (Photo 2). During the growing period, the piglets were kept identically in group pens on fully slatted floors, with 75 heads in each pen at a stocking density of 0.32 m² per head.

Photo 2. Conditions for keeping piglets during the rearing period
Source: own calculations.

Their feeding was carried out with liquid feed mixtures in a ratio of three parts water to one part dry complete feed. Until the 41st day of life, all experimental piglets were fed the same pre-starter feed they received during the suckling period. From the 42nd day of life, they were switched to a second starter feed, which was fed until they reached an average weight of 15 kg, after which they were switched to starter compound feed, which was fed until they were transferred to fattening. The recording of feed consumption was conducted by the feed station processor for each pen for each feed distribution, converted into the amount of dry compound feed. All zootechnical and veterinary procedures for the animals in the experimental groups, both during the suckling period and the growing period, were identical.

During the growing period, the removal of piglets was recorded in the research journal with the date of removal, quantity, and weight of the removed piglets. On the 49th day of rearing, all piglets were individually weighed and transferred to fattening. The feeding conditions of the animals, housing, and all veterinary procedures in the experiment complied with European and domestic requirements for the care of pigs during the experiment.

The data of the experiment were processed using the method of variation statistics with the use of the MS Excel 2016 and presented as M±m. The significance of the differences in piglet growth rates was determined by Student's t-test.

RESULTS AND DISCUSSIONS

In the purebred and intra-line breeding of pigs from the original maternal breeds and the paternal line, a significant difference in the growth rate and survival of piglets between the maternal and paternal genotypes was established. As shown in Table 2, the highest growth intensity during the rearing period was observed in piglets of the synthetic line PIC-337 with intra-line breeding. They maintained the growth rate advantages gained during the suckling period and had higher average daily gains during the rearing period by 121–104 g ($p<0.001$) compared to the purebred offspring of the maternal breeds Large White and Landrace, respectively. Due to the higher growth intensity during the rearing period, they demonstrated significantly ($p<0.001$) higher absolute gains by 5.8 and 5.0 kg compared to the peers of the Large White and Landrace breeds. Due to the higher live weight of the piglets at the start of rearing and the greater absolute gains, the animals of group III surpassed the peers of groups I and II in terms of piglet weight at weaning by 7.9 and 6.8 kg, respectively ($p<0.001$).

Table 2. Productivity of purebred piglets for rearing

Indicators	Groups		
	I	II	III
Age of piglets at the beginning of rearing, days	28.7	28.6	28.9
The average weight of one piglet at the beginning of rearing, kg	6.75±0.137	7.01±0.159	8.77±0.203 bbb ccc
Age of piglets at the end of rearing, days	77.0	77.0	77.0
Weight of piglets at the end of rearing, kg	26.8±0.397	27.9±0.356 a	34.7±0.606 bbb ccc
Absolute growth of piglets during the rearing period, kg	20.0±0.389	20.9±0.356	25.9±0.609 bbb ccc
Average daily growth of piglets during the rearing period, g	415±12.7	432±13.3	536±18.9 bbb ccc
Preservation of piglets during rearing,%	98.7	98.0	96.0

Notes: probability of difference between groups: d – 4 and 5; e– 4 and 6; f– 4 and 7; g– 5 and 6; h – 5 and 7; i – 6 and 7
Source: own calculations.

When comparing the growth intensity of crossbred and hybrid piglets, the latter were found to have an advantage in almost all performance indicators. Hybrid piglets of group VI significantly exceeded crossbred animals of groups IV and V in average daily gains ($p<0.01$) by 37 and 51 g, in absolute gains during the rearing period ($p<0.001$) by 1.79 and 2.46 kg, in piglet weight at the end of rearing ($p<0.001$) by 2.77 and 3.38 kg, but had lower survival rates during rearing by 0.67 and 1.33%. Hybrid piglets obtained from crossbred sows (♀L×♂LW) and boars of the synthetic line PIC-337, which formed group VII, also had significant advantages in all performance indicators during rearing compared to piglets of groups IV and V. They exceeded their crossbred counterparts from groups IV and V in average daily gains by 56 ($p<0.01$) and 70 ($p<0.001$) g, in absolute gains by 2.70 and 3.38 kg ($p<0.001$), had higher live weights by 3.76 and 4.38 kg ($p<0.001$) when transferred to fattening, and had better survival rates by 1.3 and 0.7% during rearing.

No significant difference in the productivity of hybrid piglets from groups VI and VII was established in our studies. However, there was a trend towards a slight improvement in the productivity of animals in group VII over those in group VI, with average daily gains higher by 19 g, absolute gains higher by 0.92 kg, live weight at the end of rearing higher by 1.0 kg, and survival rate during rearing higher by 2.0%.

Thus, hybrid piglets obtained from crossbred sows of the maternal breeds Large White and Landrace through direct and reciprocal crossings with boars of the synthetic paternal line PIC-337 surpassed their crossbred peers from direct and reciprocal crossings of these two maternal breeds in average daily and absolute gains by 8.0–15.7%, in live weight at the end of rearing by 9.5–15.3%, and in survival rate during rearing by 0.7–1.3%. Meanwhile, crossbred animals from direct and reciprocal crossings of the maternal breeds showed no significant differences in reproductive performance indicators, although there was a trend towards a 3.0% increase in average daily and absolute gains, a 2.1% increase in average piglet weight at the end of rearing, and a 0.7% increase in survival rate in animals of the (♀L×♂LW) combination compared to their counterparts from the reciprocal crossing of these breeds. A similar situation was observed among the groups of hybrid piglets, where there was a trend towards a slight improvement in the productivity of animals from the combination ♀(♀L×♂LW)×♂PIC-337 over those from crossbred sows (♀LW×♂L) and the same boars in average daily and absolute gains by 3.8%, in live weight at the end of rearing by 3.2%, and in piglet survival rate by 2.0%.

The different growth intensities of purebred, crossbred, and hybrid piglets led to varying daily feed consumption, resulting in different amounts of feed per animal during the rearing period. As shown in the graph in Fig. 1, the purebred piglets of the maternal breeds (Groups I and II) consumed 0.78–0.79 kg of feed daily. Animals in Groups III and IV, consisting of crossbred animals of these breeds, consumed 0.01–0.3 kg more feed daily, while their hybrid peers in Groups VI and VII had daily feed consumption 0.07–0.13 kg higher compared to purebred animals and 0.05–0.11 kg higher compared to crossbred animals of Groups IV and V. Piglets in Group III, represented by animals of the synthetic line PIC-337, consumed more feed daily than purebred and crossbred piglets of the maternal breeds and had this indicator at the level of hybrid piglets in Groups VI and VII.

The different amounts of daily feed consumption over the same rearing period led to varying amounts of feed consumed per piglet during the rearing period. The most feed was consumed by the hybrid piglets of Groups VI and VII and the piglets of Group III, which belonged to the paternal line. The least feed was consumed by purebred animals of the Large White and Landrace breeds, which consumed 0.3–1.8 kg less feed compared to their crossbred peers of these breeds and 3.5–5.7 kg less compared to the hybrid piglets of Groups VI and VII and 3.5–4.2 kg less compared to the piglets of Group III (Fig. 1).

Despite the higher feed consumption by the offspring of boars from the synthetic line PIC-337, their higher growth intensity during the rearing period and correspondingly higher absolute gains during this period contributed to improved feed conversion efficiency. Thus, the best feed conversion was observed in the piglets of the synthetic line PIC-337 under intra-line breeding (1.62 kg) and in the combination of these boars with crossbred sows of the maternal breeds under both direct and reciprocal crossing variants – 1.76–1.74 kg. Meanwhile, piglets of the maternal line, both under purebred breeding and crossing, had worse feed conversion by 0.01–0.13 kg compared to hybrid piglets and by 0.15–0.25 kg compared to their analogues under intra–line breeding of the synthetic paternal line.

Thus, during the rearing period, hybrid piglets consumed 5.5–14.0% more feed daily and in total compared to their crossbred peers and 9.1–17.0% more compared to purebred animals of the maternal line. At the same time, they had 0.6–2.8% better feed conversion compared to crossbreds and 3.8–5.0% better compared to purebred peers of the maternal breeds. Crossbred piglets consumed 0.7–4.8% more feed daily and in total during the rearing period and had 2.2–5.3% better feed conversion compared to the original maternal breeds.

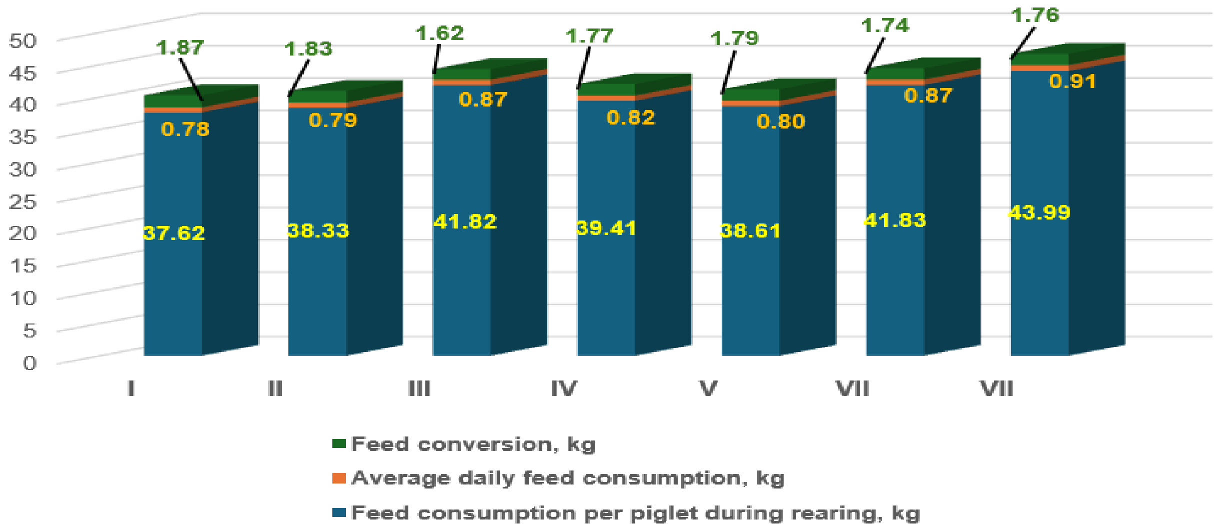

Fig. 1. Feed consumption by purebred, crossbred and hybrid piglets and their conversion during rearing
Source: own calculations.

Meanwhile, piglets of the synthetic paternal line consumed almost the same amount of feed daily and during the rearing period as their hybrid peers, 6.3–7.7% more than crossbreds, and 9.1–11.2% more than purebred animals of the maternal breeds. Additionally, these animals demonstrated the best feed conversion among all the experimental animals, which was 7.4–8.6% better than hybrid piglets, 9.3–10.5% better than crossbred animals, and 11.5–13.5% better compared to purebred analogues of the maternal genotypes.

The amount of feed consumed by purebred, crossbred, and hybrid piglets and their slightly different costs, depending on the growth intensity of the piglets, also affected the cost indicators of the rearing process and the cost of one piglet at the end of the rearing period. As shown in the graph in Fig. 2, the lowest feed cost was observed in piglets of the Large White and Landrace breeds – 15.75–16.06 EUR, which outperformed their crossbred peers of Groups IV and V by 0.11–0.75 EUR, hybrid piglets of Groups VI and VII by 1.16–2.35 EUR, and animals of the synthetic paternal line by 1.16–1.46 EUR.

Since the share of feed in the operational cost of rearing one piglet was almost equal for all groups of animals, the dynamics of the operational cost of the experimental groups of pigs were similar to their feed cost. As shown in the table, the lowest cost was for purebred piglets of maternal genotypes, while crossbred animals of these genotypes had 0.14–0.95 EUR higher costs, and piglets of the synthetic paternal line had 1.47–1.85 EUR higher costs.

The highest operational cost was found in hybrid piglets, which had an operational cost 1.47–2.98 EUR higher compared to purebred piglets of the Large White and Landrace breeds.

The operational cost of one piglet at the end of the rearing period included the rearing cost and the operational cost of the piglet at the start of this process. The highest operational cost per head at the end of the rearing period was in piglets of the synthetic paternal line, at 67.11 EUR. The sixth and seventh groups had slightly lower costs, by 2.27–3.81 EUR.

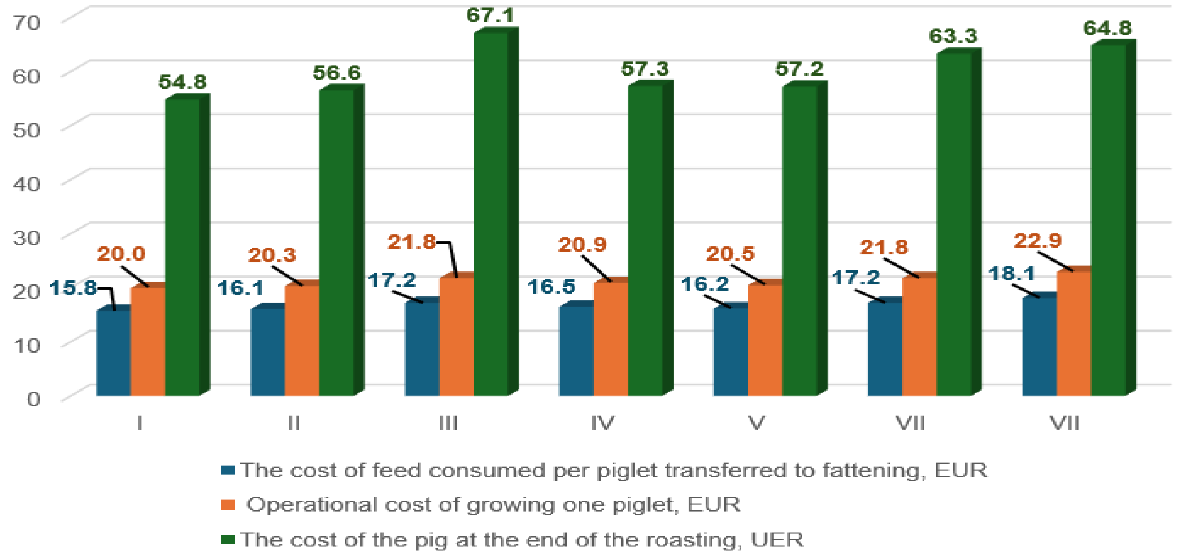

Fig. 2. Fodder and operational cost of rearing piglets and their cost upon completion of rearing
Source: own calculations.

Crossbred animals of maternal genotypes had even lower costs, by 9.78–9.90 EUR. The lowest costs (10.56–12.28 EUR) were in purebred animals of maternal genotypes.

Thus, piglets of the Large White and Landrace breeds had the lowest feed cost, operational cost, and cost per animal at the end of the rearing period. Crossbred piglets from combinations of maternal genotypes had higher feed, operational, and end-of-rearing costs compared to purebred animals, but these costs were lower than those of hybrid animals and piglets of the synthetic paternal line. The highest operational cost per piglet at the end of the rearing period was found in animals of the synthetic paternal line.

However, different results were obtained when comparing these same indicators per 1 kg of weight gain during the rearing period (Fig. 3).

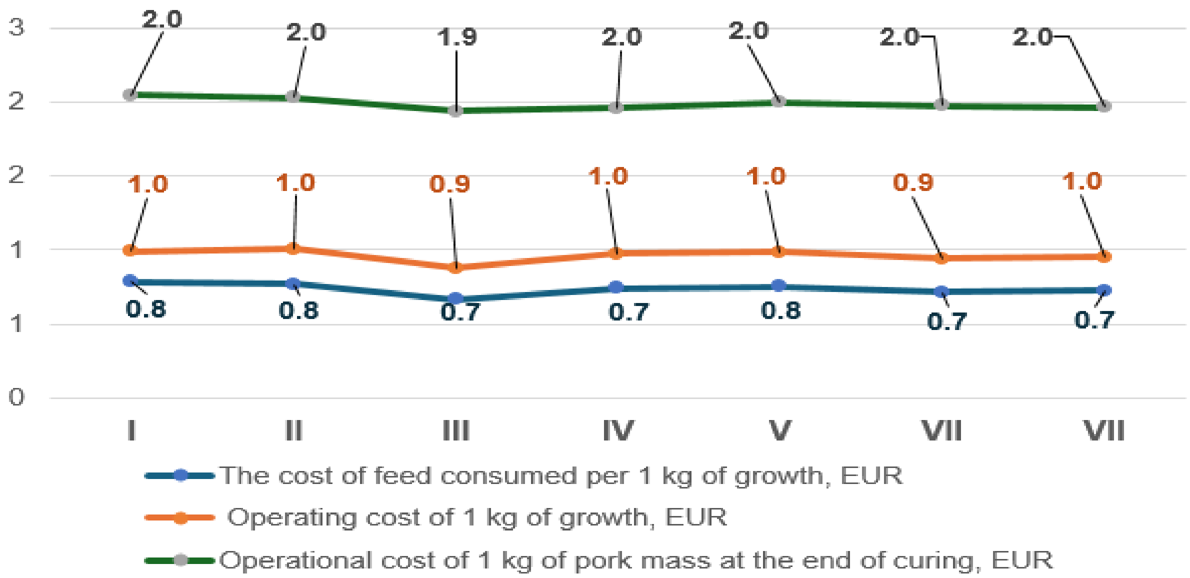

Fig. 3. Feed and operating cost of 1 kg of gain and 1 kg of live weight of piglets after the completion of rearing, EUR
Source: own calculations.

Due to higher growth intensity and greater absolute gains, the animals from the synthetic paternal line exhibited the lowest feed cost per kilogram of gain, outperforming the hybrid piglets of the sixth and seventh groups by 0.056–0.057 EUR, the crossbred animals of the fourth and fifth groups by 0.073–0.083 EUR, and the piglets of the first and second groups by 0.11–0.13 EUR.

A similar situation was observed for the operational cost per kilogram of gain and the cost per kilogram of live weight at the end of the rearing period.

Thus, the piglets from the synthetic paternal line demonstrated the lowest feed cost, being 7.4–8.6% lower than the hybrid piglets, 11.2–12.4% lower than the crossbred animals, and 13.0–14.8% lower compared to the maternal breeds.

The highest operational cost per kilogram of gain was found in purebred animals of the Large White and Landrace breeds, at 0.99 and 1.00 EUR, respectively. This was 0.5–3.3% higher than the crossbred animals, 3.8–6.5% higher than the hybrid animals, and 11.5–13.0% higher compared to the synthetic paternal line under their intra–line breeding.

Piglets from these same groups also had the highest cost per kilogram of live weight at the end of the rearing period, showing this indicator to be 1.6–4.3% higher than the crossbred animals, 2.6–4.1% higher than the hybrid piglets, and 4.5–5.4% higher compared to the synthetic paternal line animals.

The ultimate goal of pig production at an industrial enterprise is profitability and cost–effectiveness. As shown in the graph in Figure 4, due to the highest weight at the end of the rearing period, the pigs from the third experimental group had the highest market value, surpassing the hybrid animals of the sixth and seventh groups by 6.68 and 4.14 EUR, respectively, the crossbred animals of the fourth and fifth groups by 13.73 and 15.3 EUR, and the purebred animals of the Large White and Landrace breeds by 20.0 and 17.2 EUR (Fig. 4).

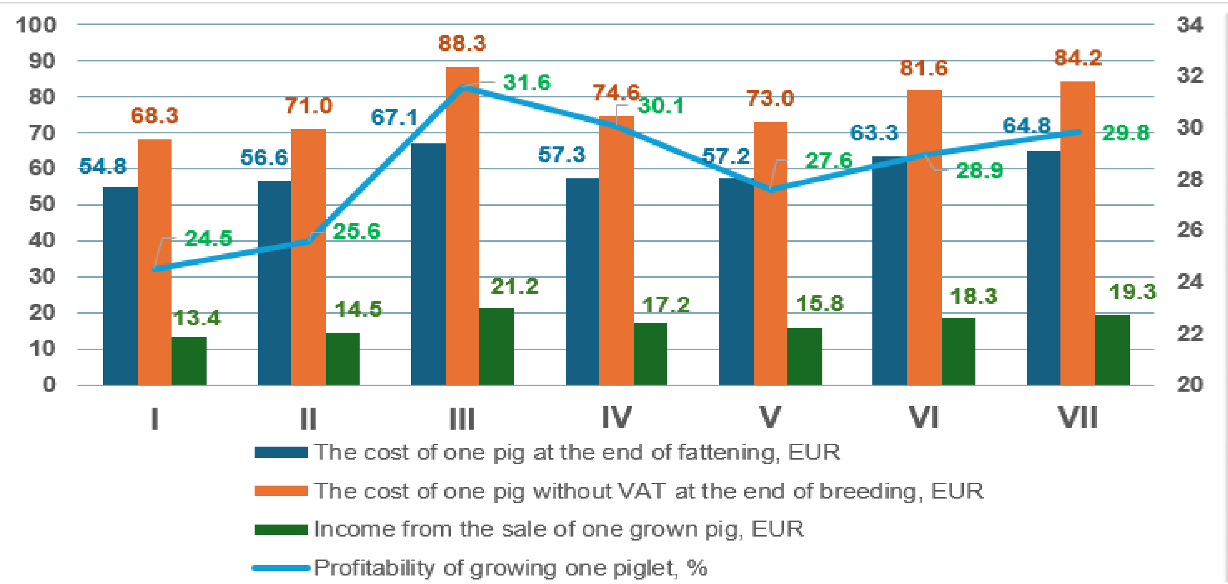

Fig. 4. Operating cost, sales value, income and profitability of raising purebred, crossbred and hybrid piglets
Source: own calculations.

Despite the highest cost for animals in this group, they showed the highest revenue per animal, which was 6.71–7.74 EUR more compared to the purebred analogues of maternal breeds, 3.94–5.4 EUR more compared to the crossbred animals of these breeds, and 1.86–2.86 EUR more compared to the hybrid piglets of the sixth and seventh groups. Due to the varying operational costs of raising one piglet and their different market values at the end of the rearing period, different profitability levels were established for raising purebred, crossbred, and hybrid piglets. As shown in the graph in Figure 4, the highest profitability level was found in the piglets of the synthetic paternal line under their intra-line breeding. The piglets of this group had a profitability level 1.49% higher compared to the crossbred piglets from the Large White and Landrace breeds (IV group), 1.77% higher than animals obtained by mating sows of the same combination with boars of the synthetic paternal line, 2.62% higher compared to hybrid animals from reverse crossing, and 3.98% higher compared to crossbreeds from Landrace sows and Large White boars, and 6.0–7.1% higher compared to purebred piglets of the Large White and Landrace breeds, respectively.

Thus, the highest profitability was obtained from rearing piglets through the intra-line breeding of synthetic paternal line PIC-337 animals, with the revenue from rearing these animals being 8.8–13.5% higher compared to rearing hybrid pigs, 18.6–25.5% higher compared to rearing crossbred animals, and 46.4–57.7% higher compared to rearing purebred animals of maternal genotypes. These same animals also showed the best profitability in production. According to the determined indicator, they surpassed hybrid animals by 1.77–2.62%, crossbred animals by 1.69–3.98%, and purebred animals by 6.0–7.1%.

Our conclusions that during rearing, purebred maternal breeds lagged behind the analogues of the synthetic paternal line PIC–337 in average daily and absolute gains and had higher live weights at the end of this period confirm the reports of [27, 29, 38, 46] about the better fattening performance of terminal line pigs compared to universal breeds and maternal lines. Our data on the 2.0–2.7% lower survival rate of piglets in maternal genotype nests compared to paternal ones are consistent with the reports [30], who also noted lower survival rates during rearing in paternal genotype pigs. The results obtained in our studies that hybrid piglets outperformed their crossbred counterparts from the crossing of these two maternal breeds in average daily and absolute gains and live weight at the end of rearing are identical to the reports of [5, 10, 28, 39] about the higher growth intensity of hybrid piglets compared to crossbreds but contradict the conclusions of [34] about better survival of hybrids compared to purebred and crossbred animals. In our experiments, no clear pattern was found regarding the influence of breeding methods on the percentage of piglet mortality during rearing.

Our reports that hybrid piglets of English origin had better feed conversion compared to crossbred and purebred maternal breed counterparts are consistent with the reports of [12, 15, 17, 31], and the results showing that synthetic paternal piglets had better feed conversion compared to maternal breed analogues, their crossbreeds, and hybrids confirm the conclusions of [29].

Our conclusions about the higher efficiency of rearing hybrid piglets compared to purebreds are similar to the reports of [8, 37], who also established greater efficiency of hybridization compared to other breeding methods in pig farming.

We believe that further research is necessary to compare different breeding options for maternal and paternal breeds of foreign origin under the conditions of central Ukraine.

CONCLUSIONS

It has been established that during the rearing period, purebred piglets of the Large White and Landrace breeds were inferior to their counterparts of the synthetic paternal line PIC-337 under intra-line breeding in terms of average daily and absolute gains, had a lower weight at the end of this period but were inferior to them in terms of survivability.

It was determined that hybrid piglets surpassed their crossbred counterparts from direct mating in terms of average daily and absolute gains, live weight at the end of rearing, and survivability.

It was proven that hybrid piglets consumed more feed during the rearing period compared to their crossbred and purebred peers and had better feed conversion. While crossbred piglets consumed more feed and had better feed conversion compared to the original maternal breeds, the synthetic paternal line piglets consumed feed at the same level as their hybrid peers, but more than the crossbred and purebred animals of the maternal breeds, and showed the best feed conversion among all the tested animals.

It was found that purebred piglets had the lowest feed, operational, and per animal cost at the end of rearing. Crossbred piglets had higher costs compared to purebred animals but lower compared to hybrid animals and piglets of the synthetic paternal line. The highest costs were recorded in animals of the synthetic paternal line.

It was determined that purebred animals had the highest operational cost per kilogram of gain and per kilogram of live weight at the end of rearing, which was higher than in crossbred, hybrid animals, and piglets of the synthetic paternal line.

It was established that the highest profitability was obtained from rearing piglets of the synthetic paternal line PIC-337, with revenue from raising them being higher compared to hybrid, crossbred, and purebred animals of maternal genotypes. They also had the highest profitability in rearing.

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STUDY OF THE EFFECT OF BETA-LACTOGLOBULIN AND PIT-1 GENES IN COWS ON HARD CHEESE PRODUCTION

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Abstract

The yield of hard cheese depends on the amount and ratio of milk components. Moreover, the yield of cottage cheese is significantly influenced by genetic variants of milk protein and other genes. The goal of this study is to examine the effect of variants A and B of beta-lactoglobulin and variants A and B of the PIT1 gene on cheese yield and its individual qualitative indicators. It has been found that the genotype of cows based on the beta-lactoglobulin gene affects the yield of cheese produced from their milk. The highest yield is obtained from milk of animals with the BB genotype. At the same time, a higher content of essential amino acids is characteristic of cheese made from milk obtained from animals with the AA genotype by beta-lactoglobulin. The PIT1 genotype has also affected the yield of cheese made from milk. Cheese samples made from milk of heterozygous animals (AB) have the best average values. The amount of essential amino acids in cheese prevails in samples made from milk of homozygous (BB) cows. Forming herds with the desired genotypes based on the studied genes for cheese production requires establishing contractual relations between milk producers and milk processing plants.

Key words**:** *milk, cheese, protein, genotype, beta-lactoglobulin, PIT1, amino acids, characteristics*

INTRODUCTION

The indicator of cheese yield is one of the most important for the profitability of enterprises from cheese making. This indicator reflects the amount of product manufactured per unit of dairy raw materials. It is significantly affected by the composition of milk and the ratio of its components. Recently, there has been a lot of interest in various genes that can affect the cheese yield [3].

Scientists note that various genetic variants of milk proteins (caseins, beta-lactoglobulin) have an impact on the indicators of milk quality, coagulation properties and cheese production [7].

According to the results of many studies, it is found that the BLG B genotype variant is associated with a higher content of dry matter, fat and protein in milk, and an increased yield of cottage cheese [1, 4]. The researchers also note that the quality of cheese from milk of animals with the BB genotype is better in this gene compared to milk from animals with the AA genotype [3, 2, 1]. Another group of scientists has concluded that variant A of BLG helps to reduce the time for rennet coagulation of milk [8]. Others have found no association between the BLG gene and quantitative and qualitative indicators of cheese production from cow’s milk [5, 12].

Pituitary-Specific Positive Transcription Factor 1 (PIT1) affects the growth hormone and prolactin genes. Animals with the BB genotype are characterized by a higher level of milk fat and protein [9]. According to the results of other studies, the A allele of this gene is associated with higher milk yields and protein content in milk. The B allele is associated with a higher fat content in milk [11].

Most authors claim the existing influence of this gene on milk yield indicators, which makes it attractive from a breeding point of view [10]. However, the literature does not mention its effect on the technological qualities of milk. Therefore, it is extremely important to study this issue as we did in this study.

MATERIALS AND METHODS

Milk (10 liters each) from cows of the Ukrainian Black-and-White dairy breed were selected for the planned research.

The animals were owned by the NAAS Institute of Agriculture of the North-East State Enterprise of Sumy Region, Ukraine. The animals were divided according to a genotype by the BLG gene (three heads with AA, AB, BB each) and by the PIT1 gene (three heads with AB, BB each).

No animals with the AA genotype were found in the herd.

Samples of Gouda hard cheese were examined. The cheese was made according to the generally accepted method. The examination of samples was carried out according to the accepted method in the conditions of the educational laboratories of Sumy National Agrarian University [6].

Mathematical and statistical processing of the obtained results was carried out on a computer using MS Excel 2016 Software.

RESULTS AND DISCUSSIONS

Our examination of the physical and chemical parameters of milk samples obtained from cows of the Ukrainian Black-and-White dairy breed with different genotypes according to the beta-lactoglobulin and PIT1 genes indicate that they fully meet the requirements for milk (in accordance with the State Standard 3662:2018). The acidity of milk, depending on the genotype of cows by the beta-lactoglobulin gene, did not differ significantly and was in the range of 6.36-6.55. The acidity of milk in animals with different genotypes according to the PIT1 gene (6.40-6.56) was approximately within these limits. In terms of milk density, there was also no significant difference between animals of different genotypes according to the studied genes (Table 1).

Among the studied animals, there were three genotypes for the BLG gene (AA, AB, BB) and two for the PIT1 gene (AB, BB).

Table 1. Comparison of physical and chemical parameters of milk from animals with different genotypes by the BLG and PIT1 genes

Studied indicators	Genotypes by BLG genes			Genotypes by PIT1 genes	
	AA	AB	BB	AB	BB
Milk acidity, pH	6.36±0.01	6.55±0.01	6.55±0.01	6.40±0.01	6.56±0.01
Milk density, kg/m^3	1.026±0.0003	1.028±0.0003	1.028±0.0003	1.027±0.0003	1.026±0.0003
Dry matter content, %	12.7±0.02	11.2±0.02**	12.3±0.02	12.3±0.02	12.5±0.02
Protein content, %	2.87±0.01**	2.96±0.01	3.01±0.01	2.94±0.01	2.91±0.01
Fat content,%	4.69±0.01	2.83±0.01**	3.89±0.01	4.01±0.01	4.28±0.01**

Note: *P<0.05; **P<0.01

Source: Own research.

According to the analysis of the content of the main components of milk, we have established intergenotypic differentiation by the BLG gene. Milk of animals with the AA genotype is characterized by a higher content of dry matter and fat in milk. Animals with the BB genotype have a higher protein content in milk. The ratio of fat to protein is in the range of 1.05-1.63 and prevails in animals with the AA genotype. In animals with the AB genotype, this ratio approaches unity.

In terms of dry matter and protein content in milk, no differences are found between animals with different genotypes according to the PIT1 gene. Only in terms of fat content in milk, animals with the BB genotype prevail.

Based on the results of hard cheese production, we have determined that among milk samples from cows with different genotypes by the BLG gene, differentiation is found in terms of cheese yield (Fig. 1).

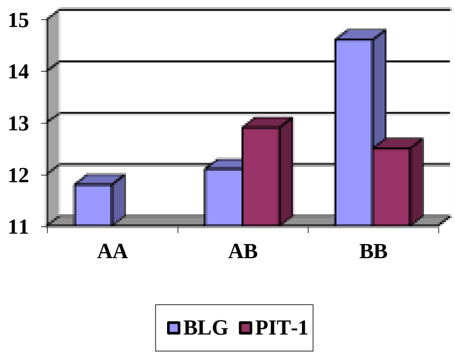

Fig. 1. Average yield of cheese from milk samples obtained from cows with different genotypes by the BLG and PIT-1 genes, %
Source: Own research.

A higher average yield of the finished product is observed in milk of animals with the BB genotype, and a smaller one – with the AA genotype.
Milk of animals with a different genotype by the PIT1 gene also varies in cheese yield. The yield of cottage cheese obtained from the milk of animals of the AB genotype is higher.
Cheese samples made from milk of cows with the AB genotype have a lower acidity value (Table 2).
The dry matter content of the finished products prevails in samples made from milk of cows with the AB genotype. The difference in this feature compared to animal samples with the AA, AB and BB genotypes is statistically significant.
A higher protein content in the finished product is observed in cheese obtained from the milk of cows with the BB genotype. Product samples obtained from an animal with this genotype significantly predominate by this trait samples from animals with the AA and AB genotypes.
Hard cheese obtained from milk of animals with different genotypes by the PIT-1 gene also has differentiation in physical and chemical parameters. Samples from the milk of animals with the BB genotype have a lower acidity value.
A higher average dry matter content in cheese is observed in samples obtained from milk of heterozygous animals (AB), while the protein content is higher in cheese made from milk samples from homozygous animals (BB).
According to the results of chromatographic analysis of the amino acid profile of the studied cheese samples, 17 amino acid residues have been identified.
The quantitative content of essential amino acids is dominated in cheese samples made from milk of animals with the AA genotype by the BLG gene.
They prevail in the content of such amino acids as: valine, leucine, isoleucine, lysine, threonine.
The content of the essential amino acid phenylalanine prevails in samples made from milk of heterozygous animals (AB).
In addition, cheese samples from the milk of these animals prevail by the content of glutamine, cysteine and tyrosine.
Samples taken from the milk of animals with the BB genotype also have a high cysteine content. In terms of the content of most amino acids, samples from milk of animals with the BB genotype prevail over samples from animals with the AB genotype (Fig. 2).

Table 2. Study of physical and chemical parameters of cheese made from milk from cows with different genotypes by the BLG and PIT1 genes

Studied indicators	**Genotypes by BLG genes**			**Genotypes by PIT1 genes**	
	AA	AB	BB	AB	BB
Cheese acidity, pH	5.42±0.01	5.13±0.01	5.45±0.01	5.48±0.01	5.20±0.01
Dry matter content, %	62.8±0.02***	66.8±0.02***	58.1±0.02	62.5±0.02**	60.8±0.02
Protein content, %	18.6±0.1	17.2±0.1	26.0±0.1**	24.8±0.1	35.6±0.1**

Note: **P<0.01; P<0.001
Source: Own research.

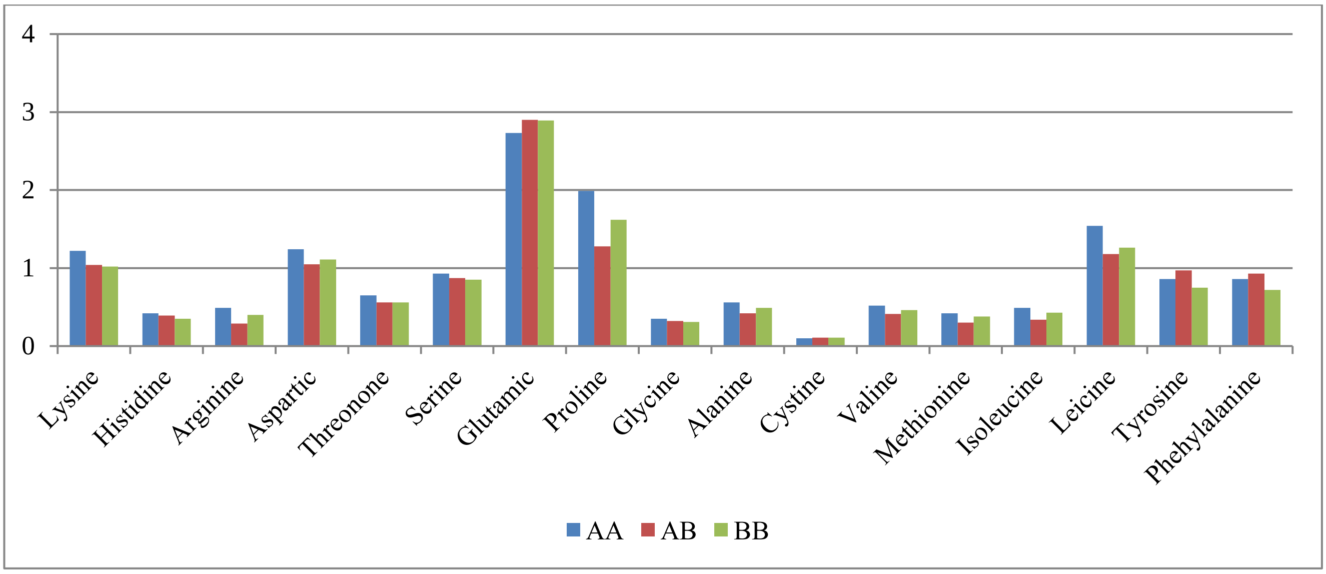

Fig. 2. Average amino acid profile of hard cheese samples made from milk of cows of different BLG genotypes, mg/g
Source: The authors' own research.

The overall average amino acid content prevailed in samples from animals with the homozygous AA (15.39 mg/g) and BB (13.72 mg/g) genotypes. In cheese made from milk of heterozygous animals (AB), their content was 12.95 mg/g (Figure 2).

The content of both essential and non-essential amino acids prevailed in cheese samples obtained from milk of animals with the BB genotype by the PIT1 gene.

The overall average amino acid content prevailed in samples from animals with the homozygous BB genotype (15.56 mg/g), while in milk samples from animals with the heterozygous AB genotype, the amino acid content was 12.42 mg/g.

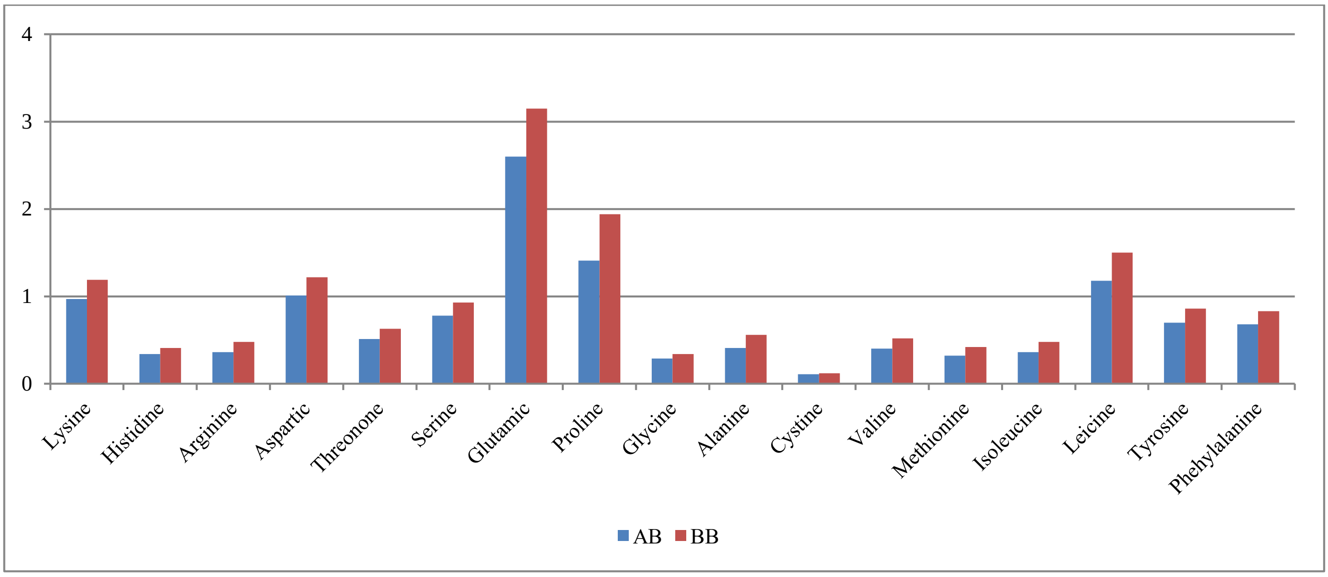

Fig. 3. Average amino acid profile of hard cheese samples made from milk of cows of different PIT1 genotypes, mg/g
Source: The authors' own research.

The formation of herds with the BB and AB genotypes, respectively, by the BLG and PIT-1 genes, requires not only genotyping of the breeding stock, but also the producers whose family is used (Figure 3). This is due to the fact that today the catalogues of producers do not contain information on the genotype of animals by the studied genes. Therefore, this work can only be carried out with the consent of farmers and processing enterprises, in order to improve the economy of hard cheese production.

The results of our studies on the effect of the BLG gene on the content of milk components partially coincide with previous studies. This refers to the higher protein content in milk of animals with the BB genotype. However, our results do not coincide with the results of other authors regarding the preference for dry matter and fat content in milk in animals with the AA genotype [1, 4].

As for the PIT-1 genotype, we note that the results of our studies completely coincide with those previously conducted, regarding the preference of the BB genotype for fat content in milk [11, 9].

CONCLUSIONS

According to the results of the conducted studies, it can be concluded that milk obtained from cows of the Ukrainian Black-and-White dairy breed fully meets the state standard.

Intergenotypic differentiation by physical and chemical parameters of milk was established between animals with different genotypes according to the BLG gene. Higher dry matter and fat content was observed in animals with the homozygous AA genotype. Animals with the homozygous BB genotype showed a higher protein content in milk. Intergenotypic differentiation by protein content in milk was found in animals with different genotypes by the PIT-1 gene. This trait was dominated in animals with the BB genotype.

The genotype of animals based on the studied genes had an effect on the yield of hard cheese produced from the milk of these animals. The highest yield of the product is characteristic of milk obtained from animals with a homozygous (BB) genotype by the BLG gene. A higher yield of cheese was observed from milk of animals with a heterozygous genotype (AB) by the PIT1 gene.

The content of essential amino acids in milk prevailed in animals with the AA (BLG gene) and BB (PIT-1 gene) genotypes.

The work of forming herds with the desired genotype based on the BLG and PIT-1 genotypes for hard cheese production requires a consortium between the milk producer and its processor.

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MARKET EVALUATION OF RAPESEED IN UKRAINE: PERSPECTIVES AND CHALLENGES

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Abstract

This paper aims to provide analysis of rapeseed market in Ukraine, perspectives and challenges that could appear due to internal and external factors. To conduct purposes in the article, the world and Ukrainian rapeseed markets were evaluated to show the importance of domestic rapeseed market development and growing demand on this crop at external markets. Analysing the rapeseed market during last years in Ukraine, it was noticed that rapeseed production has insignificantly suffered compared to other crops under the actual conditions. During the period of 2022-2023, the following trends were occurred: rapeseed area is expanding, even despite the import ban in neighbouring countries; production reached a volume of 3.5 million tons; rapeseed crushing increased to 21% inside the country compared to 6-10% in previous years; rapeseed oil and meal production and their further exports also increased. Ukrainian rapeseed is oriented to export, of which about 60% goes to the EU countries. The EU demand for rapeseed will grow due to the higher share of energy from renewable sources in gross final energy consumption accounting for 45% by 2030 in the frame of the REPowerEU plan, where demand for biodiesel fuel is projected to upward. In this regard, in the article the rapeseed prices were forecasted to evaluate their change in a short term period under a favourable external rapeseed market conjuncture. Getting results showed the domestic price decrease and at the end of 2024 it could reach 306 US dollar per tonne. The analysis showed that the Ukrainian prices are lower than the EU prices, but Ukrainian price volatility trend follows the EU price trend. However, despite of the uncertainty of country environment at present, it is expected an upward trend in rapeseed prices because of the decline in rapeseed production in the EU countries caused by unfavourable weather conditions and growing demand on rapeseed in biodiesel industry.

Key words*: *rapeseed market, forecast, export, prices, Ukraine

INTRODUCTION

The world rapeseed market has been developing dynamically over the last decades. The increase of supply level on the rapeseed market is due to high-intensity production and productivity growth of the crop in accordance with the steadily growing demand. At the same time, the volumes of rapeseed processing into oil and its consumption in the food, livestock and other industries are also growing. It is worth noting that the demand for biodiesel in EU countries has become an important factor in increasing interest in rapeseed as a raw material for biodiesel; as a result, rapeseed became a significant part of the export potential of many countries of the world, including Ukraine.

Considering the importance of the rapeseed market in Ukraine, many questions regarding the functioning of the rapeseed industry and market trends are highlighted in scientific papers, in particular, Chekhov (2016) and Hoisiuk (2018) researched indicators of rapeseed production in the natural and climatic zones of Ukraine, regions and categories of Ukrainian farms; Makarchuk and Skudlarski (2018) used a SWOT analysis for evaluation the development of the rapeseed market in Ukraine; Kuts (2011) substantiated competitiveness factors of rapeseed production; Kuzmenko et al. (2016)

evaluated market trends for oilseeds production in Ukraine; Kaletnik et al. (2021) proposed scenarios for the rapeseed sector development in Ukraine [4, 9, 11, 12, 13, 14]. Prerequisites for the further successful development of rapeseed production, i.e. increasing the organization efficiency of rapeseed production and harvesting, expanding sales markets was investigated by Parkhomets et al. (2023) [15]. At the same time, the European countries, like Romania became a significant player on EU rapeseed market, where Beciu and Arghiroiu (2023) emphasized in their article that in the last years many Romanian farmers focused on rapeseed production due to high imports demand on international markets and favourable internal production conditions [2].

The significant demand on the global market caused a rapid increase in the production of rapeseed in Ukraine due to both the sown areas expansion and the productivity growth. At the same time, most of the grown rapeseed is export oriented. Taking into account this fact, the price situation on this market is determined by the conjuncture of interdependent world oilseeds markets, their processing products and mineral diesel fuel, as well as the dynamics of the development of the biodiesel industry in the world [13]. Hamulczuk M. et al. (2019) confirmed direct and indirect integration of the Ukrainian and European Union rapeseed markets via physical trade flows of rapeseeds, rapeseed cake, and rapeseed oil, providing evidence that rapeseed prices in Ukraine and European Union are cointegrated and that adjustments to the long-run equilibrium relationship are asymmetric and seasonal [7, 8].

The novelty of conducting research on the current state of the rapeseed market and substantiating forecasts of its further development is enhanced by the need to solve a number of problems, in particular, the optimization of rapeseed production in Ukraine, the analysis of export or processing possibilities in Ukraine, taking into account the consequences and challenges that have appeared due to the hostilities in the region.

MATERIALS AND METHODS

The purpose of the article is to evaluate the state of Ukrainian rapeseed market, considering the main factors regarding the development and challenges of this market that faced nowadays.

The methodical basis of the paper is the provision of statistical data on rapeseed market. On the basis of statistical data on rapeseed, the place of Ukrainian rapeseed among other oil crops was assessed, the percentages in world production and export were determined, and the world and Ukrainian balances were analysed. Herewith the domestic self-sufficiency ratio is calculated.

Based on this, Hypothesis 1 is to establish whether Ukraine will remain an important player in the world markets, or will lose its position and will be forced to reduce the cultivated areas and actively develop internal processing.

One of important factor for rapeseed market profitability and growth are prices that are formed on domestic and world markets. In these circumstances, the forecast for Ukrainian rapeseed prices was done taking into account the hypothesis that world rapeseed prices influence on domestic rapeseed market (Hypothesis 2). Prices data were taken for the period from January 2021 until March 2024 from the APK inform source [1]. To establish a relationship tightness between Ukrainian rapeseed prices and European, regression analysis was done. There is European prices were taken into account since approximately 60% of rapeseed export belong to the EU countries. According to the received regression, the forecast of rapeseed prices in Ukraine was made. To forecast the factor sign value, i.e. EU rapeseed prices, the Holt's method was implied. The forecast reliability of the factor characteristics was evaluated using indicators such as: MAE (Mean Absolute Error), MAPE (Mean Absolute Percent Error), MASE (Mean Absolute Scaled Error), and RMSE (Root Mean Squared Error). Then the predicted values of the factor sign were added to the regression equation and the predicted values of Ukrainian rapeseed prices were determined.

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RESULTS AND DISCUSSIONS

The rapeseed market is noted for its dynamic development in the world among agricultural markets. World rapeseed production is growing as it could be observed in Table 1. According to USDA forecast data, in 2023/2024 MY rapeseed production will reach more than 85 million tons; its export volumes have almost doubled over the past decade [19].

The EU countries, Canada, China and India remain the largest producers of rapeseed. Their share in the global rapeseed production in 2022/2023 MY was 73.4 %. At the same time, Ukraine's share in world production in 2022/2023 MY was equalled to 4 %.

Table 1. Sown area, yield and production of rapeseed in certain countries of the world

Country/ Region	Area, million ha			Yield, t/ha			Production, million tons		
	2021/ 2022	2022/ 2023	2023/ 2024*	2021/ 2022	2022/ 2023	2023/ 2024*	2021/ 2022	2022/ 2023	2023/ 2024*
World	38.46	41.91	42.39	1.97	2.12	2.02	75.79	88.81	85.58
USA	0.85	0.88	0.94	1.46	1.98	1.95	1.24	1.74	1.83
EU countries	5.39	5.94	6.30	3.22	3.31	3.18	17.39	19.62	20.10
Canada	8.95	8.60	8.80	1.59	2.17	2.02	14.25	18.70	17.80
China	6.99	7.27	7.35	2.10	2.14	2.10	14.71	15.53	15.40
India	7.99	8.85	9.20	1.39	1.28	1.27	11.10	11.30	11.70
Ukraine	1.04	1.23	1.50	2.91	2.85	2.87	3.02	3.50	4.30

Source: author's calculations based on the USDA, 2023 [19].
* USDA forecast data, 2023

In 2023/24 MY USDA forecasts of rapeseed consumption increase by 0.4 % to 85.9 million tons. Rapeseed producing countries and Japan are traditional consumers, in particular EU countries consumed 24.9 million tons (29.2 % of total consumption), China – 19.3 million tons (22.7 %), India – 11.4 million tons (13.4 %), Canada – 10.7 million tons (12.6 %) and Japan – 2.01 million tons (2.3 %). Other countries account for 19.8 % of the market, in which there is an increase in processing of this crop by 5-15 %. The balance of demand and supply of rapeseed on the global market are presented in Table 2.

Table 2. The balance of demand and supply of rapeseed in the world (million tons)

MY	Area, million ha	Initial stocks	Production	Imports	General proposal	Export	Internal consumption	Total demand	Ending stocks
2010/11	33.84	8.70	60.85	10.18	79.73	10.93	60.55	71.48	8.71
2011/12	33.55	8.71	61.55	13.24	83.51	12.99	64.19	77.18	6.79
2012/13	36.07	6.79	63.67	12.83	83.29	12.57	65.68	78.25	5.52
2013/14	36.07	5.52	71.11	15.55	92.18	15.10	69.78	84.88	7.80
2014/15	35.43	7.80	70.99	14.32	93.11	15.11	71.19	86.30	7.37
2015/16	33.75	7.37	69.40	14.13	90.90	14.40	70.80	85.20	6.37
2016/17	33.80	6.42	70.17	15.80	92.38	16.15	71.59	87.74	5.31
2017/18	36.17	5.31	75.80	15.73	96.83	16.60	72.76	89.36	8.14
2018/19	36.23	8.14	73.48	14.64	96.26	14.68	72.01	86.69	9.74
2019/20	35.15	9.74	70.32	15.82	95.89	16.01	72.50	88.51	7.64
2020/21	35.33	7.64	74.72	16.66	99.02	18.14	75.19	93.33	6.36
2021/22	38.46	6.36	75.79	13.84	95.99	15.32	76.85	92.17	4.49
2022/23	41.91	4.49	88.81	19.97	113.28	20.21	85.96	106.17	7.83
2023/24	42.39	7.83	85.58	15.76	109.17	16.89	85.99	102.88	6.54
Relative deviation of 2023/24 MY to 2010/11, %	125.3	90.0	140.6	154.8	136.9	154.5	142.0	143.9	75.1

Source: author's calculations based on the USDA, 2023 [19].

Rapeseed production has grown associated with the expanding biofuel policies to ensure energy safety. Similar to the forecast before Russia's invasion of Ukraine, IEA (International Energy Agency) updated forecast expects at 11% (18,000 million litres) of new demand by 2024 that is supported by policies with energy security objectives [10]. However, as it was in 2022, only a few markets are actively trying to accelerate deployment by 2024. In advanced markets, new policies are not likely to influence production until and after 2024, and high prices, feedstock concerns and technical constraints limit additional growth beyond 2021 forecast of IAE. Based on this fact and relaying on IAE report in 2023, we come to conclusion that the demand for biodiesel will continue that consequently will contribute to further growth of the rapeseed and rapeseed oil markets. During the Covid-19 pandemic and after it, the production of liquid biofuel for road transport in the EU countries was almost at a constant level. At the same time, the share of biodiesel was the largest and consist of 74 % among the types of renewable energy in transport in the EU in 2020 (Fig. 1).

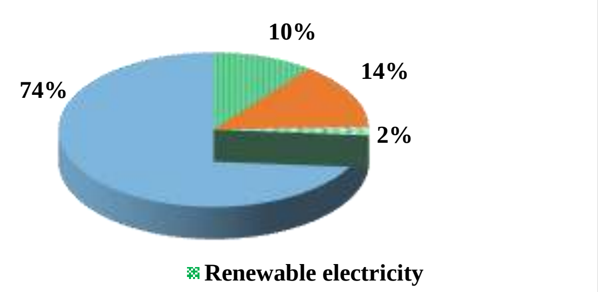

Fig. 1. Types of renewable energy in transport in the EU, 2020
Source: [10].

At the same time, rapeseed oil remained the dominant raw material for the production of biodiesel in EU countries in 2020, i.e. 38 % of the total use of raw materials. The popularity of rapeseed oil is due to internal availability, as well as better technical characteristics, in particular, higher winter stability of the obtained rapeseed methyl ester (RME). In the period from January to August 2023, in Germany, which is the leader in the production and consumption of biodiesel fuel among the EU countries, according to the data of the BAFA, more than 1.7 million tons of biodiesel and hydrogenated vegetable oil was added to diesel fuel. According to the forecast of the German Association for the Promotion of Oil and Grain Crops (UFOP), the total consumption of biodiesel in Germany in 2023 was expected at the level of 2.5 million tons. At the same time, the association notes that the increase in the quota for greenhouse gas emissions from 7 % to 8 % compared to 2022 helped to stabilize the demand for biodiesel fuel [18].

Fig. 2 shows the consumption of biodiesel and the proportion of its mixture in diesel fuel in Germany.

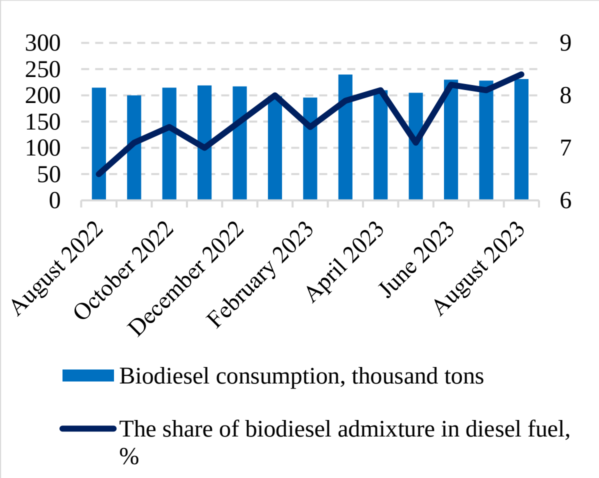

Fig. 2. Biodiesel consumption and its mixture proportion in diesel fuel in Germany
Source: author's calculations based on UFOP, 2023 [18].

The growth of global demand for rapeseed and its processing products, along with geopolitical instability in the world, significantly affects price volatility. In 2022, in some months, the price of rapeseed in the world rose to 1,101 USD/t. At the same time, from the beginning of 2023, it decreased to 600 USD/t and at the end of 2023 stabilized at the level approximately 500 USD/t (Fig. 3). The same price fluctuations could be observed in the rapeseed oil market, where from the beginning of 2022 the price of rapeseed oil reached the level of 2,200 USD/t and to the end of 2023 fluctuated in the frame of 1,000 USD/t.

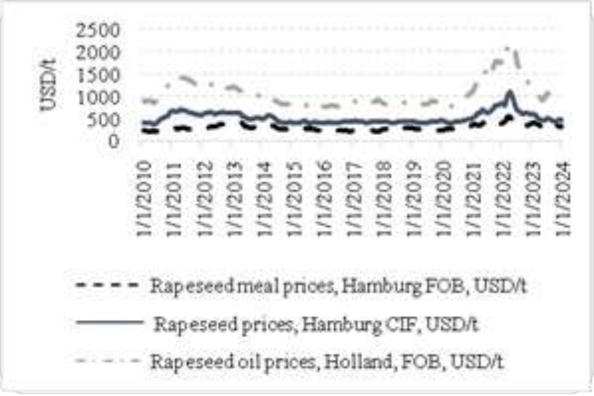

Fig. 3. Dynamics of global prices for rapeseed, rapeseed oil and rapeseed meal
Source: author's calculations based on APK inform data, 2024; FAO data, 2024 [1, 6].

Since Russia has irrupted to Ukraine in 2022, rapeseed market was suffered insignificantly compare to crops markets.
Main trends that were occurred at this market during 2022-2023 years were following:

(1) rapeseed area is expanding, even despite the import ban in neighbouring countries;
(2) record high rapeseed area and production in 2023;
(3) increase in domestic rapeseed crushing to 21% from 6-10% previously;
(4) sharp growth in rapeseed oil and meal production and their exports.

As a result of significant demand from the foreign market, during 2000-2022, rapeseed production increased in 7 times in Ukraine both due to the expansion of sown areas and the productivity growth (Table 3).
Rapeseed is cultivated in all natural and climatic zones of Ukraine, while the production of winter rapeseed dominates due to higher levels of productivity and economic efficiency, i.e. 97.9 % of the total gross harvest in 2022.
The rapeseed market in Ukraine before the war was balanced (Table 4).

Table 3. Dynamics of sown areas, yield and gross production of rapeseed in Ukraine

Indices	2000	2005	2010	2015	2020	2021	2022	2022 to 2000, %
Winter and spring rapeseed area, thousands of ha, including:	156.7	195.2	862.5	671.1	1,112.5	1,004.5	1,156.2	737.8
- winter rapeseed	98.4	116.5	760.9	651.2	1,082	971.8	1,131.6	1,150.0
- spring rapeseed	53.8	78.7	101.6	19.9	30.5	32.7	24.6	45.7
The average yield of winter and spring rapeseed, t/ha, including:	8.4	14.6	17	25.9	23	29.3	28.7	341.7
- winter rapeseed	10.3	17	17.5	26.2	23	29.4	28.7	278.6
- spring rapeseed	5.3	11	13.6	15.9	21.3	24.3	27.3	515.1
Total gross production of winter and spring rapeseed, thousand tons, including:	131.8	284.8	1,469.7	1,737.6	2,557.2	2,938.9	3,318.0	2,517.5
- winter rapeseed	100.8	198.4	1331.2	1,705.9	2,492	2,859	3,250.3	3,224.5
- spring rapeseed	31	86.4	138.5	31.7	65.2	79.9	67.7	218.4

Source: author's calculations based on the State Statistics Service of Ukraine, 2023 [17].

The level of rapeseed import was insignificant and limited to the supply of seed material mainly from Germany (31%), Poland (25%), France (22%) and other countries (22%).
Export remains the main item of demand in the rapeseed market balance in Ukraine (Table 4); in 2010/2011 MY almost the entire crop of rapeseed (96%) was exported mainly to EU countries as raw material for the production of biodiesel. Then during 2015/2016 - 2020/2021 MY exports decreased to 82-87 %. This is explained by the increase in the volume of internal processing of rapeseed by oil and fat enterprises, which considered rapeseed as an alternative raw material to load their capacities in case of a shortage of sunflower seeds. However, in 2022, as a result of the war, market operators considered export as the only channel for selling seeds. According to the State Customs Service of Ukraine, in 2022 rapeseed was exported mainly by EU countries, in particular Poland – 24%, Romania – 22%, Germany – 13 % and other countries – 40% [16].

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Table 4. Balance of demand and supply of rapeseed production in Ukraine (thousands tons)

Indicators	2010/ 2011	2015/ 2016	2020/ 2021	2022/ 2023	2023/ 2024 MY to 2010/2011 MY, %
Initial stocks	2.0	18.0	29.0	70.0	100.0
Production	1,470.0	1,744.0	2,750.0	3,500.0	292.5
Import	2.0	2.0	72.0	40.0	2,000.0
General proposal	1,474.0	1,764.0	2,851.0	3,610.0	294.6
Export	1,416.0	1,437.0	2,396.0	3,421.0	257.8
Processing	55.0	325.0	300.0	183.0	1,227.3
Internal consumption	57.0	327.0	304.0	187.0	1,193.0
Ending stocks	1.0	0.0	151.0	2.0	1,200.0
Total demand	1,474.0	1,764.0	2,851.0	3,610.0	294.6
Coefficient of self-sufficiency	25.8	5.3	9.0	18.7	X

Source: author's calculations based on the USDA, 2023 [19].

In the conditions of the isolation of the sea ports, the export of rapeseed to a number of countries (Pakistan, Bangladesh, the United Arab Emirates) was practically impossible and sharply reduced.

Canola from Australia and Canada became the main substitute for Ukrainian rapeseed on the markets of Middle Eastern countries.

Main part of rapeseed in 2022/2023 MY was exported by railway and road.

At the same time, the disruption of supply chains due to the war and the temporary measures of European countries, in particular Poland, Bulgaria, Hungary, Romania and Slovakia regarding the ban on the import of rapeseed, are the main threats that may further reduce sown area under rapeseed and, accordingly, gross harvests.

Further interests to increase rapeseed production in Ukraine will depend on conjuncture on internal and external markets. Indeed, the main factor on both markets remain favourable price to produce rapeseed. In this regard, it is important to analyse price trend and make forecast of Ukrainian rapeseed prices for shortcoming period.

Taking into account the fact that approximately 60% of rapeseed exported to EU countries, there is expected the impact of the EU prices on Ukrainian.

Thus, the regression model between Ukrainian rapeseed prices (R_rapeseed prices_Ukraine) and EU rapeseed prices (R_ rapessed prices_EU) was done. Regression results are presented in Table 5.

Table 5. Regression model between Ukrainian and EU rapeseed prices

Specification	Regression equation: R_rapeseed prices_Ukraine=-139.45+1.06 *R_ rapeseed prices _EU
R	0.89
R^2	0.80
P-value for parameter a_0	0.0227
P-value for parameter a_1	0.0000

Source: author's calculations.

The obtained results confirmed the linkage between rapeseed prices in Ukraine and rapeseed prices in the EU, where an increase in rapeseed prices in the EU by 1 USD leads to an increase in rapeseed prices in Ukraine by 1.06 USD. Indeed, the regression analysis indicates a strong closeness among the studied factors, in particular, the coefficient of multiple correlation R=0.89, which means a close relationship. In turn, the model is significant, which is confirmed by the P-value for parameter a_1, which is lower than the critical value of 0.05. Based on the reliability of obtaining regression model, a price forecast for Ukrainian rapeseed was built. Holt's method was applied to predict the value of the factor sign, i.e. rapeseed prices in the EU. The forecast substantiality of the factor sign was checked using forecast errors, where their results are following: MAE is 41.9, MAPE is 6.04, and RMSE is 2.5.

To determine the forecasted values of the Ukrainian rapeseed prices, there were substitute of the predicted value of EU rapeseed prices into the regression equation (Fig. 4).

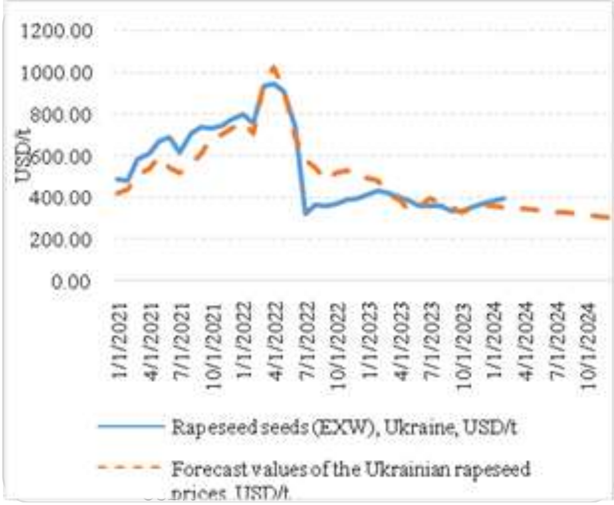

Fig. 4. Actual and forecasted values of Ukrainian rapeseed prices, USD/t
Source: author's calculations based on APK inform data, 2024; FAO data, 2024 [1, 6].

The forecast of Ukrainian rapeseed prices is showed that prices will decrease and at the end of 2024 it could be equalled to 306 US dollar/t. Such a decrease can be explained as follow: (1) the limitation of supply due to the blocking of borders, which has a negative effect on the domestic price; (2) seasonal factor; (3) decrease in prices for Canadian rapeseed, which will influence on its supply intensification to the European market and, in turn, increase competition for Ukrainian rapeseed in the corresponding market.

However, the situation on the rapeseed market could be change significantly even in 2024 due to the growing interest of European buyers in Ukrainian rapeseed [1]. The EU countries anticipate a decrease in rapeseed production that was influenced by unfavourable weather conditions. In this regard, it is forecasted the reduction on 12% in the European oilseed crop. This decrease poses a risk for European processors, who might face shortages in raw materials. Thus, this could lead to increase EU rapeseed prices and as a result Ukrainian.

Scrutinized global trends at rapeseed oil market, there is expected that this market will continue to grow, where in 2023 there are was evaluated 25.06 USD billion at a compound annual growth rate (CAGR) of 6.7% compare to 2022 with the volume of 23.49 billion USD. However, it is important to note that the war in Ukraine has undermined the chances of global economic recovery after the COVID-19 pandemic, particularly in the short-term period. Indeed, the war led to a growth in food prices and disruptions in supply chains, which in turn caused inflation in goods and services and affected different markets worldwide. Despite on it, the rapeseed oil market is expected to reach 31.52 billion US dollar in 2027 at a CAGR of 5.9% [3].

One of the main driver of the growth of the rapeseed oil market in the future will remain demand for biodiesel fuel production. In March 2023, the EU agreed a further increase in the share of energy from renewable sources in gross final energy consumption to 45% by 2030 in the frame of the REPowerEU plan [5]. Therefore, increasing demand for biodiesel fuel will contribute to the growth of the rapeseed oil market and consequently rapeseed.

CONCLUSIONS

The global rapeseed market is growing and there is could be noted its dynamic development among agricultural markets. Indeed, according to USDA forecast in 2023/2024 MY it is expected more than 85 million tons; rapeseed export volumes increased almost twofold in the past decade. Herewith EU countries, Canada, China and India remain the largest producers of rapeseed. Ukraine's share in the global production accounted to 4% in 2022/2023 MY.

Ukrainian rapeseed market is export oriented, where in different years approximately 90% of produced rapeseed goes for export. With the beginning of the war in Ukraine, one of the important problems became the violation of export channels, accordingly to it, there were evaluated possible scenarios for the development of rapeseed, i.e. (1) rapeseed production should become more active; (2) reduction of sown areas; (3) domestic increasing the volume of seed processing into oil or biodiesel.

The global demand for rapeseed and rapeseed oil is constantly growing due to necessity of biodiesel production that ensure domestic agricultural enterprises benefits at the local market. Based on the Hypothesis 1 that was stated in the article, we came to conclusions that Ukraine will enhance rapeseed production mainly for export purposes. However, the presence of unfilled capacities at oil and fat factories in Ukraine may contribute to the further increase of domestic processing rapeseed into rapeseed oil in the frame of approximately 20% with its further export.

Evaluation of the influence global rapeseed prices on Ukrainian was done within the regression model between Ukrainian and EU rapeseed prices, where the increase of 1 USD of rapeseed prices in EU will lead to growth by 1.06 USD of rapeseed prices in Ukraine. Linkage tightness of the domestic rapeseed market and the EU market confirmed by the multiple correlation coefficient R=0.89. Further growth of the domestic rapeseed market mostly defined by prices development on global market. In this regard, based on getting regression model, there was forecasted Ukrainian rapeseed prices that showed domestic prices decrease for short-term period and fluctuate between 300-400 USD/t during the current year. This situation could be explained by such factors as the limitation of supply due to the blocking of borders, which has a negative effect on the domestic price; seasonal factor; prices decrease for Canadian rapeseed that consequently will influence on its supply activation to the European market and, in turn, increase competition for Ukrainian rapeseed. In contrary to such statement, the development of domestic rapeseed market could have positive trend in 2024 due to the growth demand for rapeseed of European enterprises in the frame to fulfil obligatory to increase renewable energy sources, in particular, biodiesel.

High demand for rapeseed and rapeseed oil will remain for both food and energy purposes. However, it is necessary to take into account the economic changes in the market for the production and distribution of biofuels of the first and second generation, which will take place in the future, in particular in the EU countries.

Our further research may concern the assessment of the market integration of Ukrainian rapeseed market with European, as well as the study of European principles of sustainable development of rapeseed in the context to get economic, social and ecological benefits.

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EFFICIENCY OF MAIZE AND SUNFLOWER CROPS UNDER THE IMPACT OF DROUGHT IN BRAILA COUNTY, ROMANIA

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Abstract

The main objective of the research is to evaluate the efficiency of crops under the influence of drought. In the development of agriculture, a challenge is to obtain high yields under the action of climatic factors. During the research, numerous other secondary objectives were achieved, and starting hypotheses were established, which are verified at the end of the article. The objective of the research falls within the current guidelines of PAM 8, which aims at the efficiency of water use in Romania. The research is located at the Brăila county level, we aimed to evaluate the efficiency of the most vulnerable crops (maize, sunflower) under the impact of water shortage. The study was analyzed over the last 33 years, and the results suggested that the potential of crops is proven by the contribution to the turnover of over 8% that it has in the county's economy. Further research is needed to elaborate on these findings in other counties to have a comprehensive nationwide diagnosis for stakeholders.

Key words*: *maize, sunflower, efficiency, drought

INTRODUCTION

Given the high-frequency nature of weather variables relative to yield and other agricultural outcomes, researchers are faced with a unique model selection problem in assessing climate change impacts. If farmers do not respond to climate change in a way that is meaningfully different from how they respond to weather shocks, then using weather fluctuations to identify climate impacts could be perfectly justified [2].

Drought assessment involves analyzing and measuring the impact of drought on various aspects such as the environment, agriculture, economy, and society in general. The present research looks at some key aspects that are considered in the evaluation, as follows:

Monitoring of meteorological indicators, at the level of Brăila county, after 1990, including here, the significant decrease in precipitation amounts, an increase in temperatures and soil moisture;

Monitoring the behavior of crops under the influence of groundwater levels, the flow of rivers and lakes;

Soil moisture and agricultural productivity monitoring [10].

Analysis of the impact of the drought on agricultural production, especially those most sensitive to these changes (corn, sunflower, soy), behaviors that can have serious consequences on the food and economic security of this county. Impact on ecosystems: Drought can affect biodiversity and the natural habitat of various species.

Ecosystem impact assessment is crucial for environmental conservation.

Drought can have significant economic effects, including lower agricultural production, higher food prices, lower farm incomes, and losses in other economic sectors affected by water shortages.

The social impact is assessed by the degree of damage to rural and urban communities, causing migration, lower living standards, and increased social tensions.

It is also important to develop and implement drought adaptation and mitigation measures to reduce vulnerability and improve the resilience of communities and the environment to this type of extreme events [12].

Climate change presents an unparalleled difficulty to human society, and the magnitude of its effects depends on how well the world understands the need for appropriate concessions. As the effects of climate change intensify, both actual and alternative expenses will increase, affecting the population's health and economic prosperity. The primary societal obstacle is the incorporation of sustainable measures into economic development. Plants adapt to climatic conditions through physiological, biochemical, and morphological changes, demonstrating their adaptive potential to survive and thrive in changing climates [1].

We aim from the outset to connect recent work that traces the link between climate change, including changes in precipitation regimes, and the frequency of extreme weather events that can have a significant impact on agricultural production. Farmers can take steps to adapt to climate change, such as using more water-efficient farming techniques, choosing more drought-resistant crops, or developing more advanced irrigation systems.

In conclusion, climate plays a crucial role in determining the success or failure of agricultural production, and farmers and agricultural communities must be prepared and consider adaptation strategies to cope with climate change.

The main objective of the article is to identify the efficiency of crops sensitive to drought in Brăila County under the impact of climate indicators. Achieving this goal requires a data set that identifies the influence of key indicators that leave their mark on crops (maize and sunflower). Along with this, the research aims at **several objectives**, presented below, in the form of O1-O4 [10].

O1 Determining the effect of drought on the efficiency of corn cultivation in Brăila county

O2 Determining the effect of drought on the efficiency of sunflower cultivation in Brăila county

O3 Economic evaluation of the reasons why Brazilian farmers choose crops for the development of their businesses;

O4 Economic assessment of the reasons why the farmers recognize that certain environmental factors can influence the production of certain crops.

The assumptions from which the research started are presented for each objective and are established based on previous studies, specialists, or empirical reports.

I1. Objective 1 *assumes that maize yields have performed somewhat better, reaching peaks of over nine tonnes/hectare in 2018 and a low of 1.2t/ha in 2008. Farmers' challenges are marked by summer drought, farmers in the area of Brăila County face the adverse effects of climatic conditions, encountering significant difficulties for the beginning of the vegetation of crops. Both autumn-sown crops face unprecedented challenges due to months of very low rainfall and unusually high temperatures for this period, but especially spring crops whose vegetation cycle overlaps with extremely dry periods.*

I2. Objective 2*, starts from the hypothesis that sunflower production varied between one ton and almost two tons per hectare, being affected by the reduced amounts of precipitation. These conditions emphasize the importance of adapting agricultural practices to individual plots and the need to assimilate premium genetics supported by advanced technology for a successful harvest.*

The lack of rains at an optimal level during the period of establishment of autumn crops, associated with the current absence of snow and unusually high temperatures, which lead to the evaporation of the water reserve from the soil, are reasons for concern in Brăila County. Precipitation levels vary nationally, with Brăila being one of the most affected counties, and there is even a risk of crops returning. Farmers are therefore advised to choose maize and sunflower hybrids that can withstand drought conditions in the coming spring and summer months and ensure satisfactory yields.

I3. ***Objective 3,*** Determining farmers to cultivate corn or sunflowers, shows that for one hectare of land cultivated with corn, not irrigated, with an average production of 5-6 tons/hectare, a farmer reaches an income of 2,000 euros, from which remains with a profit of around 600 euros/hectare, after deducting expenses. The price of corn in 2022 was 340 euros/ton.

"The whole process, from establishing a crop to harvesting, varies between 1,000 and 1,400 euros/hectare, without irrigation. The variation of 400 euros depends on what technology the farmer applies, and what investments he has made. 2022 was a special agricultural year because the drought deeply affected Brăila counties, some farmers had their harvests almost completely affected [13].

I4. Objective 4 starts from the hypothesis that specialists emphasize the importance of the pillars of innovation and sustainability in the dynamic landscape of agriculture, local farmers face a series of environmental challenges that require the assimilation of practices and technologies adapted to these conditions. Thus, they offer farmers the solutions with the highest tolerance to drought and heat, ensuring a significant increase in productivity, regardless of the climate impact, through the efficient use of limited water resources.

In this context, the number one choice among Romanian farmers is corn and sunflower hybrids, recognized for their tolerance to extreme environmental conditions.

These hypotheses have been established empirically.

MATERIALS AND METHODS

To achieve this objective, the research focused on exploring statistical data from Brăila County and using the regression function for crop efficiency and farm management performance.

Using FAO data, in the context of the global report on the Sustainable Development Goals (SDGs), we tried to identify what are the opportunities to further increase the efficiency of water use in agriculture, the world's largest user of water. Romania falls within the current recommendations for accelerating the achievement of the SDG target of sustainable water use.

Since in the last four years, there have been major changes in soil and air temperatures much higher than the multi-year averages for the period 1991 - 2020, the crops mentioned above have been affected in the sense of diminishing them, in varying degrees up to calamity, they have subject to compensations granted by the Government.

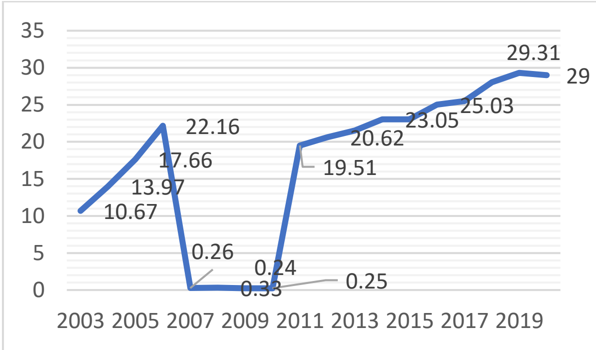

Fig. 1. Efficiency of water use in agriculture \$/m3 in Romania after 2003
Source: [5].

Figure 1 shows how in Romania different intervals of efficiency were registered, as the economy registered different stages in its evolution.

Decreases in water withdrawals can result from structural changes in a country's economy, such as industrial relocation, that create increases in virtual water imports.

As previously explained, the indicator can provide an overview of the change in water use efficiency globally from 2003 to the present (latest validated data available 2019). Globally, water use efficiency increased from USD 17.18/m3 in 2015 to USD 18.89/m^3 in 2018 worldwide representing an increase of 10% [8].

However, global values hide regional differences.

To determine the effect of the drought on agricultural production in Brăila County, we used the data set of the type:

Precipitation Index (SPI) – Standardized Precipitation Index: This index standardizes the amount of precipitation in Brăila County and the period, allowing the evaluation of the drought in statistical terms. The Crop Rainfall Index is a measure of the amount of rainfalls over a given period and in a given geographical area, relative to the water needs of the crops during that period.

Moisture Deficit Index (PDSI): This is an indicator that assesses soil moisture deficit based on precipitation and potential evapo transpiration. PDSI can be used for regional or national drought monitoring. Soil moisture deficit refers to the difference between the amount of water available in the soil and the amount of water needed to meet plant requirements. It is a measure of how much water is lacking in the soil to support plant growth and development optimally.

Optimum real evapotranspiration (ETRO) is a method of estimating the water consumption of crops and represents the water consumption that allows photosynthesis to take place corresponding to obtaining an economically efficient harvest. It was indirectly established based on the formula:

ETRO = k_p · ETP................................(1)

where:

ETRO isthe actual optimal evapotranspiration, in m^3/ha

k_p – coefficient characteristic of the analyzed plants, grown in the pedoclimatic zone

ETP – potential evapotranspiration, established by the Thornthwaite method in m^3/ha.

Water consumption during the vegetation period was obtained by adding up the monthly products for which this indicator was determined.

ETRO is determined for each crop and the resulting values are used to calculate the water balance and to determine the water requirement.

These meteorological indicators are used by meteorologists, environmental agencies, and authorities responsible for drought monitoring and management, helping to identify and address water scarcity issues and impacts on the environment and communities.

SPI values (March – September) for Brăila county, lower than -0.8 indicate periods of at least moderate meteorological drought, with values lower than -1.6 indicating at least extreme drought for the two time intervals. Droughts during this period are very significant for agricultural production in particular, as most annual crops end their lifecycles within them.

The prevailing pedoclimatic conditions associated with the Black Sea basin have been favorable to cereal growing in these regions since ancient times.

Today, Romania is recognized worldwide as an important grower, producer, and exporter of maize. In 2021, it was ranked 3rd in terms of area under maize cultivation, with 2,554,680 hectares and a production of 14,820,690 tonnes [3].

The examination of maize production and area in Romania reveals several key findings. Maize remains the predominant crop, cultivated across approximately 2.5 million hectares, representing 47.6% of the area dedicated to cereals and 30.8% of the total cultivated area. Regional distribution shows South Muntenia, South East, and North East as the primary regions for maize cultivation. While there was a slight decrease in maize cultivation area in 2021 compared to 2011, macro-regions experienced varied changes, with notable increases in Macro-regions 1, 2, and 3, but a significant decrease in Macro-region 4. Despite fluctuations in cultivation area, maize production increased by 26.5% between 2011 and 2021 [6].

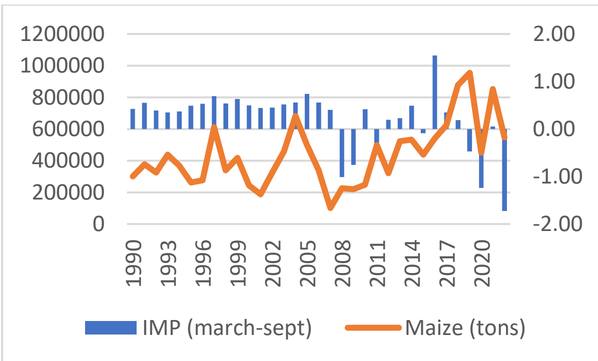

Fig. 2. The evolution of corn production and SPI in Brăila County from1990 to2022
Source: [4, 13].

Toillustratetheeffect of drought on agriculturalproduction in Brăila County, weusedthe linear regression model for theproduction of sunflower, andgrain corn, as dependent variables.

The regression function was used to assess the sensitivities and resistance of crops to drought and to quantify the effects of drought on crop production (Fig. 2).

However, agriculture suffers from these seasonal events. Thus climatological factors trigger lower-than-normal precipitation and/or a late end to the dry season.

SPI is important to farmers because the amount and distribution of rainfalls can significantly influence the yield and quality of the maize crop. From the analysis of the SPI Index for the Braila area in the period 1990-2022, the frequency of droughts varied from 3% extreme drought, 6% moderate drought, and 87.8% normal years - mild drought for the period March-September (Fig. 3).

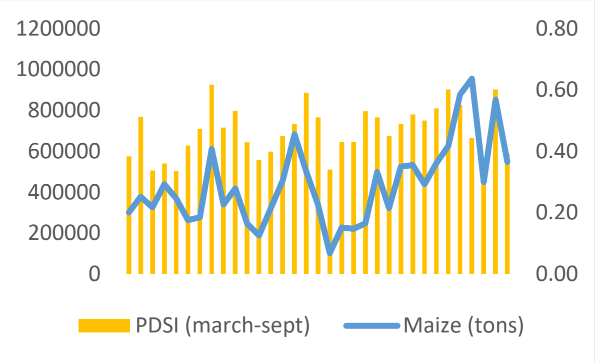

Fig. 3. The evolution of corn production and PDSI in Brăila County from1990 to2022
Source: [4, 13].

The water consumption for the corn crop reached an average value of 703.4 mm/m^2 in the period 1990-2022, and the amount of precipitations during the entire vegetation period was 289 mm (Fig. 4).

In the last 33 years, corn was harvested on average from an area of 89 thousand cultivated hectares within Brăila county, the reported average production being almost 2.4 tons/ha.

From the analysis of these data, it can be concluded the dependence of this agricultural crop on irrigation, complete the difference between the cumulative precipitations during the vegetation period and the calculated crop consumption.

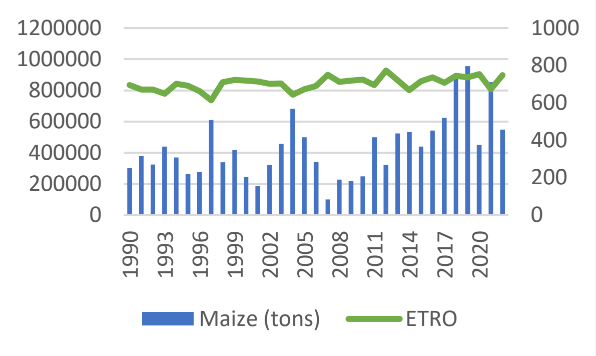

Fig. 4. The evolution of corn production and ETRO in Brăila County from1990 to 2022
Source: [13].

The dynamics of sunflower production and SPI is shown in Fig. 5.

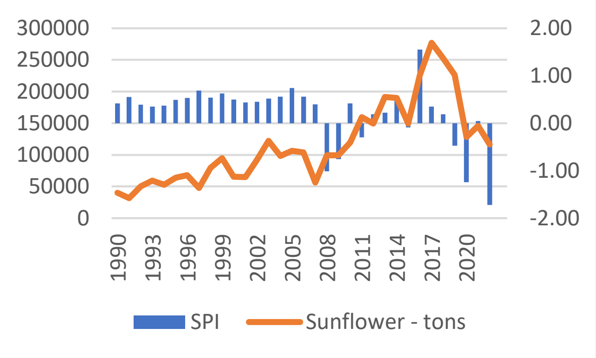

Fig. 5. The evolution of sunflower production and SPI in Brăila County in the period 1990-2022
Surce: [4, 13].

Sunflowers are grown in many countries because of their remarkable ecological adaptability. Over 45 million tonnes of sunflower seeds are produced worldwide, a considerable rise from previous years. However, there have been significant geographical variations in the growth of global sunflower production [7].

Farmers in Romania will grow sunflowers on the long term because it has both technical and economic advantages [11]. The sunflower is part of the group of mesophytic plants, with a medium resistance to drought. Sunflower achieved a high performance of 3,041 kg/ha in 2018 and the lowest of 1,858 kg/ha in 2020 [9]. The weakest crop years for these two crops were 2020, but 2018 favored maize and sunflower.

The sunflower is part of the group of mesophytic plants, with a medium resistance to drought. After sunrise, the need for water

increases progressively, with a maximum consumption during flowering and fruiting.
Regarding sunflowers, in Brăila County total production (on average) was 116,000 tons in the last 33 years. The sunflower yield reported in Brăila County was 2.9 tons/ha (Fig. 6).

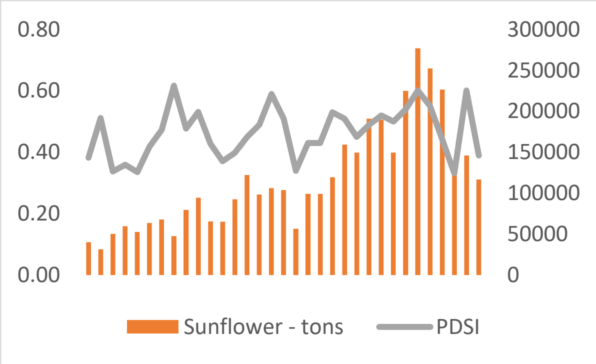

Fig. 6. The evolution of sunflower production and PDSI in Brăila County in the period 1990-2022
Surce: [4,13].

It turns out that sunflower is a basic crop in this area, but the prolonged droughts of the last 20 years that have hit Romania also affect sunflower production, which has decreased by approximately 30% (Fig. 6).
In the following figures, we study the dispersions in the analysis of the efficiency of the program and sunflower crops under the impact of the drought using th etwo indicators, taking into account the climatic conditions but also the crop's response to these conditions at the Brăila county level.

RESULTS AND DISCUSSIONS

Climate change is expected to affect agriculture, drought will occur more often, start earlier, and last longer. Higher temperatures and less precipitation are expected to reduce crop yields, although more extreme weather events are likely to increase crop yield volatility.
In the following figures, we study the dispersions used in the analysis of the efficiency of corn crops under the impact of drought using the two indicators, taking into account the climatic conditions but also the crop's response to these conditions at the level of Brăila county.

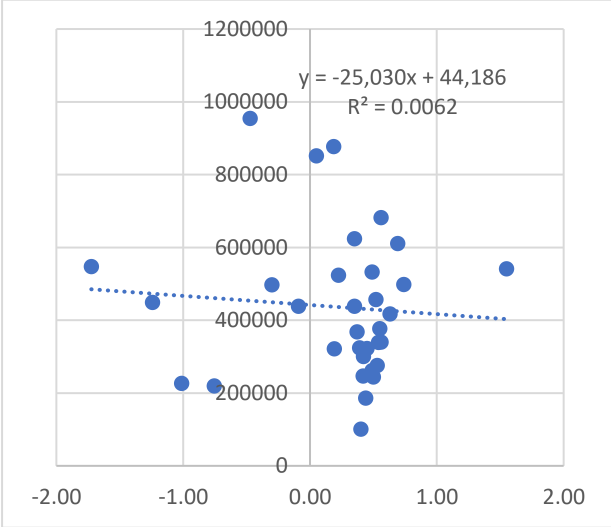

Fig. 7. Dispersion relationship between corn production and SPI in Brăila county during 1990-2022
Source: processingbytheauthors.

An evaluation of the SPI, based on rainfalls records over the last thirty years, using the regression function, shows that the dispersion relationship between the indicators is negative, indicating a percentage of 0.6% of the variability of production to rainfall in this crop from Braila (Fig. 7).
The relationship between the two factors is negative, which shows an un even distribution of precipitations throughout the growing season that affected corn production. Also, poorly drained soils led to excessive water accumulation in the roots, which negatively affected plant growth.
From the SPI evaluation, it can be seen that maize shows a high degree of vulnerability to high temperatures and lack of precipitations, and consequently yields are low. High evapotranspiration from the grain filling period limits production potential. In drought-prone areas, SPI is an effective indicator for evaluating the effects of drought on maize productivity (Fig. 8).
An evaluation of PDSI, using linear regression, based on soil moisture index records over the last thirty years, the dispersion shows that this indicator describes 26% of the variability of the production of this crop in Brăla, and ETRO contributes 1.3% to the variability production, (Figures 7 and 8).

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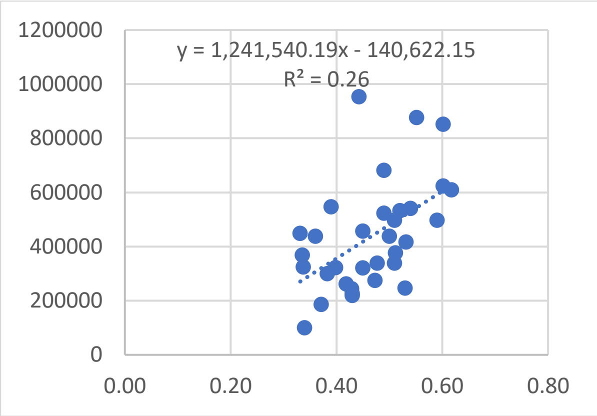

Fig. 8. Dispersion between maize production and PDSI in Braila county in the period 1990-2022
Source: processing by the authors.

Figure 9 shows a small dispersion of only 1.3% between evapotranspiration and maize production, indicating inefficient water use over the past 33 years, and poor crop management.

The amount of water available for evapotranspiration is strongly influenced by temperature, humidity, wind, and precipitation.

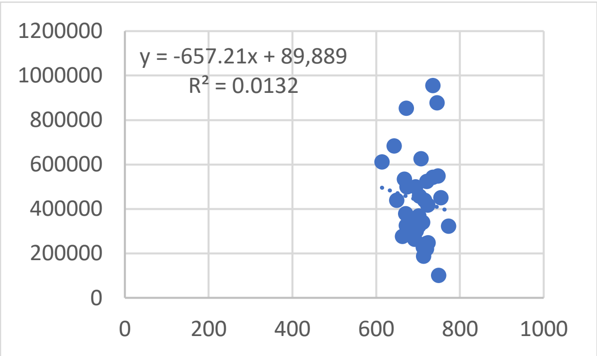

Fig. 9. Dispersion between corn production and ETRO in Brăila County during 1990-2022
Source: processing by the authors.

In Brăila County, the high temperatures and dry weather of recent years have left their mark on the evapotranspiration of the corn crop. The soil's ability to hold water and release it gradually can influence the availability of water to plants. Moreover, the small dispersion of 1.3%, but the function is negative, shows us a weak efficient management of irrigation in the county, which failed to ensure the optimal amount of water necessary for the growth and development of corn (Fig. 10).

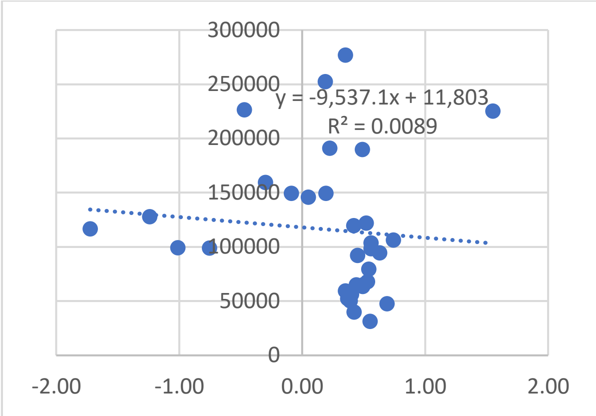

Fig. 10. The dispersion between sunflower production and SPI in Brăila County during 1990-2022
Source: processing by the authors.

Figure 11 shows a positive correlation between soil moisture and sunflower production, the trend is increasing because an adequate level of soil moisture is essential for plant development and growth.

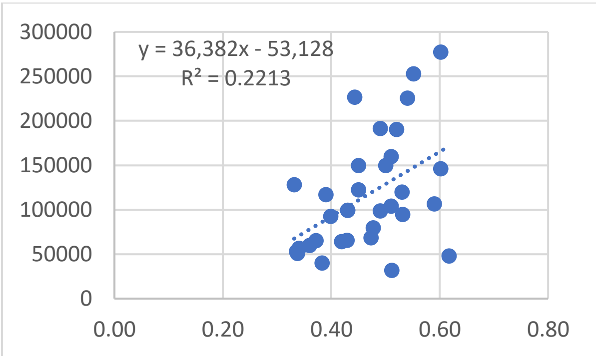

Fig. 11. Dispersion between sunflower production and PDSI in Brăila County during 1990-2022
Source: processing by the authors.

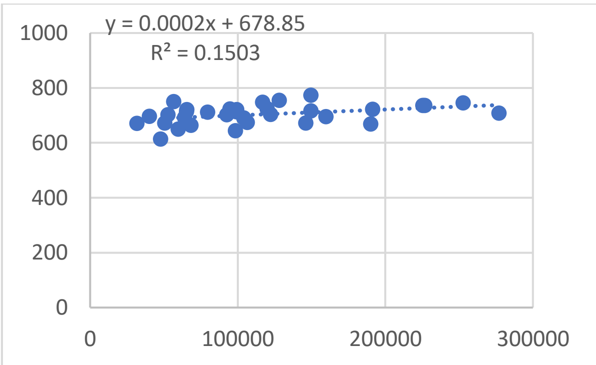

Fig. 12. Dispersion between sunflower production and ETRO in Brăila county during 1990-2022
Source: processingbytheauthors.

In Brăila County (Figure 12), R^2 = 15%, indicating a greater dispersion between evapotranspiration and sunflower production.

This variation is explained by the reduced capacity of water retention in the lands intended for sunflower crops, which were exposed to drought.

Under the influence of high temperatures and dry weather conditions, evapotranspiration increased, increasing the differences between evapotranspiration and agricultural production. This phenomenon can be attributed to a higher plant water requirement in the context of drought, causing additional pressure on available water resources.

The water consumption for the sunflower crop reached an average value of 669.8 mm/m^2 during the period 1990-2022 and the precipitation intake during the entire vegetation period was 289 mm. From the analysis of these data, it can be concluded the dependence of the sunflower culture for irrigation, in the pedoclimatic conditions of Brăila, even if it is known that this culture has better tolerance to drought, to obtain some high production it is necessary for irrigation.

CONCLUSIONS

Periods of drought or flooding can adversely affect plant development and seed production. For example, corn loses 15.6% of its water during sunny periods of the day and 40% of its water during long periods of drought.

Dispersion is usually expressed statistically, using measures such as standard deviation or coefficient of variation. However, it is important to note that there is no "standard" value for the dispersion between environmental indicators and outputs, as this may vary according to local conditions and other context-specific factors.

From the statistical analysis, it was found that there was a negative correlation between the precipitation index and corn production, due to its uneven distribution.

In practice, these values can be determined by analyzing field data or by using agricultural and hydrological models to estimate the relationship between environmental indicators and agricultural production in Brăila County. Such analyses can help farmers and agricultural specialists better understand the water requirements of their crops and optimize water resource management to maximize crop yields.

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THE DEVELOPMENT OF A BRAND STRATEGY FOR THE ROMANIAN WINE INDUSTRY – A PERSPECTIVE FROM ROMANIAN WINE EXPORTERS

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Abstract

The global wine industry is facing numerous challenges, such as declining consumption, consumer preferences (especially among younger people) for other types of beverages, the shrinking or disappearance of certain markets, and the effects of the COVID-19 pandemic, which have impacted purchasing and consumption behaviour and caused significant disruptions in supply chains. To promote overall economic growth and wine exports in particular, more and more wine-producing countries are choosing to build and promote a sectoral brand for their wine industry. The Romanian wine industry should also align with this global trend. The aim of this paper, which is based on applied qualitative research, is to present the perception of Romanian wine exporters regarding how Romania is viewed as a wine-producing country in foreign markets, what the export objectives are for the next five years, and which are the most important target export markets. Additionally, the paper seeks to evaluate the main critical success factors for entering international markets, the key elements of a brand strategy and brand architecture for the wine industry, and who should manage the project of building and promoting such a brand, as well as how it should be managed.

Key words: *wine, exporters, sectoral brand, brand strategy, brand architecture, market, Romania*

INTRODUCTION

In recent years, the international wine market has been under constant pressure. The global decline in wine consumption (221 million hectolitres in 2023 compared to 241 million hectolitres in 2017, a decrease of 8.3%), the shrinking of significant markets (the Chinese market, the 8th largest in the world, saw a drop in consumption from 1,928 million litres in 2018 to 685 million litres in 2023, a decrease of 64.5%), or the near-disappearance of others (the Russian market, due to the war with Ukraine) [13], the reduction in consumer income, the shift of some consumers toward a healthy lifestyle that involves eliminating alcohol consumption, or conversely, the preference of certain consumer segments for high-alcohol beverages, and the constant pressure from substitute products (e.g., beer) have placed the wine market and industry at a crossroads [14]. In response to these challenges, one of the strategies many countries have adopted is the creation and promotion of a sectoral brand to support their national wine industry [14]. The concept of a sectoral brand is derived from the concepts of nation branding, country branding, and country of origin of products [8].

A nation generally refers to a large group of people of the same race and language, while a country represents a land area occupied by a (part of a) nation. Although "nation" and "country" are often used interchangeably in academic literature, there is a difference between nation and country branding [5]. The concept of nation branding refers to the nation as a whole and describes its intangible assets without any explicit connection to a specific product [5]. The only benefits that a nation brand might create for a target audience are rather emotional than functional. A nation has only one official name, which cannot be easily changed, but it can have multiple "brands" depending on its objectives [5].

At the same time, research suggests that consumers are more willing to purchase products from countries with developed economies, consistently using information about the nation of production as an indicator of quality [2]. A brand with strong origin has impact on increasing tourism and investments, and also hold up the sale of its products abroad. Country-branded outcome highly benefit from the existing perceptions of the country to increase their observability, generate image, and influence consumer thinking about their quality [9]. If a country brand is stronger, this will bring more advantages in terms of preference, price, and commitment [5].

The country of production has relevant impact on consumers' attitudes and behaviours in relation with a product or service [5]. Many examples show the connexion between various categories of products and the country they belong, having an important role in differentiation and in adding value for the consumer. These products, bring besides their intrinsic quality, meaningful experiences related on the production traditions that connect them to their country of origin.

Starting from the definition of a brand, the concept of a sectoral brand is extrapolated and defined as "a group of products from a specific sector of a country whose purpose is to identify and differentiate them from products in the same category from other countries" [17].

A sectoral brand operates based on both competitive and comparative advantages [10]. The same author associates the sectoral brand with the existence of a territorial concentration related to a product or economic sector. A sectoral brand involves the collaboration of entrepreneurs within the same sector, with or without support from the country brand (which would function as an umbrella brand in this situation). Each sectoral brand represents an economic/industrial sector with its own distinct identity, but a very large number of such brands can be difficult for the country to manage [4].

In the current context of international trade, when competitors offer similar products in terms of price and quality, consumers begin to look at other factors to help them choose between brands from different countries [3]. Intangible resources, including sectoral brands, do not deteriorate over time and are more difficult for competitors to imitate because they involve unique elements developed over time based on a distinct organizational culture [12].

In the case of wine, various conceptual categories have been developed to classify wine-producing countries, and the classification that divides the wine industry geography into two "worlds" has been widely applied [16]. According to this taxonomy, we have "Old World" wine-producing countries and "New World" wine-producing countries [6]. Other authors [15] argue that "Old World" wine-producing countries have emphasized the origin of the grapes and promoted the names of wine regions, while the "New World" has primarily focused on supporting branding through proprietary labels and grape varieties.

Another perspective suggests that the classification of wine-producing countries into "Old World" vs. "New World" can be combined with the categorization of "traditional producer" vs. "non-traditional producer" [18]. While the "Old World" vs. "New World" categories consider the country’s history as a wine producer, the "traditional producer" vs. "non-traditional producer" classification refers to the country's relevance in global wine exports. Therefore, a non-traditional exporter indicates a country with a limited presence as an exporter in the international wine market.

In the higher and higher market competition, each country tries to develop more efficient brand strategies [11].

In this context, the purpose of the paper is to analyze the perception of Romanian wine exporters regarding how Romania is viewed as a wine-producing country in foreign markets, what the export objectives are for the next five years, and which are the most important target export markets.

MATERIALS AND METHODS

The research methodology is based on the "honeycomb" model elaborated by Wilson [21].
From a research philosophy standpoint, the epistemological approach follows interpretivism, while the ontological stance is rooted in subjectivism [21].
The research approach is seen as inductive, and the research strategy is seen as qualitative. While the type of research is considered exploratory, the research plan combines elements of action planning and case study. The data used are primary, and their interpretation is qualitative with elements of quantitative analysis [21].
The study was conducted from March 10 to 12, 2024, at the largest international wine fair, ProWein Düsseldorf.
The information was collected through direct interviews based on a questionnaire with 21 closed-ended questions, with either a single or multiple response options.
A total of 26 representatives from Romanian wine exporters participated in these interviews, one from each company present.
The first four questions of the questionnaire were designed to identify the company's main business activity, the wine region it belongs to, the respondent's position within the company hierarchy, and the company's revenue (expressed in millions of euros, in the form of a value range).
The purpose of questions 5-9 was to further profile the companies by identifying the share of exports in their revenue, the main export markets they operate in, how they conduct their exports, their objectives for increasing exports over the next 5 years, and their primary target export markets.
Questions 10, 11, and 12 (multiple-choice questions on a 5-point Likert scale) were structured based on the model developed by Keller [7] regarding the strategy for building a strong consumer-based brand.
Thus, a strong brand (expressed through its equity) is created through shaping the brand associations that occur in consumers' minds. Consumer-based brand equity is defined by Keller [7] as "the differential effect that brand knowledge has on consumer response to brand marketing". This framework maps brand knowledge as a cognitive construct that must exist in consumers' minds for the brand to be recalled and/or recognized.
Brand image consists of a set of attributes, benefits, and attitudes developed by the consumer towards the brand. Consumer-based brand equity is a framework through which the strength, favourability, and uniqueness of a brand can be measured against those of the competition [7].
Questions 13 and 14 aim to gather the participating companies' views on the need for government involvement in supporting Romanian wine exports and the specific ways in which this support could be implemented. Question 15 aimed to identify the critical success factors that exporters consider when entering new export markets or seeking to expand their activities in markets where they are already present.
Questions 16, 17, and 18 aim to understand the perspective of Romanian wine exporters on the need for creating a sectoral brand for the Romanian wine industry, the potential differentiating elements of this brand, and the structure of the brand architecture. To identify differentiating elements, the approach proposed by Trout and Rivkin [19] was followed, while for understanding a potential brand architecture, the "brand relationship spectrum" model [1] was used.
This model proposes four main strategic options for organizing a brand portfolio and the concept of the driving brand role, which reflects the importance of the brand in influencing the customer's purchasing decision. Despite criticisms, this model is considered one of the most comprehensive in the study of brand architecture [20].
Finally, questions 19, 20, and 21 aimed to identify aspects related to the management of a project for building a brand for the Romanian wine industry (who should finance it, who should develop and implement such a project) and the main obstacles to its implementation.

RESULTS AND DISCUSSIONS

The responses to the first question (*Q1 – What is your company’s main business activity?*)

revealed that the vast majority of participating companies (92.3%) have wine production as their primary objective, while only 7.7% focus on marketing and management consulting. There were no responses selected for wine exporter, wine importer or consulting in wine production. A preliminary conclusion is that Romanian producers prefer to be directly involved in their own wine export activities.

In terms of the wine region, they belong to (*Q2 –Which wine region is your company located in?*), most companies come from *"Dealurile Olteniei si Munteniei"* (38.5%), *"Dealurile Moldovei"* (19.2%), and *"Colinele Dobrogei"* (15.4%), which together accounted for 73.1% of the total participants. *"Podișul Transilvaniei"* had 11.5% of participants, while *"Dealurile Banatului"* and *"Dealurile Crișanei și Maramureșului"* each had 7.7%. No responses were recorded for the regions of "*Nisipurile din Sudul Țării"* and *"Terasele Dunării"*.

In terms of company representation (*Q3 – What is your position within the company?*), the largest share is held by *"top managers"* (65.4%). Together with *"shareholders"* (15.4%), they account 80.8% of the participants, reflecting the significant importance that top executives place on promoting exports and opening new markets/distribution channels. Only 19.2% of participants hold *"middle management"* positions in the companies they represent.

The objective of *Q4 - What is your company's revenue?* (expressed in millions of euros, in the form of a value range) was to understand the profile of the participating companies in terms of revenue and subsequently, to relate the value of exports to these figures (Table 1).

Table 1. What is your company revenue?

	Your company's revenue is:	**Responses**
1	Bellow 1 million euro	15.4%
2	Between 1 - 5 million euros	46.2%
3	Between 5 - 10 million euros	19.2%
4	Above 10 million euros	15.4%
5	Don't know/Prefer not to answer	3.8%

Source: Own calculation.

It is observed that companies with a revenue between 1 and 5 million euros are predominant (46.2%), and companies with revenue between 1 and 10 million euros' account 65.4% of the total.

Questions *Q5 – What is the share of exports in your revenue?* and *Q8 – By what percentage do you want to increase export value over the next 5 years?* aimed to understand the orientation of the participating companies towards exports and to assess their determination to increase their revenue from sales in international markets.

The largest share is held by companies with exports between 5% and 10% of their revenue (42.3%), while companies with export values up to 25% represent 88.5% of the total.

Only 3.8% of companies reported exports ranging from 25% to 50% of their revenue. An immediate conclusion is that, even for the companies that engage in exports, the domestic market remains the primary market.

Regarding export objectives for the next 5 years, their "aggressiveness" stands out, with 84.6% of companies aiming to increase export value by percentages ranging from 25% to over 100%.

These bold export targets further underscore the need for developing and promoting a sectoral brand for the Romanian wine industry.

Questions *Q6 –What are the main countries/geographic regions where you currently export?* and *Q9 – What are the main countries/geographic regions you are targeting for exports in the next 5 years?* highlight a shift in the focus of Romanian wine exports.

Markets such as those of BeNeLux, Germany, and the United Kingdom seem to be losing their importance and attractiveness, while others like Ireland, Denmark, Sweden, the United States, Poland and Canada are becoming increasingly significant (Table 2).

Regarding the methods used for exporting (*Q7 – How do you handle exports?*), the majority of producers (50%) use multiple local distributors, 23.1% work through a single distributor, and only 19.2% export directly to international retailers.

As for question *Q10 - How would you like Romanian wine to be perceived in international markets with respect to the following attributes?*, 96.1% of respondents

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disagree or strongly disagree with the attribute *"low value for money"*, 88.5% agree or strongly agree with the attribute *"good value for money"*, 80.8% agree or strongly agree with the attribute *"high value for money"*, and 88.5% disagree or strongly disagree with the attribute *"low price (cheap product)"*. It is noteworthy that Romanian producers do not want their products to be perceived as having low quality and, consequently, low (cheap) prices.

Table 2. Main export countries/regions

No. Crt.	Country/ Region	Q6 - Countries where you export (number of responses)	Q9 - Targeted export countries in the next 5 years (no of responses)	Variation
1	BeNeLux	17	11	-35.3%
2	Canada	10	12	20.0%
3	China	3	13	333.3%
4	Denmark	5	8	60.0%
5	Switzerland	3	3	0.0%
6	Germany	14	11	-21.4%
7	Irland	3	4	33.3%
8	United Kingdom	16	10	-37.5%
9	Poland	5	11	120.0%
10	United States	10	19	90.0%
11	Sweden	3	9	200.0%

Source: Own calculation.

Through question *Q11 –How do you evaluate Romanian wine in international markets with respect to the following statements?*, the aim was to understand Romanian exporters' views on how Romanian wine is perceived in foreign markets. These statements were structured based on the model proposed by Keller [7] for constructing Customer-Based Brand Equity, which involves developing brand awareness and brand image through attributes, benefits, and attitudes. The first three statements refer to attributes of Romanian wine. Regarding the first attribute, which concerns the optimal price at which Romanian wine is sold in international markets, opinions are polarized: 46.2% of respondents disagree or strongly disagree with the statement that Romanian wine has an optimal export price, while the same percentage (46.2%) believes Romanian wine does have an optimal export price. For the second statement related to the quality of wine, 84.6% of Romanian exporters agree or strongly agree with the statement that Romanian wine is perceived as having optimal quality. Concerning the distribution of Romanian wine in international markets, all participants disagree or strongly disagree with the statement that Romanian wine is easy to find/purchase.

In terms of the advantages related with consuming Romanian wine, over 88% of questioned people agreed that Romanian wine pairs very well with food, the same percentage believed that Romanian wine offer moments of relaxation, and almost 85% thought that Romanian wine means sensory gratifications.

In terms of the attitudes generated by consuming Romanian wine, only 57.7% of respondents agree or strongly agree that Romanian wine fits their lifestyle, and just 46.2% believe that Romanian wine is a good reflection of their social status.

As for the general attitude of foreign consumers towards Romanian wine (*Q12 - How would you describe the general attitude of foreign markets towards Romanian wine?*), 61.5% of Romanian exporters consider this attitude to be unfavourable or not very favourable, compared to only 38.5% who view it as somewhat favourable or favourable. Notably, no respondent believes that the attitude of foreign consumers towards Romanian wine is very favourable.

Through question *Q13 - Do you believe that the government should support the export of Romanian wine producers?*, the aim was to understand how Romanian exporters view the need for government intervention/support in Romanian wine exports. With an almost absolute majority (92.3%), exporters desire the involvement of the Romanian government in supporting wine exports.

Regarding specific ways of support (*Q14 - What ways do you want the Romanian government to support the export of Romanian wine?*), participation in fairs and exhibitions (96.2%) and conducting advertising campaigns (76.9%) are the most desired forms of support by Romanian wine exporters. Additionally, 61.5% of them seek support from diplomatic missions, 53.8% request assistance with networking and negotiation, and only 42.3% desire help with market research.

Through question *Q15 - How do you evaluate the importance of the following factors for entering foreign markets?*, the aim was to understand the critical success factors that Romanian exporters consider important when penetrating new external markets or increasing their presence there. Access to distribution channels is considered very important and important by all respondents (100%), as is collaboration with local distributors (96.2%), products with an optimal price/quality ratio (88.5%), running advertising campaigns (84.6%), access to HORECA channels, knowledge of local buying and consumption habits, and having sufficient stock for consistent delivery (80.8%). Only 61.5% of respondents consider low transportation and storage costs to be very important and important.

Question *Q16 - Do you consider the creation of a "country brand" for the Romanian wine industry necessary?* aimed to clarify Romanian wine exporters' stance on the subject of developing a brand for the Romanian wine industry. A percentage of 84.6% considers the creation of such a brand to be very necessary, while 15.4% consider it necessary. In practice, 100% of those interviewed believe that such an initiative is necessary or very necessary.

In the context of developing such a brand for the Romanian wine industry, question *Q17 - What do you think is Romania's competitive advantage compared to other wine-producing countries?* aimed to understand the elements that could differentiate the Romanian wine sector from wine sector in other regions with which it is in direct competition on the world market. The most important criteria for differentiating the Romanian wine sector are *"wide variety of national grape varieties"* (80/8% of responses), *"tradition in wine production"* (61.5% of responses), and *"new & advanced production technologies*" (34.6% of responses). *"Optimal geographical positioning for access to international markets"* received 19.2% of responses, while *"high productivity"*, *"positive perception in international markets"* and *"low production costs"* each received less than 10% of responses (7.7% for each). *"International recognition"*, *"significant foreign investment in the industry"* and *"advanced research in viticulture"* each received only 3.8% of responses.

Building a sectoral brand also involves defining the brand architecture, and the purpose of question *Q18 - How do you assess the importance of the following elements in the brand strategy for the Romanian wine industry?* was to determine the importance of the master brand (Romania – wine-producing country), sub-brands, and the hierarchy among them. The master brand *"Romania – wine-producing country"* is considered very important by 92.3% of respondents and important by 7.7%. The *"wine-growing region"*, as a sub-brand in the brand architecture, is seen as very important and important by 75% of respondents, and not very important and not important by 19.2%, with 5.8% being indifferent. Other evaluated sub-brands, such as *"vineyard"* are considered very important and important by 73.1% of respondents, *"national grape variety"* is considered very important and important by 65.4%, and *"producer's brand(s)"* is considered very important and important by 88.5%. The

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analysis of these data indicates that Romanian exporters want to create a sectoral brand for the wine industry but do not wish for it to overshadow their own brand(s).

Regarding the management of such a project, in response to question *Q19 - Who should develop and implement the branding strategy for the Romanian wine industry?*, 65.4% of respondents indicated the Ministry of Agriculture, 61.5% opted for one of the professional organizations of wine producers, 38.5% mentioned a new private structure under the coordination of wine exporters and only 34.6% indicated an independent consulting firm.

As for the funding of such an initiative (*Q20 - Who should fund the development and implementation of the branding strategy for the Romanian wine industry?*), 76.9% of respondents indicated the Ministry of Agriculture, 46.2% pointed to one of the professional organizations of wine producers, 26.9% mentioned only the wine exporters from Romania, and only 23.1% indicated all of the above.

The final question of the questionnaire aimed to understand the obstacles to implementing such a project (*Q21 - What do you believe are the current obstacles to developing a branding strategy for the Romanian wine industry?*). 80.8% of respondents mentioned lack of involvement from the Ministry of Agriculture; 57.7% indicated lack of involvement from professional organizations of wine producers; 46.2% chose major producers/exporters prefer to manage on their own; lack of know-how was mentioned by 42.3% of respondents, and 11.5% selected both high costs of such a project and all of the above.

CONCLUSIONS

Romanian producers choose to be directly involved, through top managers and shareholders, in export activities. They predominantly come from the wine regions of Dealurile Olteniei and Munteniei, Dealurile Moldovei and Colinele Dobrogei.

Even for Romanian companies that engage in exports, the domestic market remains the primary sales market. This reflects a major disadvantage and a lag compared to competitors from other wine-exporting countries.

The vast majority of companies aim to increase their export value by percentages ranging from 25% to over 100% compared to current levels. These bold export goals further underscore the need for developing and promoting a brand for the Romanian wine industry.

In terms of perception in international markets, Romanian wine producers do not want their products to be perceived as having low quality or low (cheap) prices. The vast majority of exporters believe that the attitude of foreign consumers towards Romanian wine is either not favourable or not very favourable.

With an almost absolute majority, exporters desire the involvement of the Romanian Government in supporting wine exports, and all respondents unanimously consider the creation of a brand for the Romanian wine industry to be necessary and very necessary.

The most relevant criteria for differentiating the Romanian wine industry, according to exporters, are *"a large variety of national grape varieties"* (80.8% of options) and "tradition in wine production" (61.5% of options). They desire the creation of a sectoral brand for the wine industry but do not want it to overshadow their own brand(s).

Romanian wine exporters identify the Ministry of Agriculture as the main organization that should be involved in financing, creating, and implementing a branding strategy for the Romanian wine industry. The lack of involvement by this Ministry is also cited as the primary obstacle to realizing such an initiative.

The authors aim for this study to be followed by another one that will seek to determine the perception of foreign professionals in the global wine industry and foreign wine consumers regarding Romanian wine. The results of both studies will need to be compared to identify positioning gaps and to determine the actions required to improve the global perception of the Romanian wine industry.

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BASIL PERFORMANCE EVALUATION AND WATER QUALITY MONITORING IN A RECIRCULATING AQUAPONICS SYSTEM

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Abstract

Resource scarcity and food security concerns have driven the adoption of innovative farming methods like aquaponics. This sustainable system merges aquaculture and hydroponics, offering a solution to drought and declining soil fertility while efficiently producing both fish and vegetables. The global aquaponics market is projected to more than double by 2028 due to its economic and environmental advantages. This study investigated basil (Ocimum basilicum) growth performance and water quality dynamics in a recirculating aquaponic system stocked with common carp (Cyprinus carpio). The system demonstrated effective nutrient cycling with stable water quality parameters conducive to plant health. Over four weeks, basil exhibited vigorous growth with significant increases in stem length, leaf size, and leaf number. These results highlight aquaponics' potential for efficient resource use and sustainable production of fish and high-value crops. The study provides valuable insights into optimizing aquaponic systems for improved food security and environmental sustainability.

Key words**:** *aquaponics market, basil (Ocimum basilicum), basil performance, water quality*

INTRODUCTION

Feeding a projected global population of 10 billion by 2050 poses a monumental challenge. To meet this demand, food production must increase by 50% [10], but obstacles such as climate change, pollution, and shrinking farmland stand in the way [13]. Despite advancements in agriculture, current production trends are insufficient to meet future needs [5]. A study by Goddek et al. (2019) [13] indicates a notable decline in the global area allocated to agricultural activities over the past five decades. The research indicates that the global agricultural area declined by more than 50% between 1970 and 2013. Addressing the urgent issue of food insecurity, which already affects a billion people, demands innovative solutions in food production systems and practices.
One promising solution is aquaponics, an innovative system that integrates aquaculture (fish farming) and hydroponics (soilless plant cultivation) [27, 33]. Aquaponics stands out as a beacon of sustainability in food production, leveraging circular and biomimetic principles to optimize resource utilization while seamlessly aligning with intensive agricultural practices [24]. This dynamic system presents a promising avenue to address food security challenges posed by climate change, especially in arid regions. Due to practical improvements in design and methodology, which have significantly increased both fish and crop yields and production efficiency, aquaponics is rapidly transitioning from a primarily backyard-based practice to an industrial-scale operation [6].
This approach is rapidly expanding globally. It effectively addresses food security concerns, minimizes water usage, and reduces the environmental impact inherent in traditional agriculture. The statistical data illustrated in Figure 1 delineates the projected market valuation of aquaponics on a global scale from 2017 to 2028. The global aquaponics market reached a valuation of approximately 523.7 million U.S. dollars in 2017, reached 870.60 million dollars in 2022 and is projected to expand to a valuation of about 1,807.29 million U.S. dollars by 2028. This translates to an anticipated compound annual growth rate (CAGR) of approximately 12.9% during the forecast period [12].

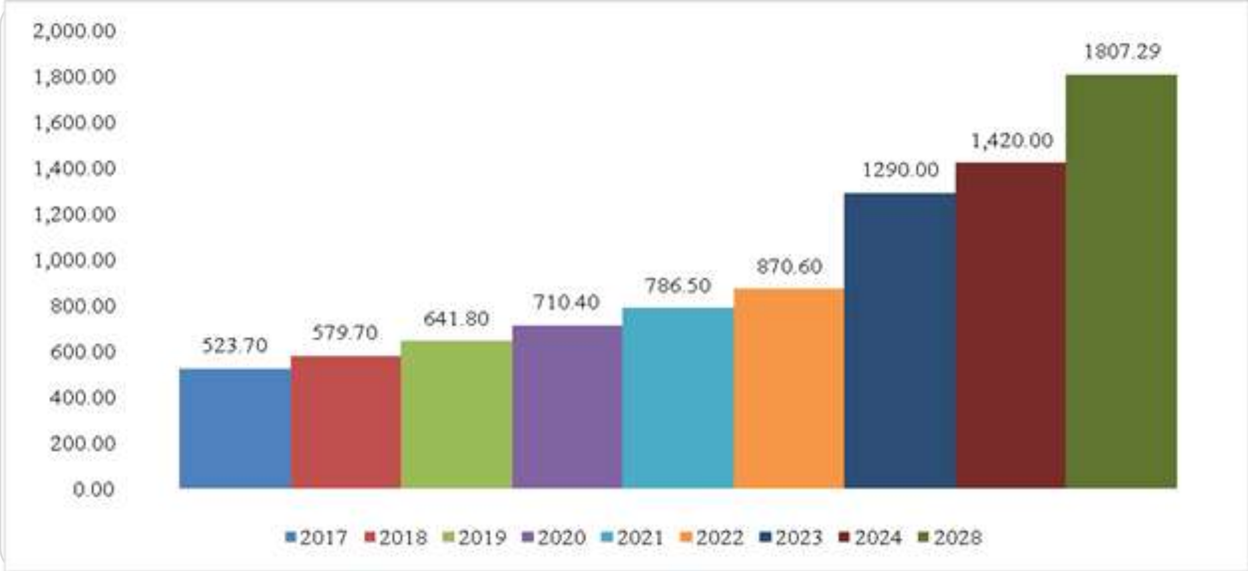

Fig. 1. Global aquaponics market value 2017-2028 (USD Million)
Source: Own representation based on data available on Global Aquaponics Market [12].

North America boasts the world's largest aquaponics market, fueled by the adoption of modern agricultural practices and the growing demand for organic produce. The Asia-Pacific region follows, driven by technological advancements and the need for improved agricultural output in countries like China and India. Europe holds the third-largest market share, benefiting from established infrastructure, user-friendly technologies, and rising incomes. Aquaponics is also gaining traction in Latin America, the Middle East, and Africa due to its low operating costs and the increasing demand for organic food [3].

The European aquaponics market, valued at USD 219.24 million in 2023, is projected to reach USD 565.66 million by 2030, exhibiting a CAGR of 14.5% during the forecast period [9]. The European aquaponics market is thriving, driven by a desire for sustainable, locally produced food. This innovative system combines fish farming and soilless plant cultivation, promoting resource efficiency and environmental responsibility. Market expansion is further fueled by growing awareness of food security, environmental concerns, and consumer preference for fresh, chemical-free produce. With government support, aquaponics is poised for a promising future in European agriculture. The EU Aquaponics Hub initiative (2014-2018) catalyzed aquaponics' growth in Europe by fostering collaboration between research and industry, leading to its recognition as a potential game-changer. Germany leads the European aquaponics sector, accounting for 24.8% of market revenue, due to its advanced agricultural practices, commitment to innovation, and consumer preference for sustainable food. Government support has also significantly contributed to the sector's expansion. France is the fastest-growing region, with a projected CAGR of 14% during the forecast period, driven by consumer demand for eco-friendly and locally sourced produce, coupled with government incentives.

The long-term sustainability of aquaponics is evaluated by examining its environmental, economic, and social impacts.

Economically, these systems require a substantial initial investment, but operating costs are low, and there's a dual income stream from fish and vegetable production.

Environmentally, aquaponics prevents pollution by containing aquaculture waste and allows for better control over water usage and production processes. The absence of chemical fertilizers, pesticides, and herbicides also results in safer food.

Socially, aquaponics enhances quality of life by promoting local food production and culturally relevant crops. It can also create livelihood opportunities, providing food security and income for disadvantaged communities.

Aquaponic systems have proven versatile, successfully cultivating various plant types, including vegetables, herbs, flowers, and even small trees. These diverse plants have flourished in various aquaponic setups, ranging from research laboratories to residential and commercial operations. Leafy green vegetables such as basil, spinach, and lettuce are particularly well-suited to aquaponic systems due to their ability to efficiently absorb and accumulate nutrients [17, 26].

In the European aquaponics market, leafy greens and herbs collectively represent approximately 67% of the market share. These crops are among the most frequently cultivated and harvested in aquaponic systems across the continent. Leafy greens and herbs flourish in the highly nutritious aquatic environment characteristic of aquaponics.

Their relatively short growth cycles allow for quicker harvesting and higher turnover, further enhancing their marketability. Savidov's Alberta [31] trials showed annual aquaponic yields varied by species, with water spinach and Swiss chard producing 50-60 kg/m², while amaranth, lettuce, and other herbs yielded 20-30 kg/m² (Fig. 2). With robust and consistent consumer demand, these crops represent an attractive option for growers engaged in aquaponics, supplying local markets, restaurants, and supermarkets [9].

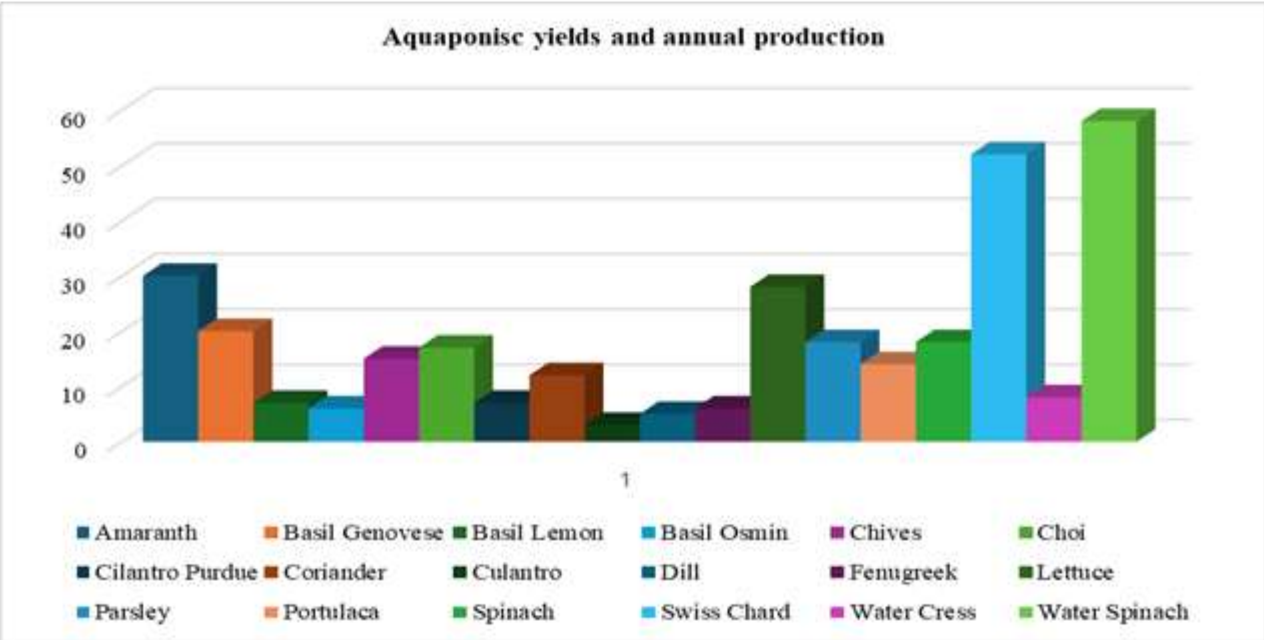

Fig. 2. Aquaponics yields and annual production (kilograms of leafy greens per square meter)
Source: [31].

Furthermore, as many aquaculture investors and farmers seek to improve both environmental and economic sustainability, basil emerges as a prime candidate [18]. Its exceptional ability to absorb nutrients and its high market value make it a particularly attractive option for achieving these combined objectives [8, 28]. The herb basil (*Ocimum basilicum*) dominated plant production in aquaponics, accounting for 81% of all cultivated herbs [19]. Basil is utilized as a medicinal herb and a culinary ingredient, and its dried and fresh forms are staples in many cultures worldwide [1, 2, 23]. The demand for basil among aquaponics and hydroponics producers is high due to the plant's suitability for soilless cultivation [25, 36]. Basil has been used in numerous aquaponics and hydroponics experiments due to these attributes [15, 29]. Under aquaponic production, basil can yield up to 1.8 kg per square meter, significantly higher than its yield in soil cultivation, which is only about 0.6 kg per square meter [4].

Mourantian et al. (2023) [22] found that decoupled aquaponic systems outperformed hydroponics in basil growth and efficiency while using less fertilizer, suggesting aquaponics as a greener option for commercial farming. Modarelli et al. (2023) [21] showed that while basil grown in aquaponics and hydroponics had comparable photosynthesis and fresh biomass, aquaponics yielded higher dry biomass and matter, suggesting its potential for reducing fertilizer use and boosting sustainability.

Bonea (2020) [7] found that basil extracts can stimulate maize seed root and shoot growth, suggesting basil's potential allelopathic influence on plant development.

Given their economic importance, plant species such as basil (*Ocimum basilicum*) warrant further investigation in aquaponics. The present study aimed to monitor the physicochemical parameters of water in a recirculating aquaponic system to facilitate basil (*Ocimum basilicum*) growth. Furthermore, the study evaluated basil performance characteristics, including stem length, leaf length, and the number of true leaves over four weeks.

MATERIALS AND METHODS

Experimental design

In this study, we employed an ecological recirculating aquaculture system for the controlled indoor rearing of fish (Fig. 3). This system mimics the natural nutrient cycles found in aquatic environments. Water flows continuously, starting from the fish tank, passing through filters and plant grow beds, and returning to the fish tank, creating a self-sustaining ecosystem. This symbiotic relationship between fish, plants, and bacteria creates a thriving and balanced environment when properly maintained [11, 16, 32]. The combined cultivation of fish and plants in aquaponics offers economic advantages by generating two crops and boosting production through nutrient recycling and efficient water use. Additional benefits include a smaller environmental footprint, year-round plant production, and the ability to grow organic produce with minimal chemical additives [14].

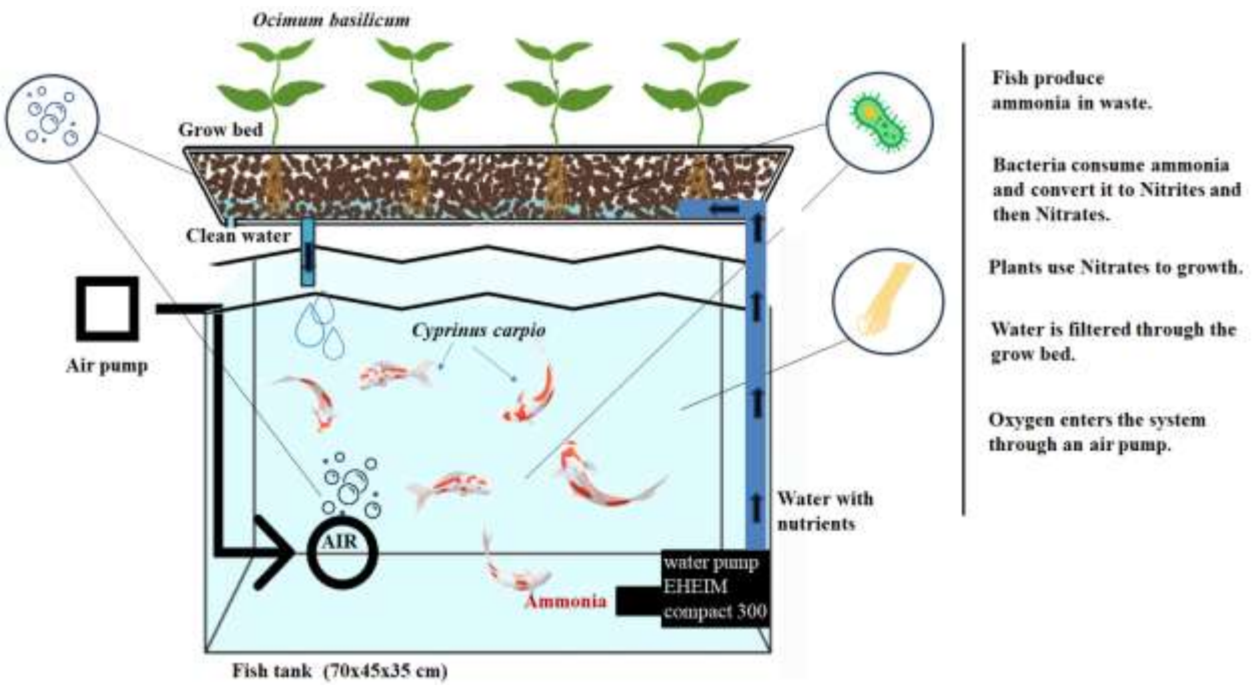

Fig. 3. Aquaponic system with recirculation - schematic representation
Source: Authors' drawing.

The aquaponic system consisted of several key components:

-a reservoir/tank for fish rearing (70x45x35 cm, 100 cm³ volume).

-a biofilter, crucial for providing an environment where bacteria can thrive and carry out the nitrification process.
-biofiltration material (expanded clay) with a specific surface area of 600 m^2/m^3.
-a water recirculation pump (EHEIM compact 300 model) with a capacity of 150-300 l/h to ensure continuous water circulation.
This configuration facilitates effective communication between fish and plants, maintaining a conducive habitat. The four-week experiment integrated an aquaponic system with light-expanded clay substrate, common carp (*Cyprinus carpio*), and basil (*Ocimum basilicum*). Native to Asia, *Cyprinus carpio*, is currently the most cultivated carp species worldwide [34].
The implementation of this system will serve to mitigate the potential for adverse environmental impact, as well as the potential for adverse effects upon carp production (as evidenced by the findings of Mihai et al. (2023) [20].

Water quality parameters

Table 1 outlines the ideal ranges for various water parameters in aquaponics, striking a balance necessary for maintaining optimal water quality and ensuring a thriving ecosystem for both plants and fish.

Table 1. The optimum ranges for aquaponics parameters

Parameter	Optimal range	Reference
pH	6.0–7.0	[38]
Water Temp.	17–34°C	[37]
Dissolved Oxygen	> 5 mg/L	[37]
Electrical conductivity	30–5,000 µS/cm	[35]
Nitrites	0.25–1 mg/L	[38]
Nitrates	5–150 mg/L	[8]

Source: Set up by authors based on the cited references.

Key water parameters were monitored weekly to maintain ideal growth conditions: temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), ammonia content (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-) and phosphate (PO_4^{3-}) levels.

Physical water parameters (DO, temperature, pH, EC) were recorded Monday and Friday at 12:30 pm using a using a HI9811-5 portable meter (Hanna Instruments).
Water samples were collected on Wednesdays and Fridays for analysis of chemical parameters (NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}) using an SP-830 Plus spectrophotometer, following ASRO Standard Methods.
Nitrate concentration (NO_3^-) was quantified using the phenol disulphonic acid method. This method involves converting nitrate to nitrite, which is then quantified through the Griess reaction. The Griess reaction involves treating the sample with sulphanilic acid and naphthyl-1-amine in an acidic environment. Ammonia nitrogen (NH_4^+) was quantified spectrophotometrically at 420 nm through the Nessler reagent method. The concentration of phosphate (PO_4^{3-}) was determined through the molybdenum blue method at a wavelength of 720 nm [30].
Instruments were calibrated before determinations to ensure quality and precision.

Basil performance evaluation

Plant performance evaluation assessed basil's developmental stage, overall health, vegetative growth, and adaptation to the aquaponic environment.
Seedling cells (5.6x6.8x5 cm) with a bottom hole for water absorption supported plant seedlings initiated from seeds. Coconut coir, chosen for its water retention and aeration properties, served as the substrate in aquaponic cultivation beds (Photo 1).

Photo 1. *Ocimum basilicum* seedling in the aquaponic system
Source: Original photo obtained through the laboratory experiment.

The following measurements were taken:
-Plant height: base of the stem to the tip of the highest leaf/flower cluster;
-Number of leaves: count of all fully developed leaves;
-Leaf measurement: from the middle of the stem.

RESULTS AND DISCUSSIONS

Water quality parameters

The fluctuations in physicochemical parameters remained within the recommended standards for aquaponics. Table 2 presents the physicochemical characteristics of the water parameters.

The recorded water temperature (23.81 ± 0.61°C) aligns with the recommended range for basil cultivation (20–25°C) proposed by Saha et al. (2016) [29] to enhance market quality and production. The average temperature remained around 23.8°C with slight weekly variations. Temperature significantly influences aquaponics parameters. Temperatures below 17°C hinder nitrification, limiting bacteria production for ammonia/nitrite oxidation. Conversely, high temperatures can restrict calcium absorption by plants.

Initially, conductivity exceeded 250 µS/cm, increased to over 270 µS/cm in the following two weeks, and then declined to 180 µS/cm. The average EC (247.25 µS/cm) indicates moderate dissolved salt levels. Optimal EC for basil in aquaponics ranges from 300 to 600 µS/cm, positively affecting shoot axis height and leaf number [25].

The pH values were slightly acidic, averaging 6.58. Maintaining a pH of approximately 7.0 can achieve equilibrium between nitrification and nutrient availability in aquaponics.

Dissolved oxygen is vital for fish health and nitrifying bacteria. A minimum DO level of 5 ppm is recommended. The average DO (7.31 mg/L) suggests healthy oxygen levels. As expected, dissolved oxygen decreased as temperature increased, as warmer water holds less oxygen.

In well-functioning aquaponic systems, ammonia and nitrite levels typically remain between 0 and 1 mg/L, posing no threat to plants. The average ammonium nitrogen concentration (0.27 ± 0.21 mg/L) fell within this safe range. The mean nitrite concentration was 0.56 mg/L. The monitored parameters stabilized after 28 days, with ammonium and nitrite concentrations dropping, ensuring optimal conditions for the aquaponic system and healthy growth. Nitrates increased from 40 mg/L initially to 140 mg/L in the last week. Nitrates primarily originate from nitrification, where aquaculture waste is broken down into ammonium/ammonia and then converted into nitrates by bacteria. This explains the observed rise in nitrate levels. However, the nitrate concentration remained stable, not exceeding 140 mg/L, likely due to plant absorption and the bacterial community reaching maximum nitrification capacity. Although less toxic than ammonia and nitrites, nitrate levels must be monitored to prevent excessive buildup, which could negatively impact plants and fish.

Table 2. Results obtained to monitoring the water in the aquaponic system

Week No, Day	T (^{0}C)	pH	EC µS/cm	DO mg O_2/L	NH_4^+ mg N/L	NO_2^- mg N/L	NO_3^- mg N/L	PO_4^{3-} mg P/L
W_1 Monday	23.1	6.81	268	7.93	0.05	0.2	40	0.02
W_1 Friday	23.5	6.53	263	7.68	0.05	0.25	50	0.2
W_2 Monday	24.4	6.65	279	6.82	0.05	0.5	60	0.3
W_2 Friday	24.6	6.37	273	6.42	0.1	0.7	70	0.2
W_3 Monday	24.5	6.23	250	7.02	0.3	0.6	90	0.2
W_3 Friday	24.2	6.74	255	7.23	0.5	1.0	110	0.3
W_4 Monday	23.6	6.56	210	7.52	0.1	0.7	130	0.2
W_4 Friday	23.2	6.72	180	7.88	0.1	0.5	140	0.2
Median value	*23.81*	*6.58*	*247.25*	*7.31*	*0.27*	*0.56*	*55*	*0.20*
Standard deviation	*0.61*	*0.20*	*34.49*	*0.54*	*0.21*	*0.26*	*12.91*	*0.09*

Source: Original data from the experiment.

Phosphates averaged 0.20 ± 0.09 mg/L, indicating rapid absorption by plants, reflecting good plant nutrition.

Basil performance evaluation

Plant performance evaluation involves the collection and analysis of various physical and physiological characteristics of plants to track their growth, health, and overall development.

Table 3 illustrates the biometric measurements of basil (*Ocimum basilicum*) growth and development in an aquaponic system over a four-week period (W_1-W_4).

Throughout the experiment, all plants survived, and no mortality was observed.

Table 3. *Ocimum basilicum* growth parameters

Week No	Stem length (cm)	Number of leaves (pcs)	Leaf length (cm)
W_1	3.5÷4	6÷8	2.5÷3
W_2	14÷15	10÷12	5.1÷5.5
W_3	15.5÷21	16÷18	5.5÷6.2
W_4	29÷35.1	22÷28	5.6÷5.3

Source: Original data from the experiment.

Over four weeks, basil demonstrated notable growth, with consistent increases in stem length, leaf length, and leaf number (Photo 2).

Photo 2. *Ocimum basilicum* thriving in aquaponics: a 4-week journey
Source: Original photo obtained through the laboratory experiment.

Week 1 (W_1): early growth stage with short stems (3.5-4 cm) and small leaves (2.5-3 cm). Limited leaf number (6-8) reflects initial development.

Week 2 (W_2): significant increase in all parameters. Stem length expands to 14-15 cm, leaves grow to 5.1-5.5 cm, and leaf number rises to 10-12, indicating vigorous foliage production.

Week 3 (W_3): continued growth with stem length reaching 15.5-21 cm. Leaves increase to 5.5-6.2 cm, and leaf number grows to 16-18.

Week 4 (W_4): advanced development stage. Stem length peaks at 29-35.1 cm. Leaves reach maximum size (5.6-6.3 cm), and leaf number reaches its highest point (22-28), reflecting a dense and vigorous crown.

Figure 4 depicts healthy and vigorous basil growth. The increase in stem length and number of leaves, coupled with the initial rapid leaf growth, points to successful plant development.

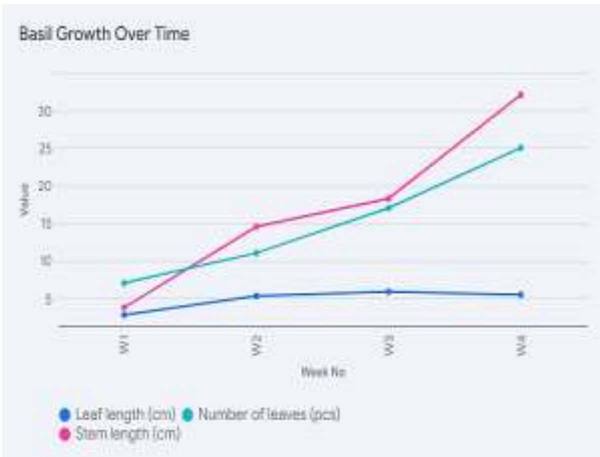

Fig. 4 . The basil plant's growth over four weeks
Source: Original figure.

The plateauing of leaf length in the later weeks suggests that the plant's resources might be shifting towards stem elongation and leaf production rather than further increasing individual leaf size.

Stem length increased consistently, with the most significant growth between W3 and W4, peaking at approximately 30 cm in W4. Leaf length showed a slight increase from W1 to W2 but remained relatively stable afterward, generally under 6 cm. The number of leaves grew steadily, mirroring the stem length pattern, with the most substantial increase between W3 and W4, reaching a maximum of about 25 leaves in W4.

Figure 6 illustrates a clear positive relationship between stem length and the number of leaves. As stem length increases, so does the number of leaves, suggesting a close link between these growth parameters. In contrast, leaf length appears less influenced by growth stages, maintaining relative consistency throughout.

CONCLUSIONS

The escalating global demand for food, coupled with the challenges of climate change, resource depletion, and shrinking arable land, necessitates innovative and sustainable solutions for food production. Aquaponics, an integrated system combining aquaculture and hydroponics, emerges as a promising answer. Its inherent resource efficiency, environmental friendliness, and potential for local food production position it as a viable alternative to traditional agriculture.

Market trends further underscore aquaponics' potential. The global market is projected to experience substantial growth in the coming years, driven by rising consumer awareness and government support. This growth is particularly evident in regions like Europe, where Germany leads the market and France demonstrates rapid expansion. The cultivation of leafy greens and herbs, particularly basil, is a key driver of this growth, given their adaptability to aquaponic systems and strong market demand.

Research highlights the advantages of aquaponics over traditional hydroponics, showcasing its superior nutrient utilization and potential for reducing fertilizer use. Additionally, studies on basil, a prominent crop in aquaponics, suggest its potential to enhance the growth of other plants, underscoring the need for further exploration of its role within aquaponic systems.

Our research findings indicate that an aquaponic system, integrating fish (*Cyprinus carpio*) farming with basil (*Ocimum basilicum*) cultivation, can successfully support the growth of both species. This is achieved by maintaining suitable water quality and promoting increased plant yields.

The collected data demonstrate the optimal functioning of the nitrification process, crucial for converting toxic ammonia into nitrates, essential nutrients for plants. The low levels of ammonia and nitrites, along with the steady rise in nitrate levels, confirm the effectiveness of nitrifying bacteria in maintaining a safe environment for fish.

The evolution of the basil plant over the four-week observation period reveals an accelerated growth pattern, marked by substantial increases in stem length, leaf size, and leaf number. The study underscores the potential for rapid growth and robust development in basil plants. This accelerated growth suggests that basil is a resilient and adaptable plant, capable of thriving in favorable conditions. Understanding these growth patterns can help optimize basil cultivation and maximize production. Moreover, the study highlights the adaptability and resilience of basil, demonstrating its potential for high yields in aquaponic environments.

This study serves as a steppingstone towards a more comprehensive understanding of aquaponics and its role in shaping a sustainable future for food production.

Overall, aquaponics represents a promising avenue for addressing the complex challenges of food security in the 21st century. Its environmental, economic, and social benefits make it an attractive option for a wide range of stakeholders, from small-scale farmers to large commercial operations. As research and technology continue to advance, aquaponics has the potential to play a pivotal role in shaping a more sustainable and food-secure future.

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CONDITION AND TRENDS OF WALNUT PRODUCTION IN THE WORLD AND IN REPUBLIC OF SERBIA

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Abstract

Walnut is recognized by consumers as a healthy food with rich nutritional characteristics, which is widely used in the food and pharmaceutical industry. The aim of the research in this paper is to analyze the trend in the production of walnut in the period 2013-2022 observing world and Serbia. In this period the calculated base and chain indexes show a positive growth trend of the demand in the world for walnuts in shell and shelled. Production in Serbia has a negative trend, although the characteristics of the soil and climate and the needs of the market lead to the conclusion that there are all the necessary conditions for the participation of the production of this fruit species to have a much larger share in the agricultural production of Serbia. With the increase in the state's role in supporting producers of this stone fruit, benefits would be multiple, from employment of the workforce and increase in exports, to environmental protection and prevention of soil erosion.

Key words**:** *walnuts in shell, walnuts shelled, production, trends, indexes*

INTRODUCTION

Walnut (*Juglans regia* L.) is a type of stone fruit that, due to its characteristics, has been used in human nutrition in Europe since at least 8,000 years ago, which was established during excavations in the southwestern part of France [20]. Found remains of wild varieties of walnut are date back to 10,000 years ago [13] [18]. Information about the first walnut plantations dates back to about 2,000 years BC in Babylon [20].
Apart from food, walnut has been used as medicine since ancient times [1] [4]. Modern medical research has recognized the building elements of tree bark, walnut leaves and all parts of the fruit (hull, shell, kernel and walnut internal septum) as sources of compounds which are used in improving human health [11] [17] [25]. In addition to medicinal properties, the walnut is very popular stone fruit [10] [28].
The walnut tree can be found in nature as wild, partially cultivated or cultivated and is a quality raw material in the wood and furniture industry, but also a tool that prevents soil erosion with its strong root system [1] [2]. In Serbia, there is a long tradition of growing walnuts, and since the trees were mostly planted from seeds, there are a large number of them with different genotypes [5]. The conditions for planting walnuts are favorable in all fruit-growing regions of Serbia [5] [13]. The production, as well as the processing of walnuts, today appears as a market niche, which could be used in the development of agriculture, but only with the application of modern cultivation and processing technologies, with the correct selection of the planting scheme, the percentage of pollinators, the use of modern irrigation systems, proper crop selection varieties for existing microclimatic conditions [29] [30]. The application of innovations in the cultivation of walnuts, as well as in the processing, contribute to greater success in production, but it is a stable business environment that which provides producers with a secure market and it something that must be considered during production planning [29]. A constant increase in the yield of walnuts can be expected after the sixth year from the raising of the orchard, and considering the long life span of the walnut tree, cultivation ensures a secure profit for many years [29] [12].

The subject of this research is the analysis of the production of walnuts in shell and walnuts shelled in the world and in Serbia, with the aim of determining whether the said production is promising and whether the economy of Serbia could participate more seriously in providing walnuts for the world's needs.

MATERIALS AND METHODS

In the paper were used datasets providing information about production of walnuts in shell and shelled for the period 2013-2022 available in the database of the Food and Agriculture Organization of the United Nations (FAO UN) and Statistical Office of the Republic of Serbia (SORS). The trend of walnut production was analyzed by applying statistical methods with the use of the earlier mentioned data and for a better insight into Serbian walnut production, both the base and chain index were used. The geometric mean of the chain indexes was calculated using the formula:

$$G = \sqrt[N-1]{\frac{Y_N}{Y_1}}$$ [16]...............................(1)

The average rate of the observed phenomenon was calculated according to the formula:

$$\bar{S} = (G-1) \cdot 100$$ [16].......................(2)

which takes into account the initial and final value of the observed phenomenon and shows the change in percentages [26] [14]. Professional literature and previous research related to walnut production also were used.

RESULTS AND DISCUSSIONS

Walnut production is recognized as a profitable activity, which confirms the fact that at the world level in 1990 it was 890,515 t [8], and in 2022 it was 3,874,025 t [8]. In recent years, production has increased due to investments in large orchards of high productivity with up to 400 trees per hectare, which was also contributed to by financial assistance from countries that are traditional walnut producers [21]. According to statistical data, in the analyzed period at the world level, an average annual production of 3,144,060.70 t of walnuts in shell was produced from an average picked area of 1,012,693.00 ha with an average yield of 3.10 t/ha [8]. At the world level, the surface area under walnuts in shell has been constantly growing since 2018 (Fig. 1).

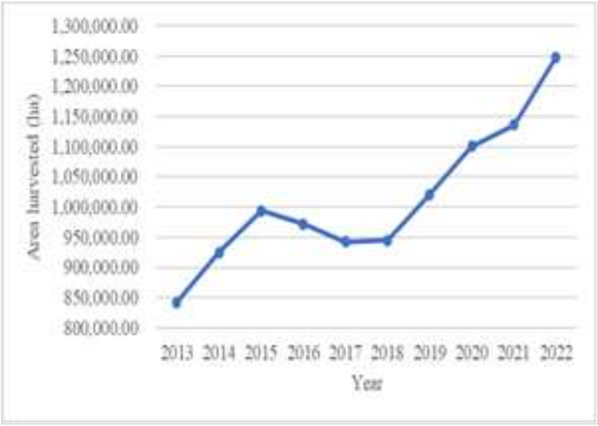

Fig.1. Areas under walnut orchard in the world (ha), 2013-2022
Source: FAOSTAT, 2024 [8].

The increase in the area under walnut orchard in the world, in the analyzed period, is accompanied by the growth of walnut production (Fig. 2).

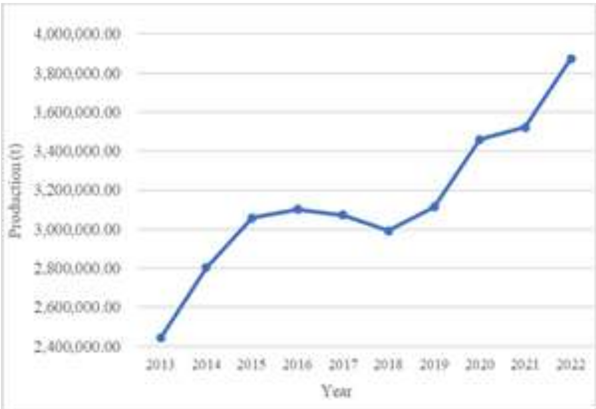

Fig. 2. World production of walnuts in shell (t), 2013-2022
Source: FAOSTAT, 2024 [8].

The increase in production is conditioned by the application of modern technologies that have influenced the increase in yield, the efficiency of work in the orchard and the quality of products [3], but also a change in the awareness of consumers who want to eat healthily and safe food [27]. Research

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confirms that consuming walnuts or products that contains walnuts has a positive effect on the condition of the human organism [19].

The absolute leader in the production of walnuts in shell in the observed period was China [1] [29], with its average production of over a million tons and a world production share with 32.41% [8]. The nine countries shown in Table 1 produce 91.43% of the world's total production of walnuts in shell.

Table 1. Average production of walnuts in shell in leading countries and share of world production, 2013-2022

Country	Average production (t)	Share in world production (%)
China, mainland	1,019,000.00	32.41
United States of America	598,470.62	19.03
Iran (Republic of Islamic)	352,092.30	11.20
Turkiye	237,465.30	7.55
EU	185,906.82	5.91
Ukraine	117,353.76	3.73
Mexico	141,900.02	4.51
Burkina Faso	109,595.54	3.49
Chile	112,940.00	3.59
Other countries	269,336.35	8.57
SUM	1,019,000.00	100.00

Source: Own calculation on the basis of data from FAOSTAT, 2024 [8]

In addition to the production of walnuts in shell, the processing to the semi-finished product provides the kernel, which is recognizable for its nutrition, impact on health and sensory characteristics [17] [15].

In order to get to the kernel, in addition to harvesting, it is necessary to peel the nut from the greenish hull, dry it and remove it from the shell. The kernel of the walnut is mainly used raw or as a snack after frying and seasoning, but it is also an important raw material in the food industry [23] [24].

The increase in demand for walnut shelled has influenced the increase in the area under walnut [23].

At the world level, the production of walnut kernel shelled less in the observed period mostly grew, except in 2019, when there was a sharp drop in production. However, the positive trend continues until 2022 (Fig. 3).

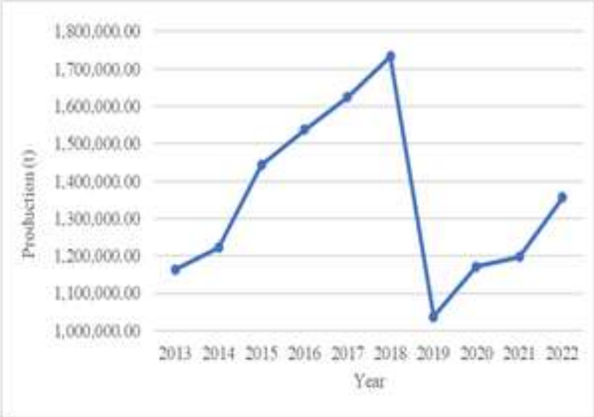

Fig. 3. Production of walnut shelled in the world (t), 2013-2022.
Source: Own calculation on the basis of data from FAOSTAT base, 2024 [9].

Walnut shelled at the world level, were produced on average per year 1,348,780.07 t in the observed period (Table 2). The largest producer was China with an average production of 759,152.15 t, which represents an average annual 56.28% of world production [9]. The top six walnut shelled producers provide an average of 92.01% of world production.

Table 2. Average walnut shelled production in leading countries and share of world production, 2013-2022

Country	Average production (t)	Share in world production (%)
China, mainland	759,152.15	56.28
United States of America	185,577.06	13.76
Turkey	127,806.14	9.48
European Union (27)	72,922.58	5.41
Ukraine	40,211.66	2.98
Mexico	55,350.93	4.10
Other countries	107,759.55	7.99
SUM	1,348,780.07	100.00

Source: Own calculation on the basis of data from FAOSTAT base, 2024 [9]

The research of walnut varieties in Yugoslavia, and later in Serbia, with the aim of providing quality varieties that would be optimal for the area of Serbia, began in 1973 at the Faculty of Agriculture of the University of Novi Sad. On that occasion, five varieties were selected and proposed for further planting, and work is ongoing on four varieties [7]. However, the field situation is not optimistic. In the observed period, Serbia produced an average of 12,384.40 t of walnuts in shell, which represents an average of 0.39%

of world production, on an average area of 3,440.00 ha. The areas under walnut orchard, and therefore the production in Serbia, do not follow the trends at the world level (Fig. 4 and Fig. 5), although the characteristics of the soil and climate in Serbia provide good opportunities for walnut cultivation [6].

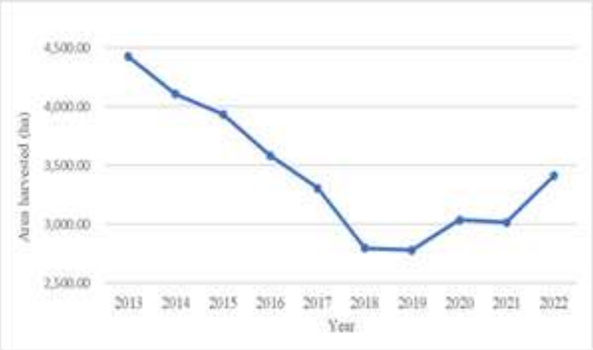

Fig. 4. Areas under walnut orchard in Serbia (ha), 2013-2022
Source: FAOSTAT, 2024 [8].

The areas under walnut plantations have been decreasing in period 2013-2019, after which a slight increase is observed until 2022. Production of walnuts in shell in Serbia declines in period 2013-2021, and then records a sharp increase in 2022 (Fig. 5).

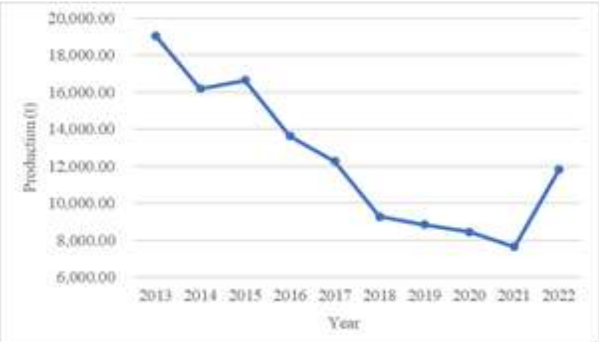

Fig.5. Produced in shell walnut in Serbia (t), 2013-2022
Source: FAOSTAT, 2024 [8]

The analysis of the base indexes with 2013 as a benchmark, concludes that the production of walnuts in shell is lower, compared to the base year (Table 3).
Also, there is a noticeable oscillation of the indicators. However, a constant decline is noticeable in the period 2015-2021 with a base index of 40.12%. Although the situation is a little better in 2022, production in 2023 is again in decline with a base index of 51.95%. Chain indexes (inter-annual rate of changes) show that the production of walnuts in shell in Serbia in 2014 is higher compared to 2015, as well as in 2022 compared to 2021, when the highest growth with the chain index of 154.80% is evident (Table 3).

Table 3. Base and chain indixes of in shell walnut production in Serbia, 2013-2023

Year	Chain index (previous year=100)	Base index (2013=100)
2013	-	100
2014	84.99	84.99
2015	102.71	87.30
2016	81.93	71.52
2017	90.07	64.41
2018	75.53	48.65
2019	95.30	46.36
2020	95.69	44.36
2021	90.43	40.12
2022	154.80	62.11
2023	83.64	51.95

Source: Own calculation on the basis of data SORS, 2024 [22]

The biggest drop in production is noticeable when comparing 2018 to 2017, when the chain index is 75.53%. Based on the obtained chain indexes, the average rate of decline in the production of in shell walnuts in Serbia was 6.34%. During the analyzed period, Serbia produced an average of 153.71 t of walnut kernels, which is the main form of walnut trade [24], and this represents an average of 0.0114% of world production. In the observed period, production was generally in decline with a noticeable increase in 2022 (Fig.6).

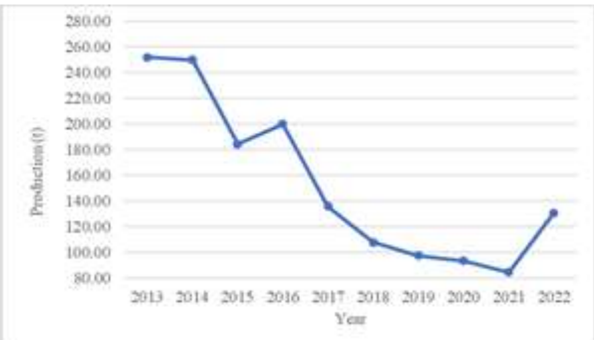

Fig.6. Walnut shelled production in Serbia (t), 2013-2022
Source: Own calculation on the basis of data from FAOSTAT base, 2024. [9].

The analysis of the base indexes, with 2013 as a benchmark, concludes that the production of walnut shelled is lower compared to the base year with a constant decline (Table 4).

Table 4. Base and chain indixes of walnut shelled production in Serbia, 2013-2023

Year	Chain index (previous year=100)	Base index (2013=100)
2013		100
2014	99.23	99.23
2015	73.74	73.17
2016	108.50	79.38
2017	67.99	53.97
2018	79.47	42.89
2019	90.34	38.75
2020	95.88	37.15
2021	90.52	33.63
2022	154.37	51.92

Source: Own calculation on the basis of data from FAOSTAT base, 2024. [9].

Chain indexes (inter-annual rate of changes) show that production in 2016 is higher compared to 2015, as well as in 2022 compared to 2021 when the highest growth is evident with a chain index of 154.37%. The biggest drop in production is noticeable when comparing 2017 to 2016, when the chain index is 67.99%. The calculated chain indexes indicate that the average rate of decline in shelled walnut production in Serbia was 7.03%. It is evident that Serbia is in an unenviable position, production of walnut kernel was mostly in decline and if something is not done, the same negative trend will continue. Investing in the production and processing of walnuts, as a kind of stone fruit, would positively affect the increase in GDP, growth of employment and improvement of exports [29]. A total income of €4,800.00 could be expected with a potential kernels yield of 1.8 t/ha per hectare of full-grown crops and with a price of €6 per t [13]. In addition to the above, everyone in the walnut chain of value should strive to use modern technologies so they could ensure maximum productivity [30].

CONCLUSIONS

The analyzed indicators shows that the production of walnuts in shell at the world level is constantly growing with an average production rate of 1,019,000.00 t per year for the period 2013-2022, as well as the production of walnut shelled, which is constantly growing since 2019 with an average annual production of 1,348,780.07 t in the same period. In contrast to the situation at the world level, production in Serbia has a negative trend with an average rate of decline of walnut in shell production at 6.34% and an average rate of decline of walnut shelled production at 7.03%.

In order for Serbia to improve the production and export of walnuts, it would be necessary to form associations of producers and sellers. Through mutual cooperation, they could enable greater market participation of Serbia in world trade. It is necessary for the state, in cooperation with all interested parties in the walnut chain of value, to provide support, especially in the first 5-10 years from the start of production and processing, with the provision of subsidies. The producer association should provide each supplier with the necessary information on the current market situation. Everyone in the walnut chain of value would have to respect the standards of production and processing. Also ensuring organic production would have a positive effect on the price of the product both on the EU market and on the world level.

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THE IMPACT OF HAZARDOUS WASTE INCINERATION ON THE ENVIRONMENT

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Abstract

The aim pursued in this paper is to estimate the impact produced on the surrounding environment by a furnace for the incineration of hazardous waste. For this purpose, the analysis bulletins of the main pollutants responsible for this were studied, the methods by which they are neutralized before being eliminated in the environment. The parameters considered the most dangerous for human health and the environment were analyzed: total dust, total organic compounds (TOC), sulfur oxides (SOx), nitrogen oxides (NOx), dioxins and furans, as well as heavy metals. Although we were able to ascertain that there was exceeding of the daily average, depending on the origin of the incinerated waste, during the 24 hours the average value allowed by the legislation in force was not exceeded.

Key words: *combustion furnace, hazardous waste, incineration, industrial emissions, limit value*

INTRODUCTION

In Romania, waste incineration has become a major concern in recent years, because it represents an efficient way to reduce the negative impact of waste on the environment [17]. Modern incinerators can significantly reduce dioxin and furan emissions to levels below the limits set by the European Union, through the use of advanced filters and temperature control [3], as well as heavy metals and nitrogen oxides, through methods of capturing and filtering these dangerous pollutants [6]. Also, this method prevents soil and groundwater pollution and can generate energy, compared to waste storage.

According to Directive 2000/76/EC, a waste co-incineration plant is any plant, whether stationary or not, the main purpose of which is to obtain energy or material products and where waste is incinerated, as a rule or as additional fuel, or in which waste is thermally treated for disposal. In Annex II of this directive, conditions are stipulated regarding the determination of emission limit values. These special emission limit values refer to combustion plants where waste is co-incinerated. Through this method, the hazardous waste resulting from a certain sector can reach the position of fuel for another branch of activity [1]. Gas incineration is a technology that uses gas to heat and burn waste. The advantages include cleaner combustion and increased energy efficiency [2]. Disadvantages of this method include higher operating costs and the need for pre-treated waste to ensure efficient combustion. [18] Operating conditions, technical requirements and restrictive emission limit values are established for incineration and co-incineration plants, which should prevent negative effects on the environment and public health risks respectively, or, as far as possible, to limit them [4].

When building a waste co-incineration facility, the following characteristics must be taken into account:

- the technical construction of the combustion plant (temperature, residence time of the fuel in the combustion chamber, resistant to corrosion, the possibility of regulating the supply of waste);
- a sewage gas treatment facility to ensure compliance with the more restrictive emission limit values (dedusting, desulfurization, denitrification) [5];
- a waste water treatment facility and the possibility of waste disposal [8] (filter ash,

slag, added additives, sludge) resulting from co-incineration.

Solid waste is received for co-incineration, as a rule, in closed delivery places (bunkers), specially designed. These teaching places are equipped with dust removal facilities. Transport to the boiler hopper or directly to the waste combustion chamber [11] (partly together with the regular fuel) takes place in closed transport systems. And the existing drop-off points along the transport system must be dusted off. The installation must be designed and operated in such a way that no fugitive emissions occur. Wastes that can be co-incinerated in LCP (Large Combustion Plant) installations can be the following: sewage sludge, waste from historical pollution (e.g. fuel oil, sludge, contaminated soil), paint sludge, protein meal from meat and blood derived from the disposal of animal carcasses, prepared and treated urban waste.

The combustion plant must be constructed and operated in such a way that even under adverse conditions the flue gas temperature must reach a minimum of 850°C for two seconds. If hazardous waste is co-incinerated with a content of halogenated organic substances, calculated as derivatives of (salts of) chlorine, greater than 1 percent of their weight, then the temperature must be raised to 1,100°C [12]. The plant must be equipped with an automatic waste dosing interruption system for cases where the temperature drops below 850°C and below 1,100°C respectively (eg during plant start-up and shutdown processes). Gasification and pyrolysis represent alternative thermal treatments that limit the amount of combustion air to transform waste into process gas, increase the amount of recyclable inorganics, and reduce the amount of flue gas cleaning. In this context, the goal of this study was to quantify the impact produced on the surrounding environment by a furnace for the incineration of hazardous waste.

MATERIALS AND METHODS

The basic activity of the company under study is the treatment and disposal of hazardous waste, with a capacity of over 10 tons/day. The company goal was and is to obtain an activity that corresponds in terms of emissions with Law 278/2013. In order to reach this target, the incineration plant is provided with high-performance gas analyzers, which monitor the plant emission parameters [13].

The incineration plant consists of the following equipment: feed sluice, rotary furnace, ash chamber, burner 1, ash conveyor with scrapers, combustion station 1, burner 2, combustion station 2 with emergency chimney, cooling tower, combustion gas stationary chamber, pressure boiler, steam drum, sodium bicarbonate silo, activated carbon silo, bag filter 1, bag filter 2, scrubber, pump group, demineralized water tank 30 m^3, turbine, exhauster, final chimney, water cooling towers, condenser, gas analyzer, control cabin, compressor.

The technological flow starts once the waste enters the incineration platform. Each type of waste corresponds to a sheet, in which the composition and concentration of the substances that compose it are presented. The waste is weighed and sent to the landfill. After they have been unloaded in the warehouse, samples are taken from each type of waste to check if what is written on the sheet corresponds to what is in the packaging. The determinations are made in the specialized laboratory by personnel trained to do this type of chemical analysis [14.] After the results of the analyzes have come out, the waste is taken from the waste warehouse and stored in the pre-treatment hall, where the batches are prepared for incineration depending on the concentration of dangerous substances and the determined calorific value [7] [12]. The waste batches are then sent to the incineration plant hall, respectively to the untreated waste bunker. From here, the waste is picked up with the help of the overhead crane and fed into the shredder, where it is chopped up to the size of 30 mm and reaches the chopped waste storage hopper. Then, the waste is picked up with the help of the crane and scale crane and is passed into the feed hopper of the incineration plant. Chemically compatible waste is first chopped through a shredder, in order to obtain a mixture as homogeneous as possible, given their large amount, between

300 and 600 tons. We try not to exceed the concentration of 2-5% of halogens and 1-% of sulfur [5] for each batch, as well as a calorific value as close as possible to 18 MJ/Kg. In the case that, due to various situations, the waste does not have or exceeds these elements, alternative solutions are sought, such as liquid injections or mixture in the feed.

From the feed bunker, the waste reaches the rotary kiln, where the burning (incineration) of the waste takes place. Waste incineration occurs at a temperature between 850-1,100°C. The waste destruction efficiency at this temperature is 99.99%. The ash resulting from the incineration reaches the ash chamber, in a funnel with a valve; when the bunker is full, the valve opens and the ash reaches the conveyor with scrapers, with the help of which it is discharged into a container. The gases resulting from the burning of waste reach post combustion 1, then post combustion 2, where they are burned at temperatures between 1,100-1,300°C. The dwell time in the two post combustion is between 3 and 6 seconds. These two combustion chambers, post combustion 1 and 2, are used for the complete destruction of corrosive and toxic gases, as well as the organic compounds found in the combustion gases (HCl, HF, CO, Dioxins and Furans). From combustion station 2, the gases reach the cooling tower, where they are cooled from a temperature of 1,100-1,300°C to a temperature of 850°C. The temperature of the gases is maintained until they enter the boiler membrane. Here, the temperature starts to drop, reaching 600°C - the temperature of the flue gases entering the boiler. In the boiler, the gases are cooled to 200°C and steam is formed, which then reaches the steam drum and then the membrane drying circuit up to a temperature of 370°C. Having this temperature and a pressure of 21.5 bar, the steam is sent to the turbogenerator. The capacity of the turbogenerator is 650 Kw/h. The steam comes out of the turbogenerator (turbine) with a pressure of 1.5 bar, reaches the condenser, where it condenses. The condensate reaches the treated water tank, from where it returns to the boiler's cooling circuit [12]. After the boiler, the combustion gases are subjected to chemical treatment in the circuit. The first stage of treatment is carried out with sodium bicarbonate $NaHCO_3$, the second stage of chemical treatment is with activated carbon [15]. Further on, the gases reach the two bag filters, where they are filtered. The dust particles are evacuated from the filters with the help of screw conveyors, the dust reaching a heat exchanger, where it is cooled to a temperature of 40-60^{0}C. From the heat exchanger, the dust is evacuated and packed with the help of cellular dispensers in 1 m^3 big-bags. The filtered gases reach further into the scrubber, where the gases are washed with a 30% NaOH alkaline solution. After the scrubber, the gases reach the exhauster, and then they are discharged to the chimney [10]. The exhaust chimney has a height of 30 m. On the chimney there are probes that are connected to the analyzer, with the help of which emissions into the atmosphere are continuously monitored. The monitored parameters must comply with Law 278/2013, regarding industrial emissions (transposition of Directive 2010/75/EU) [9].

In order to be able to estimate the neutralization capacity of the resulting gases, we have centralized the analysis reports of the main dangerous pollutants that can result from such an installation within 24 hours: total dust, total organic compounds (TOC), sulfur oxides (SOx), nitrogen oxides (NOx), dioxins and furans, as well as heavy metals.

RESULTS AND DISCUSSIONS

All parameters monitored by the analyzer are calculated at a temperature of 273.15 degrees K and a pressure of 101.3 KPa, at an oxygen content of the waste gas of 11%.

The total dusts monitored in a normal working day must have a maximum daily average value of 10 mg/Nmc. The total dust is removed with the help of the two post-combustion chambers 1, post-combustion 2 and the Scrubber with NaOH solution and stored in the filter bags. Fine filtering takes place in the sequins, that is, here the powders will be taken out. If average values exceeded by dust are found, the speed of the exhauster is reduced, so that they are retained in the filters. Thus, these values will decrease (Table 1).

Table 1. Values of total powder concentration during one day

Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Total powders [mg/Nmc]	4.8	3.5	3.7	4.2	4.9	5.1	5.6	6.8	7.3	9.1	12	11
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Total powders [mg/Nmc]	9.6	10.2	8.3	7.7	5.5	4.7	4.5	5.3	5.9	6.2	8.1	7.6
Average value over 24 hours	**6.73**											

Source: internal documents of the company.

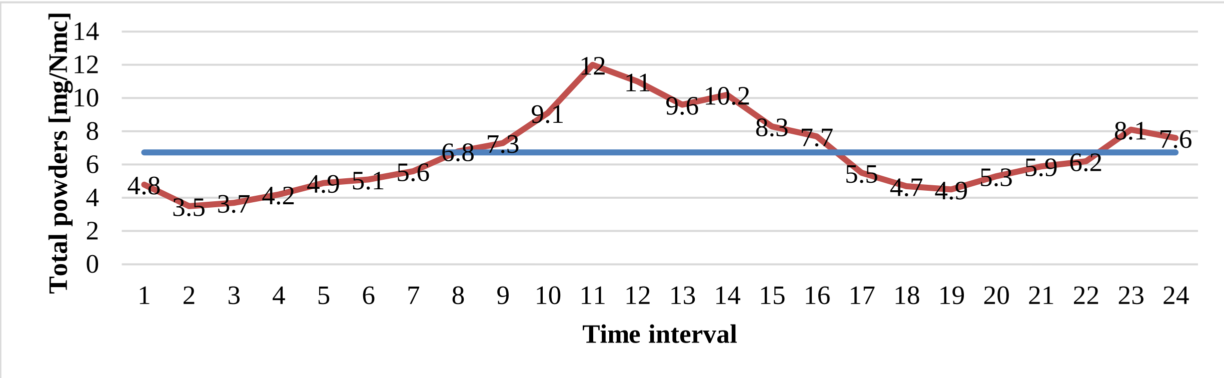

Fig. 1. Variation of total powder concentration during one day
Source: Elaborated by authors.

As we can see from Figure 1, during the time 08:00 and 16:00 it is noted exceeding of total powder values - with a percent of maximum 78.3% compared to daily average, powders eliminated with the help of the two postcombution chambers 1 and 2 and Scruber with solution of NaOH and stored in the filter sacks. Thus, these increased concentration of total powders are decreased with the help of solution of NaOH. Because the average value during 24 hours is of 6.73 mg/Nmc, this means the maximum daily average value was not exceeded - that is of 10 mg/Nmc [9].

The total organic compounds (TOC) in a normal working day must have a maximum daily average value of 10 mg/Nmc. When total organic compounds (TOC) increases, this means that CO and CO_2 at the analyzer will also increase. When they grow, increase the NaOH concentration by 5% per hour in the Scrubber. After these compounds accumulate in the filters, they are disposed of in the garbage (Table 2).

Table 2. Values of total organic compounds concentrations (TOC) during one day

Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Total organic compounds [mg/Nmc]	3.8	2.2	4.1	3.5	4.3	3.9	4.5	5.6	6.2	5.9	8.6	10.2
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Total organic compounds [mg/Nmc]	13	11	10.4	9.8	8.9	7.7	6.9	6.3	5.7	6.2	6.4	6.8
Average value over 24 hours	**6.74**											

Source: internal documents of the company.

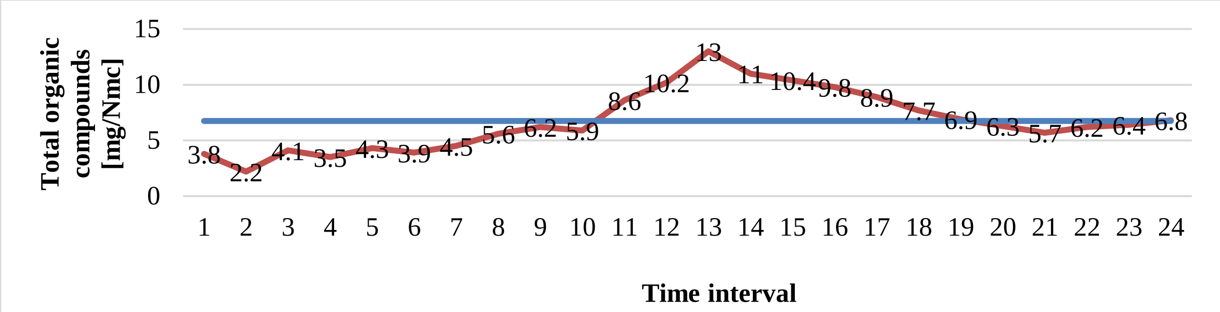

Fig. 2. Variation of total organic compounds concentration (TOC) during one day
Source: Elaborated by authors

In Figure 2, in the time period 11:00 and 18:00, it is noted an exceeding of the values of total organic values with a percent of maximum 92.87% of daily average, exceeding due to introducing in the furnace of animal waste. These increased concentration of total organic compounds were decreased with the help of solution of NaOH. As the average value during 24 hours is of 6.74 mg/Nmc, this means that it did not exceed the maximum daily average value, which is of 10 mg/Nmc, according to legislation [9]. In furnace **SO_x** and **NO_x** are formed, that will go to Scruber, where will be eliminated. In case exceeded values of NO_x and SO_x are seen, NaOH concentration is increased (caustic soda) in Scruber. The increase of dosage concentrations are of 5% to an hour for the solution of liquid reduction NaOH (caustic soda) and of 10% to an hour for solid reduction compounds ($NaHCO_3$-sodiu bicarbonate) and active coal.

Sulphur oxides (SO_x) in a normal working day must have a medium daily average value of 50 mg /Nmc (Table 3) [9].

Table 3. Values of sulphur oxides concentrations during one day

Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Sulphur oxides [mg/Nmc]	24	28	32	36	40	48	59	62	55	49	43	38
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Sulphur oxides [mg/Nmc]	35	38	33	29	37	34	41	30	26	30	27	25
Average value over 24 hours	**37.45**											

Source: internal documents of the company.

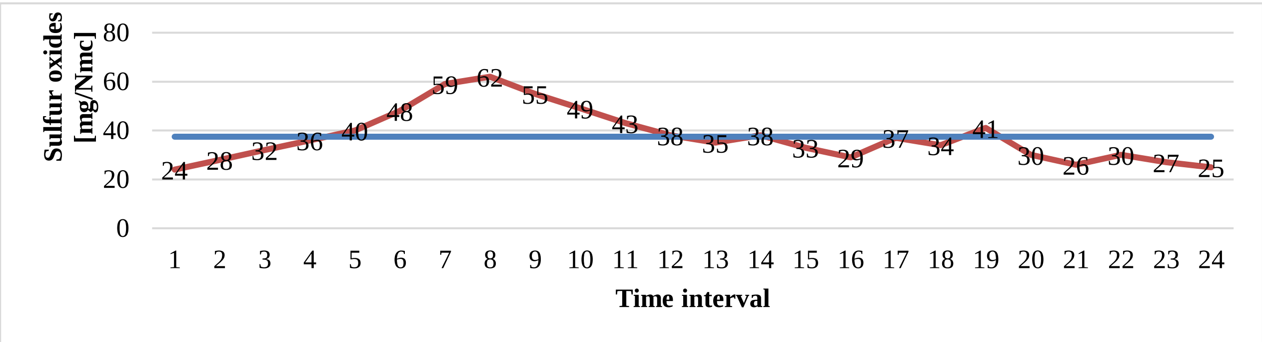

Fig. 3. Variation of sulphur oxides concentrations during one day
Source: Elaborated by authors.

In Figure 3, in the period of time 05:00-12:00 we note increased values of SO_x concentrations with a percent of maximum 65.55% compared to daily average, due to introduction in the furnace of some waste with an increase concentration of sulphur (for example: paints, tires, gum). These increased values of SO_x will be reduced in Scruber according to above dosage concentrations. As the average value during 24 hours is of 37.45mg/Nmc, this means that the maximum daily average value of 50 mg/Nmc was not exceeded, so we comply with the parameters foreseen by law [9].

Nitrogen oxides (NO_x) in a normal working day must have daily average value of maximum 200 mg/Nmc (Table 4) [9].

Table 4.Values of nitrogen oxides concentration during one day

Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Nitrogen oxides [mg/Nmc]	79	84	91	99	108	130	143	161	184	210	226	212
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Nitrogen oxides [mg/Nmc]	201	193	181	163	144	132	121	138	146	129	112	107
Average value over 24 hours	**145.58**											

Source: internal documents of the company.

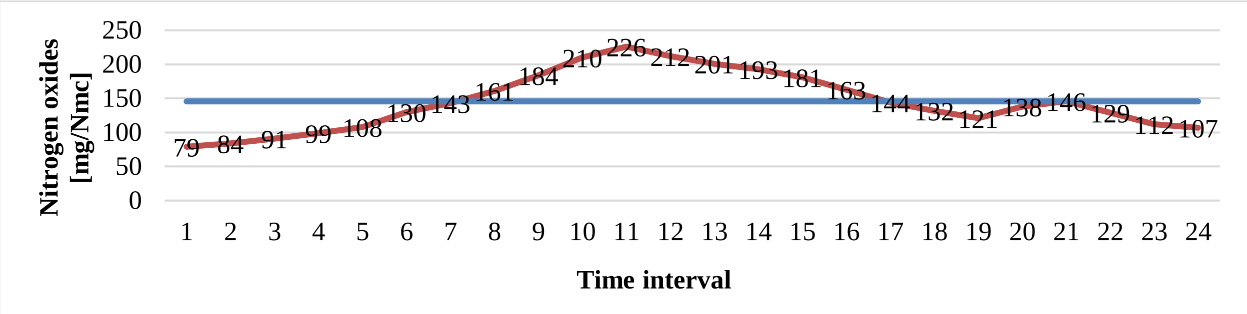

Fig. 4. Variation of nitrogen oxides concentration during one day
Source: Elaborated by authors

In Figure 4, in the period of time 08:00-16:00 we note increased values of concentration of NO_x with a maximum percent of 55.24% compared to daily average, due to introducing in the furnace of some waste with increased composition of nitrogen (de ex. Solvents based on nitrogen, paints that have a nitrosolvent composition (pesticides, herbicides) [16]. These increased values of NO_x will be increased in Scruber according to above dosage concentrations. As average value during 24 hours is of 145.58 mg/Nmc, this means maximum daily average value was not exceeded, of 200 mg/Nmc [9].

Dioxins and furans in a normal working day must have a maximum daily average value of 0.1 mg/Nmc. Dioxins and furans are dangerous gases, which form many compounds when the temperature in the furnace is suddenly decreased from 1,500^{0}C to 450^{0}C and a pressure increase of more than 4 Bars. To reduce the appearance of these dangerous gases, the temperature in the oven must be as constant as possible (Table 5).

Table 5. Values of dioxins and furans concentration during one day

Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Dioxins and furans [mg/Nmc]	0.003	0.0012	0.005	0.008	0.01	0.03	0.06	0.09	0.12	0.13	0.09	0.07
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Dioxins and furans [mg/Nmc]	0.05	0.02	0.009	0.007	0.003	0.001	0.005	0.008	0.006	0.04	0.009	0.05
Average value over 24 hours	**0.034**											

Source: internal documents of the company.

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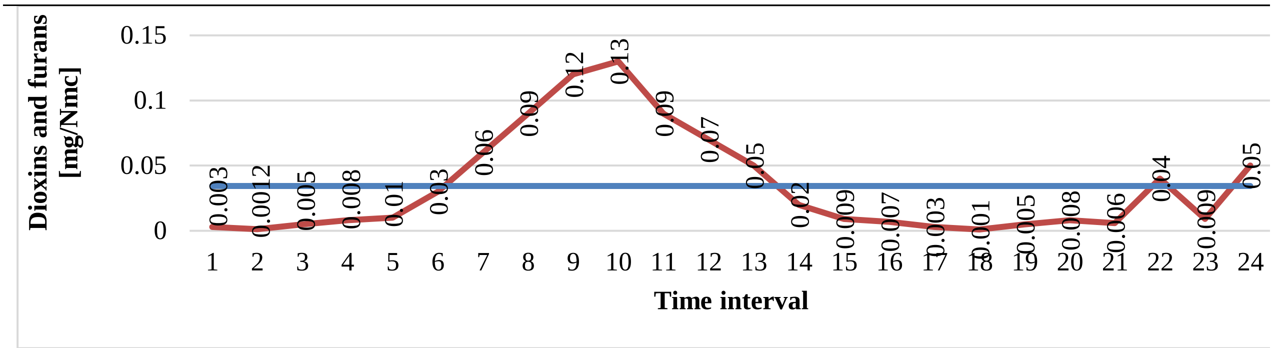

Fig. 5. Variation of dioxins and furans concentration during one day
Source: Elaborated by authors.

In Figure 5 we can note in the period of time 07:00-13:00 increased values of dioxins and furans concentration, with a percent of maximum 82.35% compared to daily average, due to sudden decrease of temperature in the furnace from the value of 1,400^{0}C to 450^{0}C and an increase of pressure higher of 4 Bars.

Once returning to temperature to the value of 950^{0}C, dioxins and furans concentration will decrease. As the average value during 24 hours is of 0.034 mg/Nmc, this means that maximum daily average value was not decreased, of 0.1 mg/Nmc [9]. Thus, we comply with the values foreseen in the legislation.

Heavy metals accumulate in water from Scruber, and when they reach the chimney it means that the concentration of lime, soda and active coal concentration must be increased in order to decrease their value to the chimney. Increasing the lime, soda and coal concentrations will increase also the quantity of heavy metals accumulated in water from Scruber and the quantity of heavy metals eliminated in the air will decrease (Table 6).

Heavy metals monitored are: Cobalt+Chrom+Arsen+Lead+Stibiu+Copper+ Mangan+Nikel+Vanadium. In a normal working day the concentration of heavy metals must have daily average value of maximum 0.50 mg/Nmc [9].

Table 6. Values of heavy metals concentration during one day

Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Heavy metals[mg/Nmc]	0.2	0.27	0.25	0.29	0.33	0.37	0.41	0.45	0.64	0.71	0.55	0.48
Hour	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Heavy metals[mg/Nmc]	0.42	0.33	0.27	0.25	0.23	0.29	0.32	0.36	0.34	0.37	0.31	0.35
Average value over 24 hours	**0.366**											

Source: internal documents of the company.

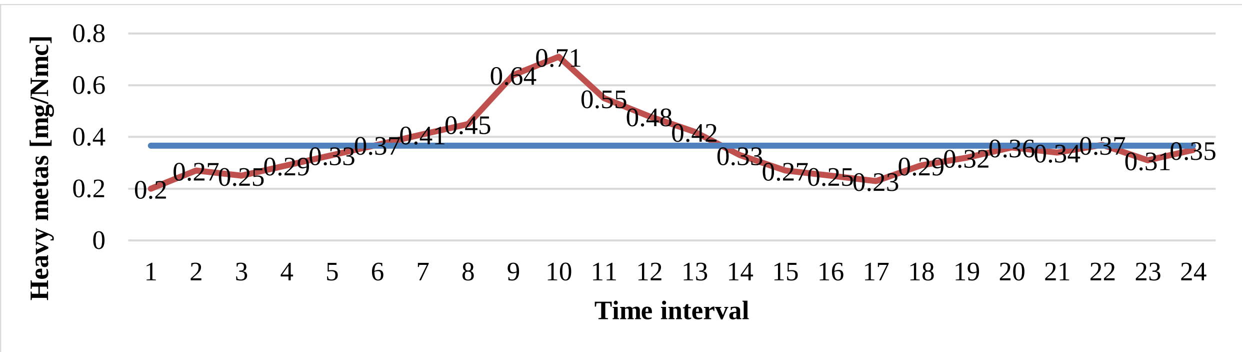

Fig. 6. Variation of heavy metals concentration during one day
Source: Elaborated by authors.

In Figure 6, in the time interval 06:00-13:00 we observe increased values of the concentration of heavy metals with a maximum percentage of 93.99% compared to the daily average, due to the introduction into the furnace of some waste with increased concentrations of heavy metals that will be decreased by increasing the concentrations of lime, soda and coal in the Scrubber. Since the average value during 24 hours is 0.366 mg/Nmc, this means that the maximum daily average value of 0.50 mg/Nmc was not exceeded [9].

CONCLUSIONS

Incinerators have the ability to reduce waste in a very large percentage, in a relatively short time - especially if it is solid waste. Incinerators make waste disappear permanently, while the spaces allocated to warehouses favor the accumulation of odors that poison the environment.

The amount of solid material resulting from burning represents only 15-20% of the initial weight of the waste, this leads to the reduction of land areas required for storage and their use for other purposes. Also, the thermal treatment process reduces to zero the danger of infesting the water table through possible infiltration of the resulting leachate into the deposits and reduces methane emissions by abolishing the deposits [18].

The company analyzed in our study has its own treatment plant with three stages: the biological stage, the mechanical stage and the reverse osmosis stage, for the treatment of domestic and technological wastewater from the incinerator and from the company activity.

In order to avoid soil pollution, the temporary storage of all raw materials (waste to be incinerated), auxiliary materials, products (resulting waste to be recovered / disposed of) is done only in sealed containers resistant to the type of substance stored and appropriately labeled located in places specially arranged (waste deposit to be incinerated) provided with concrete platforms and retention tanks, cold rooms, as appropriate.

Following the study carried out in this work, we can conclude that the incinerator emissions fall within the limits of law 278/2013, because the average daily concentrations of the emission parameters evaluated in the analysis bulletins fall within the legal norms.

We can see that the methods of neutralization of the main pollutants discharged into the environment are effective.

Depending on the origin of the incinerated waste, there was exceeding of the average, but during the 24 hours the average allowed value was not exceeded.

Incineration must be a solution of last resort, after the options of reduction, reuse and recycling have been taken into account and must be integrated into a wider waste management strategy. The role of incineration in the context of circular economy and sustainability is important. The objective is to minimize waste, reuse resources and recycle as much as possible. Incineration, although at first sight it seems to contradict these principles, can actually play a complementary role: by transforming waste that cannot be recycled into energy or heat, incineration contributes to reducing dependence on fossil resources and promoting an economy with low emissions of carbon.

Other alternative methods of disposing the hazardous waste are: *controlled storing in environmentally friendly landfills* (this method can prevent direct contamination of the environment, but if the insulating materials deteriorate, soil and groundwater contamination and methane generation may result); *solidification and stabilization* (this consists of mixing these wastes with substances such as cement; the risk of contamination is lower, but in the long term this stabilization may diminish); *neutralization of waste with chemicals* (heavy metals can be precipitated from solutions, acids can be neutralized with bases) - this method can however generate toxic by-products; *bioremediation (*inoculation of bacteria or fungi that break down the waste) - this is a lengthy process and is greatly influenced by temperature and humidity; *nitrification* (melting the waste at very high temperature and turning it into a solid, glass-like material) - this is an energy-intensive process; *pyrolysis and gasification* (these are only effective for chemical and organic waste and can generate toxic gases).

Certainly, all these methods have advantages and disadvantages. Incineration coupled with controlled landfilling can reduce the volume of these wastes immediately, but can generate pollution in the long term if managed improperly. Vitrification and bioremediation - can be slow and expensive, but are more sustainable methods.

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VARIATION OF QUALITATIVE PARAMETERS OF DRINKING WATER PROVIDED BY THE COMPANY ECOAQUA S.A. CĂLĂRAȘI IN 2023

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Abstract

The aim of the paper is to compare the most important physico-chemical parameters of the drinking water supplied by the company ECOAQUA S.A. in Călăraşi municipality, taken from monthly average analysis bulletins carried out within the company in 2023, both at the entrance to the treatment plant and at the exit - to be able to evaluate the degree of water treatment and the quality of drinking water supplied to consumers. The parameters analyzed in the paper are: pH, turbidity, residual free chlorine (only analyzed for drinking water), nitrates, total hardness and aluminum. They were represented graphically, and the values of the parameters at the exit from the station were compared with the maximum limit provided in the Government Ordinance 7/2023 and Government Decision 971/2023, in order to be able to estimate the qualitative level of drinking water. We found exceedances of a maximum of 22% only in the case of free residual chlorine in November 2023, due to the water disinfection process. The other physico-chemical parameters did not exceed the legal limits.

Key words: *consumption, drinking water, physical-chemical parameters, raw water, quality*

INTRODUCTION

Supplying the population with drinking water is an essential aspect of water resource management, having a direct impact on the health and well-being of communities [1, 13]. Access to safe, potable water is fundamental to meeting people basic needs and preventing diseases associated with drinking contaminated water [18].

In order to ensure water supply for the population, it is crucial to have a well-developed infrastructure that includes all stages from water capture and treatment to its distribution to homes and communities [9]. This activity frequently requires the maintenance and construction of water distribution networks and treatment systems [11]. Also, the application of strategies to protect water sources against pollution and degradation [3].

Launched during a session of the European Parliament on 15th February 2000, the White Paper on European governance introduced a new concept: democratic partnership between the different levels of government in Europe. It addresses the issue of public services of general economic interest, including water supply and sanitation, considering them of particular importance for social cohesion, improving the quality of life in Europe and promoting sustainable development [4].

Romania territory is rich in fresh water sources, including rivers, lakes and underground sources [2]. The main sources of water are the Danube and inland rivers, and natural lakes, although abundant, have a minor contribution to the total volume of water resources in the country [14].

In Călăraşi municpiality, drinking water supply is provided by EcoAqua SA, through Chiciu Water Pretreatment Station and Călăraşi Drinking Water Treatment Station [4].

Chiciu Water Pretreatment Station has the role of collecting raw water from the Danube with the help of the pumps located at the station or with the help of the pumps from the Floating Station when needed (drought, frost, etc.). After capture, the raw water goes through the pretreatment processes and is transported through the two DN 1,000 mm pipes to Călărași Drinking Water Treatment Plant.

Călăraşi Drinking Water Treatment Plant has the role of receiving pre-treated water and passing it through the treatment processes, ensuring that it is potable for human consumption, and then distributing it to consumers through the distribution network [12].

An analysis of the water networks replaced in the last 25 years reveals that most of them were modernized through two programs funded by the European Union. The SAMTID program, initiated in 2008, generated the replacement of 42.9 km of network, representing 27% of the total distribution network. At the same time, SOP Environment program, started in 2016, involved the replacement of 23.2 km of network, constituting 14.6% of the entire network [4].

With all the network replacements done, networks older than 30 years (19.3 km) and even older than 40 years (24.2 km) are still in operation which together represent 27.3% of the total network. Most of these networks, about 30 km, were planned to be replaced by POIM program, the works contract CL1 Extension and rehabilitation of water networks and the expansion of sewerage networks in Călărași municipality.

In this context, the goal of the paper is to assess the most important physico-chemical parameters of the drinking water supplied by the company EcoAqua S.A. in Călăraşi municipality, using the information presented in the monthly analysis bulletins carried out in 2023, both at the water entrance to the treatment plant and at the exit. In this way, we could be able to evaluate the degree of water treatment and the quality of drinking water supplied to consumers.

MATERIALS AND METHODS

In order as water to be suitable for human consumption, it is necessary for be supposed through a whole treatment process, including: water capture, pretreatment, transport to the treatment plant, treatment of pretreated water, storage, pumping and repumping of drinking water [10].

The water capture step is carried out by means of two methods. Normally the pumps in the Pretreatment Station suck the raw water and direct it to the first stage of treatment through a network of screens (pipes). In drought situations, the Floating Station comes into action, having specialized pumps that extract water from the surface of the Danube River, ensuring the supply in periods when water collection from the cribs is limited. After this stage, the raw water is directed to Chiciu Water Pretreatment Station, where a complex treatment process takes place. Here, the water undergoes several operations, including chlorine oxidation, coagulation, flocculation and decantation. The decanted water is then transported through a network of pipes (approximately 6,625 m) to Călărași Treatment Plant, where it is subject to a second treatment process. Here, the water is filtered through sand filters, then through granular activated carbon (GAG), chlorinated (liquefied chlorine gas) and stored in tanks (2 x 10,000 m^3 and 1 x 3,000 m^3). The treated water is then distributed to consumers through the distribution network, being pumped at various pressure levels through the pumping station, repumping and hydrophore.

The company goal was and is to obtain drinking water (which corresponds from a physico-chemical and bacteriological point of view to Government Ordinance 7/2023 and Government Decision 971/2023 [7] [8], transposing into national law Directive 2184/2020[5])

Particular attention was paid to equipping the laboratories for physical-chemical and bacteriological analyses. At the moment, they are equipped to the standards, at the laboratory in Călăraşi, the attestation being renewed by the Ministry of Health through the registration certificate no. 341 of 04.12.2018 and there is also an ERA laboratory competence attestation certificate (laboratory competence scheme company).

The laboratory is equipped with: Centrifuge-ROTOFIX 32 A; Thermoreactor CR 4200; NABERTHERM calcination furnace; Pharo UV/VIS spectrophotometer; Raypa water bath; Laboratory oven POL-ECO; Thermoreactor COD ECO 6-Velp; Kjeldal-Velp apparatus - Digestive system (Neutralization unit, distillation unit, gas

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suction pump); pH-meter Vario; Incubator POL-ECO; Raypa sand bath; Sampler PB-6-1 (mobile); Cyclon type bidistillator; Autoclave Raypa; Analytical balance Kern ABT; Talassi chemical hood; Atomic absorption spectrophotometer NOVA 400; pHoto Flex portable photometer.

In this paper, we aimed to study the quality of water supplied to Călărași municipality by the company ECOAQUA SA in 2023, comparing the physico-chemical parameters evaluated in the analysis reports carried out: pH, turbidity, free residual chlorine, nitrates, total hardness and the aluminum. For this purpose, the raw and drinking water analysis reports were analyzed. (The values of the analyzed parameters represent the arithmetic mean of the parameters in the daily analysis bulletins of the respective month). The values of the drinking water parameters were compared with the maximum permissible limits stipulated by the legislation in force, in order to be able to observe possible deviations, which could affect the quality of the water and, consequently, the health of its consumers.

RESULTS AND DISCUSSIONS

In 2023, the main indicators of the quality of raw and drinking water recorded the following average monthly values:

The hydrogen potential of water, known as **pH**, indicates how acidic or basic it is. The closer the water is to 7, the more beneficial it is considered for human health and consumption [16].

In accordance with the provisions Government Ordinance 7/2023 and Government Decision 971/2023, the pH level of drinking water should be in a recommended range between 6.5 and 9.5, according to established legal standards [7] [8].

The tests were conducted based on the national standard SR EN ISO 10523:2012[4].

Table 1. Value of pH in raw water and drinking water in 2023 - Călărași Treatment Plant

Month	Value of raw water pH (Unit)	Value of drinking water pH (Unit)	Admited limit (Unit)
JAN.	7.92	7.457	6.5-9.5
FEB.	7.96	7.452	6.5-9.5
MAR.	7.929	7.451	6.5-9.5
APR.	8.03	7.565	6.5-9.5
MAY.	7.93	7.490	6.5-9.5
JUNE.	7.359	7.334	6.5-9.5
JULY.	8.268	7.429	6.5-9.5
AUG.	8.137	7.479	6.5-9.5
SEP.	8.18	7.531	6.5-9.5
OCT.	8.11	7.504	6.5-9.5
NOV.	8.10	7.648	6.5-9.5
DEC.	8.163	7.744	6.5-9.5

Source: According to analysis bulletin provided by the company [4].

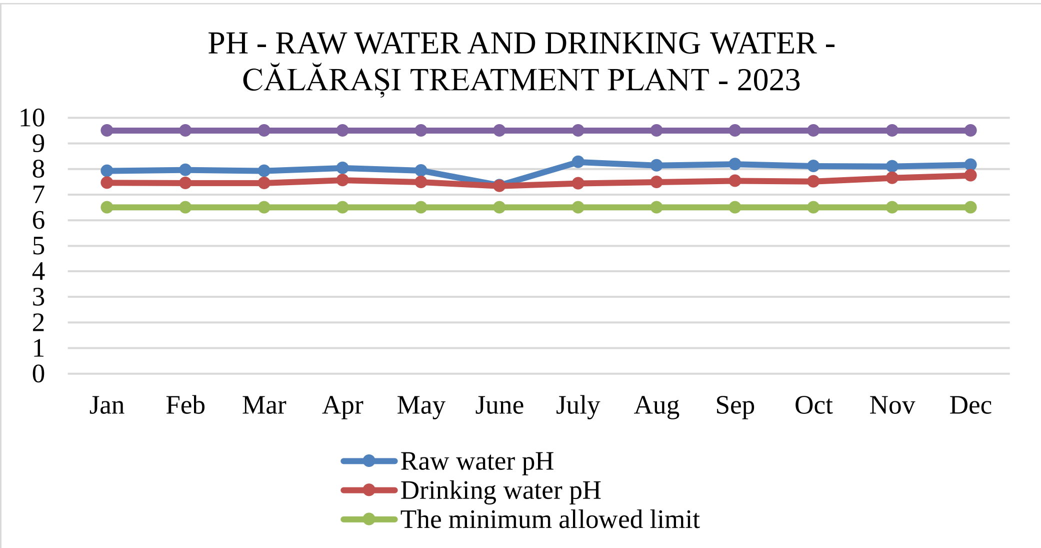

Fig. 1. Variation of pH of raw water and drinking water in 2023- Călărași Treatment Plant
Source: Elaborated by authors in accordance with the analysis bulletins.

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Figure 1 shows that the raw water has a pH between 7 and 8. It is observed that in 7 of the 12 months the values are over 8 Units, the highest recorded being 8.268 Units in July, while that in the other 5 months the values are below 8 Units, the lowest being registered in June, with a value of 7.359 Units.

Water leaving the treatment plant has a pH between 7 and 8 Units, without ever exceeding this limit.

The highest value is recorded in December, with 7.744 Units, and the lowest in June, with 7.334 Units.

Analyzing the data, we notice that the treated water has an average value of 79% of the legal limit allowed.

After treatment, the pH value approaches the neutral value of 7, making it safe for human consumption.

Turbidity is a physical-chemical property that measures the level of water clarity, it shows how cloudy or opaque the water is due to the presence of suspended particles in it. The level of particles in water directly influences the level of turbidity in that water: the higher the number of particles, the higher the turbidity of the water [17]. Water turbidity is determined using an electronic turbidimeter and is expressed in NTU.

In accordance with the provisions of Government Ordinance 7/2023 and Government Decision 971/2023, the maximum limit admitted for turbidity of drinking water is 1NTU [7] [8].

The tests were carried out based on national standard SR EN ISO 7027/2001 [4].

Table 2. Value of Turbidity in raw water and drinking water in 2023 - Călărași Treatment Plant

Month	Value of raw water (NTU)	Value of drinking water (NTU)	Admitted limit (NTU)
JAN.	38.5	0.17	1
FEB.	44.625	0.19	1
MAR.	20.68	0.17	1
APR.	29.08	0.162	1
MAY.	22.18	0.142	1
JUNE.	45.36	0.155	1
JULY.	21.39	0.14	1
AUG.	28.03	0.135	1
SEP.	12.9	0.152	1
OCT.	9.21	0.163	1
NOV.	26.89	0.164	1
DEC.	40.79	0.15	1

Source: According to analysis bulletins provided by the company [4].

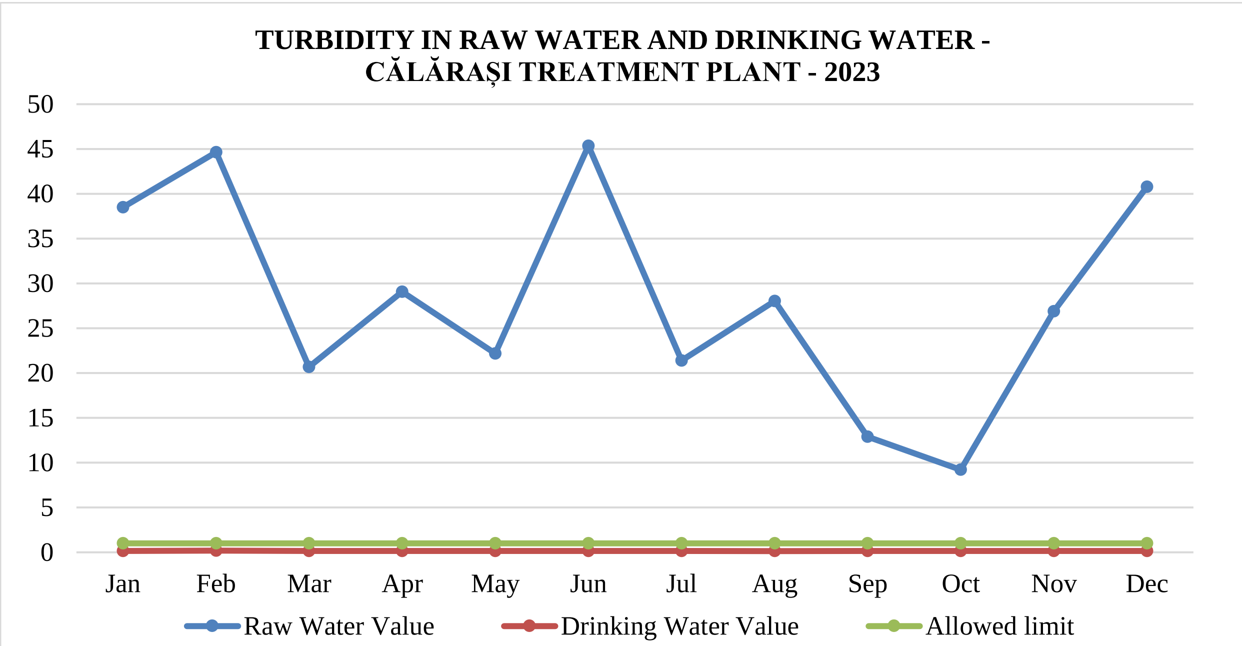

Fig. 2. Variation of Turbidity in raw water and drinking water in 2023 - Călărași Treatment Plant
Source: Elaborated by authors in accordance with the analysis bulletins.

In Figure 2, raw water has the highest turbidity of 45.36 NTU in June, and the lowest value of 9.21 NTU in October. The largest difference in raw water turbidity is observed between June and July, a difference of 23.97 NTU. The water leaving the

treatment plant has a turbidity between 0 and 1 NTU, never exceeding the legal limit.
The highest value is recorded in February, with 0.19 NTU, and the lowest in August, with 0.135 NTU. Analyzing the data, we notice that the treated water has an average value of 16% of the legal limit allowed.
Following its treatment, the turbidity values are greatly reduced, making it safe for the population.
Free residual chlorine is a physico-chemical element that remains in the water following the water disinfection process and has the role of destroying the existing microorganisms in the water and reducing the spread of diseases caused by them [19]. This process takes place in the chlorination plant and is carried out using the automatic liquefied chlorine gas plant. Disinfection is done before water pretreatment, as well as before the storage station.
In accordance with the provisions of Government Ordinance 7/2023 and Government Decision 971/2023, the maximum limit allowed for the amount of free residual chlorine in drinking water must not exceed 0.5 mg/l [7] [8].
The tests were carried out based on national standard SR EN ISO 7393-2/2018 [4].

Table 3. Value of Free Residual Chlorine in drinking water in 2023 - Călărași Treatment Plant

Month	Value of drinking water (mg/l)	Admitted limit (mg/l)	Exceedances of maximum allowable limits for drinking water (%)
JAN.	0.52	0.5	4%
FEB.	0.51	0.5	2%
MAR.	0.53	0.5	6%
APR.	0.45	0.5	0%
MAY.	0.44	0.5	0%
JUNE.	0.39	0.5	0%
JULY.	0.42	0.5	0%
AUG.	0.46	0.5	0%
SEP.	0.43	0.5	0%
OCT.	0.48	0.5	0%
NOV.	0.61	0.5	22%
DEC.	0.49	0.5	0%

Source: According to analysis bulletin provided by the company [4].

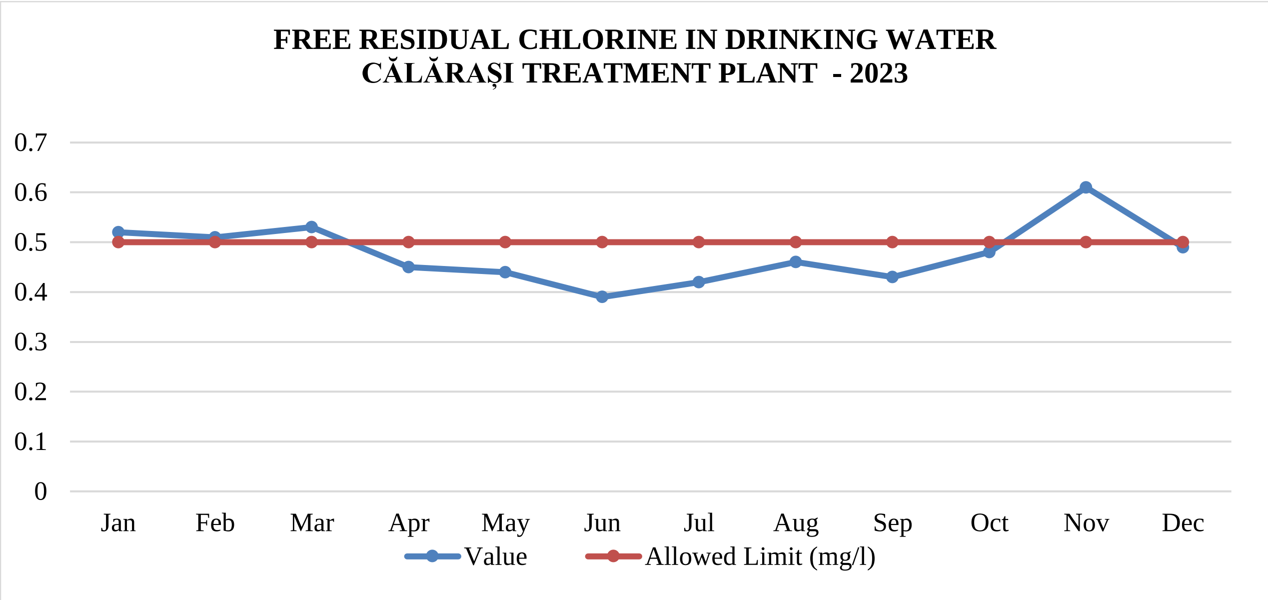

Fig. 3. Variation of Free Residual Chlorine in drinking water in 2023 - Călărași Treatment Plant
Source: Elaborated by authors in accordance with the analysis bulletins.

In Figure 3, the water at the exit from the treatment plant has a free residual chlorine level between 0.39 mg/l and 0.61 mg/l, exceeding in 4 of the 12 months the allowed legal limit. The highest value is recorded in November, with 0.61 mg/l, i.e. approximately 22% more than the legal limit, and the lowest value in June, with 0.39 mg/l, approximately 78% of the legal limit. The exceedance may be due to the use of a larger amount of liquefied chlorine gas in the water disinfection process, probably caused by the higher flow of the Danube. The same has been observed by other authors [3].

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Residual chlorine can react with organic matter in water, forming disinfection by-products such as trihalomethanes and haloacetic acids. In high concentrations, these substances can cause liver problems, kidney issues, and bladder cancer [3].

We observe that in the other eight months of the year even if legal limits are sometimes exceeded, the quality of the water is ensured following the disinfection process, making it safe for consumption.

Nitrites can appear in water from various sources, such as: decay of organic matter, erosion of rocks and soils, nitrogen oxidation processes, industrial pollution and agricultural pollution through excessive use of nitrogen [22]. A high concentration can affect the taste and smell of drinking water.

Drinking water with nitrites leads to serious health problems, such as: acute or chronic poisoning, difficulty breathing, increased risk of heart disease and stroke. However, the most serious is infantile methemoglobinemia or “blue baby disease”, as it is also known by the population. This disease affects the blood ability to carry oxygen throughout the body [6].

In accordance with the provisions of Government Ordinance 7/2023 and Government Decision 971/2023, the maximum allowed limit for the amount of nitrites in drinking water must not exceed 0.5 mg/l [7] [8].

The tests were performed based on the standard SR EN ISO 26777:2002.

Table 4. Value of Nitrites in raw water and drinking water in 2023 - Călărași Treatment Plant

Month	Value of raw water (mg/l)	Value of drinking water (mg/l)	Admitted limit (mg/l)
JAN.	0.057	0	0.5
FEB.	0.066	0	0.5
MAR.	0.068	0	0.5
APR.	0.055	0	0.5
MAY.	0.053	0	0.5
JUNE.	0.048	0	0.5
JULY.	0.051	0	0.5
AUG.	0.042	0	0.5
SEP.	0.043	0	0.5
OCT.	0.046	0	0.5
NOV.	0.061	0	0.5
DEC.	0.053	0	0.5

Source: According to analysis bulletin provided by the company [4].

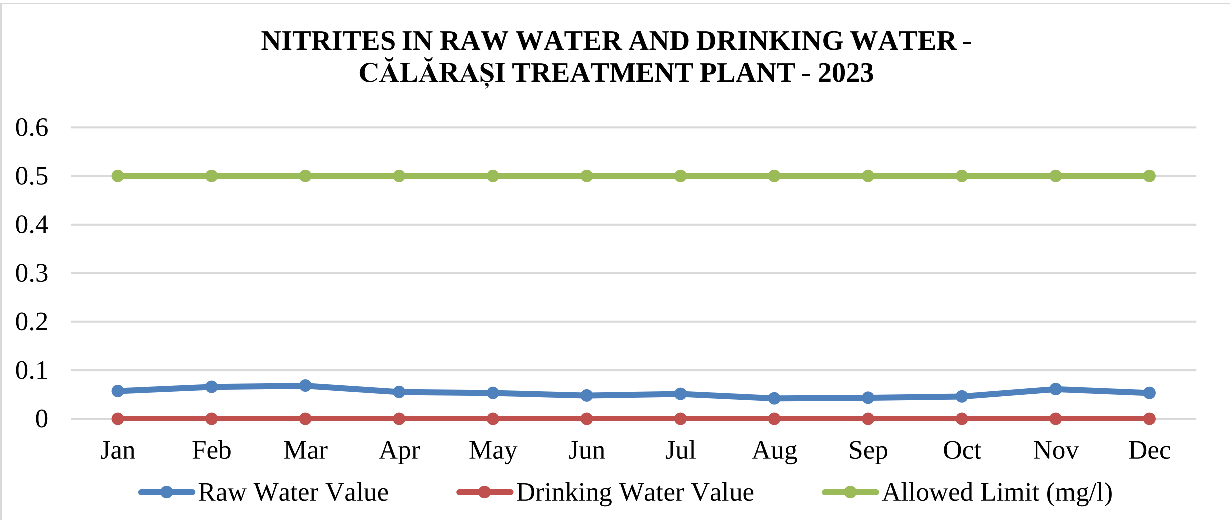

Fig. 4. Variation of Nitrites in raw water and drinking water in 2023 - Călărași Treatment Plant
Source: Elaborated by authors in accordance with the analysis bulletins.

In Figure 4., the raw water has a nitrite level between 0.042 mg/l and 0.068 mg/l. The highest amount of nitrites is 0.068 mg/l in March, and the lowest value is 0.042 mg/l in August. The biggest difference in raw water nitrites is observed between October and November, where the difference is 0.015 mg/l. The water leaving the treatment plant has a constant nitrite level of 0 mg/l.

Total water hardness is a physical-chemical property that determines the total amount of calcium and magnesium salts dissolved in drinking water. Total hardness includes both permanent hardness, represented by soluble calcium and magnesium salts, and temporary hardness, represented by calcium and magnesium bicarbonates [15]. These salts, mainly carbonates and bicarbonates, give water a specific property of forming solid deposits or causing precipitation of salts when the water is heated or chemically treated [20]. Because of this, limescale deposits form in pipes, boilers and other household appliances. The greater the amount of salts, the greater its hardness.

On the other hand, water hardness can also have health benefits by providing additional calcium and magnesium in the diet.

However, they can affect the skin and in exceptional cases can lead to heart disease or stroke [21].

In accordance with the provisions of Government Ordinance 7/2023 and Government Decision 971/2023, no maximum limit is provided, but it is provided as the minimum permitted limit of drinking water hardness which must be 5 German degrees [7] [8].

The tests were conducted based on the national standard SR ISO 6059/2008 [4].

Table 5. Value of Total Hardness of raw water and drinking water in 2023 - Călăraşi treatment Plant

Month	Value of raw water (°G)	Value of drinking water (°G)	Minimum admitted limit (°G)
JAN.	10.294	10.143	5
FEB.	10.279	10.108	5
MAR.	10.2	10.142	5
APR.	10.25	10.017	5
MAY.	10.372	10.117	5
JUNE.	9.881	10.093	5
JULY.	10.044	9.876	5
AUG.	9.376	9.416	5
SEP.	9.372	10.041	5
OCT.	10.639	10.128	5
NOV.	11.058	10.926	5
DEC.	10.368	10.144	5

Source: According to analysis bulletin provided by the company [4].

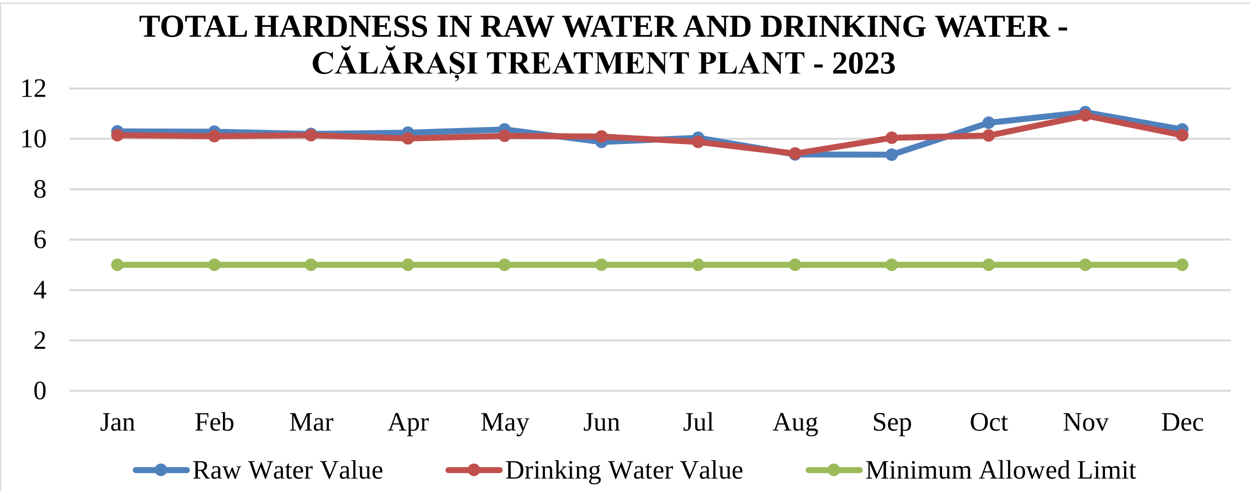

Fig. 5. Variation of Total Hardness in raw water and drinking water in 2023 - Călăraşi Treatment Plant
Source: Elaborated by authors in accordance with the analysis bulletins.

In Figure 5, we can see that raw water has a total hardness between 11.058°G in November and 9.372°G in September. The largest difference in hardness is found between September and October, which is 1.267°G.

The highest value of drinking water hardness is recorded in November, with 10.926°G, and the lowest value is observed in August, with a value of 9.416°G. Analyzing the data, we notice that the treated water has double values compared to the minimum allowed value, which shows a high content of salts, indicating a semi-hard water.

The semi-hard drinking water observed from analysis brings us essential minerals in the body (calcium, magnesium) but for those prone to kidney stones, it can bring possible deposits of limescale in the body (the risk is not as high as for hard water). The semi-hard drinking water observed from analysis brings us essential minerals in the body (calcium, magnesium) but for those prone to kidney stones, it can lead to possible limescale deposits in the body (the risk is not as high as for hard water). Despite these small risks, it is within legal limits.

Aluminum is an essential nutrient for the human body. It is found in drinking water as suspended particles or dissolved form. Aluminum can end up in water following drinking water treatment. In small amounts, aluminum is necessary for the body, for example, aluminum is a necessary cofactor for the activity of some enzymes involved in energy metabolism and the formation of neurotransmitters. However, in large quantities, aluminum has negative effects on human health, for example: neurological toxicity, kidney disease and involvement in the development of serious diseases such as Parkinson's and Alzheimer's [23].

The World Health Organization recommends a maximum aluminum level of 200 µg/l in drinking water [3]. In accordance with the provisions of Government Ordinance 7/2023 and Government Decision 971/2023 [7] [8], the maximum allowed limit for aluminum in drinking water must not exceed 200µg/l.

The tests were conducted based on the national standard SR EN ISO 12020:2008 [4].

As we can see in Figure 6, the highest value of aluminum in raw water is 67.93 µg/l in January, and the lowest value being 36.66 µg/l in December. The biggest difference in the aluminum level is found between the months of November and December, which is 9.59 µg/l.

Table 6. Value of Aluminum in raw water and drinking water in 2023 - Călărași Treatment Plant

Month	Value of raw water (µg/l)	Value of drinking water (µg/l)	Admitted limit (µg/l)
JAN.	67.93	170.05	200
FEB.	69	85.662	200
MAR.	56.65	84.936	200
APR.	50.37	119.818	200
MAY.	49.18	136.32	200
JUNE.	48	148.1	200
JULY.	39.8	194.98	200
AUG.	56.93	184.5	200
SEP.	50	189.8	200
OCT.	48.75	185.5	200
NOV.	46.25	164.025	200
DEC.	36.66	140.4	200

Source: According to analysis bulletin provided by the company [4].

The highest value of aluminum in drinking water is recorded in July, with 194.98 µg/l, and the lowest value is observed in March, with a value of 84.936 µg/l. Analyzing the data, we notice that the water leaving the station has a higher aluminum level than the raw one, and these increased values can be explained by the fact that aluminum polyhydroxychloride is used in the treatment station. However, it is observed that the treated water has an average value of 75% of the legal limit allowed.

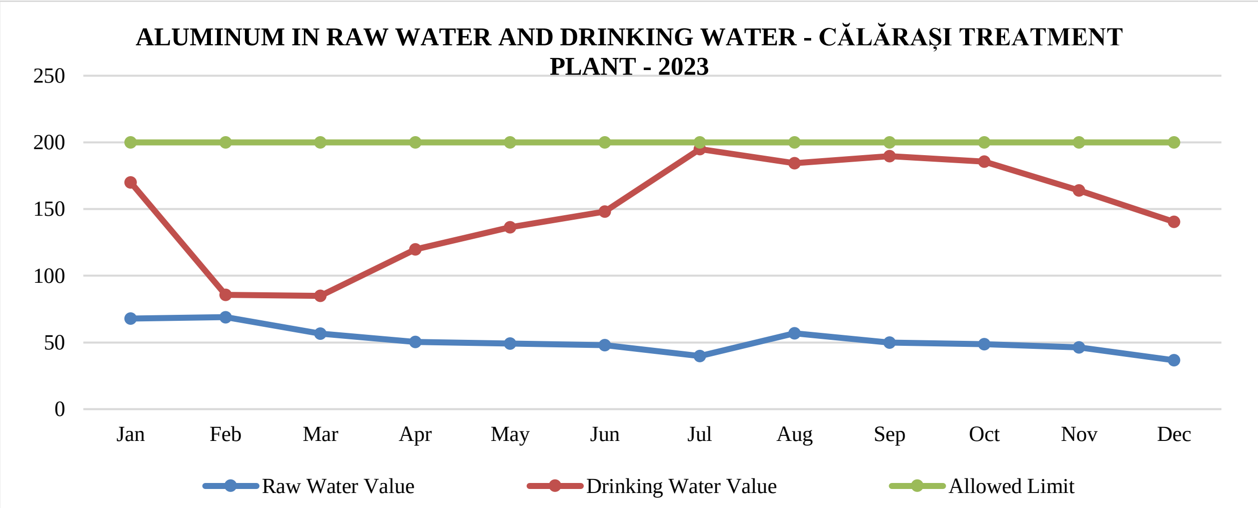

Fig. 6. Variation of Aluminum in raw water and drinking water in 2023 - Călărași Treatment Plant
Source: Elaborated by authors in accordance with the analysis bulletins.

CONCLUSIONS

The purpose of the case study carried out in this work was to evaluate the quality of water from the water network of the Călăraşi municipality in the year 2023, by comparing the main physico-chemical parameters of the raw water and the water at the exit from the Călăraşi Treatment Plant. The water treatment process is an efficient one, this can also be seen from the graphic representation of the monthly variation of the 6 analyzed parameters.

The physico-chemical parameters monitored were: pH, turbidity, free residual chlorine, nitrites, total hardness and aluminum. The analysis bulletins were provided by the company EcoAqua SA, and the analyzes carried out in accordance with the national standards imposed by law.

Following the analysis of the evolution of the physico-chemical parameters presented previously, we can draw the following conclusions:

• In 2023, the pH level of the water leaving the station was below the maximum limit allowed by law, and after the treatment, the pH is quite close to the neutral value of 7.

• Water turbidity after treatment reaches values between 13-19% of the maximum allowed value.

• Free residual chlorine, even if in some months it exceeds the legal limit, does not affect too much the health of consumers in the respective doses.

• Nitrites found in raw water are completely removed following the water treatment process.

• When we talk about hardness there is no maximum value, but a minimum one (50^0G). The treated water is between 9-11^0G, classifying it as a semi-hard water.

• Aluminum is the only one that increases a lot after treatment, increasing even 4 times, reaching several times close to the legal limit allowed.

In conclusion, all parameters are below the legal limits, which makes the water safe for human consumption. The only exception is free residual chlorine, which in January, February, March and November slightly exceeds legal limits. However, this does not affect the health of consumers. Even though free residual chlorine can be carcinogenic and toxic in large amounts, the use of chlorine is essential in the disinfection process. It plays an important role in reducing microorganisms present in water, which can transmit disease. The taste of water can be slightly altered by the level of chlorine in the water, making it taste slightly medicinal.

In order to improve the quality of drinking water offered by EcoAqua S.A., we can suggest the following recommendations:

- Adjusting the chlorine dose: it is very important to find a balance between disinfection efficiency and residual chlorine concentration.

-Applying chlorine at another stage of the treatment process, usually after clarification and filtration, reduces the amount of chlorine needed, thus reducing the contact of chlorine with organic matter, which reduces the formation of disinfection by-products.

-Advanced techniques such as coagulation, flocculation and filtration can significantly reduce the amount of organic matter, thus decreasing chlorination requirements.

-Activated carbon filters can be used at the treatment stage to reduce the concentration of free chlorine and chloramines prior to water distribution.

-Chemical neutralization in the distribution network: agents such as sodium thiosulphate or vitamin C can be used to neutralize excess chlorine in treated water prior to distribution to consumers.

-Introduction of alternative disinfection methods: ozonation or the use of UV radiation.

-Reduced retention time in the distribution system (e.g. optimizing water circulation in tanks and pipes).

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ECONOMICS OF UNDERUTILIZED CROP PRODUCTION IN AKOKNORTH WEST LOCAL GOVERNMENTAREA, ONDO STATE, NIGERIA: A CASE STUDY OF PIGEON PEA (*Cajanus cajan*)

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Abstract

The study deals with Economics of underutilized crop production in Akoko North West Local Government Area of Ondo State, using pigeon pea as a case study. Specifically, the study describes the socio-economic characteristics of pigeon pea farmers, estimate the profitability of Pigeon pea production, identify factors that affect the profitability of Pigeon pea production and identify the constraints facing Pigeon pea production in the study area. To achieve these, 120 pigeon pea farmers were selected and interviewed with the use of a well – structured questionnaire. Multistage sampling technique was used for the study. This involved purposive selection of ten communities (Arigidi, Okeagbe, Oyin, Ogbagi, Afin, Ese, Irun, Ajowa, Ikaramu and Erusu) out of 18 communities in the study area. The second stage involved snowball sampling of which 12 respondents were selected from each village to make a total of 120 respondents in the study area. Descriptive statistics were used to analyze the socio-economic characteristics of respondents and constraints facing Pigeon pea production, Budgetary analysis was used to analyze the profitability of Pigeon pea production and Regression analysis was used to analyze the factors that affect the profitability of Pigeon pea production. The results of the estimate of Cost and return revealed that the average pigeon pea production for the last season was 105.4kg and the average price was ₦551.7. The BCR (Benefit Cost Ratio) was estimated to be ₦ 1.6 and this implies that for every one naira invested in pigeon pea farming, the farmer. Will realize ₦1 and 6 kobo. The result of the multiple regression of the factors affecting the output of pigeon Pea indicated that 96.1% of the total variation in the level of pigeon pea output is accounted for by all the explanatory variables in the regression model. The estimated coefficient of labour was negative and significant at 1 percent alpha level and the estimated coefficient of agrochemical, and quantity produce were positive and significant at 1 percent alpha level, indicating that increase in this variable will increase output and profit of pigeon pea of the constraints affecting pigeon pea farming poor road network was ranked the 1st and land problem was ranked 12th. It was recommended that government should provide funds for the Research institutes for the innovations of improved pigeon pea production and hence boost the production of pigeon pea in Nigeria. Also, more studies should be carried out to consider the future outlook of the crop. Inputs like fertilizer, improved seed varieties and farm machineries should readily be available to farmers at affordable rate and on time.

Key words: *economics, underutilized, crop production, Pigeon pea, Cajanus cajan*

INTRODUCTION

The agricultural sector in Nigeria has undergone significant challenges over the past two decades, transitioning from a period of thriving export trade in agricultural commodities to becoming heavily reliant on imports [26]. The imperative of protein intake for maintaining good health among the populace cannot be overstated, with the Food and Agricultural Organization [16, 18]. recommending a daily consumption of 71 grams of protein per person. However, animal-based protein sources such as fish, beef, and mutton are often prohibitively expensive for many Nigerian households [38]. This underscores the importance of exploring affordable protein alternatives, with plant-based sources like cowpea, pigeon pea, and soybean emerging as viable options [38]. Pigeon pea (*Cajanus cajan*), in particular, stands out as a promising protein source. Originating from Barbados, this legume is cultivated worldwide under various names such as tropical green pea and red gram [15]. Despite its potential benefits, pigeon pea is categorized as an underutilized crop due to neglect from various stakeholders, including researchers, farmers, and consumers [9, 29, 14].

Globally, pigeon pea ranks sixth among pulse crops, with significant cultivation across 82 countries, predominantly in India, where it accounts for a substantial portion of production [17]. In Africa, it plays a crucial role in countries like Malawi, Kenya, and Uganda, often grown alongside other staple crops [11]. In Nigeria, pigeon pea thrives in the guinea savannah zones of both the northern and southern regions, contributing significantly to agricultural activities, particularly in states like Oyo [10].

The economic potential of pigeon pea is substantial, serving as a key protein source for both humans and livestock, a raw material in pharmaceuticals, and a versatile food product [24, 20]. Its appeal to smallholder farmers in rural areas lies in its multifaceted benefits, including income generation, livestock feed, and food security during lean periods [4, 20]. However, despite its economic significance, research on pigeon pea in Nigeria remains inadequate, with limited data and policy frameworks to support its production and utilization [15].

Pigeon pea represents a promising avenue for addressing protein deficiencies and enhancing economic development in Nigeria's agricultural sector, particularly among smallholder farmers. Thus, making it to be highly relevant economically [36]. However, concerted efforts are needed to unlock its full potential through increased research, investment, and policy support.

Problem statement

Pigeon pea holds significant importance as a staple crop in many Asian countries, yet in Nigeria, its utilization remains notably low. One of the main hurdles is the lack of competitiveness compared to commonly cultivated legumes like cowpea and soybean. However, overcoming this underutilization challenge is feasible if the economic significance of pigeon pea is recognized and demand increases, particularly given its potential as evidenced by international demand [29, 28]. Nigeria has recently secured a substantial $100 billion offer from India to export legumes, including pigeon pea, as reported by the National Agricultural Quarantine Service [28]. This initiative is poised to generate significant revenue, particularly benefiting women who are heavily involved in pigeon pea cultivation due to its potential to enhance both income and nutritional security for households [3]. The agricultural sector's underperformance in Nigeria can be attributed to inefficiencies and the limited availability of resources such as land, labor, and capital along the production chain. Additionally, high transactional costs and the weak performance of enterprises are prevalent, stemming from challenges such as elevated transportation costs, inadequate storage facilities and equipment, and insufficient market infrastructure [2]. Capital is limited, and investment in agricultural production is minimal, while traditional and outdated techniques are still prevalent. Research indicates that the challenges facing small-scale agriculture in Nigeria encompass a scarcity of high-yielding seed varieties and cultivars, insufficient information regarding new production technologies, a lack of basic farm inputs, and reliance on traditional, low-productivity methods [7]. There exist farmers in the Akoko North West Local Government Area of Ondo State engaged in pigeon pea production. Therefore, it is imperative to assess the profitability of these crops and to raise awareness among farmers about the global opportunities that pigeon pea farming can offer them.

This study will explore the stated research question as well as any additional inquiries that may arise during the investigation:

(i)what are the socio-economic characteristics of respondents in the study area?

(ii)how profitable is Pigeon pea in the study area?

(iii)what are the factors that affect profitability of Pigeon pea production in the study area?

(iv)what are the problems associated with Pigeon pea production in the study area?

Objectives of the Study

The main objective of this research was to assess the profitability of pigeon pea production in the Akoko North West area of

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Ondo State. The specific objectives of the study were to:

(i)describe the socio-economic characteristics of respondents in the study area;

(ii)estimate the profitability of Pigeon pea production

(iii)identify factors that affect the profitability of Pigeon pea production in the
study area

(iv)identify the problems facing Pigeon pea farmers in the study area.

Justification

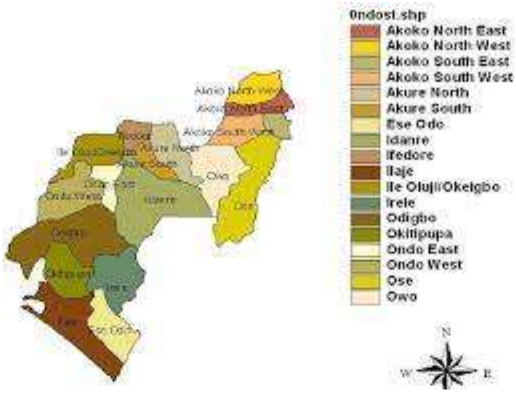
Numerous research endeavors have explored the nutritional significance of pigeon pea [33, 34, 19, 25]. Additionally, other studies have examined the correlation between pigeon pea yields and economic aspects [21]. Additional research has focused on the utilization and challenges associated with pigeon pea production [22, 27, 3].

While research on the preference and consumption of pigeon pea is available [23], there remains a dearth of studies focusing on the profitability of pigeon pea production, its production prospects, and the constraints inhibiting its cultivation in Nigeria. Additionally, the majority of studies on pigeon pea have not been specifically conducted within Nigeria, resulting in a lack of current information regarding pigeon pea production activities. This study aims at providing information on the Economics of Pigeon pea Production in Akoko North West Local Government Area of Ondo State, Nigeria.

MATERIALS AND METHODS

The Study Area

This research was carried out in carried out in Akoko North-West Local Government of Ondo State. The choice of Akoko North-West area for this study was deemed to be appropriate given its antecedent in agriculture and farming activities. Generally, Akoko is a large Yoruba cultural sub-group in the North Eastern part of Yoruba land and it extends from Ondo State to Edo state. It has a population of about 815,360 people (Federal Government of Nigeria, 2007) with a land area of 1,283,443 km2 and with the coordinates of 7°23'51.58" N 5°41'40.67" E. It takes 4 out of the 18 local government areas in the state. The local government areas include Akoko North East, Akoko South West, Akoko North West, and Akoko South East. The major occupation there is farming and most of the people in the district are engaged in small- and large-scale farming with major arable crops cultivated. Some of the crops grown include groundnut, tomatoes, maize, cocoa, cassava, yam, plantain etc.



Map 1. Nigeria
Source: Wikipedia.org [40].

Map 2. Map of Akoko Districts, Ondo State
Source: Wikipedia.org [37].

Sampling Technique

Akoko North-west LGA was chosen because of the heavy concentration of pigeon pea (*Cajanus cajan*) crop in the area. Multi-stage sampling was used to select samples for the study. The first stage involved the purposive selection of one local government from the eighteen local government areas that make up the entire Ondo state while the second stage involved a simple random selection of ten (10) out of thirteen (18) communities in the local government area. The last stage involved a snowball sampling technique selection of twelve (12) rural farmers from each selected community, which totalled one hundred and twenty (120) rural farmers in all the selected communities.

Data Analysis

Data for analysis were generated primarily using interview scheduled and structured questionnaires administered to one hundred and twenty (120) respondents selected for the study.

Analytical Technique

Data for the study were analyzed using both descriptive and inferential statistics. Objectives(i) and (iv) were analyzed using descriptive statistics such as mean, percentages and frequency distribution. Objective (ii) was analyzed using Budgetary Analysis Technique. Objective (iii) was analyzed using Regression Analysis.

Model Specification

Budgetary Analysis Technique

Farm budgetary model was constructed to determine the profitability of Pigeon pea production. Net income was computed as the difference between the Gross Revenue and Total Cost of Production. Total Cost of production is the total expenses incurred during the production period. It includes Variable and Fixed costs. Return on Investment (ROI), Benefit cost Ratio (BCR) are indicators that determine the worthiness of an investment.

NI = TR-TC ……………………………(1)

Recall that, TR = P.Q ………………….(2)

TC = TFC + TVC ………………………(3)

Therefore, NI = P*Q-(TFC + TVC)………(4)

where:

NI = net income accrued to the i^{th} farmer from Pigeon pea production (₦)

TR = Total revenue realized from the sale of Pigeon pea by the i^{th} farmer (₦)

TVC = Total variable cost incurred on production of Pigeon pea by the i^{th} farmer (₦)

Q = Total quantity of produced by the i^{th} farmer (₦)

P = Current price per unit of output (₦)

TFC =Total fixed cost incurred by the i^{th} farmer (₦)

Benefit Cost Ratio: The Benefit-cost ratio analysis will be measured

Using:

BCR = TR/TC…………………………(ii)

where:

BCR = Benefit-Cost Ratio

BCR must be greater than 1 for an investment in pigeon pea farming to be worthwhile. According to Olaoye et al. (2016), an agricultural venture is profitable provided that:

TR>TC;

BCR>1;

ROI>0.00; Net Farm Income and Gross margin are positive.

P= Unit price of output (₦/kg)

Q= Total quantity of output, that is pigeon pea (kg)

Regression Analysis

Regression analysis was used to determine factors that affect profitability of Pigeon pea production. In estimating the parameters of socio–economic characteristics, the explicit production function relating income realized from the sales of grains (Y) to some explanatory variables (Xi) was expressed as:

Y1= Gross Income realized in Pigeon pea grains production by i^{th} farmer (Naira)

X1 = Sex

X2 = Age of respondents(years)

X3=Household size

X4 = Year of Experience (years)

X5=Year of education

X6=Farm size

X7=Quantity of seed

X8=Labour

X9=Agrochemical (liters)

X10=Quantity produces(kg)

E = Error term

Four functional form namely linear, exponential, double logarithm and semi logarithm functions were fitted to determine the form that best fit for the data.

Explicitly, the models were represented as follows:

The linear regression was expressed explicitly below:

$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+ \beta_6X_6+ \beta_7X_7+ \beta_8X_8 +\beta_9X_9+ \beta_{10}X_{10}+ \mu$;

Semi log

$Y= \beta_0+\beta_1LogX_1+\beta_2LogX_2+\beta_3LogX_3+ \beta_4LogX_4+ \beta_5LogX_5+ \beta_6LogX_6+ \beta_7LogX_7+ \beta_8LogX_8+ \beta_9LogX_9 + \beta_{10}LogX_{10}+ \mu$;

Exponential

$Log\ Y= \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+ \beta_6X_6+ \beta_7X_7+ \beta_8X_8+ \beta_9X_9 + \beta_{10}X_{10}+ \mu$;

Double log

$Log\ Y= \beta_0+\beta_1LogX_1+\beta_2LogX_2+\beta_3LogX_3+\beta_4LogX_4+\beta_5LogX_5+ \beta_6LogX_6+ \beta_7LogX_7+ \beta_8LogX_8+ \beta_9LogX_9+ \beta_{10}LogX_{10}+ \mu$;

Likert scale

Likert scsle was used to analyze objective (iv). Likert scale is a 5-point scale that uses an ordinal level of measurement. Likert scaling is a summative and bi-polar scaling method that measures either positive or negative response to statement. The responses to the various constraints were scored so that the response indicating the most serious constraint was assigned the highest point (i.e., 5).

As a 5-point scale, the responses were grouped into five:

(1)Very serious = 5
(2)Serious = 4
(3)Moderately serious = 3
(4)Least serious = 2
(5)Not serious = 1

For a given constraint, the mean was computed by summing the score on each constraint and dividing by the total number of responses. This method of determining the constraints is important, because it tells exactly which constraints are serious. Should the mean be less than 3, it means the 37 constraint is not very serious, and if the mean is equal to or greater than 3, that will indicate very serious constraints.

RESULTS AND DISCUSSIONS

Socio-economic characteristics

The survey analyzed a range of socio-economic factors among respondents, encompassing age, gender distribution, marital status, level of education, household size, access to credit, capital acquisition channels, experience in pigeon pea cultivation, participation in cooperative associations, utilization of extension services, cropping systems employed, preferred planting varieties, adoption of improved pigeon pea strains, and resistance to diseases.

The findings reveal a varied distribution of respondents across different age brackets. Specifically, 11.7% fell within the age range of 30-39 years, while the majority, comprising 65%, were aged between 40 and 49. Furthermore, 10% were within the 50-59 age bracket, with 5.8% and 7.5% falling within the 60-69 and 70-79 age categories, respectively. The estimated mean age of respondents was 48 years. These findings underscore that a significant portion of pigeon pea farmers sampled are still in their prime working years, indicative of a demographic actively involved in agricultural activities. The presence of younger farmers, known for their agility, willingness to embrace risk, and eagerness to adopt new technologies and practices, is particularly notable. This outcome is in line with the observations made by [7], who also noted that the majority of farmers, with an average age of 44 years, are well-positioned to contribute positively to agricultural production.

The analysis of respondent gender distribution indicated that the majority (69.2%) were male, with the remaining (30.8%) being female. This suggests a notable gender disparity in participation within pigeon pea production, with women accounting for a smaller proportion. The prevalence of male dominance in this context may be attributed to the physically demanding nature of pigeon pea cultivation, particularly when intercropped with other crops. This finding resonates with the observations made by [12], who similarly reported a predominance of male pigeon pea farmers, comprising approximately 66.6% of the surveyed population.

The findings indicate that 5% of respondents were single, 20% were widowed, and the majority (75%) were married. The prevalence of married respondents suggests a potential abundance of labour for pigeon pea production. It's worth noting that marital status is often linked to household size, with single individuals potentially relying on hired labour for farm activities. The overwhelming presence of married individuals underscores the dominance of farming activities among this demographic in the study area. As noted by [1], the capacity of households to provide necessary labour for farming largely hinges on their marital status.

The distribution of educational levels among the respondents is as follows: 5.8% had no formal education, 43.3% had completed primary education, 38.3% had attained secondary education, and 12.5% had tertiary education. This indicates that a majority of the respondents had attained relatively higher levels of education. Consequently, there is a higher likelihood that these educated respondents may be more receptive to adopting new innovations, technologies, and acquiring technical knowledge pertaining to pigeon pea farming. This observation resonates with the findings of [30], who underscored the significant influence of education in motivating small-scale farmers to embrace new innovations and research findings relevant to their agricultural activities.

The analysis of household sizes among the respondents revealed that 49.2% had households comprising 4 to 6 members, 25.0% had households with 7 to 9 members, 15.8% had households ranging from 10 to 12 members, 0.8% had households with 13 to 15 members, and 2.5% had households exceeding 15 members. With a mean household size of 4.6, it suggests a fairly large household size, potentially providing ample family labour if farmers engage their family members in agricultural activities. This could consequently lead to increased pigeon pea production in the study area. These findings align with those of [13], who similarly reported a mean household size of 4.7 among pigeon pea farmers in Riyom Local Government Area, Plateau State.

The distribution of access to credit facilities among the respondents revealed that 87.5% did not have access to such facilities, while 12.5% did. The lack of access to credit facilities has discouraged many respondents from participating in agricultural productive activities that could potentially enhance production within the study area, as suggested by [32].

The distribution of capital sources among pigeon pea farmers showed that the majority (76.7%) sourced their capital for pigeon pea farming from personal savings. This reliance on personal funds is partly due to the insufficient access to credit from formal financial institutions. This discovery mirrors the findings of [5], whose research revealed that a significant proportion of farmers in Osun State, Nigeria, initiated their agricultural ventures using personal savings.

The distribution of respondents by years of experience revealed that 37.5% had 11-20 years of farming experience, while 27.5% had 21-30 years of experience specifically in pigeon pea farming. The average farming experience among farmers in the study area was calculated to be 23.4 years. This finding is consistent with the results of [8], who noted that 50% of pigeon pea farmers had between 15 to 25 years of farming experience. This suggests that the farmers engaged in pigeon pea production in the study area have been involved in farming for a substantial period. Accumulated experience equips farmers with the necessary knowledge and management practices essential for successful pigeon pea production.

The breakdown of respondents by membership of cooperatives revealed that 83.3% were not members of any cooperative, while the remaining 16.7% were cooperative members. This suggests that the majority of respondents were not engaged in cooperative membership, potentially impacting pigeon pea production in the study area. Cooperative membership typically enhances efficiency by providing easier access to productive inputs and facilitating extension services, compared to non-members. The fundamental purpose of cooperative associations is to empower individuals to address their challenges through collective action.

Table 1. Socio-economic Characteristics of the Respondents (n =120)

Characteristics	Frequency	Percentage
Age (Years)		
Below 30	16	13.3
31-40	29	24.2
41-50	73	60.8
Above 50	2	1.7
Marital Status		
Single	3	2.5
Married	114	95
Widowed	2	2.5
Educational level		
No formal education	4	3.3
Primary education	26	21.6
Secondary education	50	41.7
Tertiary education	38	31.7
Other	2	1.7
Gender		
Male	84	70
Female	36	30
Household size		
Below 5	38	31
6-10	75	62.5
11-15	6	5.0
Above 15	1	0.8
Access to credit		
Yes	56	46.7
No	64	53.3
Cooperative membership		
Yes	75	62.5
No	45	37.5
Extension services		
None	65	54.2
Monthly	8	6.7
Quarterly	27	22.5
Yearly	20	16.6
Income per annum		
Below ₦100,000	58.68	48.9
₦100,000-₦500,000	46.68	38.9
₦500,001-₦1,000,000	9.36	7.8
Above ₦1,000,000	5.28	4.4
Frequency of meals per day		
Once per day	3	2.5
Twice per day	20	16.7
Three times per day	93	77.5
Four times per day	4	3.3
Amount spent on food per month		
Below ₦2,000	35	29.2
₦2001-₦5,000	81	67.5
Above ₦5,000	4	3.3

Source: Field survey, 2024.

This finding resonates with that of [31], who found that a significant portion of farmers declined to participate in cooperatives, often due to cultural and religious beliefs.

The distribution of respondents by extension visits revealed that 82.5% did not receive any extension services, while only 17.5% received such services annually. This indicates a lack of adequate extension services reaching the respondents. Consequently, it suggests that many pigeon pea farmers may not be sufficiently informed about recent innovations and best practices in pigeon pea farming. Research suggests that respondents who do not receive visits from extension agents have fewer opportunities to enhance their income compared to those who do [6].

The distribution of respondents based on their cropping systems revealed that the majority of farmers (74.2%) practiced mixed cropping, followed by sole cropping (15.0%), and intercropping (10.8%). This analysis suggests that pigeon pea farming often involves mixed cultivation or planting alongside other crops, optimizing the utilization of land, labour, and fertilizers.

These findings are consistent with those of [35], who noted that mixed cropping is the predominant system in pigeon pea farming.

The distribution of respondents' access to new varieties showed that the majority (82.5%) do not have access to new varieties, while 17.5% do. This indicates that farmers generally lack access to new varieties, potentially contributing to the underutilization of the crop in the study area.

Cost and Return Estimate of pigeon pea production

The incurred cost items in pigeon pea farms were grouped into variable and fixed costs. The variable cost considered include expense on labour which comprises of (land preparation, weeding, and harvesting), while the fixed cost which are at depreciated cost are cutlass, bucket, hoe, jute bag, and basket. The average cost is presented in Table 2.

The table showed that labour cost (land preparation 41.0%, weeding 17.0, and harvesting 20.0%) accounted for 78.0% of the total cost, Agrochemical accounted for 10.0%, and transportation accounted for 3.0%.

The fixed depreciation fixed cost on cutlass, basket, hoe, jute bag and basket accounted for 2.0%, 1.0%, 3.0%, 1.0%,2.0% respectively. The total fixed cost accounted for only 9.0% of total cost.

Table 2. Distribution of Cost structure and Net farm Income of the Respondents

Items	Value in (₦)	
Variable Cost	Average	Percentage
Labour	28,496	78
Agrochemicals	3,500	10
Transportation	1,200	3
TVC	33,196	91
Fixed Cost (Depreciation Cost)		
Cutlass	819	2
Bucket	508	1
Hoe	971	3
Jute bag	392	1
Basket	637	2
TFC	3,327	9
Total Cost=TFC + TVC	36,523	100
Quantity (Q) sold =	105.40	
Price (P) per kg	551.70	
Quantity	105.4	
Total Revenue (TR) = Price *Quantity	58,141	
Gross Margin= TR –TVC	24,945	
NFI =TR –TC	21,618	
Benefit Cost Ratio (BCR)=TR/TC	1.60	

Source: Field Survey, 2023.

A partial reason for this low share of fixed cost is that all fixed costs are depreciated values. The results interpret that labour is highly essential for production so as to increase the output yield of pigeon pea in the study area. The average pigeon pea production for the last season was accounted for 105.4kg and the average price was accounted for ₦551.7.

The average revenue for pigeon pea farmers was accounted for ₦58, 141 and gross margin for pigeon pea farming was estimated to be ₦24, 945. This result was in line with [12]. who estimated revenue and gross margin for pigeon pea farmers to be ₦ 50, 185 and ₦27, 564 respectively. The net farm income was calculated by subtracting the total cost of production from the total revenue in the last production season. The BCR (Benefit Cost Ratio) is estimated to be₦ 1.6 46 47 and this implies that for every one naira invested in pigeon pea farming, the farmer will realize ₦1 and 6 kobo. BCR must be greater than 1 for an investment in pigeon pea farming to be worthwhile. Pigeon pea farming is a profitable venture in the study area. Farmers in the study area should be encouraged to go into pigeon pea farming because of its profitability and economic benefit.

Factors affecting the Profitability of Pigeon pea

Four different functional form were fitted to the data and these are linear, double log, Exponential and semi-log. On the basis of criteria of choice of the lead equation, the linear model was chosen as lead equation because it has the highest R^2 The linear model has R^2 of 0.961% and this implies that 96.1% of total variation in the level of pigeon output is accounted for by all the explanatory variables in the regression model as well as expected positive signs. The estimated coefficient labour, agrochemical, and quantity produce were positive and significant at 1 percent alpha level indicating that these variables were the factors affecting the profitability of pigeon pea in the study area. The estimated coefficient of labour was negative and significant at 1 percent alpha level, indicating that increase in this variable will decrease profit of pigeon pea by 55.4%. Possible reasons for this negative coefficient could include inefficient use of labour, high wage rates, or inadequate training of labourers. For instance, if the labour input is not used efficiently or if the labour force is not skilled enough to perform the necessary tasks, then the additional labour input may not lead to an increase in output proportional to the increase in cost. Agrochemical was positively coefficient at 1 percent alpha level. The implication of this results is that increase in the use of agrochemical will increase the profit of farmers by 0.2%. The high cost of agrochemical may reduce the quantity of litres used by the farmers and these decisions may reduce the output of pigeon pea production and hence increase the profit of pigeon pea farmers. The quantity sold was positively significant at 1 percent alpha level. This result implies that increase in the quantity of pigeon pea sold will increase pigeon pea profit by 12%. This result was in line with [7] whose findings indicated that Fertilizer and farm size were the variables significant in determining the profit efficiency of pigeon pea production in Federal capital Territory Abuja.

Table 3. Distribution for OLS Regression Estimates of Production of Pigeon Pea Production

Independent Variables	**Variable letter code**	**Linear**	**Double log**	**Exponential**	**Semi-log**
Constant	Coefficient	-30313.76	-6.857	8.134	-452446
	T-value	(-4.750)	(-2.725)	(-10.267)	(-7.717)
	P-value	0.000	0.008	0.000	0.000
Sex	X_1	125.923	0.063	0.021	-1811.71
		(-0.087)	(-0.300)	(-0.115)	(-.367)
		0.931	0.765	0.909	0.714
Age	X_2	19.825	-0.138	2.71835	10502.19
		(-0.236)	(-0.312)	(-0.003)	(-1.044)
		0.814	0.756	0.998	0.299
Household size	X_3	-159.286	0.029	0.031	-616.477
		(-0.231)	(-0.16)	(-0.003)	(-0.147)
		0.818	0.873	0.998	0.883
Years of experience	X_4	18.708	-0.007	0.001	-4562.58
		(-0.216)	(-0.043)	(-0.06)	(-1.209)
		0.829	0.996	0.952	0.229
Years of education	X_5	-1742.662	0.176	-0.397	-6835.51
		(-.596)	(-0.554)	(-1.095)	(-.688)
		0.552	0.581	0.276	0.493
Farm size	X_6	-996.874	-0.138	.651*	-1832.78
		(-.326)	(-1.203)	(-1.703)	(-.688)
		0.745	0.232	0.092	0.493
Quantity of seeds	X_7	3967.787	.421**	.794*	3913.439
		(-1.098)	2.436	(-1.758)	0.976
		0.275	0.017	0.082	0.331
Labour	X_8	.554***	-0.145	-1.55435	.3956.101*
		(-5.554)	-1.62	(-1.245)	-1.898
		0.000	0.108	0.216	0.06
Agrochemicals	X_9	42.67***	1.795***	.002***	40587.551***
		13.772	6.463	4.299	6.29
		0.000	0.000	0.000	0.000
Quantity sold (kg)	X_{10}	477.764***	1.692***	.012***	54364.856***
		44.514	13.075	8.773	18.463
		0.000	0.000	0.000	0.000
R^2		0.961	0.679	0.566	0.78
Adjusted R^2		0.957	0.649	0.521	0.759
F-Ratio		242	22.4	12.6	38.2

Source: Field Survey, 2024.
Figure in first line= estimated coefficient variables; Figures in parenthesis = t value; Figure in third line= p value
***< 0.01=1%; ** 0.01-0.05= 5%; *0.051-0.099=10%

Constraints faced by pigeon pea farmers

The results of the analysis of the constraints faced by pigeon pea farmers in the study area were recorded. Multiple responses were allowed for farmers to choose which of the constraints affects them most. The analysis revealed that about (88.3%) of the sampled pigeon pea farmers were faced with the condition of poor road network that linked their farms and the markets and was ranked 1st. Generally bad roads are very terrible in Nigeria especially when conveying agricultural produce from the farm to the market or to the residence of the farmers. The results also showed the second ranking of the constraints encountered by the respondents was poor demand of pigeon pea. This may be as a results of underutilizing pigeon pea production. The crop serves a lot of purposes such as; feed for poultry birds, and for soil improvement. Lack of improved varieties ranked 3rd by farmers in the study area. Pricing problem ranked 4th, this was as a result of low demand for pigeon pea. In economics when the demand is low for a particular produce, such produce tends to be purchased in low price because of low demand. Capital and labour scarcity were ranked 5th. Marketing problem and agrochemicals was ranked 6th as the constraints faced by pigeon pea farming in the study area. When managed as a green manure crop, pigeon pea generally has few insect pests. However, if allowed to form pods, pigeon pea may attract pod borers and agromyzid fruit flies. The underutilization of pigeon pea crop will affect the marketing of pigeon pea production. Other constraints which were the least constraints were identified by pigeon pea farmers in the study area include theft, storage, natural disaster and land problem and were ranked as 9th, 10th, 11th respectively. Pigeon pea is less affected by wind that is the reason why there is low tendency for the crop to be carried by wind which may cause fire explosion.

Table 4. Distribution of Constraints faced by Respondents

S/N	Problem of Pigeon Pea Production	Frequency	Percentage	Rank	Mean
1	Poor road network	106	88.3	1st	3.9
2	Poor demand	105	87.5	2nd	3.7
3	Lack of improved varieties	102	85.0	3rd	3.53
4	Pricing problem	89	74.2	4th	3.58
5	Inadequate capital	89	74.2	4th	3.58
5	Labour scarcity	83	69.1	5th	3.1
7	Marketing problem	82	68.3	6th	3.04
8	Agrochemicals	82	68.3	6th	3.04
9	Theft	81	67.7	7th	3.02
10	Storage(process facilities)	71	60.0	8th	2.88
11	Natural disaster	46	38.3	9th	2.44
12	Land problem	44	36.6	10th	2.37

Source: Field survey, 2024.

CONCLUSIONS

The study concluded that pigeon pea farmers were predominantly male and are married in Akoko North West Local government Area of Ondo State. The study further concluded that the average pigeon pea farmers' age was 48years. The majority of the pigeon pea farmers had large household size and are literate. The study also revealed that Pigeon pea is a profitable enterprise in the study area with (Benefit Cost Ratio) which was estimated to be ₦ 1.6 and this implies that for every one naira invested in pigeon pea farming, the farmer will realize ₦1 and 6 kobo. They did not have access to credit facilities and extension services. They sourced for capital from personal savings, cooperative society and banks.

The study therefore recommends that, government should provide funds for the Research institutes for the innovations of improved pigeon pea production and hence boost the production of pigeon pea in Nigeria. Also, more studies should be carried out to consider the future outlook of the crop. Inputs like fertilizer, improved seed varieties and farm machineries should readily be available to farmers at affordable rate and on time. Farmers should be encouraged to maximize their return from pigeon pea farming enterprise by increasing their farm sizes in the study area. Policies should be aimed at ensuring that institutional credit sources reduce the current high interest rates on loans and the procedural difficulties in securing credit facilities, to encourage farmers' access to such credit facilities for increased pigeon pea production and hence, boost their profit.

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COMPARISON OF YIELD AND QUALITY OF PINEAPPLE FRUIT UNDER IRRIGATED AND RAINFED CONDITIONS IN GHANA: A PERSPECTIVE FROM FARMERS' FIELD CONDITIONS

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Abstract

While most commercial pineapple farms in Ghana cultivate under rainfed conditions, few supplement the rains with irrigation, which is a good agronomic practice. In this study, pineapple fruit yield and quality (brix and weight loss) were assessed in rainfed and irrigated fields in Ghana's Coastal Savannah agroecological zone in 2022 production period at Bomarts Farms. Forty (40) matured pineapple fruits from a 50 × 50 m plot were sampled under drip and rainfed conditions each. Weight of fruits were in the range of 609 g and 1,524 g inclusively. The average least fruit weight for drip-irrigated and rainfed fields were 652 g and 609 g, respectively. The variation of fruits weight under both conditions was not significant (p-value = 0.815). Generally, the weight loss was high in fruits from irrigated (drip) fields during the storage period. The brix for drip-irrigated pineapple was lower (12.8 ^{0}Bx, 15.6 ^{0}Bx and 19.8 ^{0}Bx) than pineapple cultivated under rainfed conditions (13 ^{0}Bx, 16 ^{0}Bx, 21 ^{0}Bx). Annual rainfall in the study area (840.7 mm) compared to requirement (1,000 mm) for pineapple plants poses a challenge to year-round production, and presents an opportunity for farmers to adopt good agronomic practices to sustain production in the coming years.

Key words*: *coastal savannah, irrigation, pineapple, rainfed

INTRODUCTION

More than 95 % of agricultural production in Africa is rainfed, providing employment to about 65 % of the people in the region in the last decade [20]. Projections from other studies [2, 10, 12] have shown that climate variability will worsen in the future because of population growth, urbanization, industrialization, and nature-based extremities such as floods, drought, amongst others [17]. These extremities affect crop production and warrant the adoption of good agronomic practices to sustain production [14].
Pineapple (*Ananas comosus*) is a Crassulacean Acid Metabolism (CAM) plant with a photosynthetic adaptation which makes it drought-tolerant. It is commercially propagated for its nutritious fruit [7] and it is the only specie in the *Bromeliad* family that is widely grown for its fruit [16]. Pineapple is considered as the third most important tropical fruit after banana and citrus, in terms of global production [13]. The exceptional aroma and flavour, appealing appearance, and important nutritional makeup (vitamins, minerals, fibre) makes it the consumer's preferred choice of tropical fruit [1].
Pineapple is an important export crop in Ghana with a well-developed and structured sector [15]. The main production area is the country's Coastal Savannah agroecological zone where most cultivation is rainfed [22]. Its growth can be retarded due to seasonal drought and water shortage [24, 11], and this will affect the fruit yield [3]. According to [8], pineapple cultivated under irrigation produces high fruit yield and good quality. It is therefore important for farmers to consider the incorporation of appropriate irrigation practices, and adjust planting calendar to account for the impact of rainfall variability [24, 14].
Good pineapple fruit quality is attributed to growing sites having a combination of relatively cool night temperatures, sunny days, and high day temperatures [11]. According to [22], climatic conditions such as

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rainfall and temperature have a significant impact on pineapple production, especially in the tropics, with a suitable temperature and rainfall range of 18 to 32 ^{0}C and 1,000 to 1,500 mm/annum of rainfall, respectively [3]. Generally, according to [4], pineapple requires a minimum monthly rainfall total of 50 to 100 mm. If the annual rainfall is less than 500 mm, irrigation is required for better yield [4]. Thus, tropical countries with enough water available for crop production are found to be most suitable for the fruit's cultivation [3, 24]. In this study, pineapple fruit yield and brix and weight loss were assessed under both rainfed and irrigated fields in Ghana's Coastal Savannah agroecological zone.

MATERIALS AND METHODS

Pineapple production in Ghana is concentrated in the Coastal Savannah (CS) agroecological zone. This zone lies between latitude of 4.5^{0}N and 6^{0}N, and longitude of -0°13'56" to 0°58'42" W, and it is distinguished by its relatively low rainfall of 800 mm distributed in two seasons (major and minor) and grassland savannah vegetation [6]. The study was carried out at Bomarts Farms in the CS agroecological zone, where pineapple is produced both under rainfed and drip irrigation.

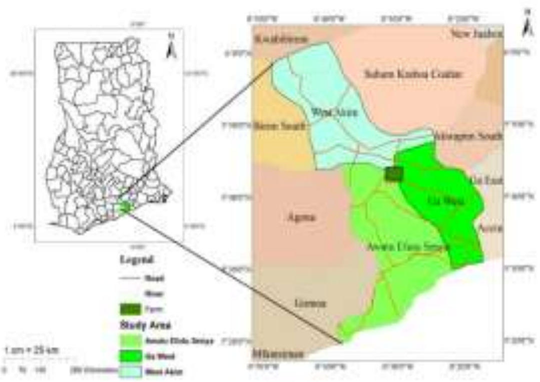

Fig.1. Map of Study Area Showing Bomarts Farms in the Coastal Savannah (CS) agroecological zone
Source: Author, 2022.

The average yearly rainfall in the agroecological zone is 800 mm. While the minor season's rainfall peaks in October and its dry phase lasts from December to March, the major rainy season spans from April to mid-July and is followed by a one-to-two-month dry period. The rainfall dispersion varies and rainfall fluctuations are a major setback for agricultural production. The zone experiences high temperatures which are about 26.5 °C on average throughout the year. Humidity is high in general (65–95 %), although it is lower during the warmer months, especially in January, when the northeast harmattan winds are prevailing [18]. Pineapple cultivation is supported by the type, texture, and composition of the soil in this area, which is home to a number of sizable pineapple farms, including Bomarts Farms, which was chosen for this study. Climate data (1989 – 2019) for the Coastal Savannah Agroecological zone, presented in Table 1 were sourced from the Ghana Meteorological Agency.

Table 1. Monthly means of climate data for the Coastal Savannah Agroecological Zone, from 1989 to 2019

Month	T_{min}	T_{max}	Humidity	Wind	Sun	Rainfall
	^{0}C	**^{0}C**	**%**	**km/day**	**hours**	**mm**
Jan	23.0	32.3	88	210	6.5	12.0
Feb	24.3	33.0	89	273	7.4	27.1
Mar	24.5	33.0	90	261	7.1	56.4
Apr	24.5	32.8	90	240	7.5	99.0
May	24.1	31.9	91	226	6.9	164.9
Jun	23.6	30.1	92	230	5.3	204.0
Jul	23.0	29.0	93	274	5.2	65.1
Aug	22.6	28.9	93	276	4.5	22.0
Sept	23.1	30.0	92	304	5.5	45.3
Oct	23.3	31.0	91	273	7.4	85.9
Nov	23.5	32.1	90	219	8.1	38.0
Dec	23.4	32.3	89	187	7.4	21.0
Avg/Tot.	**23.6**	**31.4**	**91**	**248**	**6.6**	**840.7**

Source: Ghana Meteorological Agency, 2022.

As shown in Table 1, from 1989 to 2019, minimum daily temperature was about 23.6 °C and maximum 31.4 °C, with relative humidity ranging between 88 % and 93 %, with an average of 91 %. January had the lowest monthly rainfall (12.0 mm), while June had the greatest (204 mm). Six months (January, February, August, September, November, and December) had rainfall values below 50 mm, and this is below the monthly water requirement for pineapple plants in the tropics. [3] considers annual rainfall of 1000-1,500 mm as suitable for proper growth and good yield, and in every month, according to [4], rainfall of 50-100 mm is appropriate.

Pineapple Yield and Fruit Quality Assessment

Fruit Yield and Percent Weight Loss

(i). Fruit yield: Forty (40) matured fruits were sampled from a 50 x 50 m area under both rainfed and rainfed conditions during harvesting. The fresh weight for both conditions were determined and the yield for the two fields were computed as:

$$Y_{FF} = \frac{FF}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

where:
Y_{FF} – Fresh fruit yield [t ha^{-1} or kg m^2],
FF – Total pineapple fresh fruit harvested [ton or kg],
A – Area covered by crops used in FF sampling [ha or m^2]

(ii). Percent weight loss of fruit: Percent weight loss was calculated by using the following formula:

Percent weight loss (%WL) =

$$\frac{IW - IF}{IW} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

where:
%WL – percent weight loss,
IW – Initial fruit weight with crown and
FW = Final fruit weight with crown

Moisture content: The percent moisture content was calculated using the following formula:

$$\text{Percent moisture} = \frac{IW - IF}{IW} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

where:
IW – Initial fruit weight with crown and
FW – Final fruit weight with crown

Fruit Quality

Five (5) fully grown pineapple fruits that had not yet turned yellow at the base and had fresh, green crown leaves were randomly chosen from a 50 m × 50 m drip-irrigated pineapple field and that of rainfed field each. The same storage conditions (temperature and relative humidity) were applied to these fruits. Using a digital thermometer-hygrometer clock, the temperature and relative humidity (RH) in the storage area were recorded three times a day – at 6:00 am, 12:00 pm, and 6:00 am – during the course of the 14-day storage period. Before storing each fruit, its weight and diameter were measured using a vernier calliper and a measuring scale, respectively. These measurements were taken every two days. Using a handheld refractometer, the total suspended solids (Brix) was measured.

RESULTS AND DISCUSSIONS

Fruit Weight and Yield

The weight (g) of 40 matured pineapple sampled under drip irrigation and rainfed conditions is presented in Figure 2. The area coverage of the field during the sampling of fresh fruits was 50 m × 50 m.

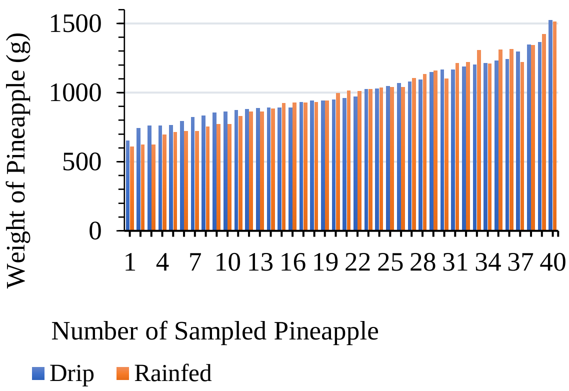

Fig. 2. Weight of fruits from drip irrigated and rainfed plots
Source: Field Studies, 2022.

Fruit weight ranged from 609 to 1,524 g, with 652 g and 609 g, respectively, being the lowest weight of examined fruits from drip-irrigated and rainfed farms. The highest fruit weights from rainfed and drip-irrigated crops were 1,512 g and 1,524 g, respectively. Under drip irrigation, most (10) of the sampled fruits were in the 800 g range as shown in Figure 3. The highest fruit weight was in the 1,500 g range, same as for fruits under rainfed conditions.

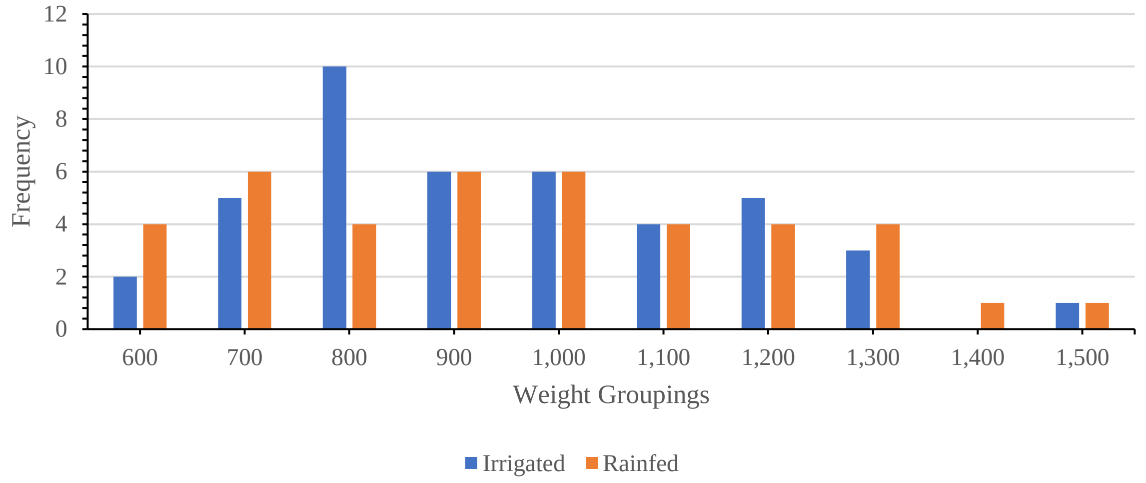

Fig. 3. Pineapple weight distribution under rainfed and drip irrigation
Source: Field Studies, 2022.

As seen in Figure 3, fruit samples from the rainfed field were distributed in weights ranging from 600 to 1,500 g. From drip-irrigated fields, most fruits weighed around 800 g. This could be profitable in instances when the customers require particular fruit size. The outcome of the study agrees with a study by [5] who investigated the effect of irrigation frequency on the growth and yield of pineapple. [9] and [4], indicated that the minimum monthly water requirement of pineapple for good growth and yield is around 50 mm, and if this quantity is not met, the average fruit weight will be compromised. Table 2 presents the statistics of pineapple weight under both conditions. There was very little variation (11.4 g) in the average fruit weight between the two settings.

Table 2. Statistical analysis of pineapple fruit weight

Variable	Obs	Mean	Std. Dev.	Min	Max	Mean Diff
Weight (g)						11.49
Drip Irr.	40	1,006.4	198.78	652	1,524	
Rainfed	40	995	234.06	609	1,512	

Source: Field Studies, 2022.

Fruit weights under drip irrigation and rainfed conditions did not differ significantly at a 95% confidence interval, according to the independent samples t-test presented in Table 2 (p-value = 0.815).

Weight loss over time

Figure 4 shows pineapple weight loss over a period of 14 days under ambient conditions (28-31 ^{0}C and 60-75 % RH).

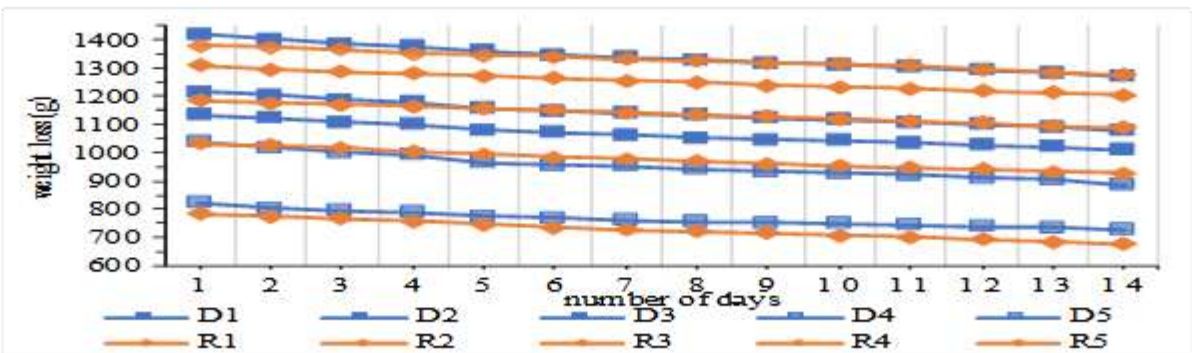

Fig. 4. Weight loss in sampled fruits under each condition, rainfed and drip-irrigation (R1, R2, R3, R4 and R5) and (D1, D2, D3, D4 and D5), respectively over a 14 days period
Source: Field Studies, 2022.

During storage, a noteworthy decrease in the overall weight of pineapples grown with drip irrigation was observed. Fruits from fields with drip irrigation often lost more weight overall over the course of storage (Figure 4). For pineapple grown with drip irrigation, weight loss was greater in the first seven days of storage than it was in the next seven. In contrast to irrigated fruits, fruits grown under rainfed settings showed a range of weight loss values during the course of the storage period. This tendency was different for these fruits. However, the common effect across both drip irrigated field and rainfed field is that the highest weight loss was seen in bigger fruits. These findings supported the work of [19]. Maturity stage and storage conditions play a crucial role in the weight loss of food crops.

Brix content over the storage period

Table 3 Pineapple brix cultivated in rainfed and drip irrigation conditions

Test days	**Brix, ^{0}Bx**		
	Day of harvest	7th day	14th day
Drip Irrigated	12.8	15.6	19.8
Rainfed	13	16	21

Source: Field Studies, 2022.

Three days during the storage process were used to measure the brix: the day of harvest, which also signalled the start of the pineapple's storage; seven (7) days after harvesting; and fourteen (14) days after harvesting. On harvest day, the pineapple planted with drip irrigation had a brix of 12.8 ^{0}Bx, whereas the pineapple grown with rainfed circumstances had a brix of 13 ^{0}Bx as shown in Table 3. After seven days, the readings for pineapple that was grown under rainfed and drip irrigation rose to 15.6 ^{0}Bx and 16 ^{0}Bx, respectively. Customers' chosen range of values was represented by the brix readings in the first week following harvest. Yet, following the first week, the brix values increased significantly to 19.8 Bx for drip feeding circumstances and 21 Bx for rainfed conditions, respectively. The common trend of increase in Total Soluble Solids (TSS) content whilst the fruit changes colour from dark green to yellow has been observed in this and several other studies [21, 23]. In the study by [21], the TSS for 'Mauritius' pineapple variety was observed to be 14.73 % whilst the pineapple shell was 100 % dark green. Nonetheless, the TSS was recorded as 17.32 % after 20 % of the shell became yellow, which is consistent with the pattern seen in this investigation.

CONCLUSIONS

Ghana's coastal savannah is the production hotspot for pineapple cultivation. However, annual rainfall in this area poses a challenge to year-round production. Field study carried on Bomarts Farms showed no significant difference between the weight of pineapple cultivated under drip irrigation and rainfed conditions. Irrigation adoption alone will not produce the desired outcome if other important agronomic practices are not adopted.

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COMPETITIVE POSITIONING OF AGRIBUSINESS IN THE WORLD FOOD MARKETS

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Abstract

The activation of globalization processes opens the access of agrarian business to world food markets. Taking into account the need to adapt to rapidly changing external markets, the justification of the system of strategic directions for the formation of competitiveness must meet the criteria of innovation, minimal riskiness, and maximum business efficiency, which allow increasing the competitive potential of agribusiness. The purpose of the research is to develop a methodological tool for developing a competitive positioning strategy for an agricultural enterprise in world food market. The research methods used are the process approach, expert and integral assessment methods, and the matrix method. The article analyzes the peculiarities and innovative aspects of the competitive positioning of agrarian business enterprises. As a result of the study, the characteristics of the main types of competitive positioning are determined. To obtain information about the indicators of the positioning of agricultural enterprises, a survey was conducted and the main indicators of competitive positioning in the agrarian business were identified. The matrix of competitive positioning strategies, taking into account the influence of the main indicators of competitiveness, was formed to select a competitive positioning strategy. The scientific novelty and originality of the research consists in identifying innovative aspects of competitive positioning for an agrarian business enterprise. The results of the study can be useful for the development of a strategy for positioning and marketing management of enterprises in the agricultural sector.

Key words**:** *competitive positioning, agribusiness, agricultural enterprise, competitive potential, world food market*

INTRODUCTION

Currently, enterprises of the agricultural sector work in rather uncertain competitive conditions and have to simultaneously solve many complex problems that affect the results of their activities. Such problems of agrarian business should include issues of productivity, increasing productivity, and sales of products. Significant lists of agricultural products are perishable goods, so untimely sales lead to losses. If we look at the problem from the point of view of the potential consumer, then, first of all, the products of well-known manufacturers are bought, that is, to solve this problem, agricultural producers must carry out branding or positioning.

The relevance and practical significance of the research topic is determined by the fact that the study of modern methods of competitive positioning reflects their real effectiveness. Some businesses try to reach different niches and target audiences. At the same time, the range of products is expanding and positioning is difficult. The company can easily lose its image in the eyes of consumers, because it is difficult to highlight the competitive advantage of the product. It is important to remember that a product has different value for different groups of consumers, and to focus on your target audience. Currently, there are a large number of agricultural enterprises on the market, which have a similar range of products. The enterprise should strive for significant and substantial positioning. Behind each enterprise or market offer should be some special idea brought to the consciousness of the target consumer; every enterprise must invent new features, services, guarantees, incentives for loyal customers, new conveniences and pleasures.

Despite the difficulties of positioning and branding, the creation of strong agricultural brands is required, which is justified by the growing level of competition both in domestic and foreign markets. Experienced companies actively promote their own products; create competitive brands that are offered to consumers through various communication channels. Such competitive products are actively purchased by retail chains, because they are easily identified and mass-purchased by customers. Undoubtedly, product branding and enterprise positioning have significant costs, but increasing the number of products sold and reducing the disposal of products that have reached the end of their sales period leads to profits [15]. So, in the process of development and transformation of the economy, introduction of modern information technologies, globalization processes, the essence and components of positioning strategies change, require detailed study and are relevant.

The purpose of the paper is the formation of the toolkit for choosing a strategy for competitive positioning of agribusiness in the global food market. To achieve the goal, such tasks as the development of the method of positional analysis of agricultural enterprises and agricultural products; evaluation of positioning indicators; development of recommendations for choosing a strategy for competitive positioning of agribusiness were formed.

The structure of the paper is, firstly, a study of the theoretical aspects of competitive positioning, secondly, the formation of indicators that allow you to evaluate competitive positions and choose the trajectory of the competitive positioning of an agricultural business enterprise, thirdly, the formation of recommendations for the development and selection of a competitive positioning strategy for agricultural enterprise.

The scientific novelty and originality of the research consists in identifying innovative aspects of competitive positioning for an agrarian business enterprise. Numerous scientists and researchers have studied various directions of positioning. Previous studies were related to the definition of types of positioning, the characteristics of directions and types of positioning, the formation of the process of actions for effective positioning, the description of tools and strategies of positioning. However, despite these contributions, there remains a need for further research into the specific problems faced by agribusiness enterprises related to the formation of innovative methodological tools for competitive positioning.

The gap in the existing works consists in the lack of a toolkit for determining the competitive advantages of agricultural enterprises and substantiating the criteria for positioning in the agrarian business, which would allow for the formation of a competitive positioning strategy. This study proposes a system of indicators for diagnosing the position of agribusiness in relation to competitors is proposed. Taking into account the available scientific sources and existing gaps, it is of primary importance to identify indicators that influence the acquisition of a competitive position in agrarian business. A comprehensive study will provide information about what competitive positioning strategy it is advisable to use for an agricultural enterprise, depending on the level of competitiveness of products. This information will allow agricultural enterprises to make informed marketing decisions in the competitive struggle on agricultural market.

The recommended methodological toolkit will have a positive impact on scientific achievements and practical implementation by agricultural enterprises. The results of the research will contribute to the formation of a strategy for positioning and marketing management of enterprises in the agricultural sector.

MATERIALS AND METHODS

The research uses various methods and approaches to assess the competitive position of an agricultural enterprise. The object of the study was the agricultural business sector.

Experts in the field of agricultural business, top managers of 9 agricultural companies with stable positions in the agricultural market were involved in the study.

The research methodology is based on the justification of the sequence of the competitive positioning of agribusiness. The first step of competitive positioning is a general diagnosis of the relevant agrarian business, and on its basis the determination of special features and characteristics of the activities of this segment of the agricultural business. At this stage, based on the expert assessment method, agricultural experts were interviewed. Based on the rating of experts' answers, criteria and indicators of agricultural products were formed, which are important for the positioning of agricultural products. When compiling a database of questions for experts, data from the Food and Agricultural Organization of the United Nations, the World Bank, official statistical materials, reports of agricultural enterprises were used.

The next stage of the research was the development of a methodology for assessing the position of an agricultural enterprise in relation to competitors. To assess the competitive position of agricultural products, it is proposed to use a complex integral indicator, which can be used to comprehensively diagnose the competitive position of the company. The study proposes to use the Harrington scale for the interpretation of this indicator.

The results of diagnostics of the company's position compared to competitors allow choosing the necessary business positioning strategy. A variant of the strategy of competitive positioning of enterprises in the agricultural sector is proposed to be chosen on the basis of a matrix based on two key selection criteria, namely the state of the agricultural enterprise on the market and the chosen trajectory of its development. For a given agricultural product, company management can choose one of five main competitive positioning strategies depending on the market situation, and also flexibly adapt it to emerging changes.

The proposed methodology allows us to understand the main indicators that need to be paid attention to when competitively positioning an agricultural enterprise, assess the effectiveness of positioning, choose a competitive positioning strategy, and plan marketing activities in conditions of fierce competition.

RESULTS AND DISCUSSIONS

The term "positioning" was introduced into the theory and practice of marketing by Rice and Trout [16], who argued that with skilful and high-quality use of positioning, the brand will be in demand. Researchers believed that positioning is an influence on consumer perception, not an influence on the product. Davis [6] notes that brand positioning involves memorizing the product and its advantages over other products in the minds of customers. Positioning forms the company's operational strategy, which allows to realize the planned position. According to Aaker [1], the position of the product is a set of associations that the customer associates with the product, such as physical attributes, lifestyle, situations of use, brand image, and places of sale. In addition, the position of the product is developed over the years with the help of advertising, rumours and experience of use. The product's position is based on the consumer's comparative assessment of this product with competitors' products [2].

Competitive positioning of the enterprise is the creation and consolidation of a certain image of the brand in the minds of consumers in comparison with competitors [7]. With the help of this marketing tool, it is possible to consolidate the competitive position of an agricultural enterprise on the market. The competitive positioning of an agrarian enterprise emphasizes the features of agrarian products, their differences compared to the offers of competitors.

Competitive positioning of the brand allows for successful business development in conditions of high competition. Thanks to a clear business concept, it is possible to see the competitive advantage of your product and strengthen your position in the market [5]. Bringing the benefits of the brand to the consumer is realized thanks to the development and implementation of an effective concept of competitive positioning. Positioning allows defining and formulating the values of the brand [11], as well as establishing stable positive associations with potential customers.

Table 1. Characteristics of the main types of competitive positioning

Classification sign	Type of competitive positioning	Characteristics
Purpose of positioning	Positioning is focused on the specifics of product use	Special features of products or non-standard ways of using them are emphasized
	Positioning is focused on benefits from product consumption	Promises are made to customers regarding obtaining benefits, benefits from the purchase, solving the problem
Nature of products	Positioning is focused on the introduction of production innovations	It is carried out on the basis of the introduction of innovations and product modification
	Positioning is focused on the introduction of marketing innovations	Marketing innovations are implemented without product changes
Product characteristics	Two-dimensional positioning	It is focused on two main characteristics of products, namely price and quality
	Multidimensional positioning	Focused on comparing products with competitive counterparts on a significant number of parameters
Relation to a competitor's product	Positioning of product differences to competing products	Focusing on the uniqueness of the product
	Positioning of products similar to competitors	Focusing on finding your own competitive advantages (cheaper, better quality, etc.)
Product novelty	Positioning of novelties	Focusing attention on special properties of new products
	Positioning of existing products	Adaptation of products to customer requirements, taking into account various changes

Source: systematized by the authors based on [3; 12; 14; 17; 18].

The main advantage of the competitive positioning of the brand is the ability to successfully promote the product. A properly prepared marketing and communication strategy forms a bright image of the enterprise and emphasizes the competitive ad-vantages of products. Positioning contributes to the formation of a loyal target audience and strengthening of the brand's position on the market [8].

Competitive positioning helps convey information to consumers about the competitive advantages of products and consolidate a positive image of the enterprise. The grouping of types of competitive positioning is presented in Table 1.

All authors unanimously emphasize that in order to win positions on the market in the competitive struggle, the company highlights the characteristics of the product and directions of marketing activities that can profitably separate this product from the products of competitors, i.e. differentiates its own products [9]. At the same time, the amount of research on practical developments regarding strategic competitive positioning in certain areas of business is quite limited.

In accordance with the situation with the products and the situation compared to competitors, the company chooses one or another competitive positioning strategy. The policy of competitive positioning of an agrarian enterprise is characterized by a unique combination of strategic ideas, based on this there are countless ways to achieve success in competition, that is, many competitive marketing strategies of enterprises.

Technologies of competitive positioning of agricultural enterprises should be based on the following principles. First, the emphasis on the quality of agricultural products has an impact, as it affects the health and satisfaction of the consumer. Secondly, it is advisable to inform about the peculiarities of production, technological processes, without tiring the listener with complex terms, attracting attention and interesting events and facts. Thirdly, for the competitive positioning of agricultural products, benefits are important, namely the presence of vitamins, useful minerals, etc., which will emphasize the benefits of the product and the problems it solves. Fourth, for agricultural enterprises that have a wide range of products and are represented in different niches and for different target audiences, it is worth focusing on each target audience, emphasizing different value and competitive advantages of products. Fifth, competitive positioning should be flexible, change in case of lack of efficiency,

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adapt to current conditions. Indicators of the state of the world agricultural market show its wide ramifications, openness and competitiveness (Table 2).

Table 2. Development dynamics of the world agricultural market

Indicators	2018	2019	2020	2021	2022	2023
Food Exports (% of Merchandise Exports)	8.3	8.5	9.3	8.5	8.5	8.7
Trade (% of GDP)	57.3	55.7	51.6	56.5	60.0	60.9
Merchandise Exports in trillion USD (US$)	19.43	18.92	17.63	22.28	24.81	25.24
Merchandise Imports in trillion USD (US$)	19.58	19.10	17.67	22.34	25.30	25.93
International Trade in trillion USD (US$)	49.14	48.45	43.75	54.26	59.84	63.39
Food Exports in trillion USD (US$)	1.61	1.60	1.63	1.90	2.10	2.19
Food Imports in trillion USD (US$)	1.58	1.58	1.61	1.90	2.11	2.16
Merchandise Trade in trillion USD (US$)	39.02	38.02	35.30	44.62	50.11	51.17
Merchandise Trade (% of GDP)	45.5	43.7	41.7	46.4	50.2	49.2

Source: compiled the authors based on [10; 19]

Taking into account the general growth of the population in the world, the volumes of consumption and production of products of the agricultural sector, namely grain and oil crops, meat, milk, vegetables and fruits, are growing, respectively (Table 3).
The advantages of forming a brand of agricultural products are, firstly, the output of products to a more favorable price segment of the consumer market, secondly, the formation of a favorable climate for investing in agrarian business, thirdly, it will contribute to ensuring the employment of rural workers and raising the social status of rural workers economy.
The process of competitive positioning of an agricultural enterprise consists of the following stages.

Table 3. Dynamics of production of agricultural products in the world, in trillion USD

Products	2018	2019	2020	2021	2022	2023
Cereals	0.78	0.78	0.75	0.85	0.86	0.90
Fruit	0.03	0.03	0.03	0.04	0.04	0.04
Meat	0.61	0.76	0.70	0.80	0.79	0.83
Milk	0.07	0.07	0.07	0.08	0.08	0.09
Oil Crops	0.34	0.34	0.32	0.37	0.37	0.40
Other Livestock Products	1.11	1.26	1.18	1.34	1.34	1.41
Vegetabl es	0.03	0.04	0.03	0.04	0.04	0.04
Total	2.97	3.28	3.08	3.51	3.51	3.69

Source: compiled the authors based on [10; 19].

First of all, it is necessary to carry out a comprehensive diagnosis of the agricultural enterprise, the conditions of its operation, to choose criteria and positioning indicators that reflect the specifics of the agricultural enterprise. Second, build a perception map. And, finally, it need to evaluate the occupied position and form a competitive positioning strategy for the future and implement it. The procedure of competitive positioning of an agricultural enterprise is shown in Fig. 1.

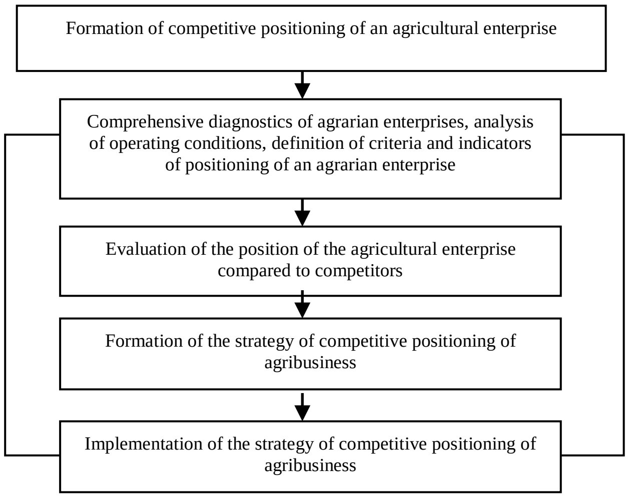

Fig. 1. Procedure of the forming a competitive positioning of an agricultural enterprise
Source: developed by the authors.

The positioning strategies of agricultural enterprises and farms are mostly aimed at large processing enterprises and exports. The positioning strategies of processing agrarian enterprises are aimed at broad segments of the population [13]. The positioning strategy of enterprises providing agrarian business depends on the perception of communication channels and guidelines for the choice of suppliers of agricultural producers and processors.

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When developing a strategy for the positioning of an agricultural enterprise, it is necessary to take into account a large number of external factors that affect business. Such factors include seasonality and weather conditions, which indicate changes in supply and demand for products throughout the year. In addition, unstable weather conditions can affect yields and profitability. The next factor is global competition, since a significant number of countries are exporters and importers of agricultural products, influencing the price and foreign trade policy. Another important factor is the influence of state policy, which is manifested in subsidies, benefits, customs regulations, etc. The factor of long-term production processes also takes place, talking about investment terms and required resources, which minimize the flexibility of this type of activity. In recent years, the influence of the factor of the introduction of technological innovations, which determines productivity, production efficiency, has an impact on the volume of costs and the quality of manufactured products, has been increasing. Finally, the factor of demand for natural products, consumers' understanding of the importance of ecologically clean, natural and organic products, leads to the possibility of actively positioning agricultural enterprises from this point of view.

Selected positioning criteria can be more fully revealed through a set of different indicators. Such indicators can be found as a result of conducting questionnaires, market testing, focus groups, expert methods, etc. We will define a system of evaluation indicators of the agribusiness market situation based on the method of expert evaluation. The results of the expert survey are given in Table. 4.

Experts assessed the degree of influence of each of the parameters by assigning ranks. The ranking was proposed to be carried out as follows.

Experts assigned a rank of one to the most important factor; the rank with the number n is the least important factor.

At the next stage, an analysis of the significance of research factors was performed. The evaluation of the average degree of agreement of experts' parameters was carried out using the concordance coefficient.

Table 4. Results of the expert survey

Evaluation criteria	Evaluations of experts								
	1	2	3	4	5	6	7	8	9
Changes in the structure of the population's needs in relation to the supply of agricultural products	3	3	2	2	5	5	4	4	6
Solvency purchasing demand of consumers for agricultural products	1	1	3	1	4	1	1	1	2
Trends in the development of the world agricultural market	6	8	7	6	6	6	7	6	6
International competition	5	2	4	5	3	2	2	3	3
Regional features for the development of agrarian business	8	7	8	7	7	8	8	8	7
Scales of agricultural market development	2	4	1	3	1	3	3	2	1
Risks of agrarian business	4	5	5	4	2	4	5	5	5
Business activity of the agricultural market	7	6	6	8	8	7	6	7	8

Source: developed by the authors.

The concordance coefficient has a value from 0 to 1. The value of the concordance coefficient is equal to 0.81, which indicates the presence of a high degree of agreement between experts' opinions.

The next step is to assess the significance of the concordance coefficient. For this, the Pearson test is calculated, the obtained Pearson test $\chi 2$ is compared with the table value for the number of degrees of freedom $K = n-1 = 8-1 = 7$ at the significance level $\alpha = 0.05$. Since the calculated $\chi 2$ is greater than the tabular one, the concordance coefficient of 0.81 is a non-random value; accordingly, the obtained results are reliable and can be used in further research.

Therefore, as a result of the study, a system of evaluation indicators of the agribusiness market situation was determined, including product supply, purchasing demand, development trends, regional features, risks, market scale, business activity, international competition. As criteria and indicators that allow assessing the requirements for agricultural products, the following can be considered, namely, the importance and significance of agricultural products for the consumer, the uniqueness of agricultural products, the presence of competitive advantages, the availability of purchase, the acceptability of agricultural products by the consumer, the profitability of agricultural products, the quality of the description brand.

To solve the task of forming a competitive position through an integral indicator, an economic-mathematical model for evaluating the competitive position of agricultural products was formed. Integral assessment of competitive positions of agrarian business is carried out according to the formula:

$$X_{integ} = n\sqrt{(X_1 * X_2 .... X_n)} \text{.......................(1)}$$

where: Xi − comprehensive evaluation of each of the indicator.

The integral indicator of the competitive position of an agricultural enterprise is calculated as the geometric mean of the values that are part of its individual indicators. Conducting a comprehensive assessment of each indicator reflecting the competitive position is determined by the formula:

$$X_i = \sum (P_i * W_i) \text{..(2)}$$

where:

Pi – assessment of experts for each indicator i;

Wi – the specific weight of the i-th indicator is a weighting factor that determines relative importance.

Therefore, a comprehensive assessment of the competitive position of an agricultural enterprise consists not only in determining the indicators, but also in determining the level of influence of these indicators on the competitive position.

The given methodology for assessing the competitive position of an agrarian enterprise is based on a system model of indicators and an expert assessment of specialists, which makes it possible to conduct a comparative analysis.

It is advisable to interpret the integral indicator of the competitive position using the Harrington scale, which provides for five levels of evaluation in the general interval of the scale from 0 to 1. The results of the complex integral indicator in the range of 0.9-1 identify a competitive position of absolute stability, which provides an opportunity to function stably and develop in the markets, implement innovative changes and expand the assortment. The result of the integral indicator in the range of 0.63-0.8 is an indicator of a normal competitive position. An unstable competitive position will be determined by the value of the indicator in the range of 0.37-0.63, which requires the development of innovations in the areas of management, production, sales, etc. The loss of competitive positions is the value of the integral indicator in the range of 0.2-0.35. The value of the integral indicator in the range of 0-0.2 indicates a critical competitive position, the need for urgent organizational and management measures.

Table 5 presents a matrix of competitive positioning strategies, taking into account the influence of the main indicators.

Table 5. Matrix of competitive positioning strategies, taking into account the influence of the main indicators of competitiveness

State of competitive position	Type of competitive positioning strategy		
	Rivalry strategy	Strategy of difference or additional benefit	Strategy of imitation
Stable competitive position	Strategy aimed at developing a competitive position	Strategy aimed at developing a competitive position	Strategy aimed at stabilizing the competitive position
Normal competitive position	Strategy aimed at developing a competitive position	Strategy aimed at stabilizing the competitive position	Strategy aimed at protecting a competitive position
Unstable competitive position	Strategy aimed at stabilizing the competitive position	Strategy aimed at protecting a competitive position	Strategy aimed at protecting a competitive position
Crisis competitive position	Strategy aimed at protecting a competitive position	Strategy aimed at protecting a competitive position	Strategy, curtailment of non-competitive positions
Limit crisis position	Strategy aimed at protecting a competitive position	Strategy, curtailment of non-competitive positions	Strategy, curtailment of non-competitive positions

Source: developed by the authors.

The perception map characterizes the benefits that consumers are guided by when purchasing products. When building a position map, the market is studied and the attributes important for a certain segment are determined, a list of competitive products is formed, and product attributes are compared with competitors' attributes. For each pair of indicators listed in Table 4, you can build positioning curves. The results of the approbation of the mathematical model are presented for two agricultural companies engaged in growing and selling apples, namely Pidhirna LLC (Ukraine) (TM Riola) and Pomi s.r.o. (Slovakia). The results of the calculations and the level of competitive positioning on the example of two agricultural companies are shown in Table 6.

Table 6. Results of assessment of the level of competitive positioning for Pidhirna LLC (Ukraine) and Pomi s.r.o. (Slovakia)

Evaluation criteria	$P_{i\ average}$		W_i	X_i	
	Pidhirna LLC	Pomi s.r.o.		Pidhirna LLC	Pomi s.r.o.
Changes in the structure of the population's needs in relation to the supply on the apple market	6.4	7	0.12	0.768	0.84
Solvency of purchasing demand of consumers on the apple market	3.6	5.5	0.14	0.504	0.77
Trends in the development of the world apple market	6.2	7.1	0.07	0.434	0.497
International competition in the apple market	4.3	4.8	0.09	0.387	0.432
Regional features for the development of agrarian business in the apple market	2.2	5.8	0.11	0.242	0.638
Scales of apple market development	8.1	8.1	0.07	0.567	0.567
Risks of agrarian business in the apple market	3.3	6.8	0.18	0.594	1.224
Business activity on the apple market	6.7	7.5	0.22	1.474	1.65
Integral assessment of competitive positions				0.499	0.721

Source: developed by the authors.

According to the results of the calculations, the integral indicator of the competitive positioning of the company Pidhirna LLC (Ukraine) is 0.499, which indicates an unstable competitive position and the need to implement innovations in various spheres of activity. For Pomi s.r.o. (Slovakia) the integrated indicator of competitive positioning is 0.721, which indicates a normal competitive position. Appropriate calculations allow you to choose a positioning strategy for the further development of the company. The implementation of a competitive positioning strategy involves the use of one or a combination of positioning methods. The main methods of competitive positioning include the method of a unique trade offer, which involves the need to emphasize some feature of products or uniqueness compared to other products; the matching method, which is focused on identifying the main competitors, comparing them and finding differences; the "register" method, which involves the analysis of competitors' advertising appeals and the determination of consumer impact criteria, such as spontaneous associations, attributes, advantages or benefits, territory, image-hero, etc.; a method of building maps that visually shows the importance of products for the target audience; the method of emotional interaction [4], which involves the use of emotional tools that influence the feelings and sensations of consumers, namely the place and meaning of the product in life, the attitude to the product, to the attitude to the company, etc. Therefore, competitive positioning involves the creation and consolidation of a certain brand in the minds of consumers. This marketing tool allows you to consolidate the company's competitive position on the market, as it focuses on product features, differences from competitors' offers. Competitive positioning contributes to the formation of the target audience and strengthening of the brand's position on the market. The changing situation associated with increased competition in agribusiness requires a special approach to developing positioning strategies for agricultural enterprises. This discussion is aggravated by the difficulties and problems associated with the diversity of agricultural enterprises and the peculiarities of their activities in certain countries. In order to operate successfully and maintain a competitive position in the agricultural market, an enterprise must constantly analyze the activities of competitors, their innovations, development directions, and predict possible directions of development. Indeed, relevant measures should be implemented taking into account modern market requirements and consumer demands. For effective competitive positioning, it is important to use all components of the marketing mix, but one of the main roles is assigned to the actions of analyzing and comparing competitors, as they are a mechanism for determining competitive advantages and conveying the position to the target audience. Ultimately, competitive positioning should lead to the formation of a competitive brand. In general, the concept of a company's competitive position is analogous to the individuality and distinctiveness of a trademark. Competitive positioning is designed to ensure the formation in the minds of consumers of the characteristics inherent in the brand and clear differences from competitors. The positioning strategy is one of the components of the development of the company's marketing strategy. It is based on the use of marketing resources, assets and opportunities along with the creation of competitive positions in the market. At the same time, it is advisable to identify the significance of each of the indicators of competitive advantages, which may differ significantly in different areas of business. The peculiarities of agrarian business leave an imprint on the specifics of competitive positioning in the agrarian sphere: the agri-food market limits certain actions of agricultural producers; land is used as a direct resource, means of production and its fertility is different; breadth of product range and market participants; rate of spoilage of agricultural products; significant dependence on natural and climatic conditions, seasonality of production; high risk of agribusiness activity; inconsistency between the working period and the production period; inelasticity of demand for agricultural products in terms of price and income; limited financial resources, etc. Assessing the competitive positioning indicators of an agricultural enterprise allows you to adapt and orient the positioning strategy and marketing strategy to achieve positive performance results. In conclusion, assessing indicators of competitive position in the agricultural market and, accordingly, developing a competitive positioning strategy requires a multifaceted approach. By predicting the behavior of competitors, agricultural enterprises can regulate supply and demand, income, and build trends in their development. This discussion highlights the importance of competitive positioning, innovation and strategic marketing in agricultural business operations.

CONCLUSIONS

In light of the research conducted on the competitive positioning of an agricultural enterprise, we can say that from the point of view of gaining market positions and strengthening competitiveness in the agricultural market, this area is of paramount importance. The results showed that the choice of competitive positioning strategy can affect the performance of the enterprise, increasing its position compared to the position of its competitors. The step-by-step methodology presented in this study in the form of a model of competitive positioning of agribusiness covers the general assessment and diagnosis of the segment of agrarian business, taking into account the external conditions of development and functioning, the formation of indicators regarding the positioning of agribusiness, the comparison of the position of an agricultural enterprise with competitors, the development and implementation of a strategy of competitive positioning of agrarian business enterprises. This integrated approach makes it possible to formulate and implement a competitive positioning strategy for an enterprise. By integrating the findings of this study and learning from previous studies, agricultural businesses can better position themselves in today's marketplace. Thus, the successful competitive positioning of agrarian enterprises is focused on a long-term perspective, helps to strengthen the company's position on the market and effectively develop agrarian business in conditions of high competition. At the same time, one should not forget that in competitive positioning it is necessary to fulfill the promises given to consumers and offer real advantages and benefits.

Since most agricultural enterprises work in an already formed market where there are similar products, when positioning the product, it should be described how and why it differs from the rest. The differences can be described by product characteristics (faster, cheaper, more economical, larger), by distribution channel (home delivery, presence in the network of resellers, online ordering options, etc.) or by service (guarantees of receipt). Also, when positioning agricultural products, you can focus on the needs that agricultural products satisfy (fats, carbohydrates, proteins, useful substances, vitamins, nutritional value, naturalness, etc.). Therefore, competitive positioning should be based on differences, voicing the vision and enthusiasm for what the result of consumption can be.

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ON THE PERFORMANCE OF LOCAL FARMER TECHNICIANS IN RICE-PRODUCING AREAS IN EASTERN VISAYAS, PHILIPPINES

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Abstract

The study determined the rice farmers' perception of the performance of Local Farmer Technicians (LFTs) in selected major rice-producing areas in Eastern Visayas. It also determined the extent of effectiveness and impact of LFTs in delivering the services and support needed by the farmers. The relationship between the rice farmers' profile and the extent of effectiveness and impact of LFTs was also observed. Descriptive-correlational research design and purposive sampling were used to cover 18 municipalities in six provinces of Region VIII reaching a total of 450 farmers. Results revealed that rice farmers were satisfied with the LFTs' services and overall performance. Farm status, other sources of income, and the number of farming years have significant relationships with the effectiveness of LFTs. All profile variables, except other sources of income, were not significantly associated with the impact of LFTs. Other sources of income were significantly associated with the impact of LFTs on farmers' farming practices and knowledge. All profile variables, except estimated family income were not significantly associated with the impact of LFTs' on crop performance. Overall, LFTs were perceived by rice farmers as knowledgeable, very informative, and competent. However, few farm visits and failure to follow the scheduled meetings are the major drawbacks. Hence, it is highly recommended that the Department of Agriculture (DA) should increase the incentives and provide funding to expand targeted municipalities and collaborate with Agricultural Training Institute (ATI) and PhilRice to design a season-long training suitable for LFTs.

Key words: *rice farmers, Local Farmer Technicians (LFTs), effectiveness, impact, rice crop performance*

INTRODUCTION

The government's plan to attain food staples sufficiency in the Philippines is to enhance the efficiency and quality of extension services provided to rice farmers [3], [4]. The main organizations offering these services, which are designed to hasten the adoption of modern farming techniques and technologies are the Local Government Units (LGUs) [9]. More extension workers are required because the small number of agricultural extension technicians is insufficient to reach a sizable number of farmers [5]. At the moment, there are more than 150:1 rice farmers to LGU technicians. More farmers will be able to make use of new and improved technology as well as other farm support interventions by helping to expand the current extension workforce of LGUs through the Local Farmer Technicians (LFT) Program [9].

The agricultural extension technician is responsible for providing the information and knowledge required for a farmer to understand and select a particular innovation, as well as for communicating that information to the farmer. In this role, the agent is seen as an extension agent assisting farmers in applying knowledge and serving as a channel for knowledge, the majority of which is technical [5]. The technical know-how and data that the agent needs to convey to the farmers are given to him together with official training for this role [20]. The main challenge facing agricultural extension in the twenty-first century is developing low-cost, sustainable service delivery systems that go beyond simply sharing knowledge to actively support farmers as the key change agents in their communities [1]. Farmers' learning and creative capacities, as well as their potential to organize for more fruitful production and marketing and to demand extension services, must all be enhanced by these initiatives [17].

An extension agent can benefit greatly from the cooperation of local leaders in many ways [5]. In addition to acting as a point of contact between the agent and the farmers, they can take on specific responsibilities in the agent's absence, aid in setting up local extension organizations, and directly contribute to the dissemination of new ideas and practices by putting them to work in their fields. The extension agent will be able to contact considerably more farms with their assistance than he could if he did it alone. Collaborating with local leaders fosters stronger relationships with farmers in the area, boosts their trust in the extension service, and increases their readiness to take part in outreach initiatives [16]. The Department of Agriculture (DA) and Local Government Units (LGUs) consider rice farmers as active partners in the LFT Program, working together to promote and disseminate rice farm technology. The long-standing requirement for farmer-to-farmer extension services is another goal of this extension strategy. Under the LFT Program, skilled and knowledgeable rice farmers are brought in as collaborators and hands-on participants in the advancement of contemporary post-production and production techniques. The scheme will be put into place in the municipalities with low-yielding performance under the irrigated lowland rice fields [18].

To assist agricultural extension workers assigned in LGUs in developing and improving modern technologies for rice cultivation and post-production, the LFT Program aims to establish a core of competent and experienced rice farmers [18]. In general, this study aimed to evaluate how well LFTs in Eastern Visayas support and develop contemporary post-production and rice production technologies, working in tandem with LGU-based agricultural extension workers. Specifically, the study tried to: (1) determine the extent of effectiveness of LFTs in delivering the services and support needed by the farmers; (2) find out the impact of LFTs on the rice farming knowledge and practices and crop performance of the farmer respondents; (3) determine the relationship between the respondents' profile and the extent of effectiveness of LFTs in delivering the services and support needed by the farmers; (4) find out the relationship between the respondents' profile and the impact of LFTs on their rice farming knowledge and practices crop performance; and (5) determine the obstacles and difficulties local farmer technicians encounter when providing extension services to the community's rice farmers. The study has assessed the effectiveness of LFTs in disseminating information, providing technical assistance, the impact of their services on rice yield and income, adoption of new rice technologies, and identification of challenges they face.

MATERIALS AND METHODS

Research Design

A descriptive-correlational research design was used in the study employing a quantitative method through a survey to assess the performance of LFTs as reinforcement of LGU-based agricultural extension workers in Region 8. Selected farmers who were students of the LFT Program per municipality in the identified study sites were included in the survey.

Locale, Respondents, and Sampling

The study was conducted in the major rice-producing areas in Eastern Visayas, where there is an existing LFT who is qualified and trained. The study covered six provinces in Region VIII (Eastern Visayas), namely; Northern Samar, Eastern Samar, Biliran, Leyte, Southern Leyte, and Samar province. Three municipalities per province having the largest irrigated rice areas were selected. Ormoc City, Abuyog, and Carigara were selected for the Leyte province, while Southern Leyte, Hinunangan, Saint Bernard, and Hinundayan were included in this undertaking. For Biliran province, Naval, Caibiran, Almeria, and Samar province, Calbayog City, Basey, and Gandara. For Eastern Samar, the three municipalities to include were Dolores, Balangkayan, and

Llorente, and for Northern Samar, Catubig, Catarman, and Las Navas (Map 1).

Map 1. Eastern Visayas, Philippines.
Source: [11].

Purposive sampling was used in selecting the covered municipalities per province based on the size of the irrigated rice area, thus the top three municipalities with the largest area were included. The study used total enumeration to obtain the number of farmer respondents, and since there are 18 municipalities under study, a total of 450 farmer respondents were involved in the study (Table 1).

Table 1. Farmer respondents.

Province/municipalities	Irrigated rice area (in hectare*)	No. of farmers
LEYTE		
Ormoc City	4,227.50	25
Abuyog	3,517.25	25
Carigara	2,726.50	25
SOUTHERN LEYTE		
Hinunangan	1,151.00	25
Saint Bernard	1,119.01	25
Hinundayan	931.00	25
BILIRAN		
Naval	1,873.00	25
Caibiran	1,852.00	25
Almeria	905.00	25
WESTERN SAMAR		
Calbayog City	1,133.88	25
Basey	647.00	25
Gandara	206.50	25
EASTERN SAMAR		
Dolores	1,485.00	25
Balangkayan	278.00	25
Llorente	206.50	25
NORTHERN SAMAR		
Catubig	449.17	25
Catarman	336.00	25
Las Navas	331.00	25
Total		**450**

Note: *2019 Validated Rice Area, DA-RFO8.
Source: Authors' computation (2024).

Research Instrument and Data Collection

The developed questionnaire prepared was used to gather data. To guarantee its applicability and that the questions are written in a way that farmers can understand, the questionnaire was pre-tested. A questionnaire was used to conduct facilitated interviews with the sample respondents to gather data for the survey. The questionnaire asked about personal details, interactions with local farmer technicians, expertise and practices related to rice farming, the yield, income, and quality of rice crops, as well as comments and general satisfaction.

Data Analysis

Descriptive statistics was used to analyze the data gathered such as means, frequency counts, percent, mean, median, interquartile range (IQR), and standard deviation were used for objectives 1, 2, and 5. It makes data presentation meaningful and comprehensible, which facilitates a more straightforward interpretation of the relevant data set. The following correlation coefficients were used for Objectives 3 and 4: Cramer's V coefficient was used to determine how strongly two variables are related to one another. The variables of interest should be categorical, with two or more unique values per category, to use it; As an alternative to computing the entire connection, contingency coefficients were utilized to determine whether an association exists between the data sets. Rank biserial coefficient was applied to quantify the correlation between a continuous variable and a dichotomous variable, or variable with two values; and Spearman rank coefficient was used to assess the direction and degree of correlation between two sets of data when sorted according to each of their respective quantities. This method helps determine the linkages between the data and the degree to which the measured results are affected by external factors.

RESULTS AND DISCUSSIONS

Profile of Farmers

Table 2 shows the profile of farmers in terms of sex, marital status, educational attainment, farm status, and other sources of income. The data showed that a great majority of the farmers are male (60.2%) the rest are female (39.8%) and a majority of them are married (92.7%) and 6.9% are single. In terms of educational attainment, farmers are either elementary graduates (24.7%), High School level (17.6%), or High school graduates (37.1%). Only a few are college graduates (4.4%) and college level (9.3%). For the farm status, most of the farmers are tenants (60.2%), 34.2% own their farms, and 5.6% are leasing their farms. More than half (52.4%) of the farmers do not have other sources of income other than income from rice farming.

Table 2. Profile of rice farmers.

Profile variables	No. of farmers	Percent (%)
Sex		
Female	179	39.8
Male	271	60.2
Marital Status		
Single	31	6.9
Married	417	92.7
Separated	2	0.4
Educational Attainment		
Elementary Level	31	6.9
Elementary Graduate	111	24.7
HS Level	79	17.6
HS Graduate	167	37.1
College Level	42	9.3
College Graduate	20	4.4
Farm status		
Owner	154	34.2
Tenant	271	60.2
Lease	25	5.6
Do you have other sources of income aside from regular income?		
Yes	214	47.6
No	236	52.4

Source: Authors' computation (2024).

Table 3 presents the profile of farmers in terms of age, number of years in rice farming, and land area planted with rice. Results show that every rice farmer in Eastern Visayas has an average age of 55.6 years old and has been in rice farming for 27.9 years. More than half of the rice farmers have an estimated monthly income of at least PhP5000.00. In terms of ecosystem tilled, out of 450 farmers, 446 of them or about 99% are cultivating lowland rice farms with an area of one hectare, on average. Only one is cultivating an upland rice farm with an area equal to 0.5 hectares. Nine farmers are cultivating rainfed rice farms with a median area of 0.5 hectares.

Table 3. Profile of farmers in terms of age, number of years in rice farming, and land area planted with rice.

Variable	Mean/ Median	Std. Deviation/ IQR
Age (N=450)[1]	55.6	10.3
No. of years in rice farming (N=450)[1]	27.9	11.9
Estimated monthly family income (N=450)[2]	5,000.0	3,000.0
Area of land planted with rice (Lowland, N=446)[2]	1.0	1.0
Area of land planted with rice (Upland, N=1)[2]	0.5	NA
Area of land planted with rice (Rainfed, N=9)[2]	0.5	0.75

1=Mean and SD were used since the data distribution is symmetrical.
2=Median and IQR were used because the data distribution is skewed.
Source: Authors' computation (2024).

Effectiveness of Local Farmer Technicians (LFT)

The frequency of farmers' interaction with LFTs, services, and support provided by LFTs, and LFT's efficacy in providing these services is shown in Table 4. Results showed that almost all (99.23%) of rice farmers in Eastern Visayas had interactions with LFTs and these interactions occurred mostly either on a weekly (46.7%) or monthly (39.1%) basis. Interactions may be in the form of farm visits, cellphone calls, text messages, and training workshops. The majority of the targeted municipalities of this program have conducted an information drive spearheaded by the Department of Agriculture – Regional Field Office 8 (DA-RFO 8) in coordination with the Municipal Agriculture Office informing farmers that their municipality has two trained local farmer technicians to assist in the promotion of modern rice production and post-production technologies in the municipality [15], [13], [19]. In the presence of LFTs in the municipality, regular interaction occurred between the farmers and LFTs. Moreover, the LFTs are focused on the improvement of the yield and income of the rice farmers, thus creating an impact on the lives of the rice farmers. This result corroborates with DA-RFO 8 year-end reports that showed records of frequent visits of the LFTs to the rice farmer farms [10].

Table 4. Farmers' interaction with Local Farmer Technicians (LFTs), services and support provided by LFTs, and LFTs efficacy in providing these services.

	No. of farmers	Percent (%)
Have you had any interactions with Local Farmer Technicians (LFTs) as a part of your province's rice enhancement program?		
Yes	447	99.3
No	3	0.7
How often do you interact with LFTs?		
Daily	6	1.3
Weekly	210	46.7
Monthly	176	39.1
Rarely	55	12.2
Never	3	0.7
Support services provided by LFTs		
Advice on managing diseases and pests (N=450)	449	99.8
Crop planting and maintenance instructions (N=450)	448	99.6
Advice on irrigation and water management (N=450)	441	98.0
Suggestions for enhancing soil fertility (N=449)	417	92.9
Advice for post-harvest treatment and storage(N=449)	391	87.1
Information on markets and value-added products (N=450)	371	82.4
Local Farmer Technicians' efficacy in providing the services and support		
Not effective	1	0.2
Slightly effective	18	4.0
Moderately effective	83	18.4
Effective	270	60.0
Very effective	78	17.3

Source: Authors' computation (2024).

Moreover, Table 4 shows the LFTs' efficacy in providing services and support to farmers. The majority of the farmers believed that LFTs are effective (60%) and some said very effective (17.3%) in providing them the necessary support services. This indicates that there is a considerable degree of trust and confidence in the expertise and support offered by these local experts to the rice farmers. In [5], it is mentioned that extension agents are one way to help develop strategies for delivering information effectively, comprehending the information needs of clients, and removing obstacles to information consumption. The researcher stressed that LFTs can communicate in farmers' common language and have a greater understanding in terms of mannerisms, farming practices, and farming needs of the farmer [5], [17], [7]. This clearly shows that the "fellow farmer" is the driving force behind the acceptance of innovations and plays a crucial role in increasing awareness of the farmers [8]. The presence of LFTs likely enables farmers to adopt and implement suggested practices, resulting in favorable outcomes in their farming operations.

The top four most common services provided by LFTs are providing advice on disease and pest management (99.8%), instructions on crop planting and maintenance (99.6%), providing advice on irrigation and water management (98%), and providing suggestions on enhancing soil fertility (Table 4). The two less popular services are giving advice on post-harvest treatment and storage (87.11%) and providing information on markets and value-added products (82.4%). Most of the farmers encounter pest and disease problems in their farms, this is one of the most critical problems they face in rice farming. In order to ensure that the issue was caused by pest damage and not by another factor, the first and most important stage in any pest is to seek advice from the LFT on how to solve the conditions of the crop.

The report of the DA-RFO 8 validated this result that rice farmers' number one problem is pests and diseases. Inaccurate pest identification leading to incomplete knowledge about a pest is the most common reason for unsuccessful pest control efforts. For instance, in a part of Leyte Province, farmers are facing tungro disease spread by leafhoppers. This disease causes stunted growth, produces fewer tillers, and yellowish leaves in rice crops. Worried about their harvests, farmers want advice from our LFTs on how to manage this disease to protect their crops. Once the pest has been identified by the LFT, they can begin researching its life cycle, behavior, and the factors that contribute to its development [15],[14]. This includes exploring preventive measures and effective control strategies [2].

The farmers seek advice on crop establishment and maintenance from our LFTs because crop maintenance practices must be done promptly and it depends on crop growth stage, soil, crop, and weather conditions [18]. The farmers must adhere to the procedures of crop establishment, land preparation, and the use of premium seeds of a variety that is advised. Likewise, the LFTs were asked for advice on irrigation and water management because the rice crop must have an adequate amount of water to promote stronger plant vigor, improved nutrient absorption, consistent growth, control of weeds and snails, promote ripeness, and enhanced farmer operations efficiency [5], [18]. The suggestions on enhancing soil fertility were sought from our LFTs because they guarantee fulfilment of the crop's potential yield. Nutrients required by the crop in which fertilization fills the discrepancy between what crop requires and what is presently found in the air, water, and soil at the moment [2], [12].

The respondents highlighted that they ask for the least advice from LFTs regarding post-harvest treatment and storage, although it's crucial to know how to manage correctly in drying, cleaning, and maintaining grain quality during storage. The way farmers manage their fields and handle rice after harvesting affects the quality and quantity they achieve. It all starts with decisions like which variety of rice to grow and continues with actions like planting, crop establishment, harvesting, drying, and milling [6], [10]. The farmers showed little interest in seeking information from our LFTs regarding markets and value-added products. However, they were encouraged to process their value-added products to gain more benefits from trading and value-added operations. Many smallholder farmers, taking inspiration from past mistakes, have adopted a new way of thinking that involves less dependence on government assistance and no longer selling their rice to middlemen [16]. It remains challenging for smallholder farmers to transition into entrepreneurs and compete in the global trading landscape. Many factors persistently hinder their capacity to broaden their involvement in the demand side of the supply chain, leading to a reluctance to seek credible advice. These findings suggest that post-harvest management and storage services market information and value-added operations were not a top priority for rice farmers. They showed less interest in these areas because their primary focus was on establishing healthy crops that lead to higher grain yields.

Impact of Local Farmer Technicians on Rice Farming

Table 5 shows the impact of LFTs on farmers' knowledge and techniques for rice cultivation which resulted in all farmers (except one) having altered their rice cultivation method after their interactions with the LFTs. The changes that farmers instituted in the farms after their interactions with LFTs were improved land and planting preparations and practices (31.8%), improved fertilization and use of organic fertilizer (20.2%), improved water management (19.8%), improved pest management (14.9%), use of technology and mechanization (7.9%), and use of quality seeds and proper seed germination procedure (5.8%). These alterations demonstrate farmers' receptiveness to extension assistance, their adoption of sustainable farming methods, and their dedication to raising agriculture's productivity, profitability, and resilience. This implies that the farmer's adoption of the technology will most likely be assimilated and implemented when the benefits of implementation are quickly realized [2], [5], such as the increase in yield and income from rice production. Suitable agricultural methods were the options supportive of the farmers' success and helped the agriculture sector become more sustainable.

Almost all (99.6%) farmers observed that their income from rice production has increased from the knowledge and practices gained from their interactions with LFTs. Several farmers (38.7%) reported that their income has increased by 20-39%. About 33.6% of the farmers reported an increase of 40-59% of their income from rice production. This overwhelming affirmation of income growth provides proof of the usefulness and efficacy of the extension services provided by LFTs. The LFTs' existence and expertise in rice production as a partner for change is convenient to farmers as they are not hesitant to seek advice about crop production if in case they encounter a challenging situation [17]. This underlines how important extension programs are in filling knowledge gaps, encouraging the use of new technologies, and strengthening farmers' resilience in the face of

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changing obstacles to increasing rice yield of rice that results in higher income [5], [6].

Based on the data, 34% of farmers believed that LFTs have a moderate impact on their knowledge and techniques in rice cultivation, while the majority of farmers reported that LFTs have either a significant impact (45.6%) or very significant impact (16.0%) on their showed knowledge and techniques in rice cultivation. All of the LFTs have expertise and understanding in rice cultivation because they achieved hands-on experience in rice farming. Besides, LFTs have firsthand knowledge of the issues encountered in the field, so they can impart to farmers easily [7].

Table 5. Impact of LFTs on farmers' knowledge and techniques for rice cultivation.

	No. of farmers	Percent (%)
After interacting with LFTs, have you altered your methods of rice cultivation in any way?		
Yes	449	99.8
No	1	0.2
Changes made in rice farming after interaction with LFTs		
Improved land preparations and planting preparation and procedures	143	31.8
Improved Fertilization	91	20.2
Improved water management	89	19.8
Improved Pest management	67	14.9
Use of technology and mechanization	34	7.6
Use of quality seeds and proper seeds germination procedure	26	5.8
Did your income from rice production increase?		
Yes	448	99.6
No	2	0.4
Percentage increase in income from rice production (Median = 30%, IQR=30%)		
Less than 20%	64	14.2
20-39%	174	38.7
40-59%	151	33.6
60-79%	28	6.2
80% and above	33	7.3
Impact of LFTs on farmers' knowledge and techniques for rice cultivation		
Slight impact	16	3.6
Moderate impact	153	34.0
Significant impact	205	45.6
Very significant impact	76	16.9

Source: Authors' computation (2024).

Farmer views of the impact are positive, indicating that farmers appreciate the guidance, advice, and technical assistance provided by LFTs in addressing their specific needs and challenges.

Table 6 presents the impact of LFTs on rice crop performance and LFTs' overall performance in making changes in farmers' rice yield or quality was observed by almost all (99.6%) of farmers after their interaction with LFTs. Of these changes, 96.7% are increased in yield and good quality of the produce (3.3%).

Table 6. Impact of LFTs on rice crop performance and LFTs overall performance.

	No. of farmers	Percent (%)
Have you observed changes in rice yield or quality since working with LFTs?		
Yes	448	99.6
No	2	0.4
Changes in rice crop performance that occurred since working with LFTs		
Higher yield	433	96.7
Good quality produce	15	3.3
Impact of LFTs on rice crop performance		
No impact	0	0.0
Slight impact	15	3.3
Moderate impact	124	27.6
Significant impact	223	49.6
Verysignificant impact	88	19.6
Farmers' overall satisfaction with LFTs		
Very satisfied	108	24.0
Satisfied	321	71.3
Neutral	20	4.4
Dissatisfied	1	0.2
Very Dissatisfied	0	0.0

Source: Authors' computation (2024).

The majority of the farmers reported that either LFTs have a significant impact (49.6%) or a very significant impact (19.6%) on rice crop performance. These results show that LFTs are essential for enabling gains in rice crop performance, which raise yields and improve product quality. The effectiveness of extension interventions in promoting sustainable agricultural practices, enhancing crop management techniques, and alleviating yield-limiting variables is indicated by positive changes in yield and quality [16].

The majority of the rice farmers (71.3%) indicated that they were satisfied with the services provided by LFTs and 24% stipulated that they were very satisfied with the services of LFTs. The findings demonstrated how effective extension programs are in satisfying farmers' needs, providing useful support, and encouraging productive rice farming methods. It also demonstrated how contented the rice farmers were in the delivery of extension services by the LFTs. High satisfaction ratings prove that extension services have a positive impact on farmers' empowerment, new perceived ideas, and agricultural output advancement [5]. For farmers who responded neutral (4.4%), either they may be satisfied or dissatisfied with the LFT's overall performance could be attributed to their minimal interactions with the LFTs.

Correlation Analysis

Table 7 depicts the relationship between farmers' profiles and the extent of effectiveness of LFTs in delivering services and support needed by the rice farmers. Based on the results, the age, sex, marital status, educational attainment, and estimated family income of farmers were not significantly correlated or associated with the effectiveness of LFTs in delivering services and support needed by the farmers. This means that younger and older farmers both male and female, reported almost similar ratings on the extent of effectiveness of LFTs. Being single or married or separated has nothing to do with the extent of effectiveness of LFTs. It is also reflected in the data that a higher level of education of farmers does not always imply a higher rating on the effectiveness of LFTs. However, regardless of family income, farmers have similar ratings on the effectiveness of the LFTs.

The data relative to farm status, other sources of income, and the number of years in farming have significant relationships with the effectiveness of LFTs in delivering services and support needed by the rice farmers. It was observed that land owners and tenants gave relatively higher effectiveness ratings than those farmers who lease their farms. The result construed with the research conducted in [6], it has been observed that land ownership significantly influences the productivity and technical efficiency of rice farmers in the Philippines, including their interaction with extension agents. Specifically, land ownership exerts a notable impact on technical efficiency, leading to a decrease in the technical efficiency levels among leasehold farmers when compared to land owner-operators. It is worth noting that elevated rental rates for ricefields may potentially lead to a decline in rice productivity and technical efficiency. The rice farms that were more independently owned and tenanted were more likely to adopt technologies to increase agricultural production and earn more income. The farmers with other sources of income gave relatively lower effectiveness ratings than those without other sources of income. In [1] and [6], it is portrayed that farmers with another source of income seek to reap financial rewards that are more likely to have relatively large-scale operations.

This is because small-scale farmers continue to struggle with limited funding. Farmer with lower income tends to have a lower level of understanding. Being in the low-income category greatly affects their financial outlook and decision-making.

The data reveals that farmers who have longer farming experience gave a higher effectiveness rating.

In [6], it is stated that farmers were more inclined to accept new agricultural technologies as they got older. They were much more inclined to adopt new technology if they had more training expertise.

Training experiences serve as a means of education, enabling farmers to grasp and become proficient in the application and financial worth of new technology while also encouraging the adoption of new technology by farmers.

Table 7. Relationship between farmers' profile and extent of effectiveness of LFTs in delivering services and support needed by farmers.

Profile Variable	Coefficient	p-value	Interpretation
Age[4]	0.0362	0.4436	Not significant
Sex[1]	0.1121	0.1296	Not significant
Marital Status[1]	0.0834	0.3738	Not significant
Educational attainment[1]	0.0933	0.7014	Not significant
Farm Status[2]	0.1247	0.0073	Significant
Estimated Family Income[4]	0.0568	0.2290	Not significant
Another source of income[3]	0.1211	0.0116	Significant
Years in rice farming[4]	0.1373	0.0035	Significant
Area (Lowland)[4]	0.0348	0.4616	Not significant

Note: Area for upland and rainfed were not included in the analysis due to very few observations; 1=Cramer's V coefficient; 2=Contingency coefficient; 3=Rank biserial coefficient; 4=Spearman rank coefficient.
Source: Authors' computation (2024).

As a result, the experienced farmers adopted the technology since they had previously evaluated the farming methods used over time.

The lowland area cultivated is not significantly associated with the effectiveness of LFTs in delivering services and support needed by the farmers.

This means that the area of the farm has nothing to do with farmers' rating of the effectiveness of the LFTs.

Tables 8 and 9 present the relationship between farmers' profiles and the impact of LFTs on farmers' practices knowledge and crop performance. Results showed that in terms of the impact of farming practices and knowledge, all profile variables, except other sources of income, were not significantly associated with the impact of LFTs on farmers' farming knowledge and practices. A non-significant association or relationship means that these farmers' profile variables have nothing to do with the ratings given by farmers on the impact of LFTs on farming practices and knowledge. Other sources of income were significantly associated with the impact of LFTs on farmers' farming practices and knowledge. This means that having or not having an extra source of income has something to do with the impact of LFTs. Farmers with an extra source of income tend to give relatively lower ratings to their extension agents than farmers who do not have an extra source of income. In line with the study in [5] and [6], it was reported that households that diversify their sources of income did a deliberate strategy to reduce risks and seize farm-promoting possibilities. The purpose of income diversification is to mitigate the impact of crop failures and economic hardships by managing risks and providing a cushion. They diversify their sources of income throughout the off-farm season to avoid becoming idle and identify their maximum labor impact of crop failures and economic hardships by managing risks and providing a cushion. This diversification of income necessitates the need to ask for advice from farm advisors such as LFTs. Thus, diversify their sources of income throughout the off-farm season to avoid becoming idle and to identify their maximum labor capability. As a result, income diversification promotes smallholder households' well-being and fights hunger and poverty.

Table 8. Relationship between farmers' profile and impact of LFTs on farmers' practices and knowledge

Profile Variable	Coefficient	p-value	Interpretation
Age[4]	0.0014	0.9758	Not significant
Sex[1]	0.0750	0.1121	Not significant
Marital Status[1]	0.0546	0.7203	Not significant
Educational attainment[1]	0.0735	0.1201	Not significant
Farm Status[2]	0.0878	0.1081	Not significant
Estimated Family Income[4]	0.0059	0.9015	Not significant
Another source of income[3]	0.1279	0.0066	Significant
Years in rice farming[4]	0.0616	0.1920	Not significant
Area (Lowland)[4]	0.0407	0.3888	Not significant

Note: Area for upland and rainfed were not included in the analysis due to very few observations; 1=Cramer's V coefficient; 2=Contingency coefficient; 3=Rank biserial coefficient; 4=Spearman rank coefficient.
Source: Authors' computation(2024).

Table 9. Relationship between farmers' profile andimpact of LFTs on farmers'crop performance.

Profile Variable	Coefficient	p-value	Interpretation
Age[4]	0.0181	0.7024	Not significant
Sex[1]	0.0235	0.6187	Not significant
Marital Status[1]	0.0623	0.6288	Not significant
Educational attainment[1]	0.0617	0.1924	Not significant
Farm Status[2]	0.0576	0.2226	Not significant
Estimated Family Income[4]	0.1199	0.0109	Significant
Another source of income[3]	0.0634	0.1792	Not significant
Years in rice farming[4]	0.0853	0.0706	Not significant
Area (Lowland)[4]	0.0146	0.7567	Not significant

Note: Area for upland and rainfed were not included in the analysis due to very few observations; 1=Cramer's V coefficient; 2=Contingency coefficient; 3=Rank biserial coefficient; 4=Spearman rank coefficient.
Source: Authors' computation (2024).

In terms of the impact on farming crop performance, data shows that all profile variables, except estimated family income, are not significantly associated with the impact of LFTs' on crop performance (Table 9). This means that these variables do not in any way influence farmers' rating of LFTs' impact on crop production. In other words, these variables have nothing to do with farmers' rating of LFTs' impact on crop production. On the other hand, the farmers' estimated family income is significantly associated with their ratings on the LFT's impact on crop production. Farmers with higher levels of income gave higher ratings on LFTs' impact on crop production. They are consequently more open to implementing new agricultural technologies and stand to gain more from doing such undertakings [2], [7], [19].

Table 10 presents the identified strengths of LFTs in delivering extension services to rice farmers. These were the common strengths identified by the respondents during their interaction with the Local Farmer Technicians. According to the farmers, LFTs are knowledgeable, very informative, and competent (31.3%). It implies that LFTs are equipped with the knowledge and skills needed to give rice farmers insightful advice, as they were equipped with training and capacity building mostly extended by the Agricultural Training Institute and the Department of Agriculture [9].

Based on the data, 17.3% of the respondents mentioned that LFTs are considered the best teachers, demonstrating their efficacy in transferring information and skills to farmers. Since they were farmers themselves, they could easily adjust to the attitudes and behaviors of other farmers. The LFTs were reliable, willing to help, and approachable since they were farmers themselves (10.7%) as stipulated by the respondents. Thus, respondents admire their dependability, readiness to provide a helping hand, and approachability. This suggests that asking LFTs for assistance is convenient for farmers. Besides, the LFTs are active, friendly, helpful, and do actual field visits as responded by 9.1% of total respondents. The respondents appreciate the active participation, friendliness, helpfulness, and readiness of the LFTs to conduct field visits. This suggests that LFTs actively take part in helping farmers and offer practical support. Thus, the LFTs are a big help to farmers in terms of rice production (4.2%).

The shortcomings identified by the farmers in their LFTs are their few visits to the field and failure to follow the scheduled meeting with farmers (14.7%). The irregularities in LFT field visits and scheduled farmer meetings are a possible weakness in the extension services' delivery, which can result in reduced chances of receiving support and direction [12]. In [20], it is noted that extension workers typically move slowly and with limited mobility since they lack the operating capital to travel. Besides, there were limited extension agents to handle every agriculturally related issue in their communities, and they were forced to deal with unanticipated occurrences that came up before the field visit, which made it challenging for them to attend the scheduled meeting.

Table 10. Challenges and constraints encountered by LFTs in delivering extension services to rice farmers.

	No. of farmers	Percent (%)
Strengths		
LFTS are knowledgeable, very informative, and competent	141	31.3
LFTs are good teachers	78	17.3
LFTs are reliable, willing to help and easy to approach since they are farmers themselves	48	10.7
LFTS are active, friendly, helpful, and do an actual field visit	41	9.1
LFTS are a big help to farmers in terms of rice production	19	4.2
Shortcomings		
Limited resources	40	8.9
Seldom visits the field and does not follow the scheduled meetings with farmers	66	14.7
Needs more training to upgrade their knowledge	22	4.9
Challenges/Constraints		
The incentive received by LFT is not enough for transportation	32	7.1
Locations of LFT are in far-flung barangays and unfavorable road conditions	26	5.8
Too many locations to attend	18	4.0
Use of social media to reach LFT	13	2.9

Source: Authors' computation(2024).

Another shortcomings of LFTs are limited resources (8.9%) which means resource scarcity is a major drawback on the part of LFT. Furthermore, the LFTs need more training to upgrade their knowledge (4.9%), suggesting improving their expertise.

The challenges and constraints identified by the rice farmer are found in Table 10. The incentive received by LFTs was not enough for transport (7.1%) which ranked first and this shows that the expenses of LFTs' travel may not be sufficiently covered by the current remuneration structure, which could affect how well they were able to reach the group of farmers. In [5], it is portrayed that the effectiveness of extension workers was significantly hampered by their slow and restricted mobility, presenting formidable obstacles in extending crucial support and services, especially to isolated barangays. To handle this challenge effectively, it is essential to strengthen programs implemented by the LGUs by facilitating the immediate transfer of financial resources. By doing so, we can mitigate reliance on funding from the national government and empower LGUs to address mobility constraints among extension workers including the LFTs more independently.

Secondly, the locations of LFTs were in far-flung barangays with unfavorable road conditions (5.8%). This illustrates the geographical obstacles that impede farmers in remote places from accessing extension services. Other constraints faced by LFTs were too many locations to attend (4%) and respondents mentioned that LFTs encounter difficulties as a result of having to visit too many places. This suggests a demanding workload, which can have an impact on the efficacy and caliber of extension services. Lastly, the use of social media to reach LFTs (2.9%) even if it's comparatively low, points to a possible chance to enhance outreach and communication tactics by using digital platforms to engage with farmers [5], [16].

CONCLUSIONS

The study's findings offer a comprehensive insight into the role and impact of Local Farmer Technicians (LFTs) in Eastern Visayas, particularly within the region's major rice-producing areas. It becomes evident that these technicians are not only perceived as effective by rice farmers but also deemed as providers of essential support services crucial for agricultural development. Furthermore, the study highlights a moderate yet discernible impact of LFTs on rice farming knowledge and practices among farmers. This impact is substantiated by observable alterations in cultivation methods and a noticeable increase in income derived from rice production, all of which point to the effectiveness of LFT interventions. Moreover, farmers report a significant positive impact on rice crop performance attributed to the services provided by LFTs, underscoring their satisfaction with the support received. Intriguingly, demographic factors such as age, sex, marital status, and educational attainment, alongside estimated family income, do not seem to significantly influence the effectiveness of LFTs, suggesting that other variables such as farm status, other income sources, and years of farming experience play more significant roles in determining the efficacy of LFT services. Additionally, the study underscores the importance of farmer perceptions in assessing the success of extension programs. These perceptions not only provide valuable feedback but also serve as indicators of trust and credibility within the farming community, thereby facilitating continuous improvement and adaptation of extension services to meet the evolving needs of farmers. However, the study also sheds light on challenges faced by farmers, such as limited incentives for LFTs, transportation issues in remote areas, and the need for better communication channels, including the utilization of social media. In general, the findings emphasize the vital role of LFTs in agricultural development and the necessity for ongoing support and innovation to enhance extension services and support for rice farmers in Eastern Visayas.

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ANALYSIS AND ASSESSMENT OF THE IMPACT OF DISASTERS AND ACCIDENTS ON THE FUNCTIONING OF RURAL AREAS IN BULGARIA

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Abstract

This article is devoted to analyzing and assessing the impact of disasters and accidents on the conditions for the socio-economic and demographic development of rural areas in Bulgaria. The topicality of the topic is caused by the necessity of the new conditions of globalization to overcome regional and local risks related to the population's way of life. To a large extent, the processes of urbanization and the relocation of the population in urban areas lead to the creation of threats to its security, mainly by disrupting the reliability of the functioning of the natural-ecological and socio-economic systems. Therefore, rural areas and their potential for security and regional development must be strengthened. In this regard, it is important to create the necessary basic conditions for the life and development of the population - minimum infrastructure, taking measures to reduce natural and environmental risks through a system encompassing activities and facilities for monitoring, maintaining, and cleaning riverbeds and forests in sparsely populated areas in Bulgaria.

Key words: *emergency, disaster, conditions, labor, rural, region, system, crisis, management*

INTRODUCTION

In the context of dynamic processes brought about by globalization and the integration of national economies, population migration gives rise to a new type of problem in rural areas of the European Union. According to the urban-rural typology, in 2023 rural-dominated regions represent almost half (45%) of the area of the European Union. According to preliminary population data from Eurostat on 1 January 2024, only about 23%. of the EU population lives in rural areas. Again, according to Eurostat, over the years 2015-2023, the population of predominantly rural areas has decreased by an average of 0.2%. per year, while the population of intermediate regions has hardly changed. On the other hand, the population in predominantly urban areas grew by 0.5% on average. per year. During the same period, the number of elderly people grew rapidly. The population of people aged 65 and over grew by 1.6% each year. in predominantly urban and intermediate regions. However, the fastest growth in this group is among residents of predominantly rural areas (1.8% per year) [32]. Rural development is the "second pillar" of the Common Agricultural Policy (CAP), which reinforces the "first pillar" of income support and market measures by strengthening the social, environmental, and economic sustainability of rural areas. In countries in transition like Bulgaria, there is a wide range of problems to be solved in rural areas. Still, we will focus on the importance of crisis management, or mainly disaster and accident management, as a factor for the functioning of rural areas, and hence the population's good health. The solution to such a range of problems is linked to the different rates of increase in economic development, which leads to increasing disparities between different territorial communities. In other words, the different rates of economic development in countries such as Bulgaria also set the daily difficulties in terms of optimal functioning of rural areas, and the human capital problems in them lead to the deterioration of the civil security system. In practice, today civil security is changing its focus and depends mainly on preventive measures of the government to deal with disasters, accidents, crises, epidemics, and not least terrorist acts in urban areas [32]. The agricultural and non-agricultural parts of the rural area form a separate entity from the urban area is characterized by a strong concentration of residents and vertical and horizontal structures. Thus, in the context of rural development, the ability of rural development action to respond to current and future challenges, such as climate change and generational change, while continuing to support European farmers to achieve a sustainable and competitive agricultural sector, also comes to the fore. The approach is further complicated by the necessity to differentiate between rural and urban areas. A distinction that is particularly challenging in countries such as Bulgaria. This is because, for example, the municipality of Stara Zagora includes an urbanized urban area and 52 predominantly rural villages. The traditional distinction between urban and rural areas in a country is based on the assumption that urban areas, as defined in that country, offer a different standard of living and usually a higher economic standard of living. The term rural does not have a common definition across countries, making it difficult to compare rural areas globally or even nationally. In this context, this report examines the concept of governance from the perspective of a systems approach, according to which governance is a system that brings together a set of interrelated elements whose functioning is subordinated to a clear and well-defined objective. This system unites two main elements - the object and the subject of management [35]. It can be assumed that the activities of planning, commanding, organizing, coordinating, and controlling are indivisible and should be considered as a whole rather than as separate and independent of each other. In the present exposition, we will try to combine, rural-governance-crisis management (disaster, emergency, and health). Here is the place to emphasize that the model of interaction: public sector - crisis management - business - population is based on ensuring normal conditions for quality functioning of the territorial system. Thus, the living environment in rural areas needs mechanisms to maintain a high level of security in the face of reduced demographic potential and difficulties in securing the financial resources for preventive action towards early recovery from disasters and accidents in these regions. In general, all European regions have distinct mechanisms for responding to crises resulting from disasters, accidents, and catastrophes. In this direction, the European Union in 2013 started to assess the risk of disaster occurrence in individual European countries [28].

In addition, rural areas should move towards digitization This means the automation and robotics introduction of production using high-performance machines and digital technologies to strengthen the rural farmer. The goal is to record every process on every machine and be able to generate it as a coverage map. This information should be able to be visualized and cross-referenced on top of other layers of information. This approach will enable farmers to digitally monitor their tillage practices and plan future operations. However, this should be done by building an integrated environment where they can anticipate possible crises, rains, hurricanes, disasters, and other events that may affect business development. Therefore, all economic actors in rural areas must be aware of the philosophy and foundation of socio-economic life in rural areas [27]. As understood by the World Health Organization (WHO), disasters and catastrophes are natural phenomena or human activities that pose or pose a threat to the lives of populations at different scales but often have very severe consequences for local development and the lives of populations. It is important to note that phenomena such as earthquakes are among the most dangerous natural disasters, as they cause enormous damage, realized in a short time. Another event associated with the disruption of the territorial system is flooding, which is a natural disaster, it is accompanied by an increase in water masses per unit area. Flooding is most often a temporary inundation of a land area or territory with a huge amount of water due to the rise in the level of water basins and riverbeds and, more recently, from large amounts of rainfall. Of course, in rural areas, water sources are important because of their agricultural profile and the need to carry out a range of activities related to the irrigation of individual crops and plantations. The reasons for the rise in the level of these water bodies can be various - intense rainfall or snowmelt, dam breaks, dike breaches, high waves, or human activity. It is another matter that, through their behavior, the public sector and local businesses are called upon to create the conditions to minimize the potential for flooding by implementing a series of activities and measures to maintain reliable infrastructure. There is a need for the whole environment surrounding communities to be monitored. Based on the assessment of the condition of critical infrastructure, it is also necessary to plan for the construction of new infrastructure and to renovate and develop it by implementing targeted programs to prevent water disasters, end the practice of turning ravines into landfill sites, and organize annual sanitary logging. It has been observed so far that due to the deterioration of infrastructural facilities, the problems of rural development are creating conditions for several problems related to the level of public works, leading to the deterioration of the regional environment and hence the quality of life. This means in rural areas to clearly understand the motive of programming and planning regional policies and measures to improve infrastructure. Overcoming the challenges associated with negative processes and a deteriorated living environment is a serious challenge for the management of the European Union, and access to funds is easier, and the public sector and local businesses must have the necessary experience and capacity to implement successful projects that are sustainable over time. This is the place to identify grant application forms that provide a variety of approaches to applying to the EU institutions. Structuring mechanisms and programs through which the European Union aims to improve the lives of people in rural and border regions, mountainous areas, disaster areas, flood areas, etc., so as not only to overcome the effects of the problems but also to create new economic opportunities for the affected populations. It is worth stressing here that, given the demographic characteristics of rural areas, more resources need to be allocated thereby continuing to implement innovative practices and policies that implement preventive regional policies linked to a series of preventive activities. Thus, in line with this policy, there is a special concern for rural areas in the countries of the European Union. This concern intensified in the 1980s, after the adoption of Greece (1981), Portugal, and Spain (1986), when rural areas were associated with values such as the preservation of nature and the improvement of life in them, as well as attempts to impose new agricultural activities and policies to develop the potential of several rural areas [5]. Following the adoption of a specific map entitled 'European rural map', the following definition of rural areas was given: rural area means continental or coastal land, including villages and small towns, where the majority of the land is used for agriculture, forestry, aquaculture and fisheries, economic and cultural activities of the inhabitants of these regions (crafts, industry, services, etc.), the function of recreation and leisure of an extra-urban nature or nature conservation and other uses.

Another aspect of orienting regional policies towards settlements is their characteristics and scope. In this direction, it is important to note that the concept of village (or rural) represents a territory (an area with land) in which a certain number of the population lives [26]. Here we should emphasize that the rural space is not a homogeneous entity, and it is not an abstract space either although the multitude of concepts and definitions given by specialists refer to the same physical (geographical) space. Thus, the implementation of targeted policies in rural areas often requires the application of solutions that are balanced, ecological, pragmatic, and efficient. This directly corresponds to the new vision in rural areas to ensure a well-fed and thriving society, responding to new issues such as climate change, animal welfare, food safety, and sustainable use of natural resources. Here, we can draw on the 2013 reform through which the European Union sought to respond to these demands by including greening payments, which increased the sustainability of agriculture. Also, a fairer distribution of aid, which limited the budget for large farms, and additional support for smaller farms through better targeting of income support. In rural areas, it was agreed to create incentives for young people to start a career in agriculture [6]. In practice, these reforms are difficult to implement because funding is available for machinery and technology, and rural areas are not building think tanks, innovation labs, special technology schools, etc. In this direction, for a better crisis management, there is a need to establish regional units of leading firms for evaluation, analysis, and monitoring and reforms should have direct practical application on the development of institutional environment in rural areas besides increasing the expenditure on rural development projects [1]. In this context, this article is devoted to analyzing and assessing the impact of disasters and accidents on the conditions for the socio-economic and demographic development of rural areas in Bulgaria.

MATERIALS AND METHODS

The research methodology is set by the object which is rural areas. In addition, the processes taking place in rural areas may have positive or negative outcomes. This gives the important methodological point that rural areas have their own framework and development potential, it is just that in this case only partial processes or phenomena are presented that pour on rural areas and change the picture. This approach needs to be institutionally regulated with the development of the necessary indicator framework of rural conditions so that we can get a comprehensive picture of the rural situation through indicators The authors' idea is to look at the vulnerabilities and opportunities for disaster and disaster prevention in rural areas, but also to assess risk management in rural areas. The management of this system determines the state and development of rural areas in Bulgaria, but this approach can also show the state of rural areas in other parts of the EU. The approach should look at key normative documents, and incorporate data on demography, history, climate, etc. by analyzing the crises that have occurred in rural areas (small settlements), and accidental events that have created conditions part of the environment that are highly vulnerable and poorly protected [7]. The collection of data from multiple and heterogeneous users created serious challenges for the old centralized systems. Today, as a result of rapid development, Blockchain technology now provides the capabilities to quickly integrate information from disparate sources and quickly transform it into useful information. The main objective of the authors is to analyze and assess the state of the system to prevent and overcome crises of various nature [3]. The authors will achieve the goal thus formulated by using a variety of approaches and methods. These can include territorial, normative, and system approaches, which include the analysis of causal relationships, statistical, descriptive, and analytical methods, induction and deduction, and analysis of normative documents. Information provision includes public databases such as the National Statistical Institute, electronic websites of municipalities, etc. In addition, we can assume that the assessment of disasters and accidents can also be presented on the basis of logarithmic regression, which was derived as an evaluation method by a group of researchers.

They do an experiment based on the characterization of countries by types of natural disasters, economic losses, mortality and other indicators that help analyze eight types of natural disasters related to droughts, earthquakes, extreme temperatures, floods, volcanoes, forest fires and land slides.

This study also emphasizes the impact of human development indicators such as per capita income and human capital (level of education) on natural disaster deaths (total deaths, total affected and total economic losses) in 79 selected countries based on of the use of dynamic panel data analysis [25].

This is a way also to evaluate these processes and phenomena and to be able to argue and show a comparative assessment of disasters and accidents. Here is the place to add that the research thesis that the authors put forward is that rural areas are exposed to greater risks of disasters and accidents, given the fact that the working conditions are field conditions and given the climatic anomalies, not always informational and technological improvements are fully effective, so there is a need to work for continuous improvement of the effective disaster prevention and management system, as the problems with accidents and accidents in rural areas must go with the imposition of correct public policies that have a significant impact on formation of quality prevention and influence on local communities and economic participants, in order to be able to effectively and everywhere overcome crisis events and deterioration of living conditions [29].

RESULTS AND DISCUSSIONS

Current Bulgarian legislation defines a disaster as "an event or a series of events caused by natural phenomena, accidents, accidents or other extraordinary circumstances that affect or threaten the life or health of the population, property or the environment to an extent that requires the taking of measures or the participation of special forces and the use of special resources Thus, the more remote areas and peripheral settlements due to the lower level of urbanization, sufficient capacity and human resources have their own problems for preventive and organizational activities to deal with disasters and accidents at the local level. In addition, it can be noted that most rural areas in Europe are undergoing a profound change, driven by the intensification of urban lifestyles and the depopulation of villages. On the other hand, urbanized territories are formed around a city, around which are located at least 4-5 settlements with a gravitational zone of about 10-15 kilometers. However, they have their own needs and a development framework that has its own local problems and difficulties. This creates a complex system of settlements that have different problems and a need to find common solutions to similar problems.

At the same time, rural areas need a significant improvement of the urban way of life by improving infrastructure and logistics at a local scale. It is characteristic of rural areas in most Eastern European countries that they are looking to develop their new economic profile as an upgrade to their agricultural foundation. This process leads to frequent contrasts in the development of the regions and the need for quality regional policies that lead to infrastructural and economic order. Thus, problems are created at the level of public works, which in turn leads to other problems related to the quality of services, education, culture, transport and the functioning of regional business. This leads to a need for a better medium-term setting of the regional development goals of rural areas. The process of searching for one's own image and sustainability of settlements often negatively affects the available human capital and pushes it towards migratory mobility. On the other hand, the deterioration of infrastructural provision and the lack of clear development programming leads to depressed development of rural areas, which makes public institutions and businesses less efficient. This further emphasizes the problems of a local nature, and hence the possibilities for effectively dealing with the disasters and accidents that any region may be exposed to. Thus, not solving a number of problems and the emergence of new ones leads to the vulnerability of the territories of rural areas from disasters and accidents. On the other hand, rural areas have a number of current problems to solve, which makes them vulnerable in terms of delineating groups of policies and activities related to village improvement and preventive action against disasters and accidents. Therefore, it can be concluded that rural areas should implement quality policies for improvement, solving spatial and social problems. In addition, the driver of local development is the regional business, which has its own approach to human capital and achieving the well-being of the respective rural area. In general, however, business and the public sector often do not realize their shared role to take some kind of preventive action against possible future disasters, accidents and problems with critical infrastructure. Here is the place to emphasize that, in practical terms, the sustainable development of rural areas is achievable when there is a symbiosis between business and public administration regarding the construction of a quality infrastructure environment [14]. Failure to achieve this symbiosis leads to the danger of crises and the creation of an unstable environment. In rural areas, it is necessary, in terms of crisis management, to assume that the object of management is the rural area (including the settlement and the land) on the territory of a municipality or district, in which dynamic changes or events can occur that change drastically their surroundings. This leads to the occurrence of a change, and from there to the implementation of a policy to regulate the change that has occurred in our surrounding environment. Often, events such as disasters and major accidents have a significant impact on the established socio-economic process and conditions of normal development, leading to a change or an emergency situation that has an impact on the population and settlements in rural areas [33]. Here we can give an example of a "crisis of a local nature" (a situation that may lead to a significant and sudden reduction and/or temporary interruption of the supply of energy products according to Annex A, Chapter 3.4 of Regulation (EC) No. 1099/2008 and heavy fuels caused by extraordinary events on the territory of the rural area (within a given country) including as a result of temporary technological and/or other difficulties. Due to their remoteness and quality infrastructure in the winter months, a number of territories often fall into the hypothesis of a crisis of Another issue is that such a phenomenon can also be defined as a change in the established state of life, covering territories, objects, sectors and spheres of the economy and public life or the environment, caused by human activity or natural phenomena, as a result in which the conditions for existence and for carrying out activities in the changed environment are severely violated. In other cases, we consider extreme weather conditions, both in frequency and magnitude. Such is the case in Louisiana, which has recorded the fastest sea level rise in the 21st century. In this case, the problem of rapid and sustainable recovery and crisis management arises. This is often related to preventive activities to deal with disasters or accidents, or conducting a series of training and preparing the population for these complex events [15]. Thus, regulating public relations related to the prevention, control and overcoming of the consequences of crises, public administration in rural areas must accept the concept of "crisis" by regulating the principles and requirements for management in crisis conditions, so as to regulate the construction and functioning of a system of crisis management in rural areas.

On the other hand, the variety of terminology used about the various processes and phenomena in agriculture brings the term 'situation' to the fore. A situation is understood as triggering the need for a response of the public management system that guarantees the state of society, the functionality of the public sector, and the vitality of the local population. It is therefore essential to elucidate the meaning of the term "health" and its implications for the public development of settlements. The population health status is of paramount importance for regional rural development. At the same time, the role of the regionalist is to manage territorial processes and find a balance in crises, disasters, accidents, catastrophes, etc. This process is about finding the balance between concepts. Therefore, it is necessary to introduce a relatively consensual term such as "disaster medical insurance [9]. It is necessary in rural areas to have the necessary functional connections in the security system at the regional level at the vertical and horizontal network level, without detailing the duties of individual departments in the crisis management process. The latter are expected to be determined by by-laws and in rural crisis management plans. The main response measures are the different types of operations - humanitarian, search and rescue, emergency rescue, firefighting, anti-terrorist and other specialized police operations, which are carried out depending on the forecasts and real parameters of the crises that may arise. [17, 5].

In order to develop the prevention process, it is necessary to have the necessary critical mass of participants in the process in the form of volunteers and interested persons, but rural areas in Bulgaria have been depopulating in recent years.

This process leads to a reduction in human potential and the possibility of greater efficiency in the implementation of preventive actions. At the same time, emigration from rural areas also leads to the impoverishment of these regions, which is expressed in an increase in significant socio-economic differences compared to urban areas and, on the other hand, a limitation of the basic living conditions in them. [18]. Table 1 can trace the population dynamics in villages and cities from 1900 to 2010, and this trend is maintained now (Table 1).

Table 1. Population in towns and villages in Bulgaria from 1900 - 2011

Years of censuses	Total	In cities	In villages
1900	3,744,283	742,435	3,001,848
1926	5,478,741	1,130,131	4,348,610
1934	6,077,939	1,302,551	4,775,388
1965	8,227,866	3,822,824	4,405,042
1985	8,948,649	5,799,939	3,148,710
2001	7,928,901	5,474,534	2,454,367
2011	7,364,570	5,338,261	2,026,309

Source: National Statistical Institute, NSI [20].

These basic conditions are related to the basic services provision such as health, education, infrastructure, and respectively the establishment of a system of prevention from crises, disasters, and accidents. This process is not isolated and is known not only in Bulgaria but also in many countries. This is evidenced by studies of rural areas in Asia where the relationship between rural disasters and emergencies and the emergency response system is analyzed [20]. Traditionally, the main economic activity in rural areas is agriculture. And agriculture is highly susceptible to natural disasters as evidenced by some studies [7]. The impact of natural disasters can be reduced through preventive activities in rural areas. This way, the challenges that arise because of the disasters are combated [4].

A more targeted analysis shows that our nation's territory, including the urbanized areas in Bulgaria, shows that rural areas account for nearly 81.4% of the national territory. This statistic is derived from the definition used by the Rural Development Program [29]. Thus, out of 266 municipalities in Bulgaria, 231 are rural (at LAU 1 level). These areas are home to 23% of the country's population, indicating that they are much less densely populated and have a greater concentration of natural resources [22]. At the same time, a territorial classification is used in the EU to consider urbanization at the district level, and according to this classification, there are 28 districts in Bulgaria, which are divided into three types: predominantly rural (15), intermediate (12) and predominantly urban (1) (Map 1).

Map 1. Map of rural-urban areas on NUTS 3 level according to EU definition 2010.
Source: [9].

According to the Institute for Market Economics in Bulgaria in a study dedicated to rural areas, some important secondary characteristics are highlighted [33]. The analysis is based on quantitative methods with the calculation of an index reflecting their position relative to the national average in terms of 4 indicators - average wages per employee, unemployment rate, levels of total economic output, and value-added per capita.

Based on this, an analysis is carried out and it is established where each district stands compared to the national average. Based on this and on the variance that exists within the regions themselves, a methodology is used to assess the ability of these regions to achieve positive growth in some of the indicators examined, to remain at their average level at which they are, or even to worsen their situation.

The socio-economic development of rural and urban areas shows differences, with rural areas performing much worse on important socio-economic indicators, compared not only with predominantly urban regions but also with intermediate regions.

According to the survey results, a positive result from a region implies a better performance compared to the national average, while negative values indicate a situation falling short of the national average. The Synthetic Socio-Economic Index scores the predominantly rural areas of the country much lower than the average score, by about 35% (index minus 0.35).

As we can see from the data for the period 2010 - 2020 there is a reduction in floods, landslides, and fires.

Floods were reduced from 651 (2010) to 100 in 2020 (Table 2).

Table 2. Floods in Bulgaria 2010 - 2020

	2010	2011	2012	2018	2019	2020
Number	651	382	692	84	108	100
Damages in BGN thousands	38,882	206,659	20,898	28,384	21,173	16,664

Source: NSI [15].

Landslides have decreased from 59 to 24 (Table 3).

Table 3. Landslides in Bulgaria 2010 - 2020

	2010	2011	2012	2018	2019	2020
Number	59	76	72	27	31	24
Damages in BGN thousands	2,182	224,790	17,384	6,248	8,101	154,996

Source: NSI [20].

Fires have also declined over the period, being reduced from 1,630 in 2010 to 754 (Table 4).

Table 4. Fires in Bulgaria 2010 - 2020

	2010	2011	2012	2018	2019	2020
Number	1,630	2,185	3,010	480	521	754
Damagesin BGN thousands	2,239	2,186	1,437	1,703	194	281

Source: NSI [20].

There were 41,348 crisis events over the entire period (Table 5).

Table 5. Crisis events in Bulgaria by group for the period 2010 – 2018

Reason for crisis event (by group)	Crisis number
Natural disasters	5,969
Fires	15,977
Accidents and disasters	19,151
Pollutions	132
Other natural and anthropogenic crisis events	119
Total	41,348

Source: NSI [20].

Flash floods, some of which even take victims, seem to pass us by less and less often. If we look at NSI data, we see that in 10 years - from 2010 to 2023 - there have been more than 100 such events. Most of them are in the Sliven region, followed by Blagoevgrad and Kardzhali region. animals) and not rarely there are human casualties. Thus, in rural areas, we are witnessing climate change and anthropogenic impacts on the riverbanks, such as the growth of residential and commercial buildings in flood plain terraces. Another problem is emerging due to reduced numbers of animals decreasing the natural water-holding capacity of the soil caused by land use, contributing to an increase in the likelihood of flooding and its adverse effects. The threat of climate change makes this need even more urgent.

There are studies in which heat waves have been observed in recent decades [22]. In practice, the duration and intensity of heat waves creates conditions for fires [22]. These findings were proven in 2024, when the summer heat wave was very prolonged, leading to a sharp increase in average temperatures and the risk of fires. As a consequence, in the mountainous areas, which are the least populated rural areas, a series of fires occurred that were difficult to contain for weeks. An interdisciplinary approach is needed to address this challenge. This calls for the combined efforts of the country's scientific potential and the executive to build lean systems for flood prevention and sustainable flood risk management to protect and mitigate the effects of floods.

Rural areas in Bulgaria are characterized by a high degree of landslide and erosion-abrasion activity. According to estimates, the funds required for the study of landslides in the country, including the design, strengthening, and monitoring of such occurrences are more than BGN 1,800 million. Funds have also been earmarked for landslide prevention and counteraction under the Operational Programmer "Environment", but these funds have been difficult to spend effectively over the years. Active landslide processes are a danger to all plant and animal species. Because landslides overwhelm vegetation, disturb natural bird habitats, and affect the population of animal species. However, very often the issue of biodiversity conservation is overexposed, and in this case, there are other, more significant, risks in rural areas, because they often lack the means to restore them.

Forest fires will continue to increase in frequency due to climate change and they will increasingly affect areas that have not been considered at risk of such natural disasters in the past. Preliminary figures for the first three months of 2024 show a near doubling of fires compared to the same period last year, but fortunately, they have not resulted in as much forest destruction. Rural areas in Bulgaria are usually the most affected.

The data show reductions in crises, but the consequences are usually significant. It is therefore important to carry out preventive activities that are regulated by national legislation. According to some experts, Bulgaria is characterized by a well-developed legislative base, but there is a process of transition towards a system of equal evaluation of prevention, preparedness and recovery activities [10].

The normative analysis shows that three laws regulate the functioning of the national crisis management system. The main law is the Law on the Management and Functioning of the National Security Protection System [9]. On the other hand, the public relations related to ensuring the protection of life and health of the population, and the protection of the environment and property in disasters is the Disaster Protection Act [17]. The third law that was in effect was the Crisis Management Act, which was repealed [18]. Linked to these laws are a disaster risk reduction strategy and plan. The National Strategy for Disaster Risk Reduction 2018-2030 [20], which sets the direction of action until 2030, outlines a coherent framework to adequately reduce existing risks and prevent new ones from occurring, enhance preparedness and response capabilities, and rapidly recover from disasters while adhering to the principle of "build again but better". To implement the national strategy, a National Disaster Risk Reduction Program 2021-2025 has been adopted to promote the resolution of several disaster-related issues, but the program is largely under-resourced. Measures to prevent or reduce the consequences of possible disasters on the territory of Bulgaria, as well as measures to protect the population, and the distribution of duties and responsible authorities and persons for these measures implementation are set out in the National Disaster Protection Plan. The Bulgarian State has certain deficits in implementing consistent policies in rural areas and acquiring the capacity to do so. The basic principles of disaster protection articulated in the legislation are the right to protection of every person, the priority of saving human life over other protection activities, the publicity of information on disaster risks, and the activities of the executive authorities in disaster protection. In recent years, the occurrence and accidents of the disaster have shown a low level of preparedness in the State and municipalities [14]. There is a need to establish regional centers and networks between municipalities in rural regions to combat disasters and emergencies and to conceptualize a new way of approaching prevention and staffing regional centers and rescue services. The measures are necessary because the consequences of such crises take years to overcome.

Socio-economic resilience is determined by access to basic resources and is one of the most important factors in predicting the coping capacity of communities at risk i.e. their ability to 'absorb the blow' and 'recover' after a disaster has occurred [37]. Socio-economic vulnerability and (lack of) resilience can be caused by contemporary social and economic conditions, but are more often rooted in long-term historical processes

[8]. Depopulation is more pronounced in rural areas with lower economic development, leading to the emergence of so-called "ghost towns" semi-abandoned areas with insufficient infrastructure and limited access to basic services [23]. Based on the rural development data, it follows that the lack of population and the deficit of targeted government policy do not help to shape visions and understandings of prevention activities at the municipality level to deal with disasters and emergencies. On the other hand, there is a need to create good living conditions in rural areas, which is directly linked to the provision of different types of services and the continuous improvement of lifestyles. These services also include preventive activities to limit crises of various kinds. The link between the socio-economic performance of regions and the territorial classification by type of urbanization is quite pronounced and rural areas, even at the district level, are much more deprived and with worse socio-economic indicators than other types. In reality, only 5 districts have higher than the national average socio-economic index values and this indicates that the stratification is very high and as a territory about 75% is below the average socio-economic index values [21]. In practice, socio-economic factors such as income inequality and poverty levels, employment patterns and livelihoods, as well as access to services and social inclusion, can determine the long-term impact of disasters on certain population groups and the potential for recovery of affected populations [19].

The analysis of rural areas in Bulgaria shows a low level of education and health services provision. Very often there is no medical center or doctor in small settlements. The same applies to territorial fire safety services, police, and other institutions providing basic services [13]. Having a prepared rural health care management system in disaste situations has an important and decisive role in achieving high efficiency. In rural areas, the activity of medical forces and means (teams, formations and facilities) is structurally determining in the medical provision of the population in complex working conditions, difficult accessibility and shortage of medical resources. In rural areas, it is necessary to build a system of medical assistance that would create conditions for the effectiveness of emergency medical assistance. The creation of "Regional Assistance" with direct Euro funding will allow to reduce the complexity of the procedures for applying the national legal and regulatory framework in crisis management, especially in rural areas and in the fulfillment of international obligations. With the formation of the "Regional Assistance" system and a special phone for rural areas, emphasis will be placed on the speed and security of assistance, as well as working with volunteers and paramedics for prevention and increasing the effectiveness of the system of rapid and urgent assistance in rural areas. One can also think about creating a special law in the field of crisis management in rural areas to assist the population and to build mechanisms for effective access to medical care. The accumulation of practice and the creation of structures to regulate the relationship between state authorities, private commercial companies, and non-governmental organizations in the management of crises, disasters and emergency situations is a necessary condition in rural areas.Thus, it is necessary to achieve a level of efficiency in rural areas that can be applied sustainably. The requirements for prevention and the implementation of targeted policies in rural areas should be universal, both for the health system in terms of medical insurance and for the actions of other authorities to manage the protection of the population in disasters. Prevention activities are an important part of crisis management, especially in rural areas, as well as the preservation of life and health of the rural population [16]. The management of the rural crisis management system, including prevention, requires system characteristics such as rigidity, flexibility, continuity, and operability. In 2014, the Commission proposed the introduction of a common standard and mechanism for the prevention and management of disasters and emergencies, including the preparation of response and management scenarios [28].

Fig. 1. National risk assessment according the European Commission.
Source: [28].

Assessing country risks is a process that should be seen as much broader than assessing individual risks. Adequate assessment involves - acquiring relevant and correct information, identifying the risk and implementing an adequate assessment system, considering which benefits to preserve and potential impacts, developing realistic scenarios, providing useful and usable results (Fig. 1) [28].

It is important to note that the establishment and maintenance of an operational picture of the general and medical situation is indispensable for effective medical management. This includes activities to collect, collate, synthesize, and summarize disseminated information about the disaster and the general and medical situation created from all relevant information sources [11]. Achieving a common operational picture allows all entities involved in the management of an incident to have the same information on the timing, actual damage and consequences, resources available on and off the scene, the status of requests for assistance, and any other data needed to support decision-making at different levels [3]. In addition, an operational picture of the medical situation is needed by the authorities managing the overall protection activities at national, district, and municipal levels, NGOs, private sector organizations, critical infrastructure owners and operators, and all other organizations and individuals who have a role in managing and containing the effects of a disaster for effective, consistent and timely decisions. Having an operational picture at the time of an incident helps to ensure the coherence of the entire disaster protection system [24]. In 2023, several rural municipalities (one located in central Bulgaria, at the foot of the Balkan Mountains; the others are located on the Black Sea but also in a mountainous area) were severely flooded as a result of rainfall. The floods caused serious damage to the infrastructure in the municipalities, from which they have not yet recovered. Services analyses show conclusively that the large tidal waves that inundate urban areas are caused by deforestation, and non-clearing forest areas and riverbeds, leading to the appearance of barriers that then unleash water on settlements. These cases show that there is a lack of preventive action by the state to prevent such disasters. Experience shows that subsequent recovery is difficult due to a lack of financial resources, administrative capacity, and people to do it [2]. Studies have been conducted in relation to the occurrence of fires and floods in Bulgaria [30]. The study analyzes the example of the city of Varna, where a huge flood occurred in 2014. It caused 11 fatalities and was a consequence of deforestation. Another study also examines the flooding in Asparuhovo (Varna), where good coordination between local and central government was observed [15, 12]. The following problem is found that after the reconstruction the basic living conditions are not created at a sufficient level, which reflects in a decrease in the quality of life. Maintaining the forest stock not only limits flooding, but on the other hand is linked to fire prevention. Bulgaria's proximity to the Mediterranean area increases the risk of fires, which requires risk assessment and preventive action. Using GIS systems, 3D modelling, mapping and sensor devices makes it possible to analyse such events and predict the direction and movement of fires. And this can improve the management and mitigation systems for disasters that occur [30]. The analysis and assessment of the impact of crises on rural development is strongly economic. On the one hand, rural areas are under-resourced, and this influences crisis management. On the other hand, the lack of resources limits the development opportunities in rural areas [35, 24]. Usually, the state policy is not focused on rural areas, which appear peripheral to highly urbanized territories [36]. The case of Greece and rural development is similar. In Portugal, we can also observe similar phenomena due to the rural nature of the country [31]. In practice, the lower level of development in rural areas makes them vulnerable to disasters and accidents. It is therefore necessary to take targeted action towards these regions. The change in the politico-economic system has led to a change in the driving force of spatial planning in Bulgaria, including the rural areas of Bulgaria. For these reasons, the spatial development of rural areas after 2007 became extensive and unsustainable. Often rural areas have parts in a depressed state and are unmaintained and some places very poor condition. Rural development policy in Bulgaria is applied selectively by functional and investment designation. Legislative changes are needed to address the delayed implementation of the adopted spatial plans. Finally, it is good to assess the possibility of achieving sustainable agricultural development, but to a large extent, business must properly manage the process before and after the disaster. Thus, some of the leading researchers suggest that it is necessary to make a detailed analysis of the possible negative consequences in advance. This type of analysis will help to accurately identify the location, area and level of damage for each farmer. The most appropriate way to solve such tasks is through spatial data analysis through GIS and remote sensing techniques [34].

Bulgaria has a strong legal and institutional basis for disaster risk management. The system thus ensures long-term resilience to climate risks. In Bulgaria, significant efforts have been made to decentralise responsibilities for preparedness, prevention and response at district and municipal level, including building the necessary capacity at lower levels. Early warning, preparedness and response systems and capacities are well developed. One of the most significant challenges in the area of disaster risk management and climate resilience are minimising financial shocks following disasters, and financing and undertaking systematic risk reduction efforts [19, 3].

CONCLUSIONS

The research results show that in practice the impact of disasters and accidents is significant in rural areas and the population living conditions are important to attract investment. Due to underdevelopment and lack of adequate infrastructure, we notice difficulties and conditionalities related to situation normalization in the respective territorial communities. In the first place, there is a lack of a financial instrument at the national level that would allow timely and decisive action to be taken when living conditions deteriorate. It is clear from the presentation that the emphasis on prevention is linked to the activities' organization to reduce the impact of disasters and accidents, without providing solutions to the case and ways of effectively restoring the quality of living conditions in rural areas. In practice, the integration of this complex set of activities and structures, in the process of disaster crisis management is only possible through competent pre-planning and assignment of tasks within the framework of general disaster protection regulations at the municipal and district levels [3]. As has become clear, there is a link between the level of development of rural areas in Bulgaria, the provision of different types of services for normal life in them, and crisis prevention preparedness [8,19]. Since the last census, it has become clear that the demographic situation in rural areas has severely deteriorated, and a process of demographic deserts has begun to form. The worsened demographic situation directly affects the possibilities of taking preventive actions and measures to reduce the risk of disasters [19].Therefore, rural areas are more vulnerable, and when crises occur, it is difficult to overcome their consequences. Data analysis shows that rural areas in Bulgaria are sparsely populated and underdeveloped, outside the focus of the state, which determines the strong dependence of these territories on emerging disasters and emergencies. It is necessary to develop the multifunctionality of rural areas, which means economic diversification and increasing the opportunities for employment of people in non-agricultural activities in the settlements and their lands. Also, to carry out training and project activities for the preparedness of economically active persons and the public sector to deal with disasters and accidents in rural areas. This will allow the regions to gain more experience and experts in disaster and accident prevention and crisis management in rural areas.

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COMPARATIVE RESEARCH REGARDING THE ENERGY EFFICIENCY OF WHEAT CROP, IN ECOLOGICAL AND CONVENTIONAL CULTIVATION SYSTEMS

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Abstract

Due to the importance of the winter wheat crop, in ensuring the food needs of the population, and for increasing the average and total production, it is necessary to ensure a high economic efficiency of the use of energy in agriculture, by increasing the degree of mechanization in production processes, the development of irrigations, the substantial increase in the quantities of chemical fertilizers used, the creation of new varieties and hybrids that are more productive and of higher quality, increases direct and indirect energy consumption. In order for this share not to increase, given the substantial growth in agricultural production, it is necessary to apply a complex of measures that ensure, along with the increase in the economic efficiency of energy use, a minimum energy consumption per unit of product or per unit area. Conserving soil and preventing soil degradation has become imperative in our efforts to ensure food security, protect biodiversity and maintain healthy ecosystems. The purpose of establishing this experiment was to compare the results regarding the production achieved in the wheat crop, the expenses incurred, the incomes achieved and the profitability of the crop both in ecological and conventional systems. In the conventional system, the incomes were higher so, the yields were higher. The energy efficiency of the two culture systems analyzed was another aspect studied. For realize one unit of product it was consumed 0.108 kwh in conventional system while, in organic variant it was consumed 0.184 kwh, witch mean a better energetic efficiently for conventional one.

Key words: *wheat, culture technology, conventional system, ecological system, energetic efficiency*

INTRODUCTION

Due to the importance of the autumn wheat crop, in ensuring the food needs of the population, in addition to increasing the average and total production, it is also necessary to ensure a high economic efficiency of the use of energy, and the calculation methods used allow to determine the contribution of the various treatments to increase production and improve energy indicators, given that the economic profitability of crops within agricultural holdings differs depending on the volume of production factors used and their influence on production obtained [4, 6]. The areas cultivated with grain corn was 3.3 million ha, absolute record being recorded in 1992 [17]. Conventional farmers should be encouraged to switch to organic farming, and organic farmers should be properly rewarded for the public goods they deliver, producing quality food while protecting nature [3]. Increased support for organic farming is a smart public policy tool to ensure that the next CAP will contribute to the green agreement and the goals of the Fork and Biodiversity Farm strategies [13,14]. Achieving 25% organic land in the EU by 2030 will only be achievable if Member States devote a much larger share of the CAP budget to organic conversion and maintenance than is currently the case in most countries(Ecological Agriculture) [3,12,14]. Mechanization creates environmental risks because it does not differ from the conventional one in terms of fuel for agricultural work [2].

A study carried out and published by the European Commission concluded the comparison made between the two agricultural models - organic and conventional - to see which is more profitable [22, 23].

Following research, it has been proven that organic farming brings slightly higher incomes in some cases [23]. When factoring in the upfront costs of pesticides, fertilizers or fuel to get the crops, organic farming has some advantages [4]. It turns out that mechanization creates environmental risks, because it does not differ from the conventional one in terms of fuel for agricultural works [7, 18]. The main conclusion of the study is the existence of small differences between the two agricultural models when it comes to invested capital, but the expenditure is aimed at obtaining certifications and investing in special equipment [2,19].

Organic farming is a management system of agricultural production that favors renewable resources and recycling and does not harm the environment [13].

Several surveys and studies have attempted to analyze and compare conventional and ecological agricultural production systems.

Organic farming is less harmful because ecological farms do not consume or release synthetic pesticides into the environment, because their use would result in damage to the soil, water and wildlife, terrestrial and aquatic; ecological farms support ecosystems. The beneficial action of the tillage system on a crop factor must keep the other factors at an acceptable level [20, 21], so that the increase of agricultural production, the decrease of fuel consumption or the increase of the soil production capacity can be possible through economic optimization solutions [1, 7, 16, 18]. Compliance with the rules and principles for the production of organic crops are regulated by national legislation. The control of the entire technological process of obtaining such a product is done by inspection and certification organizations [22].

The common wheat crops produced in organic agriculture conditions revealed the superior quality of the crop in terms of nutritional value, as well as the absence of compounds that can negatively influence the quality of the harvest [13]. Another important problem arises, namely the fact that in ecological agriculture the allocated resources are small, which can cause low productivity [9,11]. The seeds quality is another important factor for the success of the harvest, their genetic and somatic value being decisive [8,17]. Ecological agriculture, with reduced inputs, requires a lower amount of energy compared to agriculture in conventional system, which can determine the saving of allocated energy and the decrease of carbon emissions on a large scale [9, 13].

Any form of energy can be transformed into another, energies are storable and transferable in different ways [5, 7]. The quantification of energy spent in the agricultural production process is highly complex. In the specialized literature, there is no unanimous opinion regarding the coefficients of equalization of the forms of energy, as well as on the grouping of the types of energy used in agriculture [2, 5, 8]. The energy consumed to obtain agricultural production (Ec) includes a whole series of expenses and was structured as follows:

-direct active energy or direct external energy (human energy, energy mechanics, etc.);

- indirect active energy, necessary for the production of goods consumables in a single production process (seeds, pesticides, chemical fertilizers etc.);

- passive energy, necessary for the production of fixed assets (machinery, constructions etc) used in agriculture.

From the total energy consumed to obtain the vegetable agricultural production, active energy consumption holds the largest share [10]. The consumption of passive energy, being distributed over the years of use of the respective fixed assets, on works and cultures, etc., has a smaller influence on the total energy consumption.

In this context, the purpose of the paper is to comparatively analyze the winter wheat yield and production carried out in conventional versus ecological system in close relationship with expenses, incomes and profitability and also to assess the energy consumption, in order to find out which agro-system is more efficient from this point of view.

MATERIALS AND METHODS

The study carried out in the Experimental Field of the Research and Development Station for Pomiculture Băneasa during the period 2020/2021 (Map 1).

Map 1. Experimental plots
Source: Research and Development Station for Pomiculture, SCDP Baneasa.

The experimental site was located on a flat land (below 3%), with southern exposure, the soil type being typical preluvosol, formed on loess, well supplied with humus.Particle size analysis to determine the soil content of dusty clay and sand revealed a high percentage of clay ranging from 32.4% in the upper horizon 0-20 cm, 33.4% at depth 20-40 cm and 39.4% at depths greater than 40 cm. The loamy-clayey texture results in low nutrient mobility and poor soil water permeability. Apparent density at depth 0-20 cm 1.53 g/cm3 medium, high at 20-40 cm 1.50 g/cm3. Low total porosity throughout the depth of the profile. The degree of soil compaction ranges from 16%, the soil is moderately compacted to 18% at depths greater than 40 cm, heavily compacted, pH in the surface horizon of 5.27.Humus content 2.46, Nt 0.135, PAL 59, KAL 105 and C/N ratio 12.4.

Base saturation 72%, hydrolytic acidity 5.89, sum of exchange bases 15.18.

To achieve the objectives, a monofactorial experience was carried out where

a1: Conventional agriculture

a2: Organic farming

The size of the experimental plot was 480 m^2 (16x30) and that of the harvestable plot was 176 m^2 (8x22), following the elimination of the edges.

A protective strip was provided around the experiences having the working width of a seeder. The seeder used to sow the experimental plots was the D9 seeder from Amazone, with a working width of 4 m, for wheat. The biggest energy consumers are soil work, especially plowing, the basic work of the soil, this consumption being influenced by the structure, texture and humidity of the soil. The highest indirect energy consumptions are those related to the application of chemical fertilizers.

For these reasons, the possibilities of cultivation using direct seeding or basic works that do not involve turning a furrow are also evaluated from an economic point of view. The economic profitability of the crops within the agricultural holdings differs depending on the volume of the production factors used and their influence on the production obtained [12,15]. The purpose of establishing this experiment was to compare the results regarding the production achieved in the wheat crop, the expenses incurred, the incomes achieved and the profitability of the crop both in ecological and conventional systems. Another aspect followed was the energy efficiency of the culture systems.

Comparisons between fuels

Historically, mankind has generally obtained energy by consuming fossil fuels, so comparing fuel sources in terms of the amount of unit energy they contain helps with this calculation.

1 kg of anthracite (4% moisture) = 36MJ = 10 kWh

1 m3 natural gas = 39 MJ = 10.8 kWh

1 liter of petrol = 34 MJ = 9.4 kWh

1 liter of diesel = 40 MJ = 11.1 kWh

1 liter of liquefied petroleum gas = 41 MJ = 11.4 kWh

1 liter of fuel oil = 44 MJ = 12.2 kWh

By comparison, 1kg of renewable fuel such as woody biomass typically contains 4.2 kWh. 1 liter of diesel contains approximately 18% more energy than 1 liter of petrol.

RESULTS AND DISCUSSIONS

According to Table 1, soil works are the link that consumes the most energy and fuel, the costs amounting to 1,897.7 Lei/ha out of a total of 3,852.8 Lei/ha, the difference being claimed by the crop maintenance works and the necessary phytosanitary products. Complex fertilizers N:P:K +SO3+ Zn were applied in a dose of 200 kg/ha pc, for the basic fertilization.

The seed used was the Avenue variety with a rate per hectare of 200 kg/ha. This variety has been preferred by many farmers due to its qualities: very good production potential, medium-sized plants, with very good tolerance to falling, good tolerance to brown rust and Fusarium wilt, very good winter tolerance. very high power twinning (the brothers have an erect habit), ideal precursor for early sowing of rapeseed, recommended to be cultivated in all cultivation areas, but especially in the south and south-east of Romania due to the fact that it reaches flowering (not maturity) before the arrival of very high temperatures.

It has good baking qualities: G% 26-28; P% 12-12.5; W 200-250; MH 73-75 kg/hl. The seed treatment was carried out with the product Amiral Proffy 6 FS and Nuprid AL 600 FS. Fertilization, in the spring, was carried out with urea, 100 kg/ha pc. To combat weeds, the herbicide Omnera was applied in a dose of 0.75 l/ha. In April, we intervened for the treatment of diseases and pests, as well as the application of a foliar fertilizer with the products Falcon Pro, 0.7 l/ha, Cypeguard Max, 0.05 l/ha and Microfert U in a dose of 3 l/l/ha.

The next phase fertilization was carried out in April with ammonium nitrate, 100 kg/ha. In May, another phytosanitary treatment was applied using the products Microfert Alga 3 l/ha, Mizona 0.6 l/ha and Faster Delta 0.3 l/ha. The climatic conditions of the year favored the attack of foliar diseases and pests, necessitating the application of another phytosanitary treatment with the products Nativo Pro 325 SC 0.6 l/ha and Afinto 0.14 l/ha. The total technological expenses incurred for the establishment of wheat cultivation in the conventional system amounted to 3,852.8 lei/ha.

Wheat culture in conventional system

Planned production - 8,000 kg/ha. The previous culture was the rapture**.**

The consumptions in the first part of the vegetation (unfinished production) are identical, the applied works being approximately the same, with the same amount of diesel fuel consumed (Table 2).

In the second part of the vegetation, the expenses related to the application of the programmed technology are higher in the ecological culture system, expenses generated by the higher price of phytosanitary products used to fight diseases and pests, but also of fertilizing products.

To combat diseases and pests, the Aminotop MN and Aminotop Ultra products were applied along with Alggreen, Buster and Sticker bio. The seed treatment was carried out with Bio SSP, Freya Seed, Germino seed products. A soil treatment was also carried out with N-Bacter products, Country Terra Clean+P+Fix+Roots.

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Table 1. Technological sheet of the wheat crop cultivated in conventional system

Indicator	Diesel consumption Liters	Expenses Lei	Total technology expenses Lei
Stubble-turning 8-12cm	5.6	88.5	88.5
Disk 15cm	5.6	88.5	119.3
Fertilized equipment serviced			10.5
Fertilize	1.2	33.8	313.8
Plowgh	20.5	362.3	362.3
Disk 15cm	5.6	88.5	88.5
Combinator	4.0	56.3	156.3
Treat the seed with insecto-fungicides	0.9		129.8
Seed transport	2.58	3.75	7.3
Sowing	5.0	119.3	584.2
Serviced seeders	-	-	5.9
Total unfinished production	**50.9**	**841.0**	**1,843.6**
Fertilized with solid fertilizers	1.2	33.8	270.4
Foliar fertilizer + phytosanitary treatment	1.0	27.8	173.0
Herbicide	1.21	35.6	266.4
Transport	0.9	7.8	8.0
Insecticide treatment	1.7	41.9	135.1
Fungicide treatment	1.7	41.9	230.5
Harvesting	10.4	800	800.0
Transportation 5 km away	5.0	60	117.0
Straw balling	4.0	-	8.8
Total finished production	**27.1**	**1,056.7**	**2,009.2**
TOTAL GENERAL	**78.0**	**1,897.7**	**3,852.8**

Source: Own calculation.

Fertilization was carried out with Bio Ostara N, 100 kg/ha, Bio Ceres NPK, with doses of 200 kg/ha simultaneously with the work to be discussed.

Wheat culture in ecological system

Planned production - 5,000 kg/ha. The previous culture was the rapture (Table 2).

Table 2. The technological sheet of the wheat crop grown in ecological system

Indicator	Diesel consumption Liters	Expenses Lei	Total technology expenses - Lei
Stubble-turning 8-12cm	5.6	88.5	88.5
Disk 15cm	5.6	88.5	119.3
Fertilized equipment serviced			10.5
Fertilize	1.2	33.8	355.3
Plowgh	20.5	362.3	362.3
Disk 15cm	5.6	88.5	88.5
Combinator	4	56.3	284.2
Treat the seed with insecto-fungicides	0.9	-	197.8
Seed transport	2.58	3.75	8.8
Sowing	5	119.3	370.6
Serviced seeders	-	-	5.9
Total unfinished production	**50.9**	**841.0**	**1,891.7**
Fertilized with solid fertilizers	1.2	80.8	519.3
Foliar fertilizer + phytosanitary treatment	1.0	7.8	332.5
Transport	0.9	27.8	33
Herbicide	1.39	11.0	298.8
Serviced crop treated equipment	0.9	8.8	27.8
Transport	0.9	7.8	8.0
Insecticide treatment	0.4	128.0	258.8
Fungicide treatment	1.7	141.9	274.0
Harvesting	10.4	600.0	600.0
Transportation 5 km away	5.0	60.0	117.0
Chopping vegetable scraps	4.0	89.0	181.0
Straw balling	4.0	-	8.8
Total finished production	**31.8**	**1,162.9**	**2,653.1**
TOTAL GENERAL	**82.7**	**2,004.0**	**4,544.8**

Source: Own calculation.

Energy efficiency analysis - Wheat conventional system
Total energy consumption
Diesel consumption (litres) xkw/l diesel
78x11.1=865.8 kw
Energy consumption/unit of harvested product
Total energy consumption: production (kg)
865.8:8,000=0.108 kwh
Energy efficiency analysis - Wheat ecological system
Total energy consumption
Diesel consumption (litres) x kw/l diesel
82.7x11.1=917.9 kw
Energy consumption/unit of harvested product
Total energy consumption: production (kg)
917.9:5,000=0.184 kwh.

Obtaining small productions in the wheat culture cultivated in the ecological system had a negative impact on the energy balance, the energy consumption for obtaining a unit of product being high, 0.184 kwh compared to 0.108 kwh in the wheat cultivated in the conventional system (Table 3).

Fuel consumption for the establishment and maintenance of the culture was higher in the ecological system, 82.7 l/ha compared to 78 l/ha consumption recorded in the conventional culture system. The energy consumption was, implicitly, higher, increasing the technological expenses.

Table 3. Energy efficiency of the analyzed systems

Indicator	Conventional system	Ecological system
Diesel consumption-l/ha	78	82.7
Diesel consumption-lei/ha	1,897.7	2,004.0
Total technological costs–lei/ha	3,852.8	4,544.8
Total energy consumption-kw/ha	865.8	917.9
Energy consumption/unit of harvested productkwh	0.108	0.184
Yield –kg/ha	8,000	5,000

Source Own calculation.

Of the active energy consumed, the most significant share was the consumption of direct active energy, and this, in turn, is largely determined by the fossil energy consumed (fuel consumption) for the movement of agricultural aggregates in the work process during which produces mechanical work [1, 6, 3]. Energy consumption with chemical fertilizers represented the highest share in indirect active energy expenses.

Out of the total amount of agricultural work performed to obtain agricultural production, the highest energy consumption (fuel consumption) is carried out during the execution of soil works. The basic work of the soil consumes the largest amount of mechanical energy, representing about 35% of the total energy consumed for the mechanized execution of works in plant production.

Whatever culture system we choose, its efficiency is important. As a result, in order to establish the economic efficiency of each culture system analyzed, as well as the comparison of the two, conventional and ecological, it was necessary to calculate some indicators such as the expenses incurred for the establishment of the crops, therefore, the production expenses, the unit cost per product unit, recorded income, realized profit and profit rate.

Production expenses
Total production expenses (lei/h) consisting of:
- direct expenses
- indirect expenses.

In order to calculate the expenses per hectare, the technological sheet of the experimental variants is drawn up, in which all the works are listed in chronological order and expressed in value.

Direct expenses can be grouped into constant expenses and variable expenses

a) constant expenses are those that were made for all variants equally and include:
- land preparation expenses (ploughing, harrowing, harrowing, seed bed preparation, sowing)
- expenses with the application of fertilizers and their cost
- expenses related to the maintenance of the culture and the transport of the harvest
- harvest expenses.

b) Variable expenses are those that have been differentiated on each variant depending on the treatment applied.
Indirect expenses represent those expenses that do not participate directly in the production process and consist of the payment of the farm manager, CAS tax, crop protection, soil amortization, heated lighting [10].
The unit production cost (lei/t; lei/kg.), represents the value with which we obtain the product under concrete conditions. The production cost is calculated per ton of product, representing the total expenses related to the production obtained.
The total income per hectare is calculated by multiplying the production obtained with the production price (the price at which the production is sold).
V= Production x unit selling price
Cu = Cht/Qp
where:
Cu = the unit cost of production, in lei/t or lei/kg;
Cht = total expenses per ha, lei/ha;
Vps = the value of the secondary product, in lei/ha;
Qp = the quantity of the main products, in kg or t/ha;
The profit was calculated by making the difference between income and expenses
Profit rate (%) represents the ratio between profit and total expenses multiplied by 100
Rp (%) = (P/Cht)*100
where: P = profit, in lei/kg

Table 4. The economic efficiency of the studied systems

Indicator	Conventional System	Ecological System
Yield-kg/ha	8,000	5,000
Price /kg-lei	1.0	1.0
Income- lei/ha	8,000	5,000
Expenses- lei/ha	3,852.8	4,544.8
Profit- lei/ha	4147.2	455.2
Profit rate %	107.6	10.0
Unit cost/tone- lei/to	481.6	909.0

Source: Own calculation.

The profit rate of 107.6% means that the profit made is 107.6% of the initial costs or investment. Practically, for every lei invested, the company generated a profit of 0.76 lei, which indicates a very good financial performance (Table 4). The company managed to use its resources efficiently to generate profit. The high profit rate indicates a satisfactory demand for the products or services company, which is a positive sign in the long run
A high profit provides opportunities to reinvest in the business to support future growth. In general, a profit rate of 107.6% is a sign of success and financial health, but it is also important to look at the context in which this profit was achieved.
In the ecological system, a profit rate of 10% indicates that the profit made is 10% of the initial costs or investment. This suggests a positive financial performance, but less satisfactory than a rate of 107.6%. Although it is a positive result, there is room for improvement.
The business could look for ways to reduce costs or increase revenue to increase this ratio.
A profit ratio of 10% suggests that the business is able to generate profit in a sustainable way. This profit can be used for reinvestment, which what could help the long-term growth of the business. In general, a 10% profit rate is a good sign, but it should be looked at in the wider context of the market and business strategy.

CONCLUSIONS

Conventional farming and organic farming are two different approaches to growing plants and raising animals. Conventional agriculture uses pesticides, herbicides and chemical fertilizers to maximize production and control pests. Its primary goal is to increase yields and maximize profit, often at a lower cost per hectare.
As an environmental impact, there may be negative effects on soil, water and biodiversity due to the intensive use of chemicals.
Organic farming uses a number of sustainable practices. Uses natural pest control methods and organic fertilisers, promotes crop and ecosystem diversity, which can lead to better

resistance to disease and pests, focuses on producing higher quality food, often with less impact on the environment . The studied systems highlighted a higher profitability of the conventional culture system. The yields were higher, implicitly, the incomes were higher in the conventional system. The expenses incurred for the establishment of one hectare of wheat in the organic farming system were increased by 700 lei/ha compared to the conventional culture system. At the same time, the unitary cost for a unit of obtained product was 481.6 lei/ton in the conventional cultivation system and much higher, in the organic system, 909 lei/to. Regarding the energy efficiency, the fuel consumption was bigger, but insignificant, 4 l/ha, in the variant of organic culture. The energy consumed to obtain a unit of product was 0.108 kwh in the conventional agriculture system and 0.184 kwh in organic version.

suggesting a higher energy efficiency of the conventional system mainly due to the higher yields recorded in this system.

Each method has its advantages and disadvantages. Conventional farming can provide higher returns in the short term, while organic farming emphasizes sustainability and the long-term health of the environment. Increase in production energy consumption per kg of main production, for soil works, showed a decrease in energy effort per unit of product.

The ecological system did not obtain satisfactory results, possibly also due to the influence of climatic factors, the higher prices of ecological products used in the various technological links, therefore higher expenses. After the analysis of the two culture systems, it emerged that, for reduce the differences and balance the economic side, it is necessary to purchase phytosanitary products, at an advantageous price, to analyze the technological links that attract large expenses and try to adopt some less expensive but more effective technological options. The choice between the two ,depends on personal values, economic priorities and local conditions.

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EFFECTIVENESS OF BRANDING WITH LOCAL INDICATORS IN INCREASING OLIVE OIL CONSUMPTION IN VLORA, ALBANIA

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Abstract

In the area of Vlora, there is no in-depth study on the role of brand with local indicators in olive oil. The purpose of this study is to prove the influence of the brand and local indicators on the development of the olive oil market in Vlora. In this study, the role of the brand with local indicators is analyzed, as is its impact on the increase in the consumption of olive oil and the increase in the income of the agro-processing industries in the study area. Focusing on the market in this area, it is examined how branding with local indicators can influence consumer preferences and increase product consumption. Through the analysis of factors such as price, design with local indicators, quality, and promotion, it is intended to discover the most effective strategy to increase sales of olive oil in the study area. The research was conducted with the participation of over 200 consumers. To analyze the questionnaire, nominal-type econometric models were used, a suitable model to evaluate the impact of products branded with local indicators on the purchasing decisions of consumers. The program used for quantitative data processing is STATA. According to the research findings, it turns out that the brand's local indicators play an important role in the purchase decision. Also, the results of the study provide valuable guidelines for agro-processing industries and decision-makers who should pay special attention to branding with local indicators as an effective strategy to maximize the market potential for olive oil in the study area.

Key words**:** *consumers, agro-processing industry, Econometric model, STATA, brand*

INTRODUCTION

This study focuses on the analysis of the impact of the brand on increasing the consumption of olive oil in the market for Vlora. By exploring indicators such as price, design with local indicators, quality, promotion, and preferences of local consumers, it is intended to identify the most effective strategy to promote olive oil sales in the study area. The purpose of this study is to investigate the role of the brand with local indicators in the attitudes and buying behavior of consumers and, consequently, in increasing the income of the agro-processing industries of olive oil in the area of Vlora. Factors such as design with local indicators, quality, promotion, and place of origin play an important role in product branding as they differentiate and identify it as a high-quality brand in the eyes of consumers. To achieve this goal, a study was conducted, in which a questionnaire was used with 200 consumers in the study area. Data analysis was performed with a nominal ordinal-type econometric model. The results of the research show that the brand with local indicators has a strong impact on increasing the consumption of olive oil and increasing the income of agro-processing industries. Also, the analysis brings an important benefit to the agricultural agro-processing sector, which should focus on the production brand with local characteristics to increase income and position itself in the market.

Literature review

This study presents the main findings of scientific research regarding the impact of local branding. Researchers have concentrated their studies on the role that brands with local indicators play in the product purchase process [26], [5]. From the conducted studies, it is evident that the country of origin is an element that is not competed with by products coming from foreign countries [27]. In recent years, researchers in the field have paid special attention to local indicators because they categorize products as high-quality products and favor sales growth [2], [1]. The place of production of a product is positively evaluated by consumers [6]. According to Roth and Romeo [23], although the place of production of a product is an intangible element, it plays an important role in the purchase decision. Consumers are predisposed to pay a higher price for branded products that come from countries with positive reviews [18]. It is further argued that the origin of a product is evaluated by the consumer as a key indicator of quality, which guides the process of purchasing these products [11]. Identification with the country of origin affects the characteristics of products in several ways, such as performance, quality, reliability, and profitability [10]. Also, the origin of the product influences the positioning and identification of the product in the market [12]. Earlier studies show that the effectiveness of the country of origin of the product comes as a result of the effectiveness of international marketing and the development of the product brand [19], [4]. The origin of the product is also analyzed in international markets as an important element compared to foreign products and plays a competitive role in these markets [7], [15]. The results of studies confirm that local indicators increase the possibility of purchasing products and influence the formation of a positive image [18]. Also, the place of origin increases the credibility and brand potential of the product during the evaluation process [14]. For example, when the consumer has the opportunity to buy a product like Italian mozzarella, he is more predisposed to buy it because of the positive perception of the brand, which comes from the positive image of Italy as a developed country and specialized in the category of different production processes of agro-processing products [12]. The image of the country of origin plays an important role in determining the price of products. When the image of the country from which the products come is negative, high or low prices have no effect on purchase demand [22]. For example, Japan and the USA have positive and negative images in the production of different cars based on the quality of production and utility of use. A high monetary benefit for a car made in the United States will not increase the positive evaluation of its quality, while a low price for a car made in Japan will increase the probability of worsening the positive image of the country of origin, negatively affecting the quality. The agricultural products processing market cannot neglect the opportunities that come from the "country of origin effect" [2]. The country of origin is evaluated by the consumer as the best indicator of the quality [28] and safety [20] of agro-food products. Country of origin plays an important role in consumer behavior, such as intention to pay, select, and purchase [3]. The study of the place of production of the product is focused on a group of other elements, such as product features, history of origin, and brand [30], [3]. The role of the country of production of the product is evidenced in different categories of agricultural products. From Xie's study, it was evident that the place of production is a factor that influences the buying process [31]. Hussen and Fraser [17] demonstrated that when evaluating agri-food products in the United Kingdom, the origin of fresh meat is an important factor in driving consumer demand [8]. Claret [8] underlined that the place of production of the products reduces the price effect and increases the possibility of purchasing the products; elsewhere, these were also confirmed by the studies of Schjøll [24]. Different studies have shown that the country of origin and the image of the country of origin do not always match, and there are differences between different products [33]. The findings of several studies show that the image of the country of origin influences purchasing behavior and varies in effects according to the type of food product [33], [25]. From the literature research on agricultural and livestock products and by-products, limitations are evident, with very small exceptions for milk and yogurt in the European Union and Great Britain. Through market analysis in Thailand, it was confirmed that characteristics such as brand origin, name, logo, and slogan have a strong impact on price perception and stimulate consumer demand to buy [29]. Studies have confirmed that country of origin has a significant impact on consumers' decision-making to pay [24], [16]. Also, in recent years, it has been proven that the demand for imported dairy products in China depends on the country of origin of the product, based on the positive image that consumers have for American products [32].

MATERIALS AND METHODS

Study sample and data collection

Based on the poor economic performance of the agro-processing sector of olive oil in the city of Vlora in Albania, it was considered reasonable to examine the causes of this phenomenon by analyzing the interests of consumers, opinions, and their attitudes towards local branded products. The sample of the study reached over 200 consumers, who were chosen depending on their availability and free will to participate in the study [13]. The consumers who participated in the study were from the Vlora area. The questionnaire was developed electronically through the Google Forms platform. Data collection from the study sample began in November 2023 and ended in March 2024, when over 200 completed questionnaires were reached.

Research instruments

The questionnaire used to collect data from consumers is scaled from 1 (do not agree at all) to 5 (completely agree), the results of which prove the role of the brand with local indicators in the purchasing behavior of consumers for olive oil and increasing the income of agro-processing industries in the area of Vlora, Albania. It is organized into three sections:

1. The first section contains seven questions to collect data on socio-demographic features such as gender, age, place of residence, education, profession, income, and number of family members.

2.The second section contains two questions that include the type of preferred olive oil purchasing entity and whether they purchased local or foreign-branded olive oil.

3. The third section contains 25 questions and includes preferences for the selection of locally branded products in relation to their attributes such as quality, safety, information on the country of origin, promotion, branding with local indicators, brand name, quality of service in the unit of sale, the perceptions on the place of origin, food safety, and the precept on the price of olive oil.

Sampling Procedure

To collect data from consumers, a questionnaire with closed questions was used in electronic format for different categories of consumers, such as students, employees in the state, employees in the private sector, managers, administrators, and different categories of professions, in order to ensure a broad and diversified representation of their opinions and perceptions regarding the role of the brand with local indicators in olive oil. They were informed in advance during the collection of e-mail addresses about how to complete it. Participation in the study was voluntary, and ethical considerations such as confidentiality and anonymity were emphasized during the presentation.

Data Analysis

The analysis and interpretation of the collected data were carried out using a quantitative approach [9], that was developed in several stages in accordance with the need for additional information related to the purpose of the study. In the initial phase of data analysis, a report was first prepared based on the responses of the interviewees. In the second phase, the reports from the first phase were analyzed, identifying those that required additional analysis in accordance with the research objective. The methodology used for this case study is nominal-type econometric models, since the dependent variables are nominal. Ordinal models were used among the nominal models because the categories or levels of the dependent variable are ordered from the lowest to the highest [21]. The program used for quantitative data processing is STATA.

Research hypothesis

Based on the purpose of this study and the theoretical framework discussed above, the research hypothesis is presented as follows:

H1. Consumers have a higher demand for domestic products branded with local indicators as a result of the place of production, product quality, selling price, promotion or advertising, and design with local indicators.

RESULTS AND DISCUSSIONS

Socio-demographic characteristics of the respondents

In the study sample according to Table 1, it turns out that 57.6% were women and 42.4% were men, while 29.8% were 18–30 years old, 32.2% were 30–40 years old, 16.6% were 40–50 years old, 12.2% were between 50 and 60 years old, and 9.3% were over 60 years old. In terms of education, 46.3% of the interviewees had completed higher education, 40% had completed master of science studies, 7.8% had completed doctoral studies, and 5.9% had secondary education.

Table 1. Socio-demographic data of the sample

Gender	Man	87	42.40%
	Woman	118	57.60%
Age	18-30	61	29.80%
	30-40	66	32.20%
	40-50	34	16.60%
	50-60	25	12.20%
	Over 60	19	9.30%
Education	Secondary education	12	5.90%
	High education	95	46.30%
	Master of Science	82	40%
	Ph.D.	16	7.80%
Residence	Urban	179	87.30%
	Rural	26	12.70%
Occupation	Manager	22	10.70%
	Specialist	41	20%
	Administrator	16	7.80%
	Businessmen	12	5.90%
	Student	22	10.70%
	Unspecified professions	92	44.90%
Number of family members	Alone	10	4.90%
	2 to 3 members	67	32.70%
	4 to 6 members	118	57.60%
	Over 6 members	10	4.90%
Monthly income	300 Euro	10	4.90%
	350– 400 Euro	13	6.30%
	450– 500 Euro	22	10.70%
	550 – 600 Euro	44	21.50%
	Over 700 Euro	116	56.60%

Source: Author's results based on the respondents' answers.

Regarding the place of residence, it was found that 87.3% of the interviewees had an urban residence and 12.7% had a rural residence. Regarding their professions, it was found that 44.9% had unspecified professions, 20% had a specialist profession, 10.7% had a managerial profession, 10.7% were students, 5.9% were businessmen, and 7.8% were administrators.

According to the number of members in the family, 57.6% were from 4 to 6 members, 32.7% were from 2 to 3 members, 4.9% were over 6 members, and 4.9% lived alone. Finally, regarding the level of monthly income, 56.6% of the interviewees earned over 700 euro, 21.5% earned between 550 and 600 euro, 10.7% earned between 450 and 500 euro, 6.3% earned between 350 and 400 euro, and 4.9% earned 300 euro per month.

Consumer opinions, evaluations, and perceptions about olive oil

The following data reflect the opinions or perceptions of the consumer about the olive oil product in order to evaluate his buying behavior or his attitudes regarding the branding of the product with local indicators. In the following, various combined groups are constructed.

The main variables to build these groups are: country, education, profession, and income.

From this four-dimensional position, the consumer's behavior or evaluations for the brand of olive oil with local indicators or place of origin are analyzed.

Table 2. How important is the place of production of the product in choosing the brand of the agri-food product? [Olive oil]. According to the country.

	Residence		
	Rural	Urban	In total
Not important at all	0	2	2
Important	3	48	51
I do not know	3	2	5
Little important	0	17	17
Very important	20	109	129
In total	26	178	204

Source: Author's results.

In Table 2, it is shown the importance of the place of production of the product in the

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choice of the brand of the olive oil product according to the area.

The data show that 88% of the consumers in the rural area and 88% of them with urban residence affirm that the place of production of the product in choosing the brand is important and very important.

From Table 3, the data reflect the importance of the selling price of the product in choosing the preferred brand of olive oil according to the area.

54% of consumers with rural residences say that it is important and very important. This is followed by 83% of urban consumers who claim that the selling price of olive oil is very important in choosing their preferred brand.

Table 3. How important is the selling price of the product in choosing the preferred brand? [Olive oil] by area

How important is the selling price of the product in choosing a preferred brand? [Olive oil]	Residence		
	Rural	Urban	In total
Not important at all	3	20	23
Important	3	55	58
I do not know		4	4
Little important	9	60	69
Very important	11	39	50
In total	26	178	204

Source: Author's results.

The data from Table 4 regard the importance of the selling price of the product in choosing the preferred brand of olive oil according to education, 53% of consumers with higher education state that it is important and very important.

Table 4. How important is the selling price of the product in choosing the preferred brand? [Olive oil] according to education

	Education				
	HE	SE	Ph.D.	MS	In total
Not important at all	8		2	13	23
Important	28	4	4	22	58
I do not know	2			2	4
Little important	35	4	1	29	69
Very important	22	3	9	16	50
In total	95	11	16	82	204

Source: Author's results.

Whereas, 51% of consumers with a Master of Science qualification claim that the selling price of olive oil is of little or no importance in choosing their favorite brand.

Table 5 presents the importance of the selling price of the product in the choice of the preferred brand of olive oil according to the profession. From the data, it appears that 55% of consumers with a specialist profession say that it is important and very important.

Table 5. How important is the selling price of the product in choosing the preferred brand? [Olive oil] according profession

	Profession						
	Administrator	Businessman	Manager	Specialist	Student	Others	In total
Not important at all	4	1	4	6	1	7	23
Important	1	5	5	12	8	27	58
I do not know		1			1	2	4
Little important	8	2	8	12	5	34	69
Very important	3	3	5	10	7	22	50
In total	16	12	22	40	22	92	204

Source: Author's results.

It is followed by 53% of consumers with indefinite occupations, who affirm that the selling price of olive oil in choosing the preferred brand is important and very important.

Table 6. How important is the selling price of the product in choosing the preferred brand? [Olive oil] according to incomes.

	Incomes					
	300 €	350-400€	450-500€	550-600€	Over 700€	In total
Not important at all	2	1		3	17	23
Important	4	3	11	14	26	58
I do not know		1		1	2	4
Little important	2	5	6	12	44	69
Very important	2	3	5	14	26	50
In total	10	13	22	44	115	204

Source: Author's results.

In Table 6, it is presented the importance of the selling price of the product in choosing the

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preferred brand of olive oil according to income. The results showed that 64% of consumers with incomes between 550 € and 600 € state that it is important and very important. Whereas, 53% of consumers with incomes over 700 € affirm that the sale price of olive oil is little or not at all important in choosing their favorite brand.

From the data below, it is evident that about 66% of the consumers think that the promotion of agro-food products has an extremely large influence on their choice of brand.

Table 7. Does the promotion/advertisement of agri-food products influence brand choice? [Olive oil]

	In total
Nothing	21
Extremely very much	73
I do not know	1
Slightly	48
More	61
In total	204

Source: Author's results.

From Table 8, it is easy to identify the importance of design and packaging with local indicators in the choice of olive oil product brand according to education.

Table 8. How important are design and packaging with local indicators in choosing a product brand? [Olive oil] according to education.

	Education				In total
	HE	SE	Ph.D.	MS	
Not important at all	8	4		7	19
Important	33		7	18	58
I do not know	3			1	4
Little important	16	4	1	29	50
Very important	35	3	8	27	73
In total	95	11	16	82	204

Source: Author's results.

72% of the interviewees with higher education state that it is important and very important. It is followed by 55% of them with the Master of Science qualification, who state that it is important and very important.

Table 9 reflects the importance of design and packaging with local indicators in the choice of the olive oil product brand according to the area.

73% of the interviewees with rural residence state that it is important and very important. It is followed by 63% of them with urban residences, who state that it is important and very important.

Table 9. How important are design and packaging with local indicators in choosing a product brand? [Olive oil] according to area.

How important are design and packaging with local indicators in choosing a product brand? [Olive oil]	Residence		In total
	Rural	Urban	
Not important at all	3	16	19
Important	6	52	58
I do not know	1	3	4
Little important	3	47	50
Very important	13	60	73
In total	26	178	204

Source: Author's results.

From Table 10, we may see the importance of design and packaging with local indicators in the choice of olive oil product brand according to the profession.

Table 10. How important are design and packaging with local indicators in choosing a product brand? [Olive oil] according to profession.

How important are design and packaging with local indicators in choosing a product brand? [Olive oil]	Profession						In total
	Administrator	Businessman	Manager	Specialist	Student	Others	
Not important at all		2	2	3	5	7	19
Important	3	4	3	11	11	26	58
I do not know						4	4
Little important	1	1	4	7	5	32	50
Very important	12	5	13	19	1	23	73
In total	16	12	22	40	22	92	204

Source: Author's results.

The data show that the majority, about 75% of the interviewees with the specialist profession, said that it is important and very important.

It is followed by 53% of them with unspecified professions who state that it is important and very important.

Table 11 presents the importance of design and packaging with local indicators in the choice of olive oil product brand according to income.

From the data, it appears that the majority, about 55% of the interviewees with incomes ranging from 550 euro to 600 euro, state that it is important and very important.

It is followed by 73% of those with incomes over 700 euro who state that it is important and very important.

Table 11. How important are design and packaging with local indicators in choosing a product brand? [Olive oil] according to income.

How important are design and packaging with local indicators in choosing a product brand? [Olive oil]	Incomes					
	300 €	350-400 €	450-500 €	550-600 €	Over 700 €	In total
Not important at all	2	2	3	6	6	19
Important	5	3	6	13	31	58
I do not know		1		2	1	4
Little important	3	5	6	12	24	50
Very important		2	7	11	53	73
In total	10	13	22	44	115	204

Source: Author's results.

Table 12 reflects the low level of food safety risks for the purchase and consumption of products marked with local indicators, it appears that the majority, about 39% of consumers with incomes from 550 to 600 euro and 49% of consumers with incomes over 700 euro, assesses the level of risk to food security as extremely very and very low.

Table 12. Does the purchase and consumption of products marked with local indicators have a low level of food safety risks? [Olive oil] according to income.

	Incomes					
	300 €	350-400 €	450-500 €	550-600 €	Over 700 €	In total
Nothing	1		3	5	13	22
Extremely very much	2	2	7	8	36	55
I do not know	1	7	3	10	20	41
Slightly	5	2	3	12	26	48
More	1	2	6	9	20	38
In total	10	13	22	44	115	204

Source: Author's results.

Table 13 presents the data related to the level of risks to food safety. It appears that 45% of urban consumers estimate the level of risk as extremely very low and very low. It continues with 50% of consumers with rural residences who rate the level of risk as extremely very low and very low.

Table 13. Does the purchase and consumption of products marked with local indicators have a low level of food safety risks? [Olive oil] according to area.

Does the purchase and consumption of products marked with local indicators have a low level of food safety risks? [Olive oil]	Residence		
	Rural	Urban	In total
Nothing	7	15	22
Extremely very much	9	46	55
I do not know	4	37	41
Slightly	2	46	48
More	4	34	38
In total	26	178	204

Source: Author's results.

In Table 14, the analysis is made according to higher education. It was found that about 46% of them state that the purchase and consumption of products marked with local indicators have extremely low and very low levels of food safety risks. It continues with 40% of consumers with a Master of Science qualification who estimate that the purchase and consumption of products marked with local indicators have an extremely low level of food safety risks.

Table 14. Does the purchase and consumption of products marked with local indicators have a low level of food safety risks? [Olive oil] according to education.

Does the purchase and consumption of products marked with local indicators have a low level of food safety risks? [Olive oil]	Education				
	HE	SE	Ph. D	MS	In total
Nothing	9	1	1	11	22
Extremely very much	26	4	5	20	55
I do not know	22	2	3	14	41
Slightly	20	2	2	24	48
More	18	2	5	13	38
In total	95	11	16	82	204

Source: Author's results.

According to the profession, Table 15 presents that about 50% of consumers with a specialist profession say that the purchase and consumption of products marked with local indicators has an extremely low level of food safety risks. It continues with 40% of consumers with unspecified professions who estimate that the purchase and consumption of products marked with local indicators have an extremely low level of food safety risks.

Table 15. Can the purchase and use of food products marked with local indicators, such as olive oil, by occupation have a low health risk?

Can the purchase and use of food products marked with local indicators, such as olive oil, by occupation have a low health risk? [Olive oil]	Profession						
	Administrator	Businessman	Manager	Specialist	Student	Others	In total
Nothing	2	3	1	1	3	12	22
Extremely very much	11	6	9	13	2	14	55
I do not know		2	4	5	7	23	41
Slightly		1	7	14	6	20	48
More	3		1	7	4	23	38
In total	16	12	22	40	22	92	204

Source: Author's results.

Review of findings on olive oil

To analyze the data related to olive oil, nominal econometric models were used. Ordinal models were used among the nominal models because the categories or levels of the dependent variable are ordered from the lowest to the highest (Osmani, 2017) [21].

Table 16. Model 1: Ordered Logit, using observations 1-204 (n = 173)
Missing or incomplete observations dropped: 31
Dependent variable: ConsumOilLocal Brands
Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
Gender	0.454534	0.321641	1.413	0.1576	
Age	0.0149325	0.0139311	1.072	0.2838	
Education	−0.358470	0.226084	−1.586	0.1128	
Residence	0.0317766	0.558369	0.0569	0.9546	
Brand of Oil	0.342471	0.653806	0.5238	0.6004	
How important is the selling price of the product when choosing a favorite brand [Olive oil]	−0.305128	0.17584	−1.735	0.0827	*
How does the quality of service in the sales unit affect the choice of product brand [Olive oil]	0.464144	0.228061	2.035	0.0418	**
Does the promotion or advertisement of agro-food products influence the choice of brand [Olive oil]	0.512425	0.193731	2.645	0.0082	***
How important are the design and packaging with a local indicator in choosing the brand of the product [Olive oil]	0.522914	0.204204	2.561	0.0104	**
cut1	−2.59106	1.26455	−2.049	0.0405	**
cut2	0.688438	1.08982	0.6317	0.5276	
cut3	2.96155	1.12165	2.64	0.0083	***

Mean dependent var	2.208092	S.D. dependent var	0.779492
Log-likelihood	−160.3325	Akaike criterion	344.6651
Schwarz criterion	382.5046	Hannan-Quinn	360.0163

Source: Author's results.

If p-value<0.1, then the corresponding coefficient is statistically significant, and it is said that the variable next to it has a significant effect on the dependent variable.

If the sign of the coefficient is positive, the effect is positive, and vice versa.

If the likelihood ratio test is Chi-square (9) = 89.6382 [0.0000]<0.05, then the model is significant.

The consumption of products marked with local indicators depended on the country of production. quality, price, promotion, and design with local indicators such as age, education, residence, brand (domestic or foreign).

Table 16 is destined to present the results regarding Model 1: Ordered Logit, for the dependent variable oil consumption from local brands, as shown in the table below.

Number of cases 'correctly predicted' = 99 (57.2%)

Likelihood ratio test: Chi-square(9) = 89.6382 [0.0000]

^ ConsumOilLocalBrands = + 0.455* Gender + 0.0149* Age - 0.358*Education+ 0.0318*Residence + 0.342* BrandOil

(0.322) (0.0139) (0.226) (0.558) (0.654)

- 0.305* How important is the selling price of the product when choosing a favorite brand, [Olive oil] + 0.464* How does the quality of service in the sales unit affect the choice of product brand,[Olive oil] + 0.512* Does the promotion or advertisement of agro-food products influence the choice of brand, [Olive oil] + 0.523* How important are the design and packaging with a local indicator in choosing the brand of the product, [Olive oil] - 2.59*cut1

(0.176) (0.228) (0.194) (0.204) (1.26)

+ 0.688*cut2 + 2.96*cut3

(1.09) (1.12)

n = 173, loglikelihood = -160

(standard errors in parentheses)

In the above model, it was found that three variables (how the quality of service at the point of sale affects the choice of the product brand [Olive oil], does the promotion or advertising of agricultural products influence the choice of the brand [Olive oil], and how important is the design and packaging with local indications in the choice of the product brand [Olive oil] have a significant positive influence on the level of consumption of the local brand olive oil. One variable has a negative influence (how important is the price for purchasing the product when choosing a preferred brand) [Olive oil], while other independent variables have not been proven to have a significant impact on the dependent variable. Thus, people who give more importance to the price tend to consume less of this oil; people who give more importance to quality tend to consume more of this oil; and people who give more importance to advertising, promotion, and design tend to consume more of this oil. If age was significant, then we would say that as age increases, the consumption of oil labeled with local indicators tends to increase. If gender were significant, then we would say that men tend to consume more of this oil. If education were significant, then we would say that more educated people would tend to consume less. If the brand were significant, then we would say that the foreign brand tends to be consumed more. Likewise, the urban area would tend to consume more.

The choice of domestic or foreign brand depends on income, education, residence, price, quality, design, and risk.

To clarify this aspect, it was used Model 2, which includes Multinomial Logit, having Oil brand as dependent variable as presented in Table 17 below.

Number of cases 'correctly predicted' = 141 (93.4%)

Likelihood ratio test: Chi-square(7) = 10.8937 [0.1433]

In the above model, it is found that three variables (education, how important is the selling price of the product when choosing a favorite brand, and ow does the quality of service in the sales unit affect the choice of product brand) have a significant positive effect on the dependent variable, brand oil consumption.

Table 17. Model 2: Multinomial Logit, using observations 1-204 (n = 151)
Missing or incomplete observations dropped: 53
Dependent variable: Oil brand
Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
const	−5.62675	2.52507	−2.228	0.0259	**
Incomes	0.00625049	0.030803	0.2029	0.8392	
Education	0.96588	0.522061	1.85	0.0643	*
Residence	−0.0380120	1.22716	−0.03098	0.9753	
How important is the selling price of the product when choosing a favorite brand [Olive oil]	1.0239	0.51812	1.976	0.0481	**
How does the quality of service in the sales unit affect the choice of product brand [Olive oil]	−0.856175	0.514412	−1.664	0.096	*
How important are the design and packaging with a local indicator in choosing the brand of the product [Olive oil]	−0.0421193	0.461659	−0.09123	0.9273	
When buying and consuming products marked with local indicators, is there a low level of food safety risk [Olive oil]	−0.100433	0.417981	−0.2403	0.8101	

Mean dependent var	0.066225	S.D. dependent var	0.249503
Log-likelihood	−31.36141	Akaike criterion	78.72283
Schwarz criterion	102.8611	Hannan-Quinn	88.52904

Source: Author's results.

Willingness to buy a domestic or foreign brand depends on income, education, place of residence, price, quality, design, and risk.

In this case, it was developed Model 3, reflecting Ordered Logit, for the dependent variable "Desire of the respondents to buy the country olive oil" as shown in Table 18.

Table 18. Model 3: Ordered Logit, using observations 1-204 (n = 149)
Missing or incomplete observations dropped: 55
Dependent variable: Want to buy country oil
Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
Incomes	0.0251777	0.0146425	1.719	0.0855	*
Education	0.0556324	0.273699	0.2033	0.8389	
Residence	−1.23320	0.668648	−1.844	0.0651	*
How important is the selling price of the product when choosing a favorite brand [Olive oil]	−0.171455	0.205373	−0.8348	0.4038	
How does the quality of service in the sales unit affect the choice of product brand [Olive oil]	0.376197	0.241095	1.56	0.1187	
How important are the design and packaging with a local indicator in choosing the brand of the product [Olive oil]	0.509453	0.212888	2.393	0.0167	**
When buying and consuming products marked with local indicators, is there a low level of food safety risk [Olive oil]	0.707997	0.196765	3.598	0.0003	***
cut1	−1.03454	1.36439	−0.7582	0.4483	
cut2	0.626446	1.30628	0.4796	0.6315	
cut3	3.21274	1.35825	2.365	0.018	**

Mean dependent var	2.469799	S.D. dependent var	0.71241
Log-likelihood	−115.8735	Akaike criterion	251.747
Schwarz criterion	281.7865	Hannan-Quinn	263.9515

Source: Author's results.

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Number of cases 'correctly predicted' = 98 (65.8%)
Likelihood ratio test: Chi-square(7) = 72.4738 [0.0000]

In the above model, it results that two variables (How important are the design and packaging with a local indicator in choosing the brand of the product and When buying and consuming products marked with local indicators, is there a low level of food safety risk) have a significant positive effect on the dependent variable Want to buy country olive oil. Also, it is evident that the two variables (income and place of residence) have a positive effect on the dependent variable Want to buy country oil. From the above, the importance of design and packaging with local indicators in the choice of the product brand and increasing the consumption of olive oil is highlighted. Also, it is evident that the consumption of oil marked with local indicators is perceived as a product with a low level of food safety risks.

Consumption depends on income, education, residence, price, quality, design, advertising, and risk.

In this respect, it was used Model 4, Multinomial Logit for the dependent variable YVU (Consume olive oil), as shown in Table 19.

Number of cases 'correctly predicted' = 117 (78.0%)
Likelihood ratio test: Chi-square(8) = 70.7524 [0.0000]

In the model above, it is observed that three variables (how important is the selling price of the product when choosing a favorite brand, [Olive oil], does the promotion or advertising of agricultural products influence the choice of the brand, [Olive oil], and how important are the design and packaging with local indications in the choice of the product brand, [Olive oil]) have a significant positive effect on the dependent variable YVU (consume olive oil). Variables such as income and when you buy and consume products marked with local indicators, is there a low level of food security risk? [Olive oil] also have a positive impact on the level of local oil consumption (YVU).

Table 19. Model 4: Multinomial Logit, using observations 1-204 (n = 150)
Missing or incomplete observations dropped: 54
Dependent variable: YVU (Consume olive oil)
Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
const	−2.15149	1.46993	−1.464	0.1433	
Incomes	0.030411	0.01647	1.847	0.0648	*
Education	−0.366258	0.31977	−1.145	0.2521	
Residence	−0.891359	0.78062	−1.142	0.2535	
How important is the selling price of the product when choosing a favorite brand [Olive oil]	−0.666019	0.2754	−2.418	0.0156	**
How does the quality of service in the sales unit affect the choice of product brand [Olive oil]	−0.0942130	0.2932	−0.3213	0.748	
Does the promotion or advertisement of agro-food products influence the choice of brand, [Olive oil]	0.585305	0.26103	2.242	0.0249	**
How important are the design and packaging with a local indicator in choosing the brand of the product [Olive oil]	0.952578	0.28613	3.329	0.0009	***
When buying and consuming products marked with local indicators, is there a low level of food safety risk [Olive oil]	0.469229	0.24789	1.893	0.0584	*

Mean dependent var	0.613333	S.D. dependent var	0.488618
Log-likelihood	−64.70887	Akaike criterion	147.4177
Schwarz criterion	174.5135	Hannan-Quinn	158.4259

Source: Author's results.

These findings show that consumption of local products, such as olive oil, increases as a result of promotion, advertising, design, and packaging with local indications.

Willingness to consume unbranded products, but with country of origin indicators, depends on income, education, place of residence, gender, age, and number of family members.

These aspects are shown in Table 20 consisting of Ordered Logit for the dependent variable "Do you think you will buy and consume olive oil that is not branded but shows its place of production?"

Table 20. Model 5: Ordered Logit, using observations 1-204 (n = 179)
Missing or incomplete observations dropped: 25
Dependent variable: Do you think you will buy and consume olive oil that is not branded but shows its place of production?
Standard errors based on Hessian

	Coefficient	*Std. Error*	*z*	*p-value*	
Incomes	0.0155743	0.0117086	1.33	0.1835	
Education	−0.327930	0.228787	−1.433	0.1518	
Residence	−1.39931	0.483802	−2.892	0.0038	***
Gender	0.634885	0.30129	2.107	0.0351	**
Age	0.0197526	0.0121515	1.626	0.1041	
Member	0.0686962	0.118011	0.5821	0.5605	
cut1	−2.16320	1.19941	−1.804	0.0713	*
cut2	−0.557300	1.1851	−0.4703	0.6382	
cut3	2.40898	1.20509	1.999	0.0456	**

Mean dependent var	1.715084	S.D. dependent var	0.815817
Log-likelihood	−194.6106	Akaike criterion	407.2213
Schwarz criterion	435.9078	Hannan-Quinn	418.8534

Source: Author's results.

In the above model, it is found that two variables (residence and gender) have a significant positive effect on the dependent variable: Would you buy and consume products that are not branded but have indications of the locality of production [olive oil]?

CONCLUSIONS

This study aims to evaluate how brands with local indicators influence the increase in demand for olive oil and, as a result, the increase in the income of the agricultural products processing sector. The review of the literature has revealed important information regarding the role of this strategy in increasing the willingness to consume local products and increasing the income of agro-processing industries. Also, the empirical data confirm important findings regarding the impact of the olive oil marked with local indicators in increasing the demand for consumption and improving the economic performance of the industries engaged in the processing of this product. From the results of the study, it is clear that branding with local indicators plays an important role in increasing the consumption of olive oil, due to the fact that, from the point of view of consumers, it is perceived as a product with a low level of food safety risks and a product with better quality high compared to imported products. Factors such as perceived higher quality, design with local indicators, and promotion or advertising improve consumer attitudes towards olive oil branded with local indicators, encourage repeat purchases, and increase revenues for olive oil industries. Also, the findings of the study confirm that the brand with local indicators constitutes added value and provides a competitive advantage to position itself in the market, elements that should be taken into consideration by the agro-processing industries of olive oil in the Vlora area.

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ECOTOURISM IN THE DANUBE DELTA

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Abstract

This research aimed to analyze ecotourism in the Danube Delta in 2023 versus 2019 using the data from National Institute of Statistics. The methodology included description of the main ideas from the studied literature, data processing using fixed indices, polynomial regression equations, R square, comparisons, and showing the results in graphics and tables. The results showed that ecotourism niches in the Delta are: bird watching, wildlife watching and studying, fishing, canoeing, kayaking, cycling, trekking, boat tours on the canals, admiring the sunrise and sunset, tasting the specific dishes of the local gastronomy, enjoying taking part to the local traditional folk events, visiting the Danube Delta Biosphere Reserve for getting knowledge and enriching the scientific horizon. In this way, both tourists and the locals become aware of the importance of ecotourism for the sustainable development of the environment, the preservation of biodiversity and assuring the economic and social development of the residents and their communities. In 2023, in the Danube Delta, there were 493 accommodation units by 94% more than in 2019. Also, in 2023, the number of beds reached 10,942, being by 51.8% higher versus 2019. In 2023, the Delta received 136,979 eco-tourists (82.3 % of the 2019 level. Romanians are dominant with a share of 93.4%. Foreigners' weight was only 43.8% in 2023 of the 2019 level. In consequence, the overnight stays were 286,255 in 2023, by 25.4% smaller and the Romanians' share was only 80%. The main causes are the Covid-19 pandemic in the year 2020 and the war in Ukraine. In 2023, 5,621 tourists, of which 72.4% Romanians visited the Biosphere Reserve. The key aspects which need more attention in the future are: investing more in infrastructure, assuring labor force according to the needs, diversification of facilities and tourism activities, making the resident population to be more involved in the management of natural resources and solving the community problems.

Key words: *ecotourism, niches, demand and offer, economic, social and environment impact, the Danube Delta*

INTRODUCTION

According to The International Ecotourism Society (TIES), ecotourism is defined as: "*an ethical travel to natural areas that help the well-being of local people and conserves the environment*." [40].
Ecotourism is gaining a more and more importance in the world as it is a tourism form taking place in natural areas, has a positive economic and social impact sustaining local communities, and involves a learning experience. For this reason, it is considered "a bridge" between conservation and sustainable development.
But because the population is lacked of a proper environmental education, ecotourism is facing many challenges. For this reason, it should be seen as a learning tool destined to sustain initiatives for natural environment conservation and sustainable development.
Nature conservation requires as humans to be conscious of their role in the sustainable development of ecosystems. Higher investment and extended actions are called to

achieve the SDGs for *"the blueprint for a more resilient and prosperous world"* as mentioned in UN The Sustainable Development Goals Report 2024 [42].

In this context, human awareness and ecotourism could be a tool to provide environment conservation and sustainable local development [10].

In the developing countries, ecotourism is a suitable solution to protect natural environment and also for improving the level of the sustainable development indicators [29].

The triad "ecotourism- natural resource conservation and local livelihood" is the most discussed problem globally at present. However, the literature is still not so rich in sufficient evidence about how ecotourism is functioning. Rarely, there are found studies on the impact of ecotourism on the mitigation of climate change effects, carbon footprints, and about good governance [28].

Ecotourism development needs awareness, learning, and involvement of the community in ecosystems to lead to satisfactory economic, social and environmental benefits [15].

Other authors consider that the conservation goals require to work outside recreation and nature-based tourism and to take into account both protected areas, tourism industry items (accommodation, boarding, transportation, recreation activities) and locals who carried out the livelihoods in the surrounding regions as it happens in Costa Rica where ecotourism is successful and with a high contribution in the economy [9].

The European Union pays a special attention to ecotourism which is considered one of the driving factors to a "Green Europe" by 2050. Ecotourism market has a large offer which includes many attractions among which the most important ones are: "marine zones for sun and beaches, national parks and other parks with protected status, biodiversity, local cultures and traditional protectors of natural environments".

The demand of ecotourism comes from two categories of tourists:

(i)the lovers of nature tourism and ecotourism interested in a variety of natural and cultural resources, and

(ii)from those who are keen to have rich natural, cultural or historical experiences.

Therefore, ecotourism itself could have its own alternatives: a sustainable tourism, a responsible tourism, a soft tourism or a green tourism [5].

In the EU vision, the nature tourism has the following niches:

-*Wildlife watching*, preferred especially by British, German, French and Dutch tourists who are keen to visit African countries for safaris destinations for observing wild animals and their habitats.

-*Bird watching* is also very popular among the Europeans manifesting passion for leisure and desire to experience travelling and visiting the main African, Asian and Central/South American country destinations where there is a real bird paradise.

-*Ecotourism* as such in the middle of nature, helping the environment and biodiversity conservation.

-*Walking tourism* is largely practiced by Europeans who love to stay active during their vacations, week-ends practicing trekking, hiking.

-*Cycling* is a specific form of tourism which characterize the British, German, Dutch people, but during and after the pandemic of Covid-19, this sort of ecotourism has become more popular not only in the cities but also on unpaved roads in many other countries.

-*Fishing* is another alternative of eco-tourism practiced by the lovers of this sport. However, fishing is done respecting some rules regarding the fish species, the amount of fish which could be captured and the place where this sport could be practiced.

-*Adventure tourism (Adrenaline tourism)* is practiced by the people keen to enjoy adventures, the experience of discovering new landscapes in different parts of the world.

-*SAVE tourism* (Scientific, Academic, Volunteering and Educational) consists of a large range of activities which involve both high and less qualified people interested to enlarge their knowledge, to develop collaborations, friendships, to be helpful and to deliver training and skills.

-*Community-based tourism* is desired especially by the Germans, British, French, Spanish, Dutch and Swedish travellers who are interested learn about new cultures. In general, they travel in small groups or individually, many times belonging to *SAVE* sort of tourists.

-*Sun and beach tourism* is in a continuous expansion in locations away from mass tourism, to enjoy new experiences [5].

Due to Covid-19 pandemic, nature tourism in the protected areas has flourished and offered many opportunities and advantages: ecological recovery and restoration; regeneration; visitors' reflection on the travel and experience; resilience and recognition of the value of the tourism destination; a higher awareness and responsibility in protecting natural environment [5].

In Romania, tourism has registered a good dynamics during the last decade both in terms of tourist arrivals and overnights stays, the demand being met by offer and tourism proved to be an efficient of the economy. A large variety of tourism forms in practiced in Romania, ecotourism being included grace to the country varied relief and beautiful landscapes [19].

Ecotourism is for long time seen as an alternative for leisure, adventure, having beneficial effects on human body health and also as an alternative to improve the knowledge about the natural environment and especially connected to sustainable development of the local rural communities [30, 36, 31].

In Romania, ecotourism has registered a higher and higher attraction which has been intensified starting from the year 2020 when the pandemic of Covid-19 has emerged. It was one of the most attractive form of tourism when people revised their attitude towards nature which offered them a secure place to spend their vacations and week-ends, to rediscover the beautiful landscapes of various regions of the country like the seashore, the mountain areas and also the Danube Delta. That year rural tourism, ecotourism and agri-tourism have been alternatives chosen by many tourists [34].

In this context, the purpose of the paper is to analyze the status of ecotourism in the Danube Delta and quantify in what measure in the year 2023 versus 2019, the year of the tourism peak in Romania, it has had a positive trend, which where the influencing factors and what has be done to sustain tourism in this territory of the country.

MATERIALS AND METHODS

The study required to collect information on the main aspects of ecotourism (definition, principles, niches, "involved actors", actions, legislation etc., which were classified and the main important ideas have been structured and explained.

The empirical data were picked up from National Institute of Statistics regarding the main indicators characterizing tourism in the Danube Delta and the city of Tulcea: *tourism offer* in terms of the type and number of units with function for accommodation tourists, number of places, and accommodation capacity; *tourism demand* in terms of tourist arrivals and overnight stays by their origin (residents and foreigners), and *tourists* who applied to use the packages offered by tourism agencies in the Danube Delta.

The methodological tools included: descriptive paragraphs, statistical analysis and processing of the data using fixed indices for evaluating the difference of the indicators level in 2023 versus 2019, the year when tourism reached the highest performance; regression equations for showing the dynamics of tourist arrivals and overnight stays, R square determination coefficient, graphical illustration for a better understanding of the phenomenon, and tabled presentation of a part of the results.

The study summarized the key aspects concerning the economic, social and environmental impact of ecotourism and also presented the actual challenges nature tourism is facing in the Danube Delta.

The results of the data processing have been illustrated in suggestive graphics as well as in tables, accompanied by suitable comments and interpretations.

RESULTS AND DISCUSSIONS

The Danube Delta is part of the UNESCO World Heritage and it is considered the second largest and best preserved of Europe's deltas. It has a surface of 2,200 square miles, of which 83% are in Romania and the rest in Ukraine [27].

The climate is of a temperate continental type, with an average annual temperature of 11^0C(-1^0C in January and + 22^0C in July), and the average annual precipitations being around 350mm. Therefore, climate is characterized by small rainfalls influenced by proximity to the Black Sea and the humidity is given by the inland lakes and small waterways.

The Delta is a low alluvial plain, mostly covered by wetlands and water, but it also includes many canals bordered by willows and reeds, floating islands, lakes, sand dunes, subtropical forests, pastures, which allow tourists to discover the charm of the beautiful magic nature landscapes and biodiversity and human settlements.

The Danube Delta hosts 23 natural ecosystems, but the dominant environment is the aquatic one represented by wetlands, followed by terrestrial environment on the higher grounds of the continental levees, where xerophile ecosystems have also developed [44].

Having adequate conditions and being situated on major migratory routes, the Danube Delta is a good place, areal "magnet: for birds nesting and hatching and also for various wild animal species.

The Danube Delta is home for hundreds of bird species, for many sorts of fishes and also for animals (wildcats, foxes, wolves, boars or deer). Altogether, it is said that the Danube Delta is home for 3,450 animal species and 1,700 plant species.

The Danube Delta Biosphere Reserve has the third largest biodiversity in the world (over 5,500 flora and fauna species) [41].

All these reflects the unique biodiversity of the Danube Delta among the Europe's wetlands [27].

Map 1. The map of the Danube Delta
Source: Romaniatourism.com, 2024, [27].

Population

Human life is running mainly in traditional villages, but also in small cities where the population of diverse ethnicities coexists in good relationships and friendship preserving their traditions, customs and culture.

The population living in the Danube Delta accounts for about 15,000 inhabitants in its 28 villages and Sulina Town. The residents are distributed along the three main waterways: Chilia, Sulina and Sfantul Gheorghe. The local population is dealing with fishing at a small-scale and low-intensity, cattle growing and beekeeping [27].

The city of Tulcea is the starting point for exploring the Danube Delta and its branches: Chilia, Sulina and Saint Gheorghe.

Sulina is the key commercial enter and freeport where about 3,500 ships are handled annually. Other important localities are Chilia Veche, Sfantu Gheorghe, 1 Mai, Unirea and Independenta

The Danube Delta has a **high value cultural heritage** coming from its old history and being represented by Greek and Roman settlements. Also, Turkish influences could be seen in the villages surrounding the Delta [8, 27].

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Ecotourism concept in Romania and the Danube Delta

In Romania, the Association of Ecotourism in Romania (AER), aligned the concept, principles and guidelines of ecotourism to the standards issued by The International Ecotourism Society [41].

AER defined ecotourism as a type tourism which offer the tourists to experience and enjoy nature and local traditions and offer the locals an alternative for a better life under the following conditions:

-To assure the conservation and protection of the natural environment

-To become aware that the natural environment must be respected and preserved

-To involve human resources to contribute to the development of a sustainable eco-tourism

-To diminish at minimum the negative impact on the natural and socio-cultural environment [8].

The principles of ecotourism in Romania are promoted by the Association of Ecotourism in Romania (AER), and must be respected by the stakeholders creating ecotourism products and by those who develop ecotourism strategies. Also they have to be respected by visitors who are called to contribute to the environment and biodiversity preservation and sustainable development.

(i)*Focus on natural areas*- where tourists could enjoy a direct and personal experience getting knowledge about the natural landscapes geomorphology, biology, and local culture.

(ii)*Interpretation of the ecotourism product* means to make tourist to become aware that the nature should be protected and the local traditions and biodiversity should be preserved. This is based on the tourists' understanding of the natural and cultural values of the visiting destinations, using correct information before their arrival and appealing to high quality tour guided services during the tourism experience. Ecotourism programs must respond to this principle granting the local communities' access to information as well as to the visitors.

(iii)*Environment sustainability*- means that the developed activities in tourism in the middle of nature have a low impact on the natural environment, assure conservation of environment factors and preservation of the beauty of nature and landscapes and also of the cultural heritage.

(iv)*Ecotourism assists in the preservation of nature*-by involving local population and tourists in providing activities destined to preserve the natural areas, for example: participating in the restoration of the natural sites, offering financial aid and concrete work etc.

(v)*Ecotourism as constructive input in the development of local communities* which could led to increased incomes coming from tourism activities by buying local commodities and services, using guided tours and local amenities, enjoying contact with the local events, traditions and gastronomy. This could raise the living standard of the local population, the development of the communities.

(vi)*Ecotourism must raise the tourists' degree of satisfaction* which is essential for a good promotion of the experiences lived in the Danube Delta to the future potential visitors.

(vii)Ecotourism marketing should meet the visitors' expectations regarding correct and useful information, and unforgettable experiences in the natural environment of the visited areas, should prove the hospitality of the locals and led to a high satisfaction degree of the visitors **[**8].

Eco-tourism forms in the Danube Delta are of a large variety as follows: visits to the existing historical sites, taking wildlife photos, admiring the sun rise and sun set, bird watching (more than 300 migratory and resident birds species, among which the most important are: eagles, egrets, geese, cranes, ibises, cormorants, swans and pelicans), fishing (more than 160 fish species of fresh and salt water like: carp, pike, cat fish, carasius, perch etc), kayaking, canoeing, biking, having boat tours in the fishermen's boats on the canals, having accommodation in various units (villages, guesthouses etc), tasting traditional fish dishes and wines, taking part to events (International Independent Film Festival, International Rowboat Festival etc), and learning about the stories on the world and Olympic champions [8].

Ecotourism offer and demand in teh Danube Delta and Tulcea City

Number of units with reception function for tourists' accommodation

In 2019, the Danube Delta and Tulcea had together 254 units for tourists accommodation representing 3.02% of the total units of this type in Romania. In 2023, their number increased to 493 units being by 94% more numerous than in 2019 which reflects a higher offer in accordance to a larger tourist demand.

From a structural point of view, in 2023, the highest share accounting for 41.5% belonged to apartments and rooms to rent, followed by bungalows with 23.4%, tourist villas 14.8%, hotels 8.2%, tourist houses 5.2%, campsites 2.5%, and the remaining for other types of lodging units.

Figure 1 presents the structure of accommodation units for eco-tourists in the year 2019 while Figure 2 shows the structure of accommodation units for eco-tourists in the year 2023.

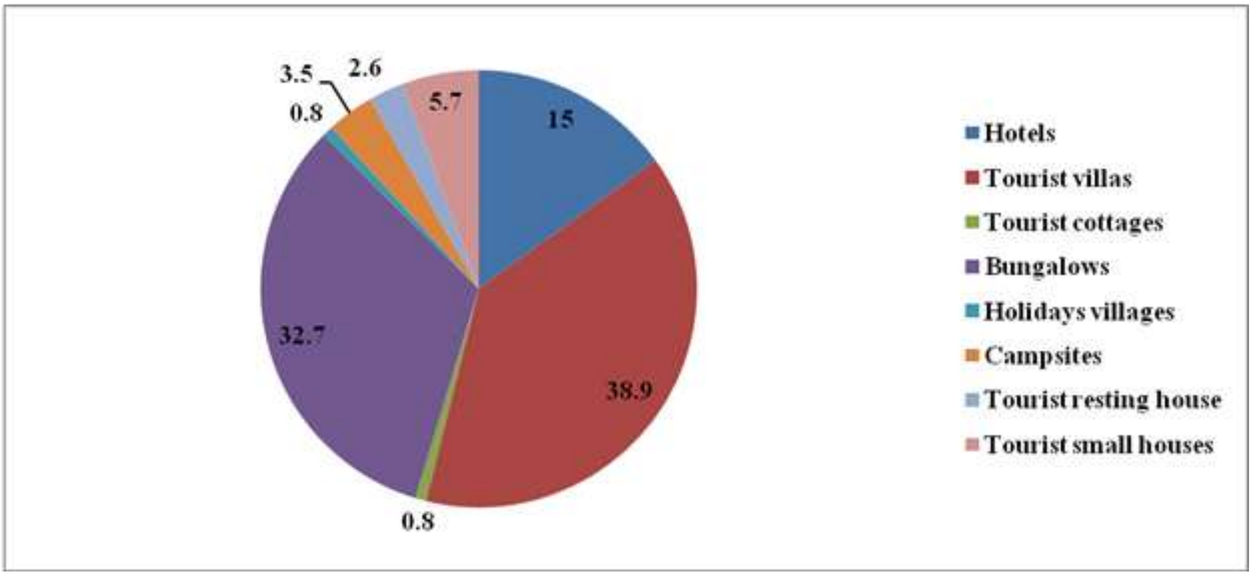

Fig.1. Structure of units with function for tourists' accommodation in the Danube Delta and Tulcea in the year 2019 (%)
Source: Own design based on the data from [11].

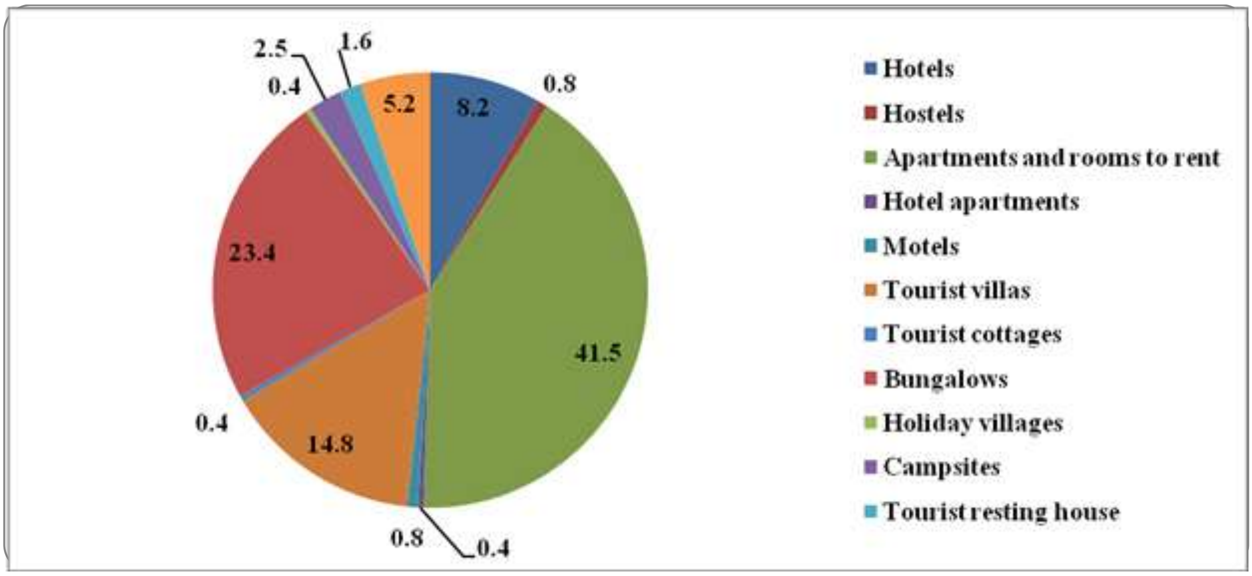

Fig.2. Structure of units with function for tourists' accommodation in the Danube Delta and Tulcea in the year 2023 (%)
Source: Own design based on the data from [11].

Accommodation capacity in the Danube Delta and Tulcea City

While in Romania, in 2023 there were 433,487 places in the units with tourist function for accommodation, by 18.58% more than in 2019, in the Danube Delta and Tulcea, in 2023 there were 10,942 places by 51.96% more than in 2019, reflecting a higher growth rate than at the national level (Table 1).

Table 1. Tourism accommodation capacity in Romania and in the Danube Delta and Tulcea (Number of places)

Accommodation capacity	2019	2023	2023/2019 %
Romania	365,562	433,487	118.58
The Danube Delta and Tulcea	7,205	10,942	151.86
Share of the Danube Delta and Tulcea in Romania (%)	1.97	2.52	+ 0.55

Source: Own calculations based on the data from [11].

There are many types of accommodation units (hotels, floating hotels, B and Bs, private houses especially in Chilia Veche, Crișan, Dunavățu de Jos, Gura Portiței, Isaceea, Mahmudia, Maliuc, Murighiol, Mila 23, Samova, Sfântu Gheorghe, Sulina, Tulcea, Turcoaia, Uzlina. The best hotels are New Lebada, Danube Delta Resort, New Egreta, Delta Boutique & Carmen Silva, Green Village.

Also, in Crisan, Murighiol, Sfantu Gheorghe, Shores of Lake Rosu there are campsites [27].

In the Danube Delta, in tourists' opinion, it is still needed to increase investment in accommodation and road infrastructure, as well as in ecotourism promotion [6].

Other authors found that visitors are satisfied by tourism accommodation in terms of accessibility and hospitality, but they are unsatisfied by the low promotion and image, the lack of local food and souvenirs shops, recreational activities and also it is a low transport service [13].

Regarding accommodation in the Danube Delta, most of tourists prefer accommodation in hotels, followed by boarding houses and tourist villas as it happened in the Razim-Sinoe area. The peak of tourists is in summers (July-August) and regarding the foreign tourists they come especially from Germany, Italy and Austria [17].

Ecotourists arrivals in the Danube Delta and Tulcea

In the pre-pandemic years, in the Danube Delta there were organized group tours for visiting the main attractions and also the seaside of the Black Sea and wine tasting at Murfatlar Vinery [18].

The year 2019 marked the peak of tourism in terms of tourist flows, overnight stays, length of stay in Romania but also in many other country destinations. In the years before 2019, tourist arrivals were concentrated much more on visiting the capital of Romania, the cities of Transilvania, the mountain and seashore resorts, the spa resorts and less the Danube Delta [20].

The year 2020 was the worst for the Romanian tourism due to the imposed movement restrictions during the Covid-19 pandemic and a short period less or without restrictions [22, 23].

During the Covid-10 pandemic in Romania, tourists have become more oriented to nature tourism and discovering the beauty of their own country, and one of their preferred destinations was the Danube Delta [25].

In 2023, the number of eco-tourists arrivals in the Danube Delta and Tulcea represented 82.31% of the total arrivals in 2019, which was the best year for tourism in this part of the country.

In case of Romanians, their arrivals in 2023 accounted for 87.68% of the 2019 level.

But, in case of the foreign tourists, in 2023 their arrivals represented only 43.82% of the number of arrivals recorded in 2019.

Also, in 2023, the share of arrivals in the Danube Delta and Tulcea represented was 0.98 % of the total tourist arrivals in Romania.

The Romanians' arrivals in the Danube Delta and Tulcea in total arrivals of Romanians at the national level was 1.08%, and in case of foreign arrivals only 0.42% (Table 2).

Table 2. Tourist arrivals in the Danube Delta and Tulcea in 2023 versus 2019 according to their origin (Number)

Tourist arrivals	2019	2023	2023/2019 %
Total The Danube Delta and Tulcea	166,411	136,979	82.31
Romanians	146,006	128,031	87.68
Foreigners	20,405	8,943	43.82

Source: Own calculations based on the data from [11].

The year 2020 when the Covid-19 pandemic emerged, a big fall was carried out in the number of arrivals both in case of Romanians and foreign visitors. Also, after a short recovery, in 2023 the number of foreign tourists declined due to the impact of the hostilities in the proximity of Romania's border (Fig. 3).

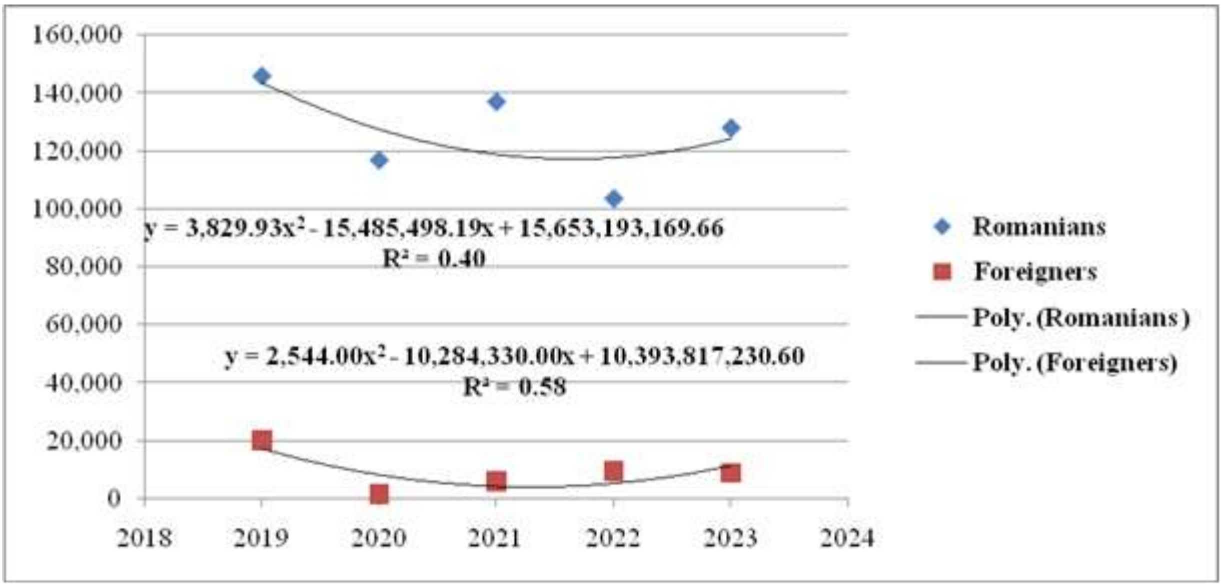

Fig. 3. Dynamics of tourists arrivals in the Danube Delta and Tulcea in the period 2019-2023
Source: Own design based on the data from [11].

After a slight recovery of the demand in the year 2021 and 2022, starting from the year 2023 and continuing in 2024, it has become to be deeply influenced by the war in Ukraine [12].

In 2024, when the hostilities have been intensified close to the border of Romania, the tourist arrivals have drastically declined. The guest houses situated at the border with Ukraine suffered a loss of 65%, while the areas situated in the natural reservation had a lower loss.

The number of overnight stays also decreased by 40%, the most affected being the tourism operators located in Chilia (-65%).

In Tulcea City, some tourism operators are facing 30% loss of arrivals in the year 2023 versus 2022.

The number of tourists in the Danube Delta decreased by 2,025 by 15 October 2024 due to the RO-alert messages during the nights which create panics. Also, the number of foreign tourists failed dramatically [26].

Ecotourists' overnight stays in the Danube Delta and Tulcea

In 2023 versus 2019, the number of stays in the Danube Delta and Tulcea represented 74.66% of the total stays, 80.12% for Romanians and only 40.28% for foreigners stays (Table 3).

Table 3. Tourist overnight stays in the Danube Delta and Tulcea in 2023 versus 2019 according to their origin (Number)

Tourist Overnight stays	2019	2023	2023/2019 %
Total The Danube Delta and Tulcea	380,375	286,255	74.68
Romanians	333,885	267,526	80.12
Foreigners	46,490	18,729	40.28

Source: Own calculations based on the data from [11].

Figure 4 shows much better the dynamics of the number of overnight stays by tourist category.

The year 2022 was unfavorable as the stay of the Romanians deeply declined. In case of foreign tourists, the high decline was registered in the year 2021 and also in 2023. The causes are the Covid-19 pandemic and nowadays the war in Ukraine.

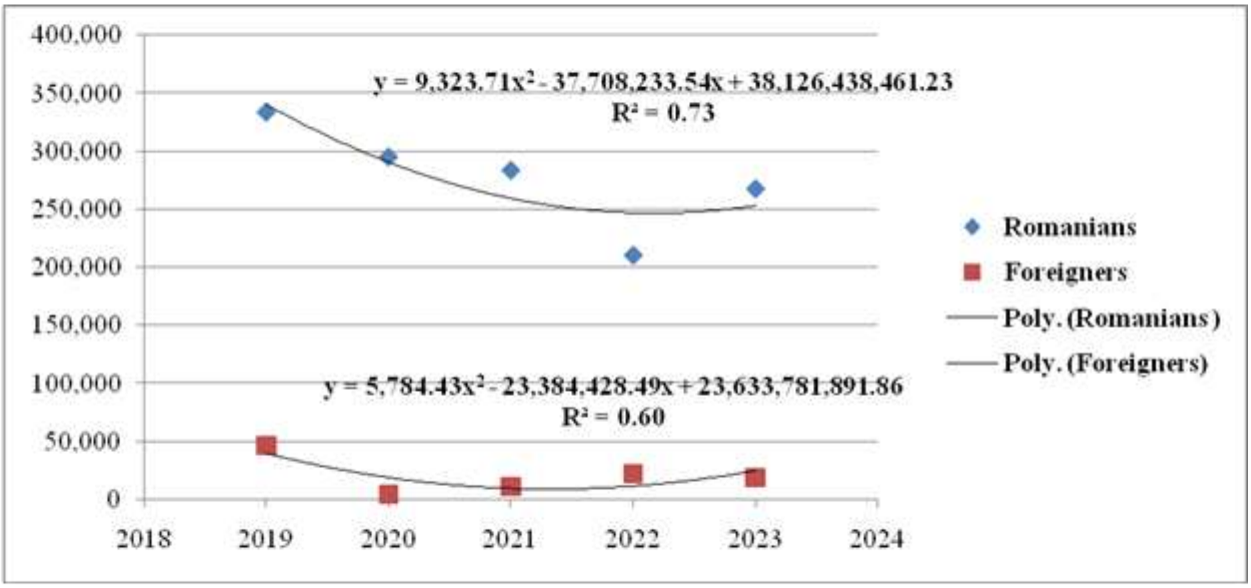

Fig. 4. Dynamics of tourists overnight stays in the Danube Delta and Tulcea in the period 2019-2023
Source: Own design based on the data from [11].

Number of Romanian tourists participating in tourist internal actions organized by tourism agencies also declined dramatically in the Danube Delta for the same reasons. In 2022, there were only 7,404 Romanian tourists who applied for such activities compared to 14,147 tourists in 2019, meaning by 47.7% less [12].

In 2023, it was observed a deep decline by 42% in the number of tourists in the Danube Delta Compared to 2022 caused by the hostilities running in Ukraine [7].

Impact of ecotourism in the Danube Delta

Ecotourism involves three aspects: economic, social and environment benefits.

From an economic point of view, ecotourism brings important income to the local population involved in tourism business like the owners of various accommodation units, restaurants, shops, boats, craftsman, tourist guides etc.

Also, fishing attracts the lovers of this type of sport in the Danube Delta [16].

In the Danube Delta, important economic and social benefits were obtained by strategic measures which joined the efforts of small industries and traditional craft development and led to a good environment conservation and biodiversity preservation and increased the income sources for the local communities.

Small revenues are obtained from the tourists who desire to visit the Natural Reservation. For doing this, they need a permit to enter the Danube Delta Biosphere Reserve. This permit should be purchased from the Danube Delta Biosphere Reserve Administration (ARBDD) or from the travel agencies and hotels in Tulcea. This permit is available for the

tourists who run low activities on the ground or water in specific zones established by ARBDD.
A free permit is available for scholars, students, pensioners, war veterans, disabled persons, for the persons living in the Danube Delta in the proximity of the reservation.
The entrance fees to visit the Danube Delta Biosphere Reserve (DDBR) are shown in Table 4.

Table 4. Official fees for permit to visit DDBR

Type of tax	Fee per tourist	Fee per car	Fee per boat
One day permit	Lei 5	Lei 10	-
7 days permit	Lei 15	-	Lei 20
One year permit	Lei 30	Lei 100	Lei 100
One night accommodation	Lei 50	-	-
6 nights accommodation	Lei 300	-	-
Recreational fishing	-	-	-

Source: The Danube Delta Biosphere Reservation, [39].

For fishing and hunting, tourists must purchase separate permits.
For visiting the Danube Delta Biosphere Reserve (DDBR), a tourist needs to apply for a multi-day trip which enable him/her to see to enjoy admiring the Delta's flora and fauna. Also, the best solution for experiencing more remote areas and wildlife is to apply for a private boat or a kayak either as a guided tour or an independent travel.
During their stay in the Danube Delta, tourists need to have at their disposal drinking water mosquito repellent [27].
Tourists visiting the Danube Delta Biosphere Reserve have the opportunity to take part to various scientific organized by DDBR, occasion on which they could be informed and get useful information to enrich their knowledge.
In 2023, the DDBR organized 28 actions for celebrating the environment events such as: The world Days of the Wetlands, The Water Day, The Biodiversity Day, The Danube Day, The Earth Day, The World Animals Day. To these events took part 531 scholars and teaching staff from the schools situated in the perimeter of the DDBR.
For visitors' information and ecological education, the DDBR puts at their disposal information centers situated in Tulcea, Crișan, Sulina, Chilia Veche, Murighiol, Sf. Gheorghe, Gura Portiței.
The number of visitors in the DDBR in 2023 accounted for 5,621, of which Romanians 4,016 (72.4%) and 1,695 foreigners (17.6%) [38].
Maintaining the production of rural traditional food made of natural ingredients, rustic cooking manner in the household, specific taste, flavour, and offering it to tourists could be a tool to a sustainable ecotourism and a greater satisfaction.
This could be achieved by combining ecotourism with agri-tourism in the rural areas which could bring additional income to the residents and better satisfy visitors' needs [3, 4].
Local traditional products are of high interest for visitors in their tourist destinations. This is because these products represent the results of the specific gastronomic traditions, are made of local natural raw materials, which are processing using traditional manufacturing techniques, are unique products concerning their aspect, color, flavor, taste. This niche of ecotourism including tasting of traditional products and drinks brings more satisfaction to tourists and also brings additional incomes to local producers and communities [32, 33, 37].
From a social point of view, ecotourism is beneficial for the local population offering jobs and important incomes to raise the living standard.
However, in the Danube Delta like in many other tourism destinations in Romania, there is a lack of personnel [21].
It is very important as in the HoReCa field the entrepreneurs to employ qualified personnel

who will be able to offer high quality services. This requires the intensification of training and development of human resources working in tourism [2].

Another social aspect of ecotourism is the fact that tourists are satisfied of experiencing new places and getting knowledge about nature plant and animal universe, enriching their spiritual level and also getting fresh air in their lungs, satisfying their eyes admiring the beautiful landscapes.

Tourists pass through a learning experience and the satisfactory results will determine to be respectful for the nature treasures and to sustain their conservation and preservation.

It is clear that taking into consideration the residents' opinions, it is possible to develop efficient ecotourism strategies [14].

From a cultural point of view, tourists could enjoy admiring:

-Local Lipovan architecture of the houses mainly in the localities Letea, Sarichioi and Mila 23.

-Fishing has a long tradition in the Danube Delta, being an occupation of the local population for centuries.

-Cuisine is based mainly on fish, the Danube Delta being well known for delicious fish dishes prepared in different manners often accompanied by a variety of ingredients.

The local Fisherman's Borscht, Danube herring, grilled sturgeon fish and zander croquettes, Saramura, big chunks of grilled carp in seasoned brine, served with polenta and garlic sauce, accompanied by a glass of Aligote, Muscat or Merlot wine could be a novel unforgettable gastronomic experience.

-Music and dance represent other aspects of the local culture and reflect the ethnic mosaic who lives in this territory. Tatars, Greeks, Turks or Lipovans are several nationalities who live in a complete harmony and understanding.

-Traditional folk suits - belong to history and show the peculiarities of the ancient culture of the nationalities living in this part of Romania. Therefore, visitors could admire a large variety of clothes and costumes belonging to each ethnic group [43].

From the environmental point of view, the behavior and attitudes of the local residents and visitors will change and be more grateful and respectful for the benefits in terms of mental and physical health for living in a clean nature, preserving its beauty and assuring the conservation of the environment factors: soil, water, wildlife, landscapes, fighting against pollution, wastes and negative impact.

Strategy for sustainable tourism development in the Danube Delta

The Danube Delta Integrated Sustainable Development Strategy of the Danube Delta (2030) signed by Ministry of Regional Development and Public Administration and the International Bank for Reconstruction and Development provides important measures to sustain the development of tourism in the Danube Delta [45].

Also, important EU funds are destined to financially support the small business in ecotourism offering maximum Euro 70, 000 Euro or Euro 200.000 Euro for Authorized Physical Persons, Ltd companies and small enterprises making business in Delta Dunarii (from guest houses and manufacturing to IT and medical assistance). It is about the Submeasures 6.2 si 6.4 within the National Program for Rural Development (PNDR) 2014-2020.

The eligible companies are: Authorized Physical Persons, individual companies, family companies, and agricultural companies. and they must have their seat on the territory of the Danube Delta.

The objectives for which the funding is available are: production activity, traditional handicrafts, tourist services (accommodation, camp sites, leisure activities, boarding, agri-tourism, catering etc), medical assistance, veterinary medical assistance, consulting, juridical services, IT services etc) [35].

Danube Delta ITI Social Entrepreneurs project for labour force integration, combating poverty

Also, In Romania, it was launched the Project "Social Entrepreneurs ITI the Danube Delta" by National Council of the SMEs in Romania. This Project is destined to integrate into the labour market the vulnerable persons and to fight against poverty by establishing social enterprises in the urban areas of the Danube

Delta for the period 2024-2027 The project is co-financed by the European Union through European Social Fund plus Program for Education and Employment 2021-2027 [1].

CONCLUSIONS

This research referred to ecotourism in the Danube Delta, a magnificent place where visitors could enjoy admiring nature and its treasures from the plant and wild animal world, and also enriching their knowledge and developing a respectful attitude for the natural environment and its beautiful landscapes.

The residents are good hosts offering the services that the tourists need: accommodation, delicious meals from the local gastronomy, boat tours on the Danube canals to observe the birds and wild animals.

Special entertainment is connected to traditional cultural events sustained by the rural population of various ethnic origin and to the scientific events celebrated by The Danube Delta Biosphere Reserve Administration.

Ecotourism has a beneficial impact on the stakeholders and local communities increasing their income and living standard, on one side, and also, on the other side, visitors have the satisfaction that they spent relaxing and interesting holidays in the middle of nature.

The number of tourists visiting the Danube Delta is not so high compared to other regions of Romania, but since the Covid -19 pandemic tourists have become aware of the benefits of nature and of the fact that environment and biodiversity must be preserved.

The most activities preferred by visitors in the Danube Delta are: bird watching, wildlife watching, cruises on the canals, fishing, tasting the specific local food based on fish, learning more about this natural paradise which is a proud for Romania.

The number of tourists increased in general, except the year 2020 due to the pandemic, and also in 2024 due to the war in Ukraine. This led to important losses in eco and agro-tourist business.

The offer in terms of accommodation units and places increased improving the comfort conditions, diversifying the facilities and activities as a reflection of the local hospitality.

In 2023, the number of units destined for visitors accommodation increased to 493 units being by 94% more numerous than in 2019. The highest share belongs to apartments and rooms to rent (41.5%), bungalows (23.4%), tourist villas (14.8%), hotels (8.2%), tourist houses (5.2%), and campsites (2.5%).

The capacity in terms of the number of places reached 10,942 beds, being by 51.8% higher than in 2019.

In 2023, the tourist arrivals accounted for 136,979 representing 82.3 % of the level attained in 2019, which was the best year for tourism. The Romanians are dominant with a share of 93.4%. However in 2023, Romanians weight accounted for 87.6% of the 2019 level, and foreigners' weight was only 43.8%.

The total overnight stays in 2023 was 286,255 by 25.4% smaller than in 2019. In case of Romanians, their stays represented 80% and in case of foreigners represented 40% of the level carried out in 2019.

In 2023, a number 5,621 tourists, of which 72.4% Romanians and 17,6% foreigners visited The Danube Delta Biosphere Reserve.

For helping the sustainable development of the environment, biodiversity and local business in tourism activities and other non agricultural activities, *The Danube Delta Integrated Sustainable Development Strategy of the Danube Delta (2030)* offers financial support by means of Submeasures 6.2 si 6.4 within the National Program for Rural Development (PNDR) 2014-2020.

Also, the Project *"Social Entrepreneurs ITI the Danube Delta"*, co-financed by the European Union through European Social Fund plus Program for Education and Employment 2021-2027 will be important for involving vulnerable persons into the labour market and combating poverty.

The main aspects for which more attention have to be paid in the future are: investments in infrastructure, assuring the labor force according to the requirements, diversification of facilities and tourism activities, making the resident population to be aware of its role in the management of natural resources and in solving the community problems.

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REGIONAL DEVELOPMENT IN ROMANIA. A BRIEF STATISTICS ON SOCIO-ECONOMIC DIFFERENCES-A MULTI-CRITERIAL APPROACH

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Abstract

The paper analyzed the development in the NUTS 2 of Romania in the year 2022 using a large spectrum of socio-economic criteria including 32 indicators, destined especially to emphasize the contribution of agriculture to the social and economic growth. The data were picked up from the National Institute of Statistics and Eurostat database. The processing methodology included: structural indices, comparisons among regions, rank-order method to establish the hierarchy based on the region performance. The results reflected the population polarization in North East, South Muntenia, North West and South East and also in Bucharest-Ilfov. Rural population and the one dealing with agriculture is concentrated in North East, South Muntenia, North West and South East. But, the occupied persons in the economy are in Bucharest Ilfov, North West, Center and West. The largest cultivated area and the highest value of agricultural production are in South Muntenia, South East, South West Oltenia, West and North East. The highest value of agricultural production per inhabitant is in South Muntenia, South East, South West Oltenia, West and North East. Labor productivity is higher in Bucharest Ilfov, West, North West and Center. The highest average monthly income, expenditures and savings rate per household is in Bucharest Ilfov, North West, Center and West. Income from agriculture per household is higher in North East, West, South East and North West, while per person is higher in Bucharest Ilfov, South Muntenia, North West and South East. GDP has the highest level is in Bucharest Ilfov, West, Centre, North West, while in North East, South Muntenia, South West Oltenia and South East is lower. In 2022, Romania achieved Euro 26,700 per capita (PPS) (75% of the EU average), coming on the 22 position among the other EU countries. Based on all these criteria, the final hierarchy of the NUTS 2 regions in Romania in 2022 was in the decreasing order: South Muntenia, South East, North West, West, Center, Bucharest Ilfov, South West Oltenia and North East which reflects the existence of discrepancies among regions. Romania has to intensify its efforts to assure a higher rate of economic growth on the principle of equity in the territory and reach a balanced and harmonized economic and social development which, also, have to reduce the gaps compared to the other NUTS 2 regions. For attaining this objective, Romania must to use the EU (TFEU) cohesion funds (2021-2027) to strengthen its economic, social and territorial cohesion and to assure a harmonious and balanced development.

Key words: *regional development assessment, NUTS 2 regions, discrepancies and similarities, Romania*

INTRODUCTION

Large territorial inequalities among countries and regions in the world have become a "common" and well known "landscape" with a negative impact on the economic development.

This theme has been and still is a research subject either from a theoretical point of view and practically, the researchers being interested to look for statistical methods and solutions to reduce discrepancies and strengthen the sustainable economic development.

In the era of economic globalization, regional development needs to be focused, first of all, on endogenous regional assets, new strategies for the global industries and evaluation of the effects of the interaction between regional assets and GPN logics on regional development [51].

A new strategy is required to ensure equitable investments in infrastructure for diminishing the gap between urban and rural areas, fostering a more balanced and sustainable trajectory of development [45].

Studying the regional development disparities in many countries, Pietak (2021), affirmed that the existence of *"rich regions or prosperous cities confirm the unbalanced nature of economic growth*" and that the transmissions channels must be analyzed because they affect regional development and lead to disparities in the economic growth [20].

The EU is an important player in the global economic and social development and its cohesion policy is destined to ensure that there are no gaps between different areas and regions in the same country, and also among the member states. At present, the green and digital transition are the EU key goals for which important financial support is allotted throughout Europe [3].

Niebuhr and Stiller (2003) affirmed that despite the EU policies have been focused on a balanced economic and social development, the territorial disparities continue to exist. They tried to identify the regions with a high development and a favorable labor market and concluded that the territorial disparities are caused by the inequalities between rural and urban areas [17].

Other authors also confirm the territorial disparities among the EU member states with a negative impact of their future development. The existence of numerous vulnerable places in terms of lack or insufficient local endowment, accessibility, or connectivity imposes that the EU policy programmes to be fully integrated and to be focused on *"the reduction of gaps between urban and rural areas, on strengthening physical infrastructure, access to schools, cultural facilities, democratic participation, migrants' integration etc"*. In this way, it could be assured a balanced economic growth and cohesion among the EU territories [42].

The excessive territorial inequality regarding welfare and living conditions between places has led to a negative feed-back in terms of "an anti-EU feeling". In consequence, the EU must set up new strategies adapted to the global political and economic situation, and promote its own efficient model of sustainable development in the future taking into account the territorial cohesion [14].

Disparities among the development of regions are also found in Rep of Macedonia as shown by the level of GDP/capita, unemployment rate and demographic indicators development indices. These differences could slow the economic growth and for this reason it is needed to establish a new future strategy [18].

In Serbia, regional disparities have grown in the last decade, as the subsidies had a low effect and that the local policies were wrong. Therefore, in this country, it is also required a new strategy to create jobs, increase labor force, productivity, and reduce migration and concentration of political power in the cities [48].

In the Slovakian agriculture, there are regional disparities as shown by the level of a series of economic indicators, which proved that the regions do not reflect a cohesion, on the contrary, they diverged in terms of life quality, wealth, living standard and working, despite that the EU policy for 2014-2020 is destined to ensure convergence of regions. In consequence, being a complex process, the topic on regional disparities requires a multidimensional approach [44].

A new thinking of alternative approaches is called to take into consideration endogenous development, economy fundamentals, income, livelihood, infrastructure and innovation. In this way, the "left behind places" will have a chance to develop and the regional disparities to be diminished [13].

A new distribution of the European Regional Development Fund (ERDF), based on egalitarian division of the funds and the losses is urgently required so that each region to have a similar chance to development [6].

Sotarauta and Grillitsch (2023) discussed the role of human agency on regional development, emphasizing the relationships between human actions and socially produced structures [46].

For Romania, at 17 years since it became an EU member, it is important to study if the national and regional development is on the right way aligned to the EU programmes for a sustainable, balanced and equitable development.

Many authors tried to approach various aspects, using a large variety of indicators and different research methods, and all of them found that in Romania there are development gaps among counties, NUTS 2 regions, urban and rural areas, cities and communes and villages and also between Romania and other EU member states.

For Romania, territorial development convergence present a high interest, in order to diminish the gaps and disparities among the EU countries and NUTS 2 regions.

The huge discrepancies in the territorial development reflect an inefficient regionalism and not a convergence. An example is given by Bucharest -Ilfov region which has the highest development, grace to a diversified infrastructure and a high qualified labor force, while the East and South regions are marginalized playing a weak role in regional development [47].

Ibinceanu et al (2021) assessed some factors connected to sustainability in Romania: child survival, poverty, education, GDP per capita with implications for regional development and emphasized the significance of a better allocation of the means which could reduce the unemployment rate and improve infrastructure for public services [12].

Otil and Boldea (2015) used capital and labor to evaluate regional development in Romania and concluded that the economic disparities are explained by "*the cultural legacies (norms, values, institutions), that impact on how people interact, communicate, investigate, think, consult, negotiate and act, influencing the behavior at community / society level*" [19].

Dobrin et al. (2010) affirmed that the implementation of the EU directions established for the territorial development strategies in Romania requires a high professional monitoring, based on the use of advanced techniques and instruments for the spatial planning destined to strengthen the administrative capacity to absorb structural and cohesion funds for assuring a good regional development [2].

Taking into consideration the need to assure food security, agriculture is the key sector called to produce high quality food to satisfy the domestic market. This requires a sustained agricultural system able to assure a bioharmonized development in the territory of Romania in the process of administrative reorganization [8, 9, 10, 11].

Analyzing the regional development, many authors make use of GDP, which is one of the main macroeconomic aggregates specific to the National Accounts System and represents in a synthetic manner the results of the economic activity carried out in a certain interval within the territory.

It could be used either in terms of nominal GDP (gross value added at current prices) or in terms of GDP expressed in purchasing power standards (PPS), the last form being used to compared GDP per capita achieved by a country with the EU average. In its last form GDP reflects the economic development and the living standard of a country.

GDP should be analyzed by sources and economic sectors, in connection with other economic and social indicators and also at the territorial level [22].

In Romania, GDP was studied in connection with fixed assets and employment in agriculture using Cobb-Douglas production function and the results proved the existence of a close relationship [33] which make us to draw the conclusion that the improvement of fixed assets and employment could grow GDP level. However, in the territory there are gaps related to these aspects.

The correlation between economic growth, unemployment and employment in Romania confirmed the existence of discrepancies in the economic development [24, 25].

The existing gaps among Romania's regions as reflected by GDP and its resources reflect that the country has not a convergent economic development [26, 34].

Final consumption has a high contribution to Romania's GDP caused by the applied policy which stimulate public and private consumption, but there are disparities among regions regarding this aspect [27].

The dynamics of GDP and its determinants in Romania reflects the unbalanced agri-food export/import ratio and the regional disparities in the agro-food system with a negative impact on food security [30, 32].

The dynamics of the GDP concentration in Romania confirms the territorial disparities among regions of development [37].

Rosu (2021) studied the territorial development in terms of GDP per capita in Romania, and set up a Sustainable Development Index (SDI) based on five criteria and including 15 indicators. In this way, it was possible to better characterize the current sustainable development status of the counties [43].

Among the EU countries there is an income inequality which is another form of discrepancy in the regional development [31]. Also, the changes and relationships between average income and consumption expenditures per household reflect the discrepancies between rural and urban areas both in a country or at the EU level [36, 41].

The high share of the population dealing with agriculture and the trends in agricultural production value in Romania confirmed an unequal development of the rural areas [40].

In the EU's agriculture there are large discrepancies concerning labor productivity among the member states which confirm the differences of agriculture development either nationally and by region [28].

In Romania's agriculture, labour productivity is much smaller than in any other EU country and also the territorial differences are sustained by the high share of rural population and low endowment in agriculture [29, 38].

Analyzing the development level in the regional space of Romanian Banat, based on a global development index including social, economic and of life standard aspects, there were found local disparities too. To improve the situation, a new territorial model of equitable development is required [1].

A synthetic index of territorial inequalities, based on a integrated use of GDP/capita, labor productivity and life expectancy was set up by Goschin (2015) in order to characterize both economic and social discrepancies in Romania, in a more suitable way than using individual indicators. After evaluating the territorial gaps and their impact on economic development, the author developed an economic growth model which cointegrated GDP and the synthetic index and which proved that in Romania the disparities in the territory will continue [7].

Also, Veres et al. (2022), elaborated a "multidimensional composite index called the PEESH (population, economic, education, social, and health) Development Index, for measuring the territorial socio-economic development in Romania. The use of this index led to a certain change in the county classification in Romania between 2000 and 2019. They proposed a changed approach of the EU territorial development from a multidimensional perspective, taking into consideration the complex character of this process [49].

In this context, the purpose of the research was to analyze the regional development of Romania in the year 2022 using a large range of socio-economic criteria for which the empirical data were available at present in the National Institute of Statistics and Eurostat databases. Among the 32 criteria used there were included indicators regarding: (a) demography, (b) agriculture, (c) labor productivity, (d) income and expenditures per household and person, (e) GDP and GDP per capita. The conception of this paper is an original one belonging to the authors and aimed to emphasize the role of agriculture in the territorial development, taking into consideration the high importance of this economic sector in assuring food security. The structural indices and the rank-order method allowed to establish the hierarchy of the regions based on their socio-economic performance and to identify the discrepancies among regions and also by means of

GDP/capita (PPS) to appreciate the difference between Romania's performance and the EU average.

MATERIALS AND METHODS

This research is based on the study of literature on the topic, data collection from the main official information sources: National Institute of Statistics and Eurostat database for the year 2022, for which there were found final data connected to the indicators selected to be analyzed at this moment.

In the text, the regions were symbolized as follows: North East (NE), South East (SE), South Muntenia (S Munt), South West Oltenia (SW Olt), West (W), North West (NW), Center (C) and Bucharest Ilfov (B If).

The system of the 32 criteria used to assess the development of each NUTs region included a large variety of socio-economic indicators which are grouped as follows:

(a) Demographic indicators: population, rural population, occupied population, population occupied in agriculture, forestry and fishing;

(b) Agricultural indicators: agricultural surface, cultivated area, agricultural production value, vegetal production value, animal production value; all these indicators have been also calculated per inhabitant;

(c)Labor productivity in the economy

(d)Average monthly income per household in the economy and in agriculture; Average monthly expenditures per household in the economy and in agriculture; the average monthly saving rate per household;

(e)Average monthly expenditures per person in the economy and per agriculturist; Average monthly expenditures per person; the average monthly saving rate per person;

(f)GDP (PPS) by region and as a share in the EU GDP (PPS) per capita and also as a share in Romania's GDP(PPS) per capita.

For the level of each indicator have been calculated the shares in Romania's level of that indicator and in the EU's level in case of GDP. Most of the indicators were determined per inhabitant for showing the social impact and enabling the calculation of differences among regions. For each indicator mentioned above, it was applied the rank-order method, considering that the rank 1 is given for the best performance or the highest level registered by that indicator and the rank 8 was given for the lowest level recorded by a region. Finally, the points received by a region for each indicator were summed and consequently, based on the total number of points, it was established the final hierarchy of the 8 micro-regions of Romania.

The results were presented in tables and graphics accompanied by the essential comments. The main conclusions were presented at the end of this research.

RESULTS AND DISCUSSIONS

The 8 micro-regions of Romania were founded in 1998 for coordinating the regional development in the pre-accession period of Romania to the EU.

Table 1. Romania's development regions: surface and counties included

Region	Surface (km^2)	Share in Romania's area (%)	Counties included
ROMANIA	238,411	100.0	
NE	36,850	15.4	Bacau, Botosani, Iasi, Neamt, Suceava, Vaslui
SE	35,762	15.0	Braila, Buzau, Constanta, Tulcea, Vrancea
S Munt	34,489	14.5	Arges, Calarasi, Dambovita, Giurgiu, Ialomita, Prahova, Teleorman
SW Olt	29,212	12.3	Dolj, Gorj, Mehedinti, Olt, Valcea
W	32,028	13.4	Arad, Caras Severin, Hunedoara, Timis
NW	34,159	14.4	Bihor, Bistrita Nasaud, Cluj, Maramures
C	34,100	14.3	Alba, Brasov, Covasna, Harghita, Mures, Sibiu
B If	1,811	0.7	Bucharest and Ilfov

Source: Own calculation based on the data from [50].

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They corresponds to EU NUTS 2 regions and play an important function in managing the funds allotted to each member state by the EU.

They have a mixtures of characteristics of various types including: geographical position and delimitations, surface, relief, natural resources, demography, economy and environment, living standard.

Surface of the development micro-regions

Table 1 shows the surface and the counties of each development region of Romania.

Population

In 2022, *Romania's resident population* accounted for 19,043,098 inhabitants, of which 17% were living in NE region, the highest share, and 8.8%, the smallest share, belonged to W region. The rest of percentages belonged to the other 6 regions in various proportions (Table 2).

The population living in the rural areas accounted for 9,083,666 inhabitants, representing 47.7% in the total population of Romania. Of the total rural population, the highest share of 21.1% belongs to the NE region while the lowest share of 3.3% belongs to B If (Table 2).

Rural population in Romania has a high share than in other EU countries [21], it is aging and dealing mainly with agriculture, has a low training level and the youth migrates to cities for better paid jobs [35, 39].

The share of the rural population in the population of the region had the highest level of 61.2% in S Munt region and the lowest weight of 13.2% in B If (Table 2).

Table 2. Romania's total and rural population distribution by region in 2022

	Share of the region population in Romania's population (%)	Share of the region rural population in Romania's rural population (%)	Share of the rural population in the region in the region population (%)	Differences among regions versus the share of the rural population by region
ROMANIA	Total population = 19,043,098 inhabitants = 100.0	Rural population= 9,083,666 =100.0	47.7	0
NE	17.0	21.1	59.4	+11.7 pp
SE	12.2	12.6	49.4	+1.7 pp
S Munt	15.0	19.2	61.2	+13.5 pp
SW Olt	9.9	11.2	54.6	+6.9 pp
W	8.8	7.8	42.2	-5.5 pp
NW	13.5	13.8	49.6	+1.9 pp
C	11.9	11.0	44.0	-3.7 pp
B If	11.7	3.3	13.2	-34.5 pp

Source: Own calculation based on the data from [15].

The occupied civilian population of Romania accounted for 7,852.1 thousand persons in 2022, while *the population occupied in* agriculture, forestry and fishing was 858.8 thousand persons, meaning 10.93%.

Table 3 shows that B If region had 18.7% of the total occupied population of Romania, while SW Olt had only 8.6%.

Regarding *the share of the occupied population in agriculture, fishery and fishing* by region in total Romania's occupied population, we may notice that 16.8%, the highest weight belonged to SW Olt and, the lowest weight of 1.05% belonged to B If.

Agricultural indicators

Of Romania's surface of 23,839,072 ha, *the agricultural area* represents 61.3%, more exactly 14,630,072 ha, according to the National Institute of Statistics (2014).

Of this surface, 8,005,889 ha, meaning 54.7% represent *the cultivated area* in the year 2022.

The largest share of the cultivated area with various crops is in S Munt and accounts for 23%, and the smallest area of 0.9% is in B If.

Taking into consideration the population, we may found that *the cultivated area per inhabitant* in Romania is 0.42 ha, varying between 0.03 ha, the smallest land surface, in B If, and 0.7 ha, the largest surface, in SE (Table 4).

Table 3.Occupied civilian population in Romania and in agriculture, forestry and fishing by region in 2022

	Share of the region occupied civilian population in Romania's occupied population (%)	Share of the region occupied population in agriculture, forestry and fishing in Romania's occupied population in agriculture, forestry and fishing (%)	Share of the occupied population in agriculture, forestry in the region in total occupied population of the region (%)	Differences among regions versus the share of the rural population by region
ROMANIA	Total occupied civilian population= 7,852.1 thousand persons = 100.0	Occupied population in agriculture, forestry and fishing = 858.8=100.0	10.93	0
NE	12.7	19.5	16.9	+5.88 pp
SE	11.0	13.9	13.9	+1.27pp
S Munt	12.5	17.6	15.5	+4.57 pp
SW Olt	8.6	13.2	16.8	+5.87 pp
W	9.8	8.8	9.9	-1.03 pp
NW	14.0	14.8	11.6	+0.67 pp
C	12.7	10.3	8.9	-2.03 pp
B If	18.7	1.9	1.05	-9.88 pp

Source: Own calculation based on the data from [15].

Table 4. Cultivated area and its distribution by region of development and inhabitant in 2022

	Share of the region cultivated area in Romania's cultivated area (%)	Share of the cultivated area of the region in the total surface of the region (%)	Cultivated area per inhabitant (ha/capita)	The share of the region in the cultivated area per capita in Romania (%)
ROMANIA	8,005,889 ha= 100.0	54.7	0.42	100
NE	15.9	34.6	0.40	95.2
SE	20.3	45.4	0.70	166.6
S Munt	23.0	53.5	0.64	152.4
SW Olt	13.5	37.1	0.58	138.1
W	9.5	23.8	0.46	109.5
NW	10.1	23.6	0.32	76.2
C	6.8	16.0	0.24	57.1
B If	0.9	34.2	0.03	7.14

Source: Own calculation based on the data from [15].

The results from Table 4 show that the cultivated area per inhabitant exceeds the average in Romania, accounting for 0.42 ha/capita, only in the regions SE, S Munt, SW Olt, and W, and in the other regions it is below this mean, in the decreasing order; NE, NW, C and B If.

The value of agricultural production in Romania accounted for Lei 109,567.7 million in 2022, of which 22.2 % was carried out in S Munt, followed by 15.5% in SE and 15.4% in NE and 12.4% in SV Olt, summing 65.5%.

The value of agricultural vegetal production was Lei 71,876.41 million, representing 65.8% of the total agricultural output value, while *the value of animal production* accounted for Lei 34,842.53 million, meaning only 31.8%.

The agricultural production per inhabitant in Romania was Lei 5,753.6/capita, with variations between Lei 8,520.1/capita in S Munt and Lei 869.4/capita in B If.

The regions which exceed the average agricultural production value per capita are: S Munt, SE, SV Olt and W (Table 5).

The vegetal production value obtained by Romania in 2022 accounted for Lei 13,584.6 million in S Munt (18.9%) and Lei 1,211,9 million (1.7%) in B If.

Among the regions, the highest share of the vegetal production value varied between 77% in S Munt and 39.6% in B If.

The animal production value by region recorded the highest share in Romania's animal production value in S Munt (22.2%), followed by 15.5% in SE, 15.4% in NE and

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12,4% in SW Olt, and the lowest weight was 1.8% in B If.
The regions with the top share of animal production value in total agricultural production value are: Centre 42.2%, NW 41.8%, NE 41.4%, W 38%, and the region with the lowest weight is B If (5.3%) (Table 6).

Table 5. Agricultural production value by region and inhabitant in Romania, 2022

	Share of agricultural production value of the region in Romania's agricultural production value (%)	Share of the average production value/capita in the region in Romania's average production value/capita (%)
ROMANIA	Lei 109,567.7 Million = 100.0	Lei 5,753.6/capita = 100
NE	15.4	91.0
SE	15.5	127.4
S Munt	22.2	148.1
SW Olt	12.4	126.3
W	9.9	112.9
NW	11.7	88.3
C	11.1	93.0
B If	1.8	15.1

Source: Own calculation based on the data from [16].

Table 6.Vegetal agricultural production value and animal production value by region, Romania, 2022

	Share of vegetal production value by region in Romania's vegetal production value (%)	Share of vegetal production value by region in the region agricultural production value (%)	Share of animal production value by region in Romania's animal production value (%)	Share of animal production value by region in the region agricultural production value (%)
ROMANIA	Lei 71,876.41 million= 100	65.6	Lei 34,842.53 million = 100	31.8
NE	16.7	57.2	15.4	41.4
SE	18.4	69.8	15.5	26.1
S Munt	18.9	77.0	22.2	21.4
SW Olt	12.2	73.3	12.4	25.8
W	9.5	60.7	9.9	38.0
NW	11.8	57.7	11.7	41.8
C	10.8	57.2	11.1	42.4
B If	1.7	39.6	1.8	5.3

Source: Own calculation based on the data from [16].

The values of vegetal production and animal production per inhabitant are shown in Table 7, where we may observe that at the national level, Romania obtained Lei 3,774.4 vegetal production and Lei 1,829.6 animal production.
Compared to this average level, the situation by region is the following:
- *The value of vegetal production per inhabitant* which exceeds the country average is recorded in SE, S Munt, SV Olt and W, and below the country mean there are the regions NE, NW, C and B If.
-*The value of animal production per capita* exceeds the country mean only in the regions: S Munt, SE, SW Olt and W (Table 7).

Labor productivity

In 2022, Romania achieved Lei 148,339.2 per person *labor productivity in the economy* (in current prices), of which Lei 29,562.2 per person came from agriculture, forestry and fishing (19.92%).
Compared to 2015 level =100, *the real labor productivity*, in terms of growth index, accounted for 104.5 at the EU-27 level, while in Romania it was estimated at 128.2.
By NUTS 2 region, the situation is shown in Table 8, which reflects that the highest growth was recorded by B If (159.6), followed by W region (140.5) and NW (137.8). The only region which did not achieve a growth was SW Olt (99).
Labor productivity in Romania is smaller than in other EU countries [23].

Table 7. The value of vegetal production and animal production per inhabitant by region, Romania, 2022

	Share of the value of vegetal production per capita by region in Romania's average vegetal production per capita (%)	Share of the value of animal production per capita by region in Romania's average animal production per capita (%)
ROMANIA	Lei 3,774.4 per capita	Lei 1,829.6 per capita
NE	98.7	91.0
SE	151.2	127.4
S Munt	126.1	148.1
SW Olt	124.3	126.3
W	108.3	112.9
NW	89.0	88.3
C	90.5	92.9
B If	14.3	15.1

Source: Own calculation based on the data from NIS [15].

Table 8. Real productivity per person in terms of real index in 2022 (2015=100)

Region	2015=100	Differences versus 2015 (pp)
NE	104.6	+4.6
SE	109.6	+9.6
S Munt	102.0	+2
SW Olt	99.0	-1
W	140.5	+40.5
NW	137.8	+37.8
C	115.0	+15
B If	159.6	+59.6

Source: Own calculation based on the data from [4].

Average monthly income per household

In 2022, *average monthly income per household* accounted for Lei 6,464.12. The NUTS 2 regions, which exceeded this national average, were: B If (148.4), NW (108.2), C (104.7), but all the other regions recorded smaller values.

From agriculture, forestry and fishing, a household registered an average monthly income of Lei 117.42 at national level. By NUTS 2 region, the national average was exceeded by NE (Lei 178.8), W (Lei 174.05), SE (167.00), and C (113.35). All the other regions registered a smaller monthly average income from agriculture and, especially, B If (6.73), the smallest level (Table 9).

Average total expenditures per household

In 2022, in Romania, *the average monthly expenditures per household* were Lei 5,610.75. By region, the level of this indicator varied between Lei 8,187 in B If, the top level, and Lei 4,588.41 in NE, the lowest level in NE.

The national average was exceeded by B If, NW and C, while the remaining regions were below.

The average monthly expenditures per household destined for purchasing food and beverages accounted for Lei 1,020.38 representing 18.18% of the average monthly expenditures per household.

By NUTS 2 region, the average monthly expenditures for food and beverages ranged between Lei 1,607.22 in B If and Lei 857.04 in S Munt (Table 10).

The average monthly savings rate per household was calculated as a percentage ratio between the difference calculated between the average monthly income per household and the average monthly expenditures per household, divided by the average monthly income. The result accounted for 13.20% of the monthly average income. By NUTS 2 region, the savings rate exceeded the national rate only the following regions: W (18.29%), C (14.78%), B IF (14.63%), SW (13.23%) (Table 11).

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Table 9.Average monthly income per household and average monthly income per household coming from agriculture, forestry and fishing, Romania, 2022

	Share of average monthly income per household by region in Romania's average monthly income per household (%)	Share of average monthly income per household by region coming from agriculture, forestry and fishing in Romania's average monthly income per household (%)	Share of average monthly income per household by region coming from agriculture, forestry and fishing in Romania's average income from agriculture etc (%)
ROMANIA	Lei 6,464.12 per household	Lei 117.42 lei per household from agriculture etc.= 1.81%	117.41 = 100
NE	79.6	3.47	152.3
SE	84.15	3.08	143.0
S Munt	92.3	1.54	78.3
SW Olt	89.0	1.42	69.4
W	99.5	2.70	148.2
NW	108.2	1.67	99.7
C	104.7	1.68	96.5
B If	148.4	0.17	5.7

Source: Own calculation based on the data from [15].

Table 10. Average monthly expenditures per household and Average monthly expenditures per household for purchasing food and beverages, Romania, 2022

	Share of average monthly expenditures per household by region in Romania's average monthly expenditures per household (%)	Share of average monthly expenditures per household by region for buying food and beverages in Romania's average monthly expenditures per household (%)	Share of average monthly expenditures per household by region for buying food and beverages in Romania's average expenditures for purchasing food and beverages (%)
ROMANIA	Lei 5,610.75 per household	Lei 1,020.38 per household for buying food and beverages = 18.18%	Lei 1,020.38 = 100
NE	81.8	19.04	85.6
SE	87.8	19.17	92.4
S Munt	92.8	16.45	84.0
SW Olt	89.0	17.74	85.5
W	93.6	19.31	99.4
NW	109.7	16.56	99.9
C	102.7	17.76	100.4
B If	145.9	19.63	157.5

Source: Own calculation based on the data from [15].

Table 11. Average savings rate per household in Romania, 2022

	The average monthly savings rate per household in Romania (%)	Differences among regions regarding the savings rate from the average monthly savings rate per household in Romania (pp)
ROMANIA	13.20 %	0 pp
NE	10.82	-2.38
SE	9.57	-3.63
S Munt	12.74	-0.46
SW Olt	13.23	+0.03
W	18.29	+5.09
NW	11.95	-1.25
C	14.78	+1.58
B If	14.63	+1.43

Source: Own calculation based on the data from [15].

Average monthly income per person carried out in Romania in 2022 was Lei 2,575.07. By region, its level varied between Lei 3,836.7 in B If, the highest level, and Lei 2,028.34 per person in NE, the lowest level.

This indicator had a higher value than the national mean in B If 9140%), NW (105.6%), C (102.3%) and W (100.4%) (Table 12).

Average monthly expenditures per person accounted for Lei 2,235.12 in 2022 at the country level.

Higher expenditures per person were done in B If (146.5%), NW (107.1%) and C (100.4%).

In the other regions, the expenditures spent by a person were lower than the national average.

The monthly savings rate per person from the average monthly income per person was 13.2% at the level of Romania and by region its level varied between 18.3% in W region and 9.5% in SE (Table 12).

Table 12. Average monthly income per person, average monthly expenditures per person and the average monthly savings rate per person, Romania, 2022

	Share of the average monthly income per person and region in Romania's average monthly income per person (%)	Share the average monthly expenditures per person and region in Romania's average monthly expenditures person (%)	Average monthly savings rate per person (%)	Differences among regions versus average monthly savings rate per person (pp)
ROMANIA	Lei 2,575.07 per person = 100	Leo 2,235.12 per person= 100	13.2%	0 pp
NE	78.8	80.9	10.8	-2.4
SE	86.9	90.5	9.5	-3.7
S Munt	92.3	92.8	12.7	-0.5
SW Olt	91.1	91.0	13.2	0
W	100.4	94.5	18.3	+5.1
NW	105.6	107.1	11.9	-1.3
C	102.3	100.4	14.8	+1.6
B If	149.0	146.5	14.6	+1.4

Source: Own calculation based on the data from [15].

Average monthly income per agriculturist

It is an indicator reflecting the fed back to the people working in agriculture for their hard work during every month. In 2022, it level was Lei 1,377.44, as an average at the country level.

By region, it varied between Lei 6,678.31 in B If and Lei 918.48 in SV Olt.

The national mean was exceeded only by the following regions: B If (4.8 times), S Munt (+40%), NW (+35%), SE (+22.42%), C (+18.86%).

In SW Olt, NE and W, an agriculturist obtained a lower average monthly income than the national mean (Table 13).

Table 13. Average monthly income per agriculturist

	Share of the average monthly income per agriculturist by region in Romania's average monthly income per agriculturist (%)
ROMANIA	Lei 1,377.44 per agriculturist = 100
NE	77.88
SE	122.42
S Munt	140.14
SW Olt	66.68
W	97.83
NW	135.00
C	118.86
B If	484.90

Source: Own calculation based on the data from [15].

GDP (PPS) per inhabitant

This is the most synthetic indicator reflecting the economic and social development of a region and country and allows comparisons among regions and countries.

In 2022, the EU-27 GDP(PPS) accounted for Euro 35,440 per capita.

Romania achieved Euro 26,700 per capita (PPS), representing 75% of the EU average, compared to 74% in 2021 and 57% in 2012.
In 2022, Romania is close to Hungary's GDP which carried out 76%, but it is still behind Poland (80%).
Among the EU-27 member states, Romania comes on the 22 position for GDP (PPS) per capita as shown in Table 14.
By development region, in 2022, GDP (PPS) per capita varied between Euro 62,900 in B If, the highest level in Romania and Euro 20,200 in S Munt region.

Table 14. Romania's position among the EU member states for GDP(PPS) per capita in 2022

EU GDP (PPS) = Euro 35,440 per capita = 100		
EU countries with a higher GDP (PPS) than the EU average	EU countries with a lower GDP (PPS) than the EU average	
1. Luxembourg 256 2.Ireland 234 3.Denmark 136 4.Netherlands 131 5.Austria 124 6.Belgium 120 7.Germany 117 8. Sweden 117 9.Finland 110 10.Malta 104	12.Italy 86 13.Cyprus 94 14.Czechia 90 15.Slovenia 90 16.Lithuania 89 17.Spain 85 19.Estonia 85 20. Portugal 79 21.Hungary 76	22.Romania 75 23. Croatia 73 24.Latvia 72 25.Slovakia 71 26. Greece 67 27.Bulgaria 62
11.France 100		

Source: Own conception based on [14].

The share of the Romanian NUTS 2 regions in the EU average of Euro 35,440 per capita varied between 177.5 in B If, the top level and 46% in NE, the smallest level.
Therefore, the only region which exceeds the EU average GDP per capita is Bucharest Ilfov. If we take into account that Romania's GDP per capita was Euro 26,700 in 2022, we may notice that only two regions exceeds the national average: B If, 2.35 times and W region by +3.7%. All the other development regions have still a lower GDP than Romania's average per capita and this reflects an insufficient development and large discrepancies among regions (Table 15).

Table 15. Romania's GDP (PPS) per capita and by region of development in 2022

	EU GDP (PPS) in 2022 = Euro 35,440 per capita			Romania's GDP (PPS) in 2022= Euro 26,700 per capita	
	Romania GDP Euro/capita = 26,700	Share in the EU GDP (%)	Differences versus EU GDP= 100 (pp)	Share in the Romania's GDP (%)	Differences versus Romania's GDP= 100 (pp)
NE	16,300	46.0	-54	61.0	-39.0
SE	21,400	60.3	-39.7	80.1	-19.9
S Munt	20,200	57.0	-43	75.6	-24.4
SW Olt	20,300	57.3	-42.7	76.0	-24.0
W	27,700	78.2	-21.8	103.7	+3.7
NW	24,700	69.7	-30.3	92.5	-7.5
C	25,200	71.1	-28.9	94.4	-5.6
B If	62,900	177.5	+77.5	235.6	+135.6

Source: Own calculations based on the data from [4].

In 2023, according to Eurostat, the EU achieved Euro 37,610 per capita GDP (PPS0 and Romania Euro 30,000, representing 80% of the EU average.
But, if we compare Romania's GDP per capita achieved in 2022 versus 2021, we may notice that in all the regions of development GDP increased in various proportions, varying between +14.46% in West, +12.7% in

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Bucharest Ilfov, +12% in the Center region and the smallest increase was + 7.)% in North East (Fig. 1).

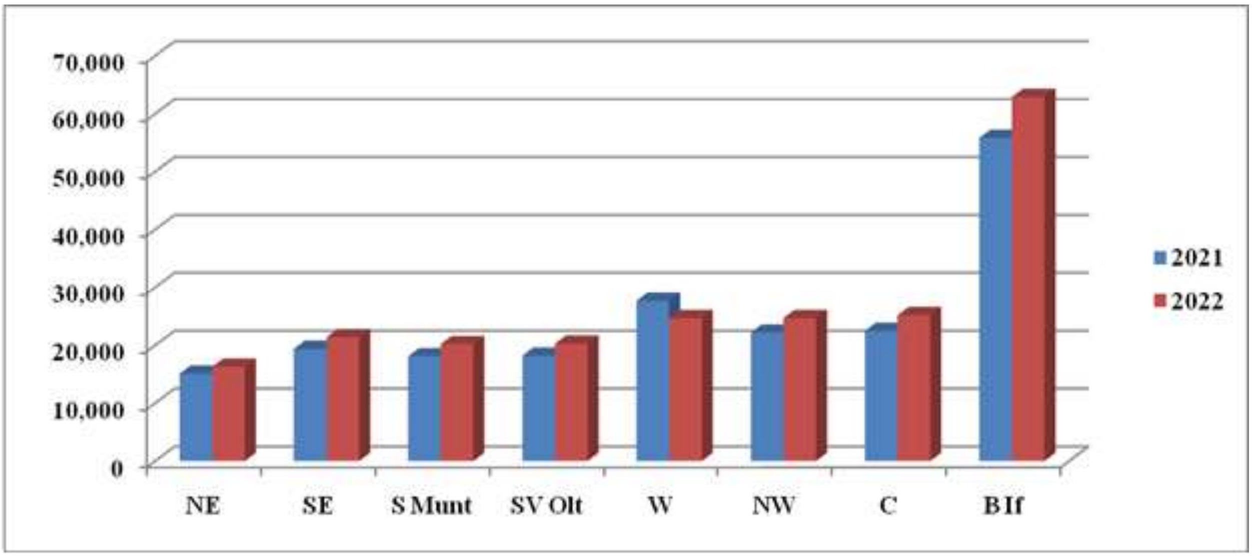

Fig. 1. Dynamics of Romania's GDP (PPS) by region in 2022 versus 2021 (Euro/capita)
Source: Own design based on the data from [5].

The classification of the development regions in Romania based on the performances achieved in 2022 according to the results found in this analysis.
Based on the cumulated points for the 32 indicators used in this research and applying the rank-order method, it was established the hierarchy of the 8 regions, taking into consideration that the region with the smallest number of total points is in the top and the region with the largest number of points is situated on the last position.

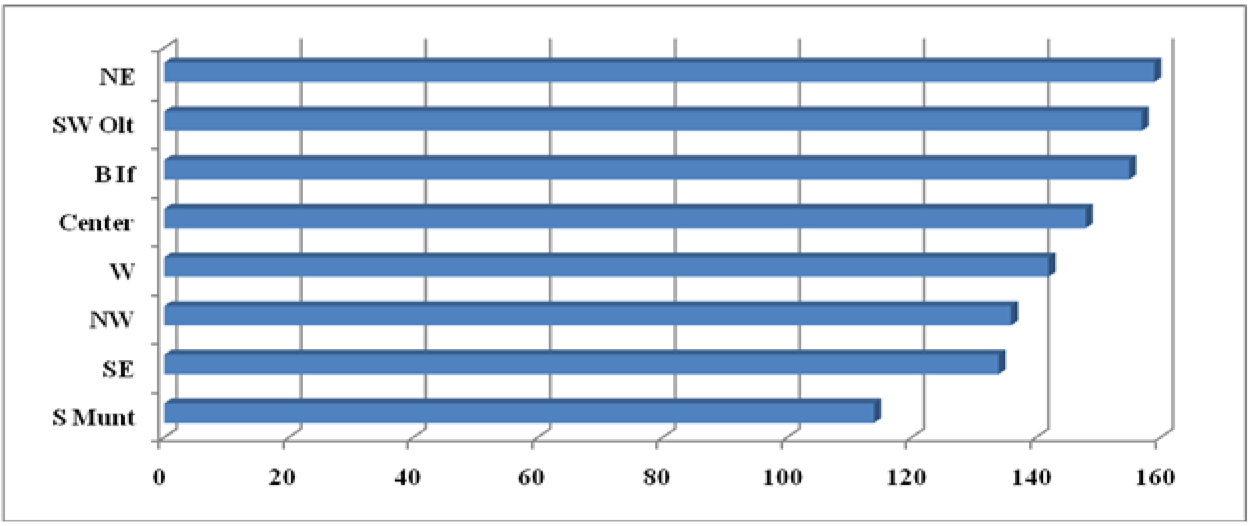

Fig.2. The hierarchy regarding the development of the NUTS 2 regions in Romania as assessed by a research in which there were used 32 economic and social indicators
Source: Own conception and results.

From this point of view, the region of development which accumulated 114 points is ranked 1st, it is about South Muntenia, being followed in the 2nd position by South East region with 134 points and on the 3rd position by North West region with 136 points. On the 4th position is situated West region with 142 points, being followed by Center region on the 5th position with 148 points, and on the 6th position by Bucharest Ilfov with 155 points. On the 7th position is South West Oltenia which accumulated 157 points.

Finally, on the 8th position comes North East region with 159 points (Fig. 2).

CONCLUSIONS

This research work studied the regional development in Romania in the year 2022 by a comparative analysis of the 8 NUTS 2 regions using a set of 32 indicators which covered a large range of aspects considered important by authors who desired to emphasize the contribution of agriculture to the social and economic growth in various parts of the country.

Regarding the demographic aspects, it was noticed a polarization of total population as follows: the largest number of residents is in the North East, South Muntenia, North West and South East and also in Bucharest-Ilfov regions, while the lowest number of inhabitants was found in the other regions, especially in the West.

Rural population is concentrated in North East, South Muntenia, North West and South East, the regions were agriculture is much more developed, and, in a smaller proportion in the West and Bucharest Ilfov regions were the opportunities offered by the capital and the City of Timisoara in finding well paid jobs are more numerous.

Also, in these four regions North East, South Muntenia, North West and South East it was found the largest population occupied in agriculture.

The occupied population in the economy has a higher share in Bucharest Ilfov, North West, Center and West.

Regarding the contribution of agriculture to the territorial development, taking into account the surface, as land is the most precious capital for producing food and nourish the population, it was noticed that the largest areas are, in the following regions, in the decreasing order being: South Muntenia, South East, South West Oltenia, West and North East. Obviously, the highest contribution to the value of agriculture production is given by these regions: South Muntenia, South East, South West Oltenia, West and North East.

Taking into account the resident population, the highest value of agricultural production per inhabitant was noticed in South Muntenia, followed by South East, South West Oltenia and West, the last two regions having a smaller population than the others. The North East region, despite that it is ranked the 3rd for the value of agricultural production, came on the 6th position due to the fact that it has a higher number of inhabitants. When we analyzed the contribution of various regions to the value of vegetal and animal production, we found again the four regions South Muntenia, South East, South West Oltenia, West and North East as it was normal to be. At the oposite pole, with a smaller contribution there are Bucharest Ilfov, West and Center regions.

Analyzing the vegetal and animal production value per inhabitant, we found that on the first four positions there are: South East, Sount Muntenia, South West Oltenia and West. On the last position is Bucharest Ilfov which reflects that in this region is not possible to cover the local market requirements in agro-food products and the other regions must be supply the difference to assure food security.

Labor productivity has the highest performance in Bucharest Ilfov, West, North West and Center, where the employees are more qualified and the jobs are more attractive especially in other fields of activity than agriculture.

Average monthly income and expenditures per household and person in the economy reflect again discrepancies among regions. The highest average monthly income per household is in the following four regions, which in the decreasing order are: Bucharest Ilfov, North West, Center and West, and these four regions have also the highest share regarding the average monthly expenditures per household, as well as the expenditures for food and beverages and the savings rate.

In the other four regions, income and expenditures are much lower per month.

Regarding the average income and expenditure per person, also these four regions are on the first position, but in the following order: Bucharest Ilfov, Center, North West and West.

Average monthly income coming from agriculture per household and person is much smaller compared to the national average. But, the regions where the average monthly income from agriculture is higher are, in the decreasing order: North East, West, South East and North West.

The average monthly income coming from agriculture per person is higher in the following regions: Bucharest Ilfov, South Muntenia, North West and South East.

Gross Domestic Product registered a different level among regions, which again could be divided into two categories:

-regions with the highest GDP, in the decreasing order: Bucharest Ilfov, West, Centre, North West;

-regions with a lower GDP, in the decreasing order: North East, South Muntenia, South West Oltenia and South East, where agriculture is better developed, but it has a smaller contribution to GDP compared to other economic sectors (industry, IT, commerce, transport etc).

Romania's GDP compared to the EU's GDP

In 2022, Romania achieved Euro 26,700 per capita (PPS), representing 75% of the EU average Euro 35,440 per inhabitant.

Compared to the level in 2021 (74%) this means an increase of 1 percentage point.

For its performance in the year 2022, Romania comes on the 22 position among the other EU member states. It is still behind Hungary (76%), Portugal (79%) and Poland (80%), but it has a higher GDP per capita than Croatia (73%), Latvia (72%), Slovakia (71%), Greece (67%) and Bulgaria (62%).

The final hierarchy of the regions of development of Romania in 2022

Based on the total cumulated number of points for each indicator taken into consideration in this research regarding the economic and social performance which emphasize the contribution of agriculture, it was established the final classification of the regions, which is the following one in the decreasing order: South Muntenia, South East, North West, West region, Center, Bucharest Ilfov, South West Oltenia and North East.

The obtained points reflect the existence of discrepancies among regions, an aspect which does not entirely fit to the EU cohesion policy.

Romania has to intensify its efforts to assure a higher rate of economic growth on the principle of equity in the territory and reach a balanced and harmonized economic and social development which, also, have to reduce the gaps compared to the other NUTS 2 regions.

The treaty on the Functioning of the European Union (TFEU) enables the EU to take measures to strengthen its economic, social and territorial cohesion and to assure a harmonious and balanced development.

The cohesion funds (2021-2027) are destined for investments through national or regional programmes to the countries with a gross national income per capita below 90% of the EU average and Romania is among the 15 countries in this situation [3]. The funds are mainly destined for investments through the national and regional programmes (environment, trans-European network of transportation), the total budget being Euro 48.3 Billion.

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ECONOMIC EFFICIENCY ANALYSIS OF THE DRIP IRRIGATION SYSTEM ON THE CORN CROP

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Abstract

The field research was carried out in the North-East development region of Romania, during 2020-2023, on a cambic chernozem type soil, with a high humus content of 7%. The data were obtained from plots cultivated with corn, analyzed according to the irrigation rate, in order to verify the differences that appear in the crop within the plots. The drip irrigation method was applied using a system where the drip line is buried below the soil surface. In the growing seasons, when irrigation was applied, the increase in production was 63.41% higher than the average non-irrigated production. This method also had an influence in the valorization of water use. With water availability inside the soil, for plants of 1.1 mm/cm depth and with annual deviations of the precipitation with values between -51 and +27 mm, an average application of watering of maximum 4.25 l/m²/day was reached. The purpose of the research was to highlight and quantify the effects of drip irrigation in corn, on the significant increase in production, by improving the operating yields of irrigation facilities, by reducing water and energy consumption and the effective application of fertilizers, with results beneficial in increasing agricultural production. The present research demonstrated a significant average production increase of 63.41% during 2020 – 2023, the studied period. Also, during the same period, the share of irrigation in covering the total water requirement was between 29.6% and 48.7% as it will be detailed.

Key words*: *irrigation, drip, corn, efficiency, climate

INTRODUCTION

Currently, obtaining a competitive cereal production in the North-East of Romania is influenced by high temperatures and low periodic precipitation. These factors lead to pedological droughts. Maize is a particularly important crop in the economy, and the quality of the production significantly depends on the irrigation in the first phases of vegetation. The occurrence of drought decreases the yield, both in terms of the quantity of production and its quality. As many researchers have reported, the application of irrigation in optimal conditions ensures the correct rate of plant growth and development, by intensifying physiological processes [1].

Irrigation systems are very important for sustaining yield performance for any agricultural crop, and in Romania this was proved in many areas affected by drought [6].

Applying various types of irrigation system in Egypt it was shown their influence on maize production for silage [7].

In Ukraine, it was experimented the effect of new technologies based on tillage and irrigation for corn culture for grains [3].

For farmers' associations, the irrigation systems improve the infrastructure level in agriculture and helps the producers to increase production [11].

the technological and economic effect of irrigation in the context of climate change was emphasized by [9].

The physical properties of the soil determine, together with the hydrophysical properties, the amount of water that is stored in the soil, the water accessible to plants, the rate of infiltration and the supply of nutrients to plants. These properties of the soil are taken into account when choosing the type of arrangement, the method and the technical elements of watering [12, 5, 2, 4].

Consequently, irrigation is effective for the success and sustainability of agricultural activities.

The analyzes regarding the irrigation regime for the corn crop were carried out during 2020-2023, within the Water User's Association "Spiridonești", Neamț county, on a cambic chernozem, on the active depth interval of H = 0.80 m, with a capacity of field for water CC = 70%. During the four-year study, the KWS KAMELIAS maize variety, which is part of the FAO 340 group, a hybrid with a vegetation period of 107-112 days, was used. The required seeding density is expressed in plants/m^2, related to the desired plant density in case of 99% emergence. The irrigation method used was drip irrigation.

MATERIALS AND METHODS

To determine the water consumption for the corn crop, using the drip irrigation method, the climatic conditions in the studied area were analyzed and the elements of the irrigation regime were decided, which differ according to the pedoclimatic and the characteristics of the area rainfall regime.

Table 1 presents the main indices studied in this experiment.

Table 1. Water regime/soil water balance

XIndices	stock
f	239.5 mm (0-100 cm depth)
countries	155.9 mm (0-100 cm depth)
p	231.06 mm (4-year average)
m	44.88 m^3/ha
Ouch	≃ 20 m
S	being a soil with a very low slope, surface runoff is insignificant
E	15-30% of evaporation at the soil surface
T	75-92%
Yaf	15-23% of precipitation
R_{CC}	17.4% w/w
R_{PM}	50%

Source: own compilation using own equipment.

For these elements the following weredetermined: soil water regime Rf-Ri=(P+m+Aaf+S)-(E+T+Iaf), Rf (final water reserve after harvesting) and Ri (initial water reserve which is in the soil in the spring), P-precipitation, m-sum of watering norms, Aaf-water supply, S-runoffsupply, E-evaporation, T-transpiration, Iaf-percolation, net watering norm $m_n = R_{CC} - R_{PM}$, R_{CC} -the reserve corresponding to the field capacity, R_{PM} -the reserve of the minimum ceiling and waterings during the vegetation periods, starting to be applied when the corn reaches the 6-8 leaf phase, requiring 12-14% of the total water requirement for the entire vegetation period.

For the analyzed soil texture, a water storage capacity of 3.6 (mm/cm depth) and a plant water availability of 1.1 (mm/cm depth) resulted.

RESULTS AND DISCUSSIONS

Following the analysis of the multiannual average temperatures over the years of study, it turned out that in the months of July and August, of each year, the temperatures were much higher in relation to the other months of vegetation.This finding is also confirmed by the entire science of agronomy and meteorology.

Moreover, the last following years were the warmest in the history of temperature measurement. Specifically, during 2012-2021, the positive thermal anomalies were between 0.69°C (2021) and 1.92°C (2019), this being the warmest period of 10 consecutive years inthe history of meteorological measurements, a fact attributed to climate warming [8].

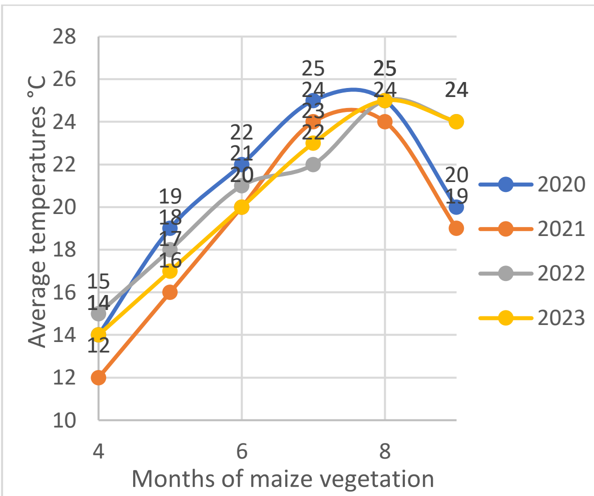

Fig. 1 Average temperatures in the growing months for the 4 years analyzed
Source: own determination using own equipment.

As can be seen, on the abscissa in the previous figure, the months of the calendar year are represented. According to specialized literature, the fourth month represents the period of the first stage of corn development (Figure 1).

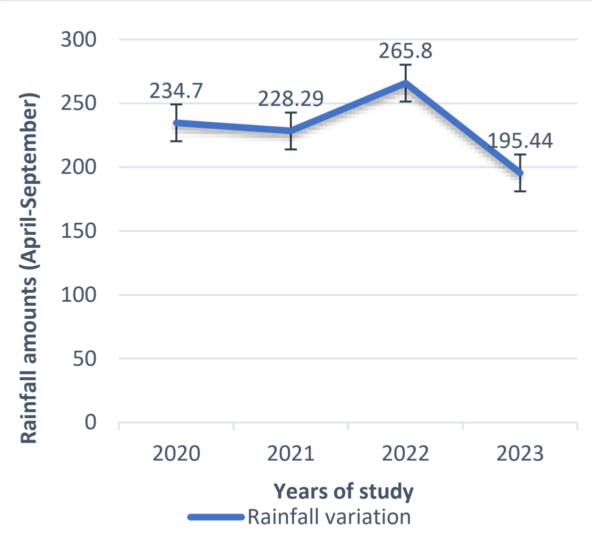

Fig. 2. Average amounts of precipitations in the studied period
Source: own determination using own equipment.

The average amounts of precipitation in the studied period, presented in Figure 2, were insufficient, or uneven, for the water requirement of the crop, during the development periods.

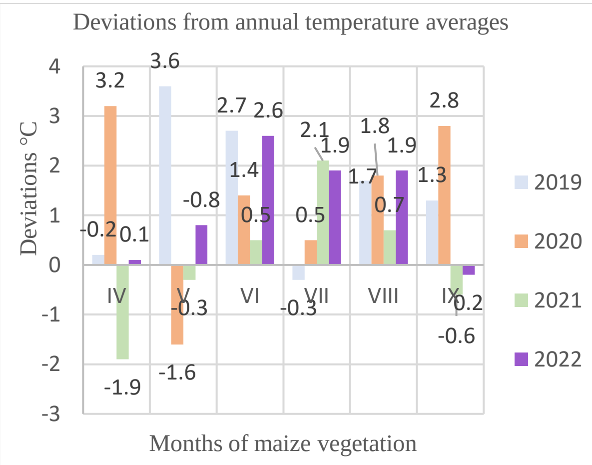

Fig. 3. Average annual temperature deviations for the 4 years analyzed
Source: own determination using own equipment.

The average annual temperature deviations of the four analyzed years (Figure 3) varied a lot throughout the vegetation period, but more pronounced values were recorded in the first month of development, in which corn has a water absorption of 27- 33% of the weight of the seed, being in the germination/emergence stage.

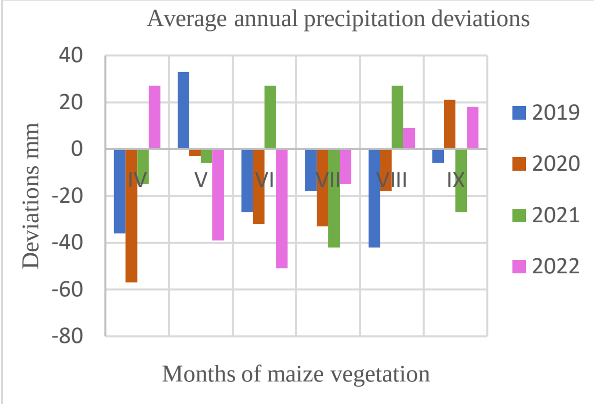

Fig. 4. Mean annual precipitations deviations for the 4 years analyzed
Source: own determination using own equipment.

The amounts of precipitation shown in figure 4, for the studied area, varied quite a lot in relation to the multi-year averages. Thus, in April 2020 a deviation of -36 mm was recorded, in August 2021 of -18 mm, values above the average were recorded in June and August 2022 (+27 mm), and in May2023 there was a deviation of -39 mm and in June of -51 mm.

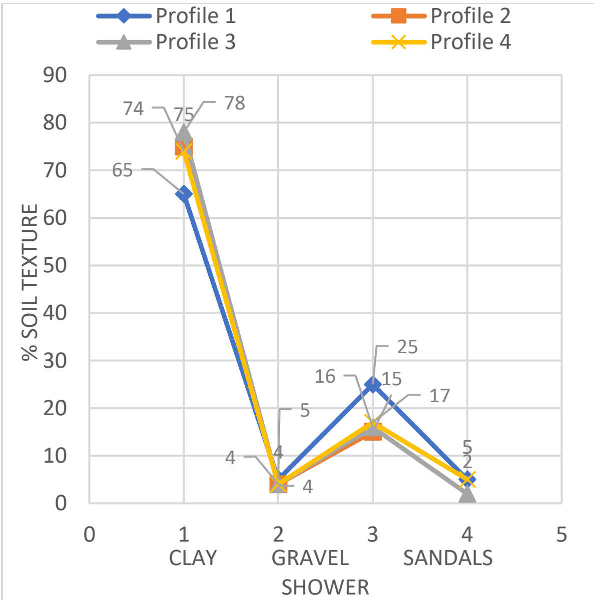

Fig. 5. Texture of the soil cultivated with maize
Source: Research Institute for Agriculture and Environment-ICAM, Iasi University of Life Sciences "Ion Ionescu de la Brad" [10].

Soil texture, shown in Figure 5, is important in the process of water and air retention. Important in the process of silification, drainage and stability or erosion. According to the analyzed texture, it results in a water storage capacity of 3.6 (mm/cm depth) and a plant water availability of 1.1 (mm/cm depth).

Knowing the bulk density of the soil (Table 2) is important in calculating the water reserve, nutrients, salts and fertilizer requirements.

Table 2 Apparent densities for the studied soil

Sample	Density values (g/ cm^3)
S1 (0-25 cm)	1.68
S2 (25-50cm)	1.80
S3 (50-75cm)	1.65
S4 (75-100cm)	1.70

Source: own determination using own equipment.

Following the analysis of the aspects presented above, the degree of water supply of the soil at a depth of 0-100 cm was within satisfactory limits only in 2021 (65%), because the amounts of precipitation were higher compared to the other years for study.

Table 3 shows the technical parameters of the drip irrigation system.

The amount of water required to irrigate the entire arable surface of the experimental fields is provided by pumping from the existing river in the northern part of the land, at a distance of approximately 1.15 km. According to the soil type, the distance between the drippers is 0.5 m, the distance between the drip lines is 1 m, with a required flow rate of 88.77 m ^{3}/h (Table 3).

Table 3. Technical parameters of the drip irrigation system

Description	UM	Details (medium values)
Crop	-	maize
Irrigated area	Ha	31.07
Spacing between rows	m	0.70
Distance between plants in a row	m	0.20
Max. working pressure of the drip line	bar	1.6 – 2.0
Flow distributed through the dropper	l/h	0.8 – 1.2
Distance between droppers	m	0.50
Distance between drip lines	m	1.00
The hourly rate of application of irrigates	mm/h	2.00
Maximum daily water consumption	mm/day	6.00
Irrigation cycle	days	1.0
Duration of an irrigation operation	h/day	3.0
The number of watering operations	no.	8.00
Maximum daily duration of irrigation operations	h	21.00
Maximum required flow rate	m^3/h	88.77

Source: own centralization of the experiment features.

Figure 6 shows the experimental field, with the surfaces related to each plot.

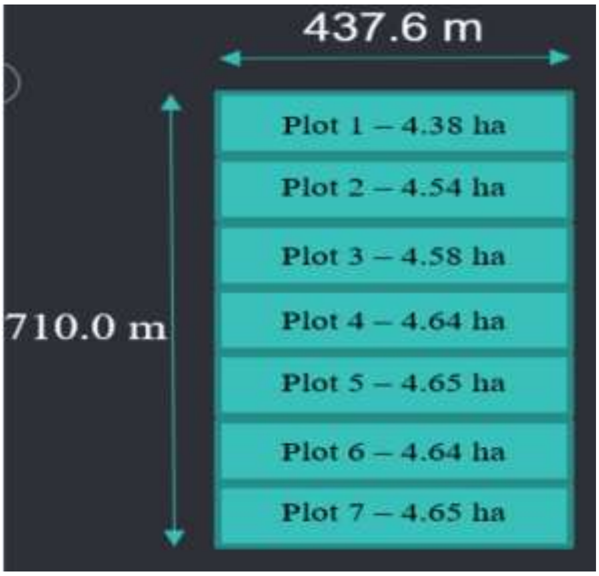

Fig. 6. Experimental field plan

Source: author graphic render of the dedicated experimental field.

The analyzed area was irrigated with the help of a pumping station provided by the farmer, which ensures a total flow of 187 m^3/hour.

The drip line chosen for researching drip irrigation techniques has an inner diameter of 20 – 24 mm, with a wall thickness of 0.3 – 0.5 mm.

The irrigation variants on the specified research areas recorded in 2020 average values of 2.31 l/m^2 /day for the month of May, 2.15 l/m^2/day for the month of June, 4.74 l/m^2/day for the month of July and 3.28 l/m^2/day for the month of August with variations between plots depending on the watering characteristics established initially.

In 2021, the watering options on the research areas recorded average values of 2.21 l/m^2/day for May, 1.07 l/m^2 /day for June, 3.83 l/m^2/day for July and 0.74 l/m^2 /day for the month of August.

The irrigation variants on the specified research areas recorded in 2022 average values of 2.50 l/m^2 /day for the month of May, 1.97 l/m^2 /day for the month of June, 4.42 l/m^2/day for the month of July and 3.94 l/m^2/day for the month of August with variations between plots depending on the watering characteristics established initially.

And in 2023, the irrigation options recorded average values of: 2.27 l/m^2/day for May, 1.75 l/m^2 /day for June, 4.25 l/m^2/day for July and August 3.45 l/m^2/day.

Irrigation of corn during 2020 and 2021 led to higher total water consumption values than in non-irrigated conditions by 56% and 58%. In the variants with interruption of irrigation, the values of total water consumption decreased compared to the variant optimally supplied with water.

Table 4. Irrigation regime of corn culturein different water supply options, 2020-2023

Alternative	April		May		June		July		August		April-August	
	ΣM m^3/ha	n	ΣM m^3/ha	n	ΣM m^3/ha	n	ΣM m^3/ha	n	ΣM m^3/ha	n	ΣM m^3/ha	n
1	2	3	4	5	6	7	8	9	10	11	12	13
2020												
V_1	-	-	-	-	12.46	2	20.00	3	20.00	3	32.46	5
V_2	-	-	14.75	2	12.46	2	20.00	3	20.00	3	32.46	5
V_3	-	-	14.75	2	12.46	2	-	-	-	-	12.46	2
V_4	-	-	14.75	2	-	-	20.00	3	20.00	3	20.00	3
V_5	-	-	-	-	12.46	2	20.00	3	20.00	3	32.46	5
2021												
V_1	6.10	1	14.75	2	57.50	3	14.37	6	88.45	4	31.05	16
V_2	6.10	1	14.75	2	-	-	14.37	6	88.45	4	25.30	13
V_3	6.10	1	-	-	57.50	3	-	-	88.45	4	15.21	8
V_4	6.10	1	-	-	57.50	3	14.37	6	88.45	4	29.60	14
V_5	6.10	1	14.75	2	57.50	3	14.37	6	-	-	22.20	12
2022												
V_1	-	-	12.99	1	58.20	3	18.32	7	21.00	2	27.53	13
V_2	-	-	-	-	58.20	3	18.32	7	21.00	2	62.33	12
1	2	3	4	5	6	7	8.00	9	10.00	11	12	13
V_3	-	-	12.99	1	-	-	18.32	7	21.00	2	50.63	10
V_4	-	-	12.99	1	58.20	3	-	-	21.00	2	45.70	6
V_5	-	-	12.99	1	58.20	3	18.32	7	-	-	47.83	11
2023												
V_1	6.10	1	14.75	2	57.50	3	14.37	6	88.45	4	31.05	16
V_2	6.10	1	14.75	2	-	-	14.37	6	88.45	4	25.30	13
V_3	6.10	1	-	-	57.50	3	-	-	88.45	4	15.21	8
V_4	6.10	1	-	-	57.50	3	14.37	6	88.45	4	29.57	14
V_5	6.10	1	14.75	2	57.50	3	14.37	6	-	-	22.20	12

Source: own determination and centralization within the present research.

The share of irrigation in covering total water consumption was between 29.6 and 43.9% in 2020, 37.9 and 47.8% in 2021, in 2022 values between 35.8% and 46.7%, and in 2023 values between 39.8% and 48.7%.

From the soil reserve, non-irrigated corn consumed the largest amounts of water: in the variant without interruption of irrigation, corn consumed the smallest amount of water from the soil reserve, and in the variants with interruption of irrigation, the values were higher, without exceeding the amount of water consumed from the soil reserve by non-irrigated corn. "ΣM m^3/ha" represents the sum of the amount of water administered at a certain number of waterings, denoted by "n" for each proposed "V" variant (Table 4).

According to Figure 7, the average production recorded in 2020 for the experimental lots was 15,915.11 kg/ha (compared to 7,564.76 kg/ha in the non-irrigated version), in 2021 it was 8,012.17 kg/ha (compared to 5,998.8 kg/ha in non-irrigated version), in 2022 it was 8,241.73 kg/ha (compared to 6,556.87 kg/ha in the non-irrigated version) and in 2023 it was 9,403.99 kg/ha (compared to 6,242.49 kg/ha in the non-irrigated version).

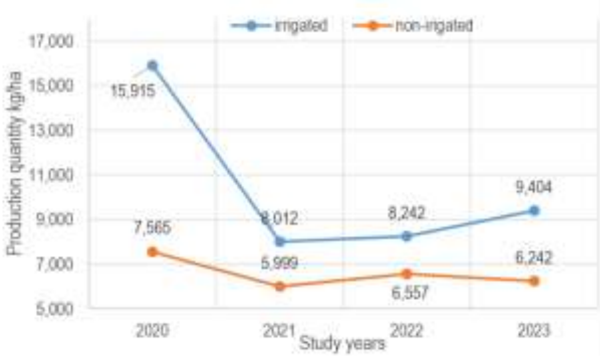

Fig. 7. Production over the years of study under irrigated and non-irrigated conditions
Source: own determination and centralization within the present research.

Next, the authors centralized the results of the determinations in the following Table 5. According to it:

-total water consumption was 309.7 l/m^2 in 2020, with a cost of 0.075 lei/m^2 related to one m^2 of cultivated land, of 184.7 l/m^2;

-in 2021 with a cost of 0.045 lei/m^2;

-in 2022 at a total water cost of 0.079 lei/m^2 to 0.326 m^3/m^2;

-and in 2023 at a total water consumption of 286.9 l/m^2 with a cost of 0.075 lei/m^2.

Table 5. Analysis of the economic efficiency of using the drip irrigation system

Feature	2020	2021	2022	2023
Total water consumption - l/m^2	309.7	184.7	326.8	286.9
Water cost - lei/m^3	0.243	0.243	0.243	0.243
Water cost - lei/m^2	0.075	0.045	0.079	0.075
Maize yield- kg/ha	5,648.86	3,505.85	8,857.14	7,995.87
Sale price for maize-lei/kg	1.11	1.2	1.2	1.2
Income related to increased yield- lei/m^2	0.607	0.421	0.687	0.677
Added economic value - lei/m^2	0.532	0.376	0.589	0.498

Source: own determination and centralization within the present research.

The added economic value was 0.532 lei/m^2 for 2020, 0.376 lei/m^2 in 2021, 0.589 lei/m^2 in 2022 and 0.498 lei/m^2 in 2023, which highlights the contribution of the system of value-added irrigation.

The importance of crop irrigation and especially its substantial and decisive influence on increasing the competitiveness of the economic unit are recognized throughout the European Union. Thus, in Romania, starting with the multi-annual financial year 2007 – 2014 (the first since Romania's accession), non-reimbursable funds were made available for the rehabilitation of the irrigation infrastructure in Romania built during the communist period. Romania is currently in the third multi-year financial envelope since accession which provides substantial non-reimbursable grants to rehabilitate pumping stations, pipelines and irrigation plots.

The financier recognizes the particular importance of this strategic sector. Consequently, as an exception to the funds granted to other links in the agricultural production sector, for the modernization of these irrigation systems the financier grants 1.5 million Euros, a much higher amount than for other links in agricultural production and, in addition, a financial intensity of the support of 100%. This contrasts with other funding where between 40% and 80% non-reimbursable financial assistance is awarded.

For the calendar period 2023 – 2027, the European Union, through the National Strategic Program, made available to Romania the amount of 400 million Euros, an amount much higher than all the financial allocations for the irrigation sector since Romania's accession. It is expected that this non-reimbursable value of 400 million Euros will cover the modernization and rehabilitation of a number of about 270 Water User's Associations at national level, which serve on average about 600-800 ha each.

Therefore, the major positive influence of crop irrigation is found at the European level, not only at the Romanian level. Moreover, in addition to the modernization of the secondary irrigation infrastructure, Romania also benefits of funds for the rehabilitation of the primary infrastructure, which supplies Water User's Associations throughout the country. These are pumping stations located on the banks of large water courses that provide the water needed for secondary pumping stations owned by farmers

CONCLUSIONS

The results presented, obtained during 2020 - 2023, varied depending on the level of humidity maintained in the soil.

The share of irrigation in covering the total water requirement was between 29.6 and 43.9% in 2020, 37.9 and 47.8% in 2021, in 2022 values between 35.8% and 46.7%, and in 2023 values between 39.8% and 48.7%.

Optimum water supply of maize with the help of irrigation determined in 2020 and 2021 values of the total water consumption higher than in the other years by 56% and 58%, because the temperatures recorded values above the average and the precipitation was uneven.

Irrigation led to a significant increase of 63.41% in production and its stability in the following period.

Regarding the economic impact of the investment represented by the drip irrigation system on the analyzed Water User's Association, this consists in the operating yields improvement of the irrigation facilities in the area, by reducing water and energy consumption and the effective application of fertilizers, with effects in increasing agricultural production.

Therefore, the investment represented by the drip irrigation system has a significant positive impact on the economic performance of the Water Users' Association.

The special importance that irrigation has on crops is recognized internationally, with the European Union granting Romania, as a Member State, non-reimbursable financing of approximately 1 billion Euros since its accession in 2007 until now.

The financing intensity is 100% non-refundable and the maximum value of a project, within the PNS 2024-2027 envelope, is 1.5 million Euros.

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DEVELOPMENT POSSIBILITIES OF THE HOSPITALITY SECTOR BY CREATING AND PROMOTING AUTHENTIC TOURIST EXPERIENCES

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Abstract

The study on developing the hospitality sector through the creation and promotion of authentic tourism experiences used a mixed approach with quantitative and qualitative methods to gain a complex insight into tourist preferences. Through questionnaires and interviews, the research collected data from tourists staying in the Sf. Nicolae Alunis guesthouse in Prahova County and at the Casa Romaneasca Hotel in Vâlcea County, Romania. The questions addressed tourists' interest in authenticity, personalization and sustainability in their tourism experiences, providing a basis for better understanding how offerings can be tailored to meet their needs. The results highlighted that most tourists value authenticity in tourism experiences, preferring activities that allow them to discover local culture and interact directly with the community. Personalization was also considered important, with tourists showing interest in activity recommendations and itineraries tailored to their interests. However, the level of interest in customization and authenticity varies, which demonstrates the need for flexible options that allow each tourist to customize their experience according to their own preferences. Another key aspect is supporting sustainable practices. Although many tourists are willing to pay extra for environmentally friendly accommodations, price sensitivity remains an important factor. This involves a balance between meeting ecological requirements and maintaining price competitiveness. In conclusion, the study shows that the hospitality sector can benefit significantly from the integration of authenticity, personalization and sustainability in the offer, aspects that contribute to increasing tourist satisfaction and loyalty.

Key words: *hospitality, authenticity, experiences, Romania*

INTRODUCTION

Hospitality is an economic sector that includes services dedicated to welcoming, hosting and ensuring the comfort of visitors, including hotels, restaurants, catering services and other agreement facilities [9]. This involves a customer-oriented approach focused on creating a positive and memorable experience for tourists and other people served. The hospitality sector is characterized by a direct and constant interaction with customers, and its success depends on the quality of services and the satisfaction offered to them [5, 16].

By attracting tourists and other visitors, hospitality stimulates local consumption, supports small and large businesses, and creates an economic chain with horizontal impact, benefiting sectors such as agriculture, transportation, and the entertainment industry [3, 6, 22]. Moreover, hospitality contributes to regional development, especially in tourist areas, boosting infrastructure investment and improving the quality of life [20, 21].

In the long term, hospitality can help create a positive image of a country or region, attracting investors and strengthening competitive advantage in the international market [4, 19]. By stimulating innovation and adapting to modern consumer demands, this sector can support sustainable development and economic diversification, contributing crucially to economic growth and the financial stability of a national economy.

Although hospitality can vary between different cultures, in some it involves only a greeting and a smile, in others the guest is treated as a member of the family, integrated into the intimacy of the home [18].

That is why one of the important directions for the development of hospitality is to focus on the creation and promotion of authentic tourist experiences, which reflect the local specificity and meet the expectations of tourists in search of unique experiences [14, 15]. This aspect is linked to global trends in hospitality, where tourists are increasingly looking to participate in activities that give them direct contact with culture, nature and local communities. Therefore, the marketing and development strategies of tourism products must focus on personalizing tourism offers, responding to the various interests and needs of visitors, whether we are talking about cultural tourism, adventure tourism, rural tourism, ecotourism or other forms of tourism. niche [2, 10]. The personalization of experiences can contribute to increasing the satisfaction of tourists and will contribute to their loyalty [17].

In the case of rural tourism, hospitality means more than accommodation, including nature activities, scenic tours and observation of local fauna and flora, etc. all this providing a sense of belonging to the rural environment [13, 22]. Agritourism, a form of rural tourism, allows tourists to experience farm life by participating in agricultural activities and supporting local farms, which enhances the sense of authenticity and learning [8, 12, 23]. The warmth and personalized attention provided by hosts creates a lasting relationship that keeps tourists coming back and recommending the destination. In addition, modern technology makes it easier to connect tourists with rural communities, allowing them to book personalized experiences and interact with hosts before their visit. Thus, rural tourism becomes an attractive alternative for modern tourists, who seek relaxation, authenticity and a deep connection with nature and local traditions [7, 11].

In this context, the paper aimed to collect information on the development of hospitality sector by creating and promoting authentic tourism experiences. In this purpose, there were used various quantitative and qualitative methods, A survey based on a strutured questionaire supplied information on tourists' preferences. The research place, where the interviewees were questioned, stayed in the Sf. Nicolae Alunis guesthouse in Prahova County and at the Casa Romaneasca Hotel in Vâlcea County, Romania.

MATERIALS AND METHODS

The research methodology was a mixed one, which combined qualitative and quantitative methods. The research involved the use of a structured questionnaire including 15 questions which had the role to assess tourists' general satisfaction, service quality, authenticity of the experience and perceived level of hospitality.

The questionnaire included both open and closed questions, questions with answers on the Likert scale (from 1 to 5) which had the role of obtaining clear and comparable quantitative data between two units, one located in Prahova county, and the other in Valcea county.

Pension St. Nicolae is located in the village of Aluniș, Prahova county, approximately 12 km from the Slănic resort. Located in a picturesque area, surrounded by meadows and forests, the guesthouse offers a quiet atmosphere and strong ozone air, ideal for relaxation and escape from the urban bustle. The guesthouse has seven rooms and a restaurant where traditional Romanian dishes are served, prepared from local ecological ingredients. For leisure, guests have various activities at their disposal: games of darts, table tennis and the possibility to rent bicycles to explore the surroundings. The guesthouse also offers a well-equipped playground for children, a garden and a sauna for relaxation.

The Sf. Nicolae guesthouse is recognized for the hospitality of the hosts and the attention given to the needs of the guests. Customer reviews highlight the quality of service, cleanliness and pleasant atmosphere, contributing to an unforgettable experience in the heart of nature.

The Casa Românească Hotel, located in the Călimănesti-Căciulata resort, close to the Cozia Monastery, offers accommodation at 4-star standards in double, twin rooms and apartments equipped with air conditioning, minibar, TV and internet. The complex includes two thermal water pools (indoor and outdoor), two saunas and a 70-seat conference room. The winery-restaurant, rustically decorated with carved wood and stone, offers traditional Romanian dishes. The location of the hotel allows easy access to the natural and historical attractions in the area, offering a complete experience in the heart of the Olt Valley.

The comparative analysis between the two units sought to highlight the strengths and challenges of each of them, and the integration of quantitative and qualitative data allowed us a complete understanding of the tourists' perception. This mixed methodology ensured obtaining relevant conclusions and recommendations with a role in improving the quality of services and increasing the satisfaction of tourists in rural accommodation units.

Right from the beginning, it was desired that the questionnaire be applied to a number of 100 respondents. Out of all of them, 37 were tourists in the St. Nicolae Alunis, and 63 in the Casa Romaneasca accommodation unit.

The purpose of applying and analyzing the answers provided was to identify the authentic preferences and experiences of tourists that were the basis of market segmentation, and especially their use for the purpose of providing personalized packages for different groups of tourists and to improve tourist experiences through based adjustments on feedback. The collected and analyzed data can also be used to adapt promotional messages, emphasizing the authenticity and uniqueness of the experiences offered, but also to identify trends for innovation and long-term strategic development. By capitalizing on the answers, businesses can better meet the expectations of tourists, maintaining relevance and attractiveness in the market.

The questionnaire had 15 questions and was applied between August 15 and October 15, 2024. The questions were divided into 6 sections, as follows: Section 1 - Demographic information; Section 2 – Experiences and preferences of tourists; Section 3 - Interaction with local culture and authenticity; Section 4 - Preferences for sustainable tourism; Section 5 - Digital interaction and personalization of the experience; Section 6 - Feedback and previous experiences. The 15 questions were the following:

(1) Your age
(2) Your Gender
(3) What is your annual income?
(4) What are the main reasons you travel?
(5) On a scale of 1 to 5 how important are they to you? the following aspects on a holiday? (1 = not at all important, 5 = very important
(6) How important is the authenticity of the location and tourism experiences to you?
(7) Have you participated in authentic tourism activities in the past?
(8) If the answer is "Yes," please describe the experience
(9) How important it is to you for accommodation units to have sustainable practices?
(10) Would you be willing to pay more for environmentally friendly tourism services?
(11) To what extent are you interested in personalizing your experience? tourism through applications and digital platforms?
(12) What kind of personalization do you think would improve your experience? tourist?
(13) To what extent have personalized experiences influenced your satisfaction? tourist?
(14) Please provide an example of a personalized experience that impressed you
(15) What improvements would you like to see in tourism offers to make them more authentic and personalized?

RESULTS AND DISCUSSIONS

The answers obtained on the basis of the questionnaires applied face to face in the 2 accommodation units were centralized and processed with the help of the Excel program.

Out of the 15 questions in the questionnaire, the first three were demographic in nature, resulting in 12% of respondents aged between 18-25 years, 14% between 26-35 years, 21% between 36-45 years, 18% between 46 -55 years, 27% between 56-65 years and 8% over

65 years. The structure was also influenced by the tourists' willingness to answer.

Of these, 57% were women, and 43% were men. Regarding the annual income, the answers provided show that 11% have an annual income of less than 50,000 lei, and 8% have an income of more than 150,000 lei. The incomes obtained by 57% of the respondents fall between 50,000 - 100,000 lei, and 24% of them have incomes between 100,000 - 150,000 lei (Table 1).

Table 1. The socio-demographic characteristics of the respondents

Age	**Frequency**	**Percentage**
18-25 years	12	12%
26-35 years old	14	14%
36-45 years	21	21%
46-55 years	18	18%
56-65 years	27	27%
over 65 years	8	8%
Gender		
Female	57	57%
Male	43	43%
Annual income		
under 50,000 lei	11	11%
50,001-100,000 lei	57	57%
100,001-150,000 lei	24	24%
over 150,000 lei	8	8%

Source: Own calculation.

Section 2 of the questionnaire tracked the measurement of tourists' experiences and preferences. Thus from the answers given to question 4: *What are the main reasons for which you travel?* it turns out that most of the tourists choose to travel for relaxation (27%) or socializing (24%). 12% of them travel for cultural purposes, and 10% of the trips are due to adventure or culinary experiences. Also, in 8% of cases, the trips have other reasons, among those indicated by the respondent, including: health, hobby (photography), educational, etc (Fig. 1).

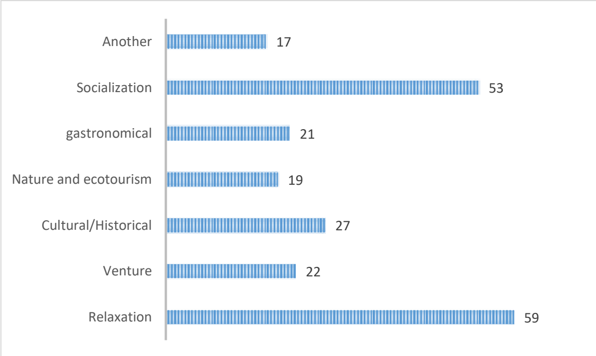

Fig. 1. The main reasons for travel (number)
Source: own processing.

To question 5: *On a scale from 1 to 5, how important are they to you? the following aspects on a holiday? (1 = not at all important, 5 = very important)*, respondents rated personalization of services as very important to respondents, with the majority choosing 4 and 5. Interaction with locals is also valued, but with a slight variation, suggesting that not all consider it essential. Environmentally friendly accommodation has a moderate appreciation, with a significant number of responses at level 2, showing that the preference for ecological accommodation is not universal authentic are important, but fewer respondents gave the maximum score, finding that these are generally those who come from the Sf. Nicolae guesthouse. Cultural and traditional activities have a large variation, with an average score of 3, indicating interest, but not a priority for all tourists.

Table 2. The structure of the answers to question 5

Likert score value	**1**	**2**	**3**	**4**	**5**
	Not at all important	Slightly important	Neutral	Important	Very important
Personalization of services	0	5	27	37	31
Interaction with locals	4	7	24	42	23
Environmentally friendly accommodation	0	19	21	33	27
Authentic experiences	0	6	39	41	14
Cultural and traditional activities	3	4	51	26	16

Source: own processing.

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To question 6: *How important is the authenticity of the location and tourism experiences to you?* we found that for the respondents, the authenticity of the location and tourist experiences has a variable importance. Only 17% consider it "very important", and 14% see it as having high "importance". The majority, 38%, perceive it as of medium importance, while 27% consider it "slightly important" and only 4% consider it not important at all. This shows that authenticity is valued but not essential for all tourists, many being neutral about it. However, it is found that those who appreciate authenticity come in the proportion of 61% from those staying in the St. Nicolae, and 39% of those staying in the Casa Romaneasca hotel. Tourists staying in guesthouses prefer authenticity due to the intimate atmosphere and direct interaction with the hosts, which offers a traditional local experience. In the hotel that offers spa services, tourists appreciate authenticity through local elements integrated into the wellness services, seeking comfort and relaxation in an authentic setting (Fig. 2).

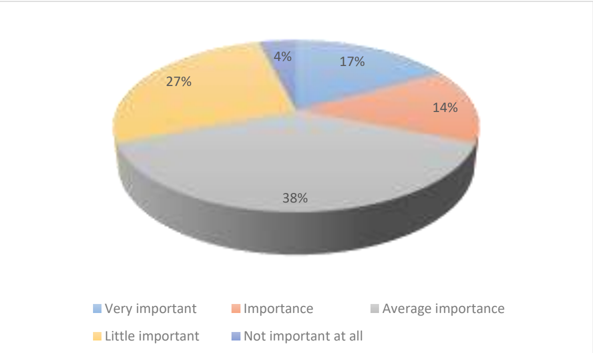

Fig. 2. The weight of the importance of the authenticity of the location and tourist experiences for tourists (%)
Source: own processing.

To question 7: *Have you participated in authentic tourism activities in the past?* 76% of the respondents indicated that they did not participate in such activities, so we note that this kind of activities are quite little developed within the accommodation units in Romania (Fig. 3).

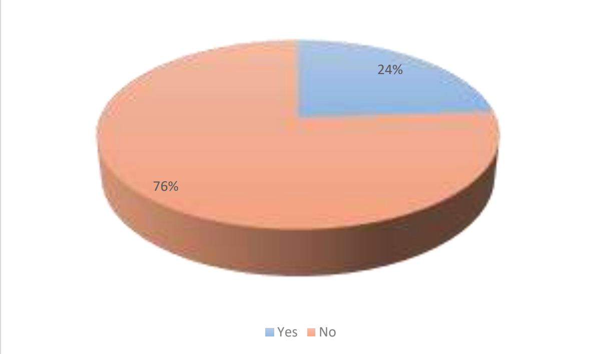

Fig. 3. The share of tourists' participation in authentic tourist activities (%)
Source: own processing.

The answers given to question 8: *If the answer is "Yes," please describe the experience*, it shows that 24% of tourists participated in activities that reflect local traditions, such as craft workshops (pottery, egg painting), visits to traditional farms and gastronomic tours with local dishes (sarmales, cozonacs, wine tastings). They also experienced the local culture through festivals, guided hikes in natural areas, visits to sheepfolds to understand the life of shepherds and pilgrimages to the monasteries of Bucovina and Maramureș. Tours of the Saxon villages and fortified churches of Transylvania completed the authentic experience, offering tourists a deep connection with Romanian traditions and landscapes.

To question 9: *How important is it to you that accommodation units have sustainable practices?* the answers show that the majority of tourists consider it important for accommodation units to adopt sustainable practices, with 21% choosing "very important" and 31% "importance", while only 5% consider this aspect "not at all important". This is due to increased awareness of environmental issues and global trends towards sustainability. Also, the desire of tourists to contribute to the protection of the environment and the preference for ecological services that reflect personal values. Thus, accommodations are encouraged to adopt green practices, such as recycling, reducing energy consumption and promoting local products, to attract customers who value sustainability, thus strengthening their reputation and increasing customer loyalty (Fig. 4).

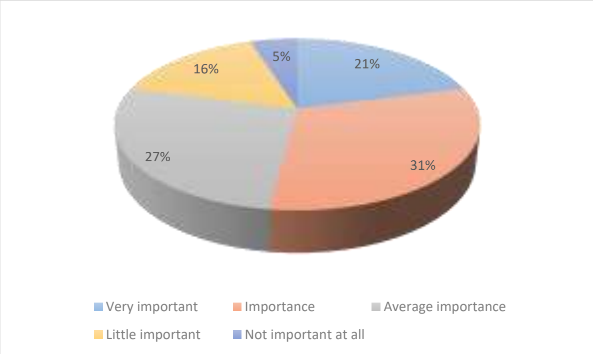

Fig. 4. The importance given by tourists to sustainable practices (%)
Source: own processing.

Answers given to question 10: *Would you be willing to pay more for tourism services that respect the environment?* it shows that opinions about the costs they would be willing to pay differ. We would thus find that 38% of the respondents would like to pay an additional cost that falls between 5-10%, while 19% of the tourists would be willing to pay cy 11-20% more, which reflected the desire to supporting sustainable tourism and its practices. On the other hand, 39% are not willing to pay more and 4% are not interested in this aspect. These responses show that although a significant portion of tourists appreciate green practices, price remains a deciding factor for many, which can influence the pricing and marketing strategies of green accommodations (Fig. 5).

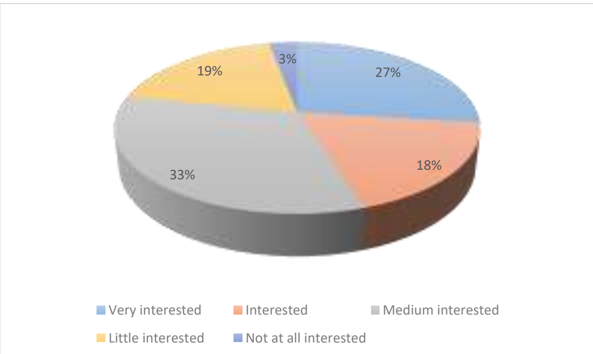

Fig. 5. The availability of tourists regarding the costs of tourist services that respect the environment (%)
Source: own processing.

To question 11: *To what extent are you interested in personalizing your experience?* tourism through applications and digital platforms? the respondents considered that the interest in personalizing the tourist experience through applications and digital platforms is varied; 27% of respondents are very interested and 18% are interested, indicating significant openness to digital personalization; 33% have an average interest, while 19% are slightly interested, and 3% are not at all interested. These data show that, although a considerable part of tourists appreciate digital personalization, there is a significant segment that does not prioritize this aspect, which implies the need for a specific approach in the integration of digital solutions, adapted to different preferences. This is also due to the age groups of the respondents (Fig. 6).

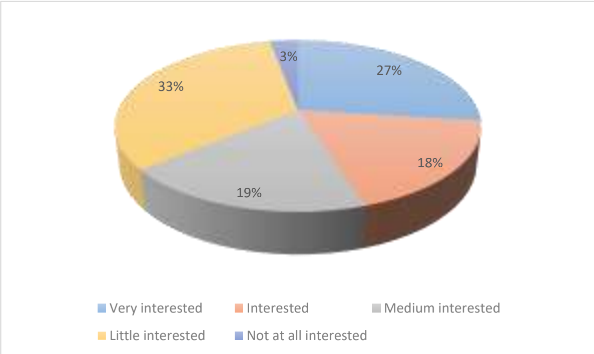

Fig. 6. The availability of tourists regarding the costs of tourist services that respect the environment (%)
Source: own processing.

To question 12: *What kind of personalization do you think would improve your tourist experience?* Respondents felt that restaurant and local attraction suggestions (27%) and personalized interest-based activity recommendations (20%) would most enhance their tourism experience. Personalized itineraries are also valued (19%), while transport options adapted to preferences are less requested (11%). Other activities represented 23% and according to the indications of tourists, these can be: notifications about local events, guided tours according to cultural preferences, special offers for unique experiences, or personalized accommodation options according to lifestyle or ecological preferences (Fig. 7).

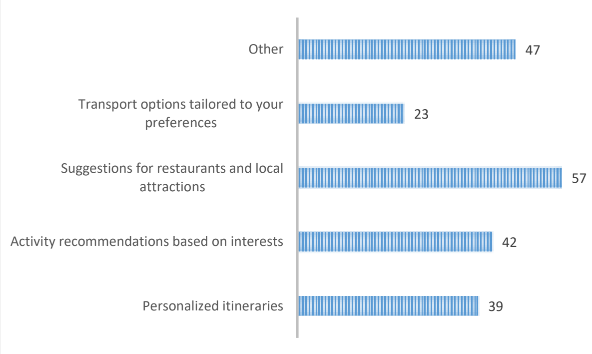

Fig. 7. Respondents' preference regarding the personalization of the tourist experience (number)
Source: own processing.

Responses to question 13: *To what extent did personalized experiences influence your satisfaction?* tourist shows that most respondents believe that personalized experiences have had a moderate influence on their tourism satisfaction, with 39% indicating a medium influence; 21% said these experiences greatly influenced satisfaction, and 17% said they greatly influenced them. However, 14% said personalized experiences had little influence, and 9% said they had no impact on their satisfaction. These responses show that although personalization contributes to satisfaction, its effect varies, implying the need to adapt personalized offers to maximize the impact on each type of tourist (Fig. 8).

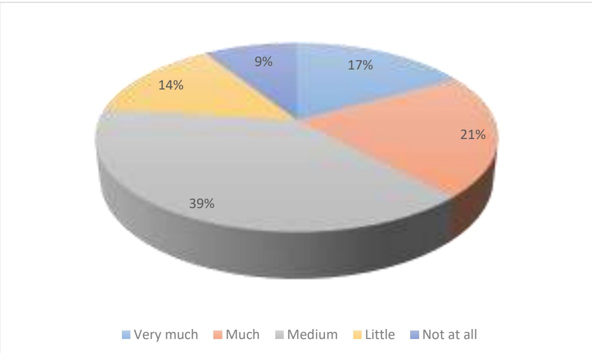

Fig. 8. The extent to which personalized experiences influence tourist satisfaction (%)
Source: own processing.

The answers given to question 14: *Please provide an example of a personalized experience that impressed you*, showed that tourists appreciated the tours through the forests around the St. Nicolae Alunis with local stories, a sarmale and cozonac cooking workshop, tastings of local cheeses and bee products, a visit to a barn to observe the preparation of cheese, wine tasting tours. In the case of the Casa Romaneasca Hotel, the following were indicated: private sessions in the thermal pool, personalized massage sessions with essential oils and evenings with popular music and dances. These activities gave tourists an authentic connection with local culture and traditions, contributing to a memorable experience.

To question 15: *What improvements would you like to see in tourism offers to make them more authentic and personalized?* tourists considered unique local activities (festivals, artisan workshops), personalized guides with detailed information, authentic culinary experiences with locals, interactions with locals, seasonal nature activities, eco-tours, cultural learning sessions (dancing, history) and access to authentic rural experiences (farm visits, agricultural activities) could give them a deep connection with local traditions and culture.

CONCLUSIONS

Agritourism and rural tourism offer authentic hospitality, offering tourists the opportunity to spend time with the hosts and being in daily activities, in a relaxing atmosphere. This hospitality, adjusted to modern needs, includes traditional elements or modern amenities and adapts to the hosts' desire to preserve privacy. From the business point of view, hospitality is essential for satisfying tourists' demand, but also for the image of agritourism, having an important role in creating the image of the tourist destination.

Moreover, hospitality is not limited to a cultural trait or a regional characteristic, but involves a personalized and trusting relationship between host and guest.

In the rural context, hospitality is personalized and intimate, being an alternative to the fast and materialistic life of the city. These unique experiences attract tourists seeking authenticity and relaxation, and rural hospitality is becoming an essential component in the success of agritourism businesses.

The current study allowed us to identify different aspects related to the development of the hospitality sector through the creation and promotion of authentic tourist experiences,

Thus, the preference for authenticity differs significantly between tourists from the Sf. Nicolae Alunis guesthouse and those from the Casa Romaneasca Hotel, which reflects opportunities to customize tourist offers to better meet these needs. Tourists staying in guesthouses are drawn to traditional experiences and direct local interactions, while tourists in spa hotels appreciate authenticity when it is subtly integrated into wellness and relaxation services.

In general, tourist guesthouses must adopt marketing strategies that highlight traditional experiences and local cultural elements, promoting authenticity through storytelling and evocative images. Hotels can attract tourists interested in authenticity through campaigns that emphasize local ingredients and wellness rituals inspired by local traditions.

To increase the attractiveness, the pensions could introduce interactive activities in the tourist program, such as craft workshops, guided tours in the community or traditional meals. Hotels can integrate local products and rituals into their wellness packages.

By implementing marketing policies and strategies, both B&BS and hotels can attract and retain authenticity-oriented segments of tourists by tailoring their offerings to meet their varied preferences.

According to the analyzed data, tourists showed a high interest in sustainability in tourism, but this interest is influenced by price and personal perception of the importance of ecology. The majority consider the ecological practices of accommodation units important, but only those who perceive a clear benefit and accept a moderate increase in costs (5-10% more) are willing to pay extra. However, a significant segment is not willing to pay extra, which shows that marketing strategies should emphasize the added value of sustainability without significantly increasing prices. Accommodations could adopt green practices and highlight these efforts to attract green customers, but they must maintain competitive prices to remain attractive to the most cost-sensitive as well.

Also, the analyzed data shows a moderate interest in personalizing tourist experiences through digital applications, and restaurant suggestions, local attractions and personalized activities are the most appreciated forms of personalization. However, the influence of these experiences on tourist satisfaction varies – most tourists believe that personalization contributes only moderately to their overall satisfaction. These results demonstrate that personalization should be carefully tailored to the individual preferences and needs of tourists in order to enhance the positive impact on satisfaction and maximize the perceived value of these experiences.

Research shows that authentic experiences increase tourist satisfaction, and the inclusion of local traditions and culture in the offer contributes to their loyalty and the growth of the hospitality sector. Tourists prefer personalized experiences, which emphasizes the need to tailor services to individual interests to add value. Sustainable practices are valued, being associated with authenticity and environmental protection, attracting tourists concerned with sustainability and supporting the sustainable development of the sector.

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RURAL RESILIENCE OF THE REPUBLIC OF MOLDOVA: EVALUATION OF THE ECONOMIC DIMENSION

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Abstract

The basic purpose of the research was to assess the economic dimension of the rural resilience in the Republic of Moldova. At the initial stage of the research, using the methodological tools of historiographical and bibliographical study, a foray into the conceptual evolution of resilience, into the crystallization of societal resilience, as well as the meaning and dimensions of rural resilience was undertaken. Having found the absence of a generally accepted framework of indicators for measuring them and, implicitly, of an evolutionary and comparative investigation methodology, the reasoning was formulated regarding the relevance of the assessment of rural resilience through the distinct diagnosis of each dimension. The second stage of the research consisted in the evaluation of the economic dimension of the rural resilience of the Republic of Moldova through the predominant application of the economic-statistical analysis. The results obtained showed that there were no visible trends of improvement, which is supported by the fluctuating trends in the evolution of the agricultural output, the low level of diversification of the economic activities, the unstable and slow economic growth, the low level of the gross domestic product per capita and of the per capita income. On the basis of these findings, recommendations were made to strengthen measures to support the economic development of rural areas through a series of actions that would facilitate the access to financial resources, rationalization and streamlining of the supply process, improved quality of natural and human resources, and better managerial skills.

Key words: *economic dimension, rural resilience, societal resilience, Republic of Moldova*

INTRODUCTION

The adversities of various nature facing society at the present stage are provoking increasingly heated discussions among the policy makers and politicians about the societal resilience and, by implication, about the measures to strengthen it.

Thus, today the term "resilience" is often associated with the communities` ability to cope with external disruptions when, in fact, it has a long deontological evolution and a wide range of uses.

Having its origins in antiquity, the first scientific use of the term "resilience" can be found in the Francis Bacon's famous work "Sylva sylvarum", being used in the context of comparing mechanical, optical and acoustic feedback, which led the scientific community to consider Bacon as the founder of the physical tradition of the notion of resilience [11].

Subsequently, resilience is increasingly present in the physical sciences, being used in the works of Samuel Gott, Henry More, Matthew Hale, etc.

In the early 19th century, the concept of physical resilience was taken up by the applied mechanics and materials science.

The term was also introduced into physiology and medicine.

In the mid-20th century the term entered ecology and psychology, where it became particularly popular in the late 1980s, and in the late 1990s, it made a transition from the natural ecology to the human ecology [3,11].

In view of the numerous resilience conceptualizations, which justifies Pells' assertion that it is a contested term [24], some common threads can be distinguished in the researchers and practitioners` attempts to reflect its essence.

Thus, Martin and Sunley have identified three basic interpretations, which are schematized in Figure 1.

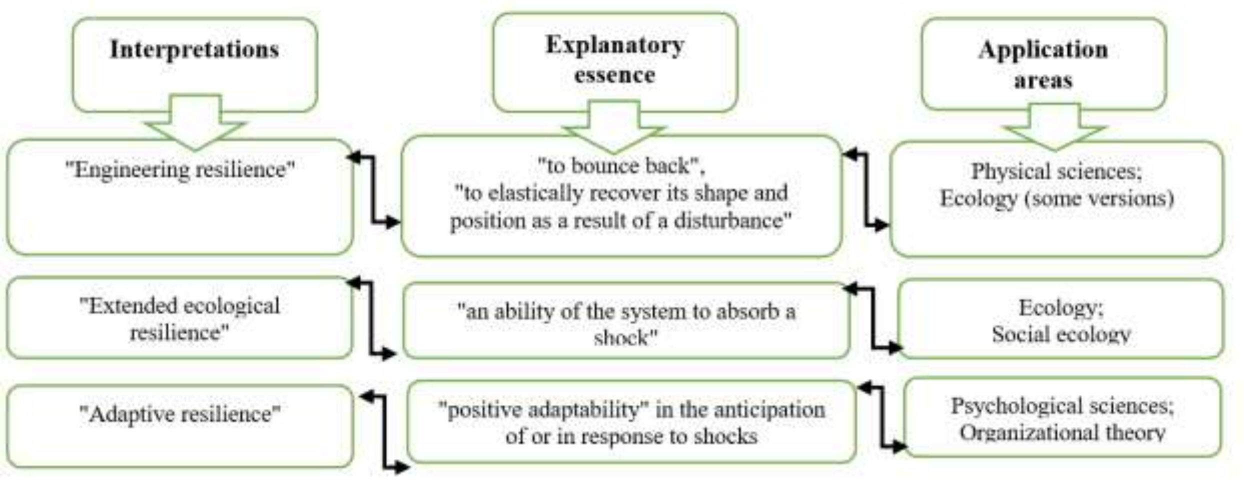

Fig. 1. The resilience interpretations
Source: Developed by the other based on [21] .

In spite of the multiplicity of the existing approaches to resilience, as well as of the diverse domains in which the term is being used, it must be recognized that, in each case, it is stated as a systems' ability to restore their initial state after the extreme phenomena, the differences between opinions consisting in:
1. the extent of the reflections - while some authors expound in a broad sense, referring to the process of returning to the initial state [27, 32, 34], others emphasize also qualifiers for the states to be returned to [4,16, 20, 31];
2. different characteristics for the states to be maintained or developed. Thus, the equilibriums approaches are distinguished, based on the idea of maintaining the equilibrium state of the systems following certain shocks, and the evolutionary approaches, oriented to the formative influence of the respective shocks, i.e. to their contribution in shaping an evolutionary dynamics of the systems, in attaining higher development levels compared to those before adversity [24].
While the current contexts in which resilience is addressed are very diverse, there is, however, an increasing use of the term to elucidate the behavioral responses of the communities, institutions and economies, i.e. there is a growing use of the term in the social sciences [17], which has led to the crystallization of the concept of social/societal resilience, focusing on the societies 'capacity to withstand and recover easily and rapidly from shocks [23], to flexibly withstand major disruptions and to recover and move forward rapidly after the inevitable decline of their basic functionalities [10], to help people and places adapt and move forward in a changing environment [22], through responses and strategies at the level of individuals, groups, organizations and societies facing complex societal problems [5,15].
Based on the above, we can specify that, even if similarities can often be identified in the conceptualization of social and societal resilience, there are separate opinions regarding certain differences between them. Thus, Burgess mentions the political aspect of the societal resilience, as well as the fact that it refers to the problems of the society as a whole, to preserving the rights and privileges, dignity and morality of the whole society, rather than of the individuals or specific groups [9]. Apostol et al highlighted the more comprehensive nature of the societal resilience, incorporating elements related to migration, identity, internal cohesion, etc. [6]. Haavik considers societal resilience to be a heterogeneous field of research with many different connotations, some of which intersect, contrast or enrich each other, while others exist more or less in parallel without much interference [12].
Starting from the societal resilience`s complexity and heterogeneity, rural resilience can be examined as a component of it, delimited according to the territorial principle, the latter representing a topic increasingly addressed in research and debates by

politicians and other decision-makers [13,14,18, 28, 29, 35, 36, 38, 40]. The increase of interest in rural resilience occurs in the context of the transfer of debates from the national level to the community level [25, 30], acting according to the principle "think globally, act locally", this principle being particularly relevant in the conditions of growing pressure caused by the economic and environmental hazards [8,19]. The COVID-19 pandemic has also played a key role in increasing the interest in rural resilience recently. However, there is a deficiency in investigating the situation of the farmers under pandemic conditions, as well as a lack of relevant conclusions with regard to the policies needed for possible future pandemics [33]. At the same time, it would be wrong to overestimate the role of the COVID-19 pandemic in increasing the interest in rural resilience. The rural environment, in fact, has been and continues to be affected by a number of negatively influencing factors, including the economic and financial crises; the extreme climatic events and, consequently, the loss of biodiversity, the soil deterioration; the increasing social inequality and legitimacy crisis with negative effects on democracy [14].Thus, we deduce that the rural vulnerabilities are characterized by diversity, flexibility and continuity. On the basis of the above, we consider relevant the definition of rural resilience by Heijman et al. as "a capacity of a rural region to adapt to changing external circumstances in such a way that a satisfactory standard of living is maintained". According to the same authors, "rural resilience perspective refers to a rural area's ability to cope with its inherent economic, ecological and cultural vulnerability" [13]. Li, in turn, defines the rural resilience as "the capacity of resistance, adaptation and transformation", mentioning the multifunctional transformations, the exercising bottom-up planning and the increasing social capital as benchmarks in its improving [18]. The need for rural communities to focus on certain reorganizations and subsequent transformations is also supported by Heijman et al. who state that "rural resilience determines the degree to which a specific rural area is able to tolerate alteration before re organizing around a new set of structures and processes" [13]. Implicitly, we also identify other aspects addressed by the authors. Thus, Rapaport et al. consider resilience as "community's ability to utilize its current resources in order to adapt to an adversity or sudden disturbance, and eventually to be able to absorb the disturbance, get back to routine, and even perform better in comparison with the pre-disturbance situation" [25]. Such a perspective includes in the area of attention not only the final effects, but also the quality of the available resource`s management, which is particularly important at the current stage, when the concern for sustainable rural development persists. Resources, especially social capital, are also highlighted by Aldrich and Meyer who consider them a key component of communities' resilience [2], while Suleimany et al. specify three categories of resources of particular significance in crisis conditions: social, economic and infrastructural capital [33].

The rendering of the rural resilience essence as comprehensively as possible is particularly important in order to identify the evaluation criteria and design the actions to increase it. Thus, the diagnosis of environmental vulnerabilities provides the necessary framework for avoiding adverse influences; emphasizing the correct ways of using resources allows to model the response reactions based on relevant rules; forecasting the aspired final states is the benchmark for visualizing the entire complex of factors and actions and developing effective strategies for increasing resilience. Last but not least, the resilience dimensions need to be examined with particular rigor, as they serve as criteria for assessing the resilience in its dynamics and for providing the informational support for the processes of developing the above-mentioned strategies. With reference to the latter, we must recognize the existence of numerous attempts to elucidate and evaluate them. Heijman et al., advocate the idea that rural resilience is based on the interface of economic, ecological and cultural resilience, a statement justified by the reasoning that this expresses, in fact, the ability of the rural area to ensure a simultaneous balancing of its functions: ecosystemic, economic and cultural [13]. Wilson defines rural resilience as a balance between the economic, environmental and social needs of the rural communities, stating that sustainable and economically, socially and ecologically resilient rural communities must develop strong multifunctional characteristics [38]. The author emphasizes the link between the rural resilience and the multifunctional quality which, in turn, depends on the level of the economic, social and environmental capital development. Implicitly, he argues for the idea that the way of interweaving the mentioned capitals creates different multifunctionality spaces, the most multifunctionality and the strongest resilience being achieved when, respectively, all three "capitals" are equally well developed.

The need to consider the interaction between ecological, economic and social dimensions is also highlighted by Hernández and Harteisen [14]. Rudiarto et al., developing the concept of livelihood resilience in the rural environment, evaluate its four basic dimensions: social, economic, environmental and physical [28], while Suleimany et al., in the context of describing community resilience to the pandemic, take into consideration five dimensions: institutional, social, economic, environmental and infrastructural, demographic and health [33].

Despite countless attempts to investigate and interpret the rural resilience dimensions, to assess them in relation to various adverse phenomena [13, 26, 28, 35, 37], at the current stage there is still a lack of a generally accepted framework of indicators for measuring rural resilience [7, 33], and therefore also a lack of a methodology for carrying out evolutionary and comparative investigations. At the same time, recognizing the complexity of the rural resilience assessment process, the need for a multidimensional and holistic approach [40], we support the reasoning that, in an operational sense, building resilience involves specific measures and not a universal approach [13]. This would mean the distinct diagnosis of each dimension, the identification of the evolutionary trends of the indicators used for this purpose and, respectively, the formulation of conclusions regarding the observed state and the necessary measures to be taken.

MATERIALS AND METHODS

In order to achieve the goal of the research, several stages were completed:

1. A synthesis of publications addressed to resilience in general, to societal resilience and to rural resilience was carried out;
2. The factors of the economic dimension of the rural resilience were delimited and systematized in two groups, according to the way of exerting the impact on it;
3. The direct factors of the rural resilience in the Republic of Moldova were evaluated and, on this basis, conclusions were drawn on their general trends and related issues.

The methodological apparatus included: bibliographic and historiographical study, economic-statistical analysis, deduction, generalization.

A wide range of scientific publications and official data sources served as sources of information.

The limitations of the research refer to the absence of official statistical data regarding the evolution of macroeconomic indicators distinctly in the rural environment. Under these circumstances, some conclusions regarding the economic dimension of rural resilience have been drawn on the basis of overall country indicators.

RESULTS AND DISCUSSIONS

The first step in assessing the economic dimension of rural resilience is to identify the basic factors that have an impact on it. Given the complexity of this dimension, the multitude of determinants and the different nature of these factors is also evident, which led to the idea of classifying them into two groups: first-degree factors, with a direct impact on the rural resilience, and second-degree factors, whose influence on resilience is mediated by the first-degree factors (Fig. 2).

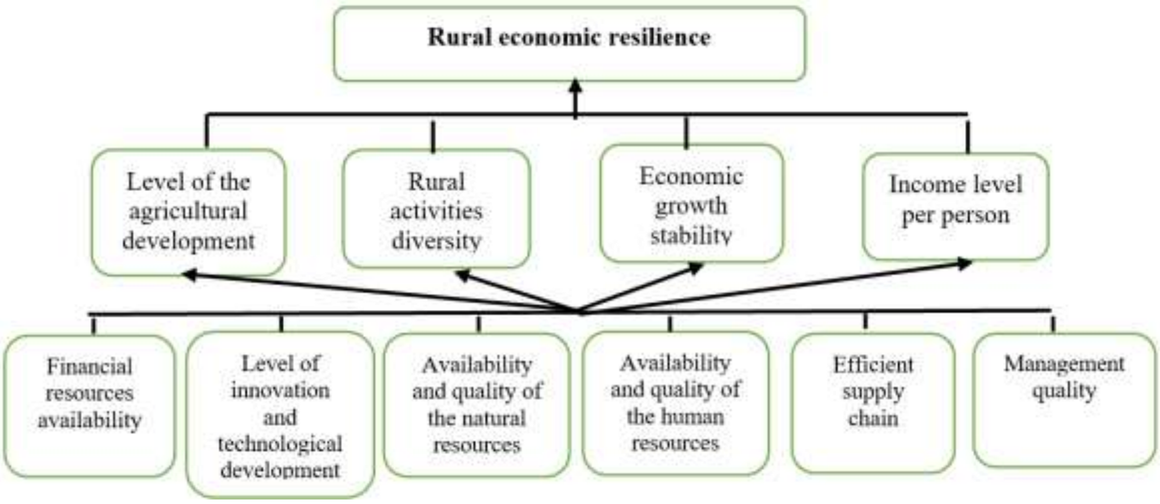

Fig. 2. Factors related to the economic dimension of the rural resilience
Source: Developed by the author based on [1,13, 33].

As a result of the evaluation of the indicators related to the first-degree factors, the level and general trends of the rural economic resilience are appreciated, while the second-degree factors serve as benchmarks in the formulation of the specific strategic objectives and, respectively, of the necessary actions to be undertaken for its consolidation.

The role of agriculture is undeniably a very important one in strengthening the rural resilience, primarily because of its contribution to ensuring food security, as well as its important role in providing raw materials for processing industries.

Agriculture also represents the branch that provides jobs for a large part of the rural population, a statement argued by the data of Figure 3, which denotes a share of approx. 37% of the rural population employed in the respective branch in the period 2019-2023 from the total number of rural population engaged in economic activities.

By assessing the agriculture performance, we estimate the extent to which the sector is able to fulfill its multiple roles and, implicitly, its contribution to overall rural resilience.

In this context, the dynamics of agricultural output obtained in the Republic of Moldova in the period 2019-2023 is further examined (Fig. 4).

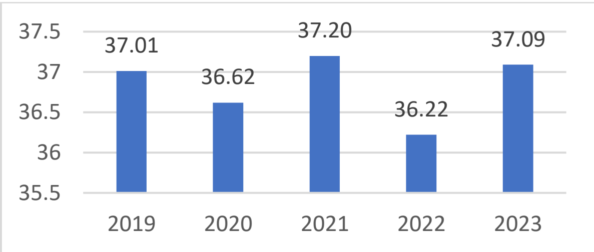

Fig.3. The share of the rural population of the Republic of Moldova employed in agriculture, forestry and fishing in the total number of the rural population employed in economic activities over the period 2019-2023, %
Source: Developed by the author based on: [41].

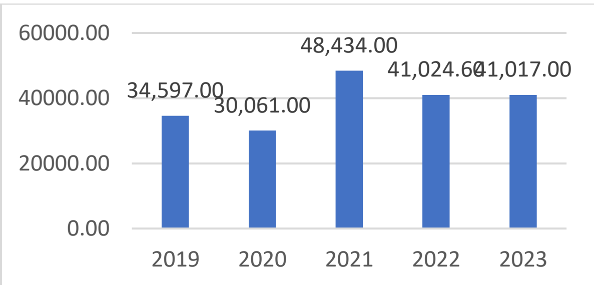

Fig. 4. The agricultural output obtained in the Republic of Moldova over the period 2019-2023, million lei
Source: Developed by the author based on [42].

Figure 4 shows fluctuating trends in the evolution of the value of agricultural output over the period examined, while in order to positively assess the contribution of agriculture in ensuring the rural resilience, it would have been necessary to model stable growth trends in the analyzed indicator.

As the researchers' opinions on the important role of the agriculture are unanimous [13, 33, 35], at the same time the need to focus efforts on the activities` diversification is emphasized, thus creating the premises for eliminating the dependence of the rural environment on a specific branch [13, 39], by creating multifunctional regions, the latter being considered more resilient compared to those that are heavily dependent on agriculture [14, 29, 39]. In order to assess the situation regarding activities diversification in rural areas, we will refer to official data on the employed population by economic activities.

Thus, the data presented in Figure 3 show the absence of positive trends in the process of diversification of activities, this fact being proven by the insignificant variation of the share of the population employed in agriculture during the examined period. The distribution of the rural areas` labor force by economic activities presented in Table 1 confirms the above statement.

Table 1. The distribution of the rural areas` labor force by economic activities in the Republic of Moldova over the period 2019-2023

Indicators	2019		2020		2021		2022		2023	
	thousand people	%	thousand people	%	thousand people	%	thousand people	%	thousand people	%
Economic activities, total	467.7	100.00	456.6	100.00	464.3	100.00	468.8	100.00	474.8	100.00
inclusive:										
Agriculture, forestry and fishing	173.1	37.01	167.2	36.62	172.7	37.20	169.8	36.22	176.1	37.09
Industry	67.5	14.43	64.4	14.10	61.5	13.25	67.6	14.42	66.1	13.92
Construction	33.6	7.18	35.2	7.71	36.8	7.93	37.0	7.89	35.5	7.48
Wholesale and retail trade, accommodation and catering activity	56.7	12.12	52.7	11.54	51.2	11.03	50.3	10.73	49.6	10.45
Transports and storage, information and communications	17.2	3.68	18,0	3,94	17,4	3,75	17,0	3,63	19,1	4,02
Public administration, education, health and social assistance	97.8	20.91	100.6	22.03	105.0	22.61	106.8	22.78	105.2	22.16
Other activities	21.7	4.64	18.5	4.05	19.7	4.24	20.2	4.31	23.2	4.89

Source: Developed by the author based on [43].

Table 3 shows the following:

1. The share of the population employed in economic activities other than agriculture did not show an upward trend in its evolution during the analyzed period, and even a slight reduction in 2023 compared to 2019 is noted (this can also be seen from Fig.5);

2. Among non-agricultural activities, 170.3 thousand persons were employed in income-generating activities in 2023, compared to 175 thousand persons in 2019. This fact denotes the reduction of human potential in the branches with economic benefits in rural areas, benefits that undeniably also have social impact.

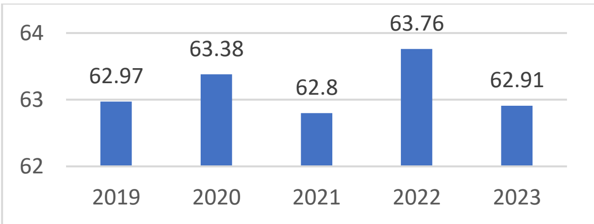

Fig.5. Evolution of the share of the rural population employed in activities other than agricultural in the period 2019-2023,%
Source: Developed by the author based on [43].

The economic growth stability is another important factor afferent to the resilience economic dimension [1], which can be examined by assessing the macroeconomic indicators` evolutionary trends. Thus, we could qualify economic growth as stable if there is a continuous upward trend in the evolution of gross domestic product, the latter being a representative economic indicator in this sense. Based on the data of Figures 6 and 7, we note that both the total gross domestic product and the gross domestic product per capita did not have stable growth trends during the analyzed period (2015-2022).

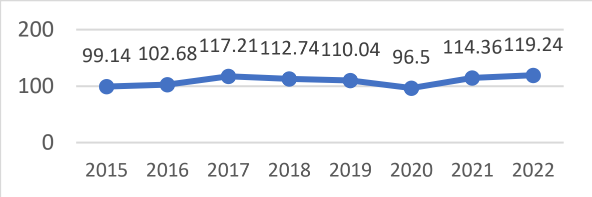

Fig.6. The dynamics of the growth index of the gross domestic product in the Republic of Moldova in the period 2015-2022, %
Source: Developed by the author based on [44].

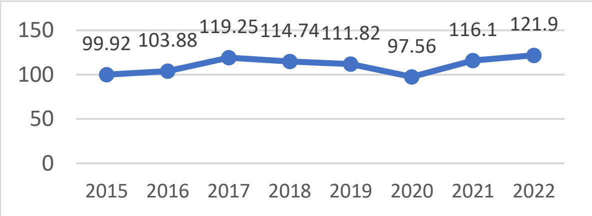

Fig. 7. The dynamics of the growth index of the gross domestic product per capita in the Republic of Moldova in the period 2015-2022, %
Source: Developed by the author based on [44].

Having observed a general positive trend of both indicators, we cannot overlook the extremely low level of gross domestic product per capita compared to the average in the European Union, where, in 2022, the indicator had a value of 29.030 Euro. The same indicator in the Republic of Moldova constituted only 5.433 Euro, being 5.34 times lower. In the same context, we note that the gross domestic product per capita in the Republic of Moldova in 2022 was 1.41 times lower than the minimum recorded in the EU (in Bulgaria) and 15.8 times lower than the maximum recorded in the EU (in Luxembourg) [47].

The economic growth instability in rural areas is also confirmed by the fluctuating trends in the value of agricultural output shown in Figure 4 and undeniably has an impact on the level of per capita income - another factor indicator of the economic resilience.

With reference to the disposable income per person in rural areas (Table 2), we can note a continuous rise in the period 2019-2023, as well as the predominance of the wage income throughout the period in the total income. At the same time, their level is very low, constituting only 3,928.7 lei in 2023, which is equivalent to about 203 Euro. In comparison with the level of consumer expenditure recorded in the same period (Table 3), we can see that, even though slightly decreasing, the share of consumer expenditure remains at a very high level, constituting more than 86% of the monthly income in 2023.

Table 2. Evolution of the per capita income of the population in rural areas of the Republic of Moldova in 2019-2022, lei

Indicators	2019	2020	2021	2022	2023
Monthly income per person in total	2,457.2	2,702.3	2,985.0	3,528.4	3,928.7
Wage activity	936.1	1,095.6	1,195.1	1,421.0	1,621.8
Individual agricul-tural activity	408.5	410.8	456.6	531.7	534.6
Individual non-agricul-tural activity	155.9	164.1	200.1	198.1	202.0
Property income	6.6	-	0.2	0.8	1.9
Social benefits	503.3	558.5	624.9	840.8	1,006.0
Other income	446.7	473.3	508.1	562.2	562.2

Source: Developed by the author based on [45].

Table 3. Evolution of the average monthly consumption expenditure per capita in rural areas in the Republic of Moldova in 2019-2023 in relation to the average monthly income

Indicators	2019	2020	2021	2022	2023
Monthly income per person, lei	2,457.2	2,702.3	2,985.0	3,528.4	3,928.7
Monthly consumer expendi-ture per person, lei	2,335.7	2,331.3	2,517.0	3,004.0	3,388.8
The share of consum-ption expendi-ture in monthly income, %	95.06	86.27	84.32	85.14	86.26

Source: Developed by the author based on [46].

CONCLUSIONS

Today the rural resilience is a topic increasingly addressed by researchers and policy makers. At the same time, there is a lack of a generally accepted framework of indicators to measure rural resilience and, implicitly, a lack of a methodology for carrying out evolutionary and comparative investigations. Under these circumstances, recognizing the complexity of the process of assessing rural resilience and the need for a multidimensional and holistic approach, we deduce on the relevance of assessing resilience, including rural resilience, through separate diagnostics of each dimension.

The assessment of the economic dimension of Moldova's rural resilience through the lens of four first-order factors revealed the absence of visible improvement trends, this conclusion being supported by the following:

- the absence of the continuous upward trends in the agricultural output;
- the low level of the economic activities` diversification;
- the unstable and slow economic growth;
- the low level of gross domestic product per capita compared to the EU average;
- the low per capita income.

On the basis of these findings, there is a clear need to strengthen measures to support the economic development of the rural areas through actions focused primarily on mobilizing the second- degree factors, namely:

- facilitating access to various external sources of financing;
- promoting innovation and its benefits more actively;
- streamlining the state mechanisms for monitoring the quality of the agricultural land;
- improving the system of staff training by bringing the educational offer in line with the needs of the labor market in terms of quantity and quality;
- improving the supply chain by facilitating rural producers' access to the necessary material resources;
- improving managerial skills through continuous training activities.

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SEA BUCKTHORN "*HIPPOPHAE RHAMNOIDES* L." - BIOLOGICAL, ECONOMIC AND SOCIAL IMPORTANCE IN ROMANIA AND NOT ONLY

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Abstract

The paper aimed to present the importance and role of sea buckhorn from a biological, agronomical, economical and social point of view. To attain this goal, an important range of scientific publications offered their support regarding the results obtained by various researchers across the time. A critical review and a personal point of view was used to highlight the main aspects of interest and in addition the experience accumulated in setting up the PhD Thesis and participation with the scientific results to various international and national Symposia and Confereneces allowed to develop exchanges of main impressions and exeprience with other researchers. This approach intends to be an alarm bell for the recovery of the white sea buckhorn as an important plant which could be included among various solutions in this period of economic, food, health, and social crises. The conclusions highlighted that the scientists of the world must understand the actual Earth crises and find, among other solutions, that sea buckthorn could be extended in scientific conditions. The optimist vision considers that a new horticultural science will be able to implement sea buckthorn in all zones with problems covering social, feeding, health and environment aspects. In this way, sea buckthorn could open a new door and occupy a new position in the history of plant utilization.

Key words: *sea buckthorn, biological characteristics, economic, social, health and environment importance*

INTRODUCTION

"Man is meant to be accomplished. It is from this that the one who does not aim at perfection is destroyed and destruction is the beginning of misfortune ... No wretched man is happy. The evil man suffers even in the midst of riches, and his soul never has peace. Thus, happiness on earth lies in the fulfilment of the purpose for which we are made, that is, of our work on us and our peers to make us better" said, almost two centuries ago, Nicolae Bălcescu [1] a Romanian personality whose name was borne by the Agronomic Institute of Bucharest, founded in the year 1852, at present University of Agronomic Sciences and Veterinary Medicine of Bucharest.

About 50 years ago, a new current in agricultural theory has appearead in Romania, according to which some species from spontaneous flora were adopted in culture, one of them being sea buckthorn [7].

Sea buckthorn is called by the Romanian peasants "berries of the Holy Virgin".

It seems that when Roman imperial legions invaded "Dacia" (the name of Romania in the old times) and saw the Carpathian Mountains at the base of them was a line of plants coloured like a metal like steel. When they arrived near the mountains, they understood that it was a plant and called it "*catena"* (latin of chain). It may be the origin of the Romanian name of sea buckthorn: *"catina alba, catina cenusie, catina de rau etc"*.

Lupe Z. Ioan [17], Grigorescu Emanoil [11], Brad Ion [5, 6], Manea Stefan [18] are some of the Romanian specialists in forestry, horticulture, medicine, bio-chemistry with many studies and applications of sea buckthorn.

In this context, the purpose of the paper is to present the biological, economical and social importance in Romania, at present and in the future.

MATERIALS AND METHODS

To set up this study, it was needed to consult a large range of books, textbooks, scientific journals, published articles for identifying the main ideas which could be selected and highlighted in the content of the paper.

The material is presented in a logical order covering the following aspects: the importance and role of the International Se buckhorn association at the global level, the situation of seabuckhorn in Romania, the georgraphical zones where this magic plant grows, biological aspects of the plant, its utilization in forestry, agriculture, nutrition, medicine, cosmetics, economic, social, health and environment importance.

The results obtained by various researchers across the time were approached in a critical manner and also the personal point of view of the author intended to highlight the main aspects of interest.

In addition, the experience accumulated in setting up the PhD Thesis and participation with the scientific results to various international and national Symposia and Confereneces allowed to develop exchanges of main impressions and exeprience with other researchers.

This approach intends to be an alarm bell for the recovery of the white sea buckhorn as an important plant which could be included among various solutions in this period of economic, food, health, and social crises.

RESULTS AND DISCUSSIONS

The role of International Sea buckthorn Association

The International Sea buckthorn Association organized world reunions as seen in the Proceedings of the first and next Congresses [13, 14, 22] where are published the essays elaborated by specialists from Bolivia, Canada, China, Estonia, Finland, Germany, India, Italy, Latvia, Romania, Russia and Ukraine.

At the second Congress there were delegates from Azerbaijan, Bolivia, Canada, Korea, Finland, Germany, India, Italy, Japan, Latvia, Mongolia, Nepal, Nigeria, Pakistan, Russia, Sweden, Turkey, Ukraine and U.S.A.

All these experts from many countries work under one flag, sea buckthorn a plant which means hundreds of years of plant arrangement architecture, research, experience, secrets, production, health of soil, health of animals and health of peoples in a self-destructive human society of the third millennium.

What displeased at those Conferences? The impossibility of put in order all important and multidisciplinary information.

There were involved specialists in: botanics, geology, marketing, medicine, biochemistry, agronomy, management etc. All of them need information.

The solution is to elaborate a statute of an interdisciplinary new science the subject being sea buckthorn and the most important, a multilingual data base, alphabetically ordered accessible for anyone interested.

Sea buckhorn in Romania

Romania has many natural and scientifically resources in all domains of agriculture. In year 2000 it had 3,500 species of plants (800 in forests, 300 weeds, 1,150 in the Danube Delta), there were 300 species of birds and 100 species of mammals.

The beginning in Romania was in the modern scientific statute of agriculture started in the inter-war period. There are important works [12, 21, 30, 34] which presented the past and actual situation.

Biological description of Sea buckthorn

In the period 1938-1943, Constantin Filipescu [10] published “The Great Agricultural Romanian Encyclopedia” where he mentioned in the introductory part: "Any country with *pretensions of civilization must have in the cultural treasure agricultural encyclopedia and dictionaries needed by anyone who is concerned by this millenary activity"*.

In the first volume of this work, sea buckthorn was ample described from page 710: “cătina albă bot. *Hippophae rhamnoides* L. Fr. Saule epineux, germ. Sanddorn, engl. Sea buckthorn (sea, buck, thorn) bush usually having 2-5 m, looking like a little tree from slippery grounds of river’s gravels.

One-year stems has silver scaly brush and ferruginous rust colored down, early they get thorns, old steams have a great number of short steams transformed in thorns. The ovoid buds are covered by a small number of golden yellow scales with silver brush. Leafs are linear lancelet or narrow oblongs 4-5 (6) cm. long and 5-6 (10) mm. breadth, short petiolated, petiole of 1-3 mm., entered edge; superior face at first has silver scales, at maturity being dark green, glabrous and only the long of principal nervure with down, inferior face is silver with scaly silver thread to golden yellow which at friction are taken on the fingers".

Photo 1. Sea buckhorn in Brebu locality, Prahova County, Romania
Source: Original by Prorocu Angel.

Dioeciously flowers are little, less apparent, greenish, situated on annual stems on which it appears simultaneous with leafs by 2-3 at the base of inferior leaf which are hiding integrally. Male flowers sessile with yellow-green perigonium on intern face have silver scaly thread in tubular form, evidently separate at the extremity in two lobs on square disk. Female flowers in raceme specula form, with a perigonium evidently separate at the extremity in two lobs, covered in exterior with scaly thread; unicarpelar pistil, one only box, with one ovule. Blossoms from April to May. Fruit is an achene covered in exterior with an induzion, seems that in the inferior part persists the perigonium which became fleshy. Fruit is ovoid like a pea bean brown-orange to golden yellow, the fleshy part has acidulous taste, contains a poisonous principium, which don't hinder birds to devour them after the snow fall. The pip, achene with solid brown shining cover, usually has one seed. The trunk may be strong developed 4-6m and at soil level it may be 10-15 cm in diameter with many ramifications has lateral direction, sinuously, covered at the beginning with brown smooth bark, in time it has a rhytidome dark brown scaly profoundly cracked. The hardwood yellow-brown, became by drying weighty, solid, may be polish, don't resist in air, the ashes are rich in potassium. The striking root is profound, because the pivoted part penetrate depth the soil and superficial by lateral roots parallels with the surface, from lateral roots in sands there are starting many suckers.

In roots there are tuberosities in which leaves in symbiosis an Actinomicete capable to assimilate atmospherically nitrogen.

The zones where Sea buckthorn is spread are the marine dunes, alluvional sands along rivers and around lakes on stonily versants and crumbling bank, coasts and cliffs, detritus degraded pasture lands, etc. Its principal area is in Central Asia from Caucasian territory to North of Persia and Ural, to the East of Asia. In Europe it is along of the Scandinavian coasts, in the Baltic Countries to the North Sea, the South of England to the South of Europe vegetating on a narrow band on the Mediterranean coast in interior on valleys in ihe mountains or hills in North of Spain, South of France, North and Center of Italy, Yugoslavia, Down Austria, Hungary, South of Romania and Bulgaria.

In Romania, Hippophae is in the hilly territories, the Meridional and Eastern Carpathians valleys of the versants from Moldavia and Muntenia along the valleys to the field to the Danube.

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An insular center of Sea buckthorn is in the Danube Delta at the Black Sea littoral in the place called Cardon at North of Sulina (5 km). The optimum of its area is in under the Carpathian zone of aflorishment of salifer, age Mediterranean inferior aquitanian in Ialomita valley, Laculete, Prahova valley and its affluent Campina, Comarnic, Telega, Slanic, Teleajan valley, Homoraciu, Buzau valley, Cislau, Nehoiasi, Ramnicu Sarat valley, valleys from Vrancea County etc. and it continues in all the basins to Bucovina.

Agronomical importance of Sea buckhorn

The plant is of high utility in forestry for the fixing the dunes or moving grounds supports more salts in soil Na Cl. It is the national essence for the restoration of Vrancea County and other regions deforested from saline under the Carpathians in which the installation of forest on salt soils is difficult. Its ample ramification and numerous thorns make it valorous for hedges.

Photo 2. The capacity of roots to generate many suckers
Source: Original photo by Proorocu Angel.

As bush it is very ornamental also with its silver leaf and its numerous orange fruits and persists on branches after the snow fall. It may be multiplied by seeds, slips, marcottage and suckers.

In 2005 spring, Romania has a great surface of flood. Sea buckthorn could be able either like the single plant or in combinations with other plants to consolidate the places sensitive in this kind of situations.

The economic phenomenon from the end of XIX Century when forests were destroyed and acaparated for the construction of railways in Central Europe was the same in the legislative vide after 1990 and the situation in Romania is dramatic because the amplitude of destruction is incomparable. The mistake in the tackle of sea buckthorn is the attempt to define all varieties as one kind of assortment. It has a great variability and adaptability.

Romanian researchers had demonstrated that the specie has the capacity to accumulate in its tissue a great level from some radioactive elements, characteristically for the soil and subsoil in its habitat zone. In soil and subsoil there are slowly transformations of radioactive elements, with variable times of halve which give to the crust a certain natural radioactivity. Alfa radioactivity results from the transformation of Radium in Radon, the beta radioactivity is given in special by the isotopic form of Potassium being in soil near K40 ions.

Photo 3. Nodules of symbiotic organisms on roots
Source: Original photo by Proorocu Angel.

Romanian measurements of fruits in regions which are known with the particularity of radioactivity, established that there were 34-37 less alfa global concentration like the maximum admitted limit in potable water and 2-3 more beta radiations. This illustrated the capacity of fruits to indicate the presence of natural radioactivity in soil, there are storing of beta radiation from absorbed radioactive elements on soil particles or dissolved in soil solution. There are other species like *Solanum nigrum* (Romanian zarna) and *Veratrum album* (stregoaie) which have toxic components influenced by the soil composition. These explain many contradictions about the beneficial or lethal effect of fruit utilization.

The authors of the Romanian Encyclopedia considered it like not recommended in feeding, their occidental formation and sources are explaining this opinion.

The variability of this species is the cause of many contradictions about the concentration of components and the large utilization of sea buckhorn.

Utilizations

Romanian people used from hundreds of years the fruits for the treatment of anemia, diarrhea, rheumatism and rash [31].

From fruits they obtained many products such as: juice, vine, jam (with cherry, apples and plums), butter etc., they used it as textile colorant.

In modern pharmaceutics it is also used in cosmetics, many treatments and for burned and irradiated tissues.

In the feeding of domestic animals were used some products, for the aspect of the hair of dogs, cats, and horses, the quality of eggs and the immunity.

Sea buckhorn is also used like a decorative plant and hedge; its green-white color is in contrast with the orange of flowers and fruits.

Hippophae rhamnoides L. was used as a solution for the rehabilitation of denuded grounds and as a quality of it, the fact that the plant assimilates atmospherically nitrogen directly by roots.

National Programs concerning of Sea buckhorn in Romania

In Romania *Hippophae rhamnoides* L. was the object of many national research programs. Now, there are no investments and no mobilized scientifical and financial forces able to use modern instruments for obtaining all the advantages of this plant at the great potential and necessity in the actual crises. Some institutions and industrial units continue the tradition with good results, but not at the potential level of Romania. It must be a solution of the rehabilitation of thousand of hectares of Romanian denuded grounds. One important step in sea buckthorn implementation as a resource in actual human crises is a handbook of Seabuckthornology, in Romania, where it is discussed about silvosofia and silvocalia, which is not a bad idea, but sea buckthorn could be one of the solutions to solve vital problems.

In this direction, at the global level and in Romania as well, there are 6 reasons as Sea buckhorn to be considered a valuable plant:

(1) Romania has a great variety of the biological material which was not catalogued and capitalized in its all aspects and possibilities.

(2) Sea buckthorn is a crises solution in soil, considered as an organism, birds, animals and human health in poor and debased regions but not only there.

(3) Sea buckthorn (as material and scientific abord) from Romania could be a source of biological material, [4] treasure of scientifical experience in many domains of human crises for the rest of Europe, harmoniously implementing the national traditions with high technologies in production and presentation on a large market interested in ecological and natural products.

(4) Being at the last “door” of the Danube, the most important and most facile way of communication and transport in the old times, there were founded solutions and made hydrological works by the European Commission for the Danube area when experts from many countries used sea buckthorn for sophisticated hydrological and consolidation works [33].

Across the time, the Romanian peasants had abilities in using the sea buckhorn for treatments, feeding, and as colorant.

After the second World War it was an emulation and it was developed the experience of the Romanian forestry specialists, peisagists, and land health and many odher domains specialists [3, 8, 9, 18, 19, 20, 23, 32, 35].

Important results were obtained by the specialists working in the research and the production of pharmaceutical, feeding, cosmetics industries.

A great part of this activity was abandoned after 1990.

At present, there are problems with forest fruits which are chaotically collected without scientific reasons by "enterprisers" to be sold to foreign firms with a little profit.

Many animals have no possibilities to find their habitual food and are migrating in cities and villages, to look for food in garbidge pubels, bears are notorious in this respect in Romania.

(5) In consequence, it is necessary a new approach of sea buckthorn with all its possibilities of utilization simultaneously applied;

(6) It is needed that in the future to be created and implemented an educational program in agricultural schools of all levels as the new generation to understand and apply sea buckthorn utilization in all domains.

It is a plant which grows in all Euro-Asia and now is also found in America.

Like in case of Viticulture, where the contribution of national schools was vital in Vitis vinifera crises caused by phylloxera and evolution of culture systems and diversified products, sea buckhorn has to be promoted.

Prof. dr. Ion Brad was the most famous researcher and promoter of sea buckthorn in Romania. Many great specialists were involved in sea buckthorn research and utilization in many domains but regrettably disappeared [16].

The absence of material and financial support does not sustain the creation of enterprises at the potential of the Romanian thesaurus in this domain.

The Danube Delta could be a good example of a place in permanent transformations, possibilities of research in many aspects and could be also an example of successful use of its potential even thou there are still many things to do to entirely exploit it.

In 2006, in the thesis entitled: "Studies about the importance of sea buckthorn (*Hippophae rhamnoides* L.) in the environmental protection and human health economy" [29], it was mentioned that: *"In the entire world it is a wrong treatment in climate soil and health crises. A reason that Seabuckhorm has to be reconsidered"!* [24-28]

CONCLUSIONS

Sea buckthorn is a plant used by world peoples from thousands of years, Romanian people having a great natural biological resource, is one of them.

Many domains were preoccupated of this plant but many accumulations of generations are not used in actual perioud. The simple production of berries is not significative. There are solutions for classic plantations (ex. China) or mechanized kind when 7 people may with adequated machines may resolve all aspects for 50 ha. (ex. Germany).

First of all, important is to be considered work and intelligence in time of Romanian people, interference with "the greatests powers" of sea buckthorn in all aspects [15] and starting producing in Romania final products with logical intern benefit.

Now when the problem off Terra is a profound crise in principal aspects of classical agriculture and environment it will be necessary a scientifical, practical and coordinated strategy and results will be grandiose!

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SHORT SUPPLY CHAINS - A NEW PARADIGM OF AGRICULTURAL MARKETING

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Abstract

Short supply chains are a new approach to agricultural marketing, responding to the challenges posed by globalization and the complexity of traditional supply chains, and changing the way agrarian producers market their products and interact with consumers. This article explores the impact of short supply chains on agricultural marketing, and the results of the study show that these short supply chains bring numerous benefits. These include increased transparency, reduced costs, and strengthened relationships between producers and consumers. The study highlights that, through short chains, the efficiency of the marketing process is improved, and the actors involved benefit from better collaboration and mutual trust. The research presents a case study to highlight the trends and potential of this model in agricultural marketing. The findings highlight the need for a wider integration of short supply chains in agrarian marketing strategies, but also for improving the sustainability and resilience of farming systems.

Key words*: s*hort supply chain, agricultural marketing, sustainability, local agriculture

INTRODUCTION

Modern agriculture has faced significant challenges due to globalization and the expansion of supply chains. This led to an increase in the distance between producers and consumers, to a decrease in transparency, as well as to difficulties in maintaining the quality of agricultural products [12].
In this context, short supply chains have emerged as an alternative solution, capable of renewing the relationship between farmer and consumer by reducing the number of intermediaries. These short chains allow a more direct link between producers and consumers, thus contributing to improving transparency and increasing trust between them. Thus, the distribution process becomes simpler and more efficient, resulting in significant benefits for both farmers and consumers. [16].
Short supply chains are defined as distribution systems that involve a small number of intermediaries from the producer to the final consumer, or even direct sales from the producer to the consumer. These short chains effectively eliminate intermediate steps, thus facilitating a faster and more transparent connection between the two main actors. In this way, producers have more control over the prices and quality of products, and consumers benefit from fresher and more affordable products [5], [4]. These may include local markets, cooperatives, direct sales at the farm, own stores or dedicated online platforms.
In this article, through the objectives of the research carried out, we set out to investigate: how short supply chains contribute to the paradigm shift in the field of agricultural marketing, how these short supply chains can be integrated into agricultural marketing strategies to ensure the sustainability of smallholder farmers and medium, but also what are the advantages and challenges of implementing short supply chains?

MATERIALS AND METHODS

To attain the objectives of this research, a qualitative methodology was used based on a series of studies from the specialized literature in the field of sustainable agriculture and agricultural marketing. Also, to better understand the applicability and benefits of this model in the Romanian context, we considered a successful example of a short supply chain from Cluj county, Romania.

RESULTS AND DISCUSSIONS

In recent years, global agriculture has undergone significant transformations, being influenced by trends such as increasing demand for local and sustainable products, as well as concerns about environmental impact and food security [1], [2], [17]. Short supply chains offer an alternative solution to traditional long chains by reducing the number of intermediaries and promoting direct relationships between farmers and consumers [6], [20].

In the European Union, short supply chains are promoted through policies and support programs that aim both to support small farmers and to increase access to fresh and quality products for consumers [7], [13], [19]. In Romania, this model is becoming more and more important, considering the potential of local agriculture and the increased interest of consumers in local and traditional products [11], [15].

Short supply chains offer a unique opportunity to meet the demands of modern consumers who are increasingly concerned about the provenance of food and the ecological impact of the products they purchase [18]. In addition, they allow manufacturers to better control prices and build direct relationships with customers, which can lead to increased loyalty and better adaptation to market demands.

The National Rural Development Program 2014-2020 pays special attention to supporting short-chain projects. Support is envisaged to facilitate cooperation between actors involved in rural development, to help them overcome and address specific socio-economic problems related to business development and provision of services in rural areas [8].

In the 2014-2020 programming period, Sub-measure 16.4 supported horizontal and vertical cooperation between supply chain actors, for the establishment and development of short supply chains and local markets, as well as for the implementation of related promotion activities in a local context. This measure aimed to strengthen collaboration between producers, processors and distributors, thus facilitating the creation of efficient structures to support the local economy and improve consumers' access to quality local products [10]. Promoting cooperation between local actors was the main objective of the measure, aiming at the marketing of agri-food products through short supply chains. The development of short supply chains in Romania can have significant potential for the development of rural communities. In the case of peasant households and small farms, the development of these short chains can represent an important factor of coagulation and stimulation of cooperation between producers, thus creating new development opportunities. By facilitating a more accessible and sustainable local market, these chains can contribute to improving economic and social conditions in rural areas, while encouraging innovation and adaptability in the agricultural sector.

An example of collaboration between farmers to capitalize on the products obtained through a short supply chain is the "Lunca Someșului Mic" Cooperative from Cluj County [9], [14]. In 2013, the "Lunca Someșului Mic" Cooperative was founded by a group of small farmers from the Lunca Someșului Mic Vegetable Basin, who joined forces to reduce production costs and create a short supply chain for agri-food products local. In the beginning, the cooperative cultivated vegetables on an area of 30 ha and had a limited range of products (cabbage, celery, cauliflower), but over time, as the client portfolio developed, the cultivated area also increased, reaching over 100 ha, cultivated in the field and protected areas. Also, in addition to the established products of the members of the cooperative: cabbage, cauliflower, celery, eggplant, lettuce, and potatoes, after 2019 when the recognition of a "Group of producers" was obtained, new products were introduced into the portfolio: tomatoes, peppers (5 types of varieties), cucumbers, pumpkins, black radishes, beetroot.

In an increasingly competitive fruit and vegetable market, the competitive advantages of the "Lunca Someșului Mic" Cooperative were, on the one hand, that the products sold are fresh and can be used even on the day of harvest, and on the other hand, the diversity of products in the portfolio, which reaches 20-25 types of vegetables sold. These characteristics allowed the cooperative to differentiate itself on the market, offering consumers high-quality products, available quickly and in a varied range, which gives them a considerable advantage over the competition. In this way, "Lunca Someșului Mic" manages to meet market demands in an efficient and adaptable way.

Also, after 2019, the cooperative, through the development plan, proposed to attract European funds through submeasure 9.1 intended for groups of producers and to create their own storage space and offer them the possibility of development on the processing side. Also, three members of the cooperative accessed European funding for submeasure 6.1. intended for young farmers, through which they made purchases of machinery and investments in protected areas.

For the future, the cooperative's plans are directed towards the expansion of crops in protected areas, collaborations with new farmers and the production of some types of vegetables in an ecological system.

The present case study shows that capitalization through a short chain using a supermarkets as intermediary to offer consumers fresh vegetables and fruit has enabled smallholder farmers of the cooperative to access local markets and increase incomes and profit.

This cooperative achieves the minimum purchase limit imposed by the large supermarkets in Romania, so it practices the sale of fresh vegetables and fruits to consumers through the supermarket, which is a short supply chain that ensures the sale of large quantities on the basis of a contract and implicitly obtaining quick and sufficient income to increase net profit. So, the marketing activity has a high economic efficiency (Table 1).

Table 1. Impact of production and marketing activity on turnover, net profit and share of net profit in turnover, "Cooperativa agricola Lunca Somesului Mic", 2013-2023

	Turnover (Thousand RON)	Net profit (Thousand RON)	Share of Net profit in Turnover (%)
2023	2,845.5	17.8	0.62
2022	2,708.2	108.0	3.98
2021	3,894 .4	163.3	4.19
2020	2,686.5	78.4	2.91
2019	2,612 .0	28.3	1.08
2018	1,547.4	1.9	0.12
2017	1,181.6	7.5	0.63
2016	1,042.7	0.6	0.05
2015	591.9	0.3	0.05
2014	557.8	1.3	0.23
2013	209.3	-75.4	-36.02

Source: Own calculations based on the data from Lista firme, 2024, Cooperativa agricola Lunca Somesului Mic, https://www.listafirme.ro/cooperativa-agricola-lunca-somesului-mic-31289775/ Accessed on November 30, 2024.[21].

The data from Table 1 show that turnover increased in the analyzed period from 209.3 Thousand RON in 2013 to 2,845.5 Thousand RON in 2023, being 13.59 times higher. in 2021, the peak of turnover accounted for 3,894 .4 Thousand RON.

Net profit also registered an upward trend from - 74.4 Thousand RON (loss) to 17.8 Thousand RON in 2023.

The highest net profit was 163.3 Thousand RON and its share in turnover was 4.18%, the highest level in the analyzed interval.

This good financial situation could not have been achieved if the producers from the cooperative had tried to sell their products by themselves.

Through the support of European funds and local cooperation initiatives, farmers have managed to overcome some obstacles and create sustainable opportunities for the development of rural communities.

Short supply chains - a new perspective in agricultural marketing

Short supply chains are fundamentally changing agricultural marketing, transforming it into a model based on direct relationships, sustainability and the valorization of the local. These changes contribute to a more resilient, fair and transparent agricultural economy, allowing farmers to become not only producers but active marketers who promote their products directly to the community.

At the same time, consumers are attracted by access to authentic, traceable and local products. These characteristics contribute to the creation of a new paradigm in agricultural marketing and provide confidence to consumers, who want to know exactly where the products they purchase come from and support local economies. Thus, agricultural marketing is transforming, emphasizing transparency and promoting the values of authenticity and sustainability, aspects that are increasingly appreciated in a society increasingly aware of the impact of its choices on the environment and community (Fig. 1).

Fig. 1. Model of a short supply chain
Source: own processing.

Short supply chains are contributing to a paradigm shift in agricultural marketing through some critical transformations that influence the way agricultural products are produced, distributed and consumed:

- Focusing on the direct relationship between producer and consumer: one of the fundamental aspects of short supply chains is the elimination of intermediaries or the drastic reduction of their number. This means that farmers sell their products directly to consumers, which changes the traditional agricultural distribution structure. Thus, farmers are no longer just suppliers of raw materials but also become marketing actors, having direct contact with consumers and better understanding their requirements. This direct relationship fosters trust and loyalty to products and farmers.
- Focus on local products and sustainability: Short supply chains promote local products, which shifts the focus of agricultural marketing from quantity to quality and origin. Consumers are increasingly interested in local products and their impact on the environment, which brings concepts such as organic or traditional products to the fore. Small and medium-sized farmers are thus encouraged to produce sustainably and capitalize on the unique elements of their region, which increases the added value of the products.
- Marketing based on authenticity and traceability: Short supply chains are changing the paradigm with marketing focused on authenticity, transparency and traceability. Modern consumers increasingly demand to know where their products come from, how they are grown and who produces them. Through short supply chains, farmers can communicate this information directly to consumers, giving them a more personalized and authentic experience. This aspect increases the confidence of consumers and makes them loyal.
- Reduction of distances and efficiency of distribution chains: Short supply chains encourage proximity between the place of production and the place of consumption, which reduces logistics costs, carbon footprint and food waste. This aspect also allows farmers to react more quickly to market demands and deliver fresh produce. This change from the traditional model, where products are transported over long distances, brings a competitive advantage to local farmers and strengthens the connection between consumer and producer.
- Marketing based on community values and social sustainability: short supply chains are based on supporting local communities and developing a circular economy. By promoting local producers, consumers contribute to the maintenance and development of small farms

and rural economies. In traditional marketing, the focus is on maximizing profits and the efficiency of global supply chains, while short supply chains shift the focus to social sustainability, maintaining jobs and promoting a healthy and fair lifestyle.

- Flexibility and adaptability: Short supply chains allow greater flexibility for farmers in how they plan their production and capitalize on their produce. Instead of being pressured by large distribution chains, farmers can adapt their supply to local demand and promote seasonal produce. This capability is a significant asset, allowing farmers to create personalized offers and respond more quickly to changes in consumer preferences.

Integrating short supply chains into agricultural marketing strategies can play an important role in ensuring the sustainability and resilience of small and medium farmers (Fig. 2).

Fig. 2. Integrating short supply chains into agricultural marketing strategies
Source: own processing.

To achieve this, farmers need to adopt new and innovative approaches to marketing, work more closely with consumers and focus on building strong and sustainable relationships [3]:

- Short supply chains can capitalize on local identity and agricultural traditions specific to a region. By integrating the concepts of origin and authenticity, small and medium-sized farmers can create a brand based on the quality and uniqueness of their products, through different agricultural marketing strategies: clearly labeling local products and emphasizing the health benefits and low environmental impact of the products; using quality certifications, such as Protected Geographical Indications (PGI) or Protected Designations of Origin (PDO), to differentiate products and attract consumers concerned about the provenance of products; promoting farmers' personal stories that give consumers an emotional connection to the products and the community they come from.

- Direct relationships with consumers: One of the biggest advantages of short supply chains is that producers and consumers can interact directly, eliminating middlemen. This can be turned into an effective marketing strategy through: community events local fairs, and flea markets. Instead of competing with supermarket chains on price, farmers can build a sustainable relationship based on transparency, traceability and product quality. Consumers appreciate the opportunity to interact directly with those who produce the food and are more willing to support such initiatives.

- Small and medium-sized farmers can become more resilient if they adopt cooperative or partnership models. This allows them to share costs and risks, access larger markets and increase their bargaining power. In this sense, agricultural marketing can be improved by: Agricultural cooperatives, groups of farmers who collaborate to sell products have the advantage of reducing distribution costs and creating a common brand image. Co-ops are more attractive to large urban markets and restaurants looking for consistent quality products. Creating direct partnerships with restaurants, schools or grocery stores that prefer local products can be an effective marketing strategy to increase sales. Farmers can become regular suppliers to these businesses, securing stable contracts and regular income.

- A modern integration of short supply chains in agricultural marketing involves the adoption of digital technologies and online platforms to attract new consumers and increase product visibility. This may include online stores dedicated to local products to sell directly to consumers; social media are powerful tools for promoting local agricultural products and allow farmers to present their story and build a loyal audience through constant updates and direct consumer engagement; home delivery and subscription services, where consumers subscribe to receive regular baskets of fresh produce from local farmers. They allow farmers to have steady income streams and cultivate a loyal customer base.

Integrating short supply chains into a well-thought-out agricultural marketing strategy based on authenticity, localism, cooperation and the use of digital technologies can ensure the sustainability and resilience of farmers.

By connecting directly with consumers, short supply chains offer a sustainable and stable development path for Romanian farmers. These chains allow farmers to more efficiently value their products, reducing dependence on intermediaries and obtaining fairer prices. At the same time, they contribute to the development of local economies, encouraging responsible consumption and supporting organic and traditional agriculture. Thus, short supply chains represent an opportunity for sustainable economic growth for farmers and rural communities in Romania.

Advantages and challenges of implementing short supply chains

On the one hand, the advantages include better transparency in the marketing process, reduced costs and closer proximity between producers and consumers, which contributes to the development of local economies. On the other hand, there are challenges related to insufficient infrastructure, the lack of clear support policies and the limited capacity of farmers to adopt new technologies or marketing practices. These factors can affect the efficiency of short chains, but with well-thought-out strategies, they can become a powerful tool for revitalizing local agriculture.

Advantages of implementing short supply chains (Fig. 3):

- it cuts out middlemen, which allows farmers to get better prices for their produce. In a traditional chain, a large part of the profit goes to the middlemen, while in the short chain, the producers keep a significantly higher percentage of the selling price. Farmers can thus obtain a higher profit from direct sales, without being subject to the pressure of low prices imposed by supermarket chains.
- facilitate farmers' access to local and regional markets. These markets allow the direct sale of fresh, seasonal produce without the need for large production volumes. Local fairs and markets, and flea markets offer farmers the opportunity to market their produce directly to consumers.
- supports agri-food diversity and gastronomic heritage. Short chains support local agriculture and traditional products, giving farmers the chance to promote varieties and cultivation methods specific to different regions in Romania.
- short chains help to reduce the carbon footprint by shortening the transport distances between the place of production and the place of consumption. This means less carbon dioxide emissions and a reduction in negative environmental impact.
- through direct sales, farmers can establish a closer relationship with consumers, which increases trust and loyalty to local products.

Fig. 3. Advantages of implementing short supply chains
Source: own processing.

Consumers have access to information about how food was grown or produced, a highly valued aspect in the current context of increasing demand for transparent and sustainable products.

The challenges of implementing short supply chains are shown in Fig. 4.

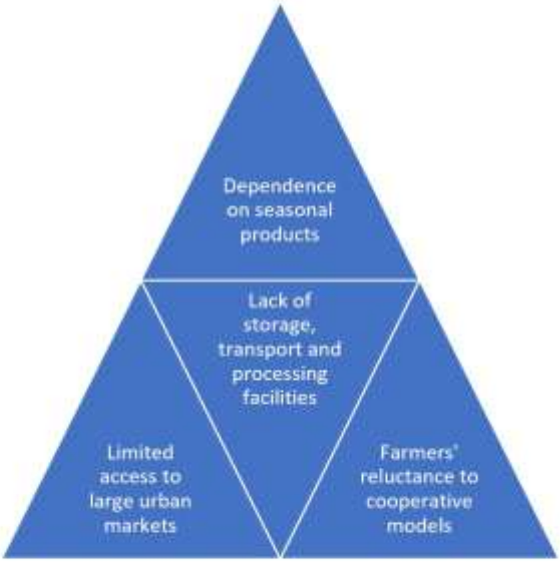

Fig. 4. The challenges of implementing short supply chains
Source: own processing.

They are the following ones:
- one of the main challenges for farmers is the lack of infrastructure to store, transport or process agricultural products. Many small farms do not have facilities for storing products in optimal conditions or for transporting them to local or regional markets. Without adequate logistics infrastructure, farmers face difficulties in maintaining product quality.
- short chains often depend on seasonal products, leading to fluctuations in supply and difficulty in maintaining a consistent market presence throughout the year. Farmers who produce fruits and vegetables have limited sales periods depending on the harvest season.
- farmers have difficulty accessing large urban markets where demand for fresh produce is high. Supermarkets dominate large urban markets and small producers face challenges in finding a place in this competitive market.
- although there is European funding that supports the formation of cooperatives, farmers in Romania are still reluctant towards this organizational model. These structures would facilitate access to larger markets, reduce production costs and increase farmers' competitiveness.

To overcome these challenges, better organization of farmers in cooperatives, investment in storage and transport infrastructure, as well as support for agricultural education and the use of modern marketing technologies are needed. Solving these problems could transform short supply chains into a central element of agricultural marketing and the rural economy in Romania.

CONCLUSIONS

In Romania, short supply chains have started to gain ground in recent years, due to the increased demand for local and healthy products. Farmers benefit from more direct market access, cutting out middlemen and getting better prices for their produce.

Short supply chains are a viable alternative to traditional long supply chains, offering multiple advantages for farmers and consumers. In Romania, short supply chains have contributed to increasing farmers' incomes, improving relations with consumers and developing the local economy. However, there are major challenges such as lack of infrastructure and seasonality of production that need to be addressed to maximize the potential of this model.

The support of the European Union is essential for the development of short supply chains in Romania, both through access to funds and through the creation of a legislative framework that facilitates collaboration between farmers and urban markets. Going forward, the focus needs to be on investing in rural infrastructure and educating farmers to take full advantage of this supply model..

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SOIL QUALITY INDICES EXPLANATION THROUGH MULTIVARIATE ANALYSIS

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Abstract

Environmental and anthropogenic factors, especially agricultural practices, generate a series of changes on the soil physico-chemical and biological indices. The periodic determination of quality indices is important to know the level of soil fertility, and the application of appropriate measures for crop yield. The present study analyzed the agrochemical indices of soil quality, and used multiparameter analysis (PCA) to obtain the loading of the indices on the main components, the mode of action, and the intensity of each soil index. PC1 comprised soil pH (r = -0.923), B (r = -0.883), Fe (r = 0.782), CaO (r = -0.777), NH_4 (r = 0.752), K_2O (r = 0.545), and Mn (r = 0.286). PC2 included Zn (r = 0.873), P_2O_5 (r = 0.786), Cu (r = 0.756), and S (r = 0.316). PC3 included Nmin (r = 0.960), and NO_3 (r = 0.950). PC4 included MgO (r = 0.888), and Na_2O (r = 0.881). In relation to the soil reaction, the 38 soil trials were classified into three categories, acid reaction (11 trials), neutral reaction (7 trials), and basic (alkaline) reaction (20 trials). Based on the PCA, the three groups were positioned differently, with an independent position in the case of the acid reaction, and with an overlap in the case of the neutral and basic reaction, as transition zones.

Key words: *component characteristics, components loading, factors action, PCA, soil fertility*

INTRODUCTION

There is a well-known tendency to decrease the area of agricultural and arable land per capita worldwide, with certain variations from one country to another [3, 8, 19]. Knowing and ensuring the quality of soils is of crucial importance for food safety and security, necessary for a growing human population [9, 12, 20, 21].

The way land is used, and agricultural practices, influence in the medium and long term soil quality indices and land productivity. The understanding of the action of these practices and the appropriate interventions, contribute to a sustainable management of soil resources and ensuring the sustainable functioning of agroecosystems [2, 7, 11, 16, 22].

Physico-chemical and biological indices are used in current studies for the analysis and characterization of soil types and sub-types [1, 17, 18]. Certain inadequate agricultural practices have led to the degradation of soil quality, under different aspects of physico-chemical and biological indices, and their identification is important for recovery measures and the sustainable use of agricultural land [5, 22].

The identification of representative soil quality indicators is important for the quick and efficient evaluation and diagnosis of soil quality, the level of soil degradation, and the forms in which this phenomenon manifests itself, when quantifying ecosystem services, and to establishing sustainable agricultural practices [22].

Changes and variations induced by agricultural practices in soil quality are important for crop yield, and associated with the high diversity of cultivated soils it is relatively difficult to use an adequate index for soil quality [16]. The authors of the study used different methods to estimate a soil quality index (SQI), based on samples from different locations (72 samples, three locations), in conditions of organic soils, and mineral soils. The authors recorded different values for SQI, in relation to the calculation methods used.

Representative indices of soil quality were analyzed over time, in relation to different agricultural practices [2]. The authors of the study recorded the differentiated variation of the considered indices, in relation to the applied agricultural practices.

In conventional farming systems, the soil has an important role in plant production, and soil health and productivity capacity is periodically evaluated, based on a comprehensive set of soil quality indices [2, 4, 15]. Soil quality indices are determined by classic laboratory methods, which are more accurate, but more expensive in terms of time, consumables, and human resources [4]. New methods, based on imaging analysis, have been tested and used with a high reliability rate for the quantification of soil quality indices [4].

The assessment of soil quality based on individual indices, or simple indices, may present certain limitations [14]. The authors considered that an integrated index is more relevant to express the soil quality of agricultural lands, especially in relation to anthropogenic influences. The authors have compared two agricultural areas, based on physical-chemical, biological and contaminant indices, as basic indices. According to the PCA, it was possible to identify and select the relevant indicators for soil quality. In relation to anthropic pressure, the soil quality index showed higher values in conditions of lower anthropic pressure.

The way of agricultural land is used generates an impact over time on the quality and functionality of the soil indices [7]. The “life cycle” is considered an important indicator of how land is used. The authors of the study analyzed the impact of land use methods on some representative soil properties. The identification of important indicators was considered, as well as options for indicators combining (aggregating), in order to express the quality of the land, under the conditions of a representative number of ways of land using (57 types of use, according to the authors).

Soil quality indices were used, under experimental conditions, for the analysis of management options in the assessment of soil health at the regional scale [15]. Based on soil samples from variable depths (0-30 cm) and a representative number of working points, the authors used different types of analyzes and methods (e.g. PCA, soil function, percentile method), and information based on soil functionality (SF), to establish and select a minimum set of data, with a certain number of parameters to result in weights of key indicators.

Factors and processes that determine soil degradation (e.g. erosion) have led to low agricultural yields [6]. The authors of the study evaluated the level of soil sustainability based on a representative number of indicators, in different land use conditions. Based on some soil quality indexing methods, and the recorded results, the authors identified that the method that considered PCA for the soil quality index, showed high sensitivity and generated more robust results.

Uthappa et al. (2024) [22] studied various land use systems (agroforestry, horticultural, agricultural systems, natural forests, and tree plantations) and analyzed how they influenced the soil quality index. Principal component analysis was used, associated with different linear and non-linear scoring methods. The authors found that the quality index (weighted value) based on non-linear models ensured an efficient assessment of soil quality.

This study used multiparameter analysis (PCA) to explain the positioning of some indices that define soil fertility, in relation to the main components, mode and intensity of action of the considered indices.

MATERIALS AND METHODS

The study took place in the conditions of specific agricultural lands, in the area of ATU Sacalaz, Beregsau Mare Locality, Timis County, Romania (Map 1).

In relation to the purpose of the study, 38 soil trials were considered, from arable land category, sampling depth 0-30 cm. For the characterization of soil, specific soil quality indices were determined, namely the soil reaction (soil pH), the content of macroelements, and the content of microelements. The soil samples were analyzed within Vantage SRL, by accredited laboratory methods. In relation to the purpose of the study, the soil quality index data were analyzed by appropriate mathematical and statistical methods.

(a) (b) (c)

Map 1. Study area; (a) Romania; (b) Timis County, ATU Sacalaz; (c) Area of study
Source: original figure, generated based on (a) [23]; (b) [24]; (c) [25]

The correlation analysis was applied to evaluate the interdependence between the quality indices considered in the study. Multiparameter analysis (PCA) was used to determine the principal components and the loading of quality indices (as factors) on each component. Appropriate mathematical and statistical tools were used [10, 13].

RESULTS AND DISCUSSIONS

Based on the soil samples and laboratory analyses, the values of the soil quality indices were obtained, presented in Table 1. The soil reaction, and the content of macro- and microelements in the soil, the upper soil horizon (0 – 30 cm depth), were considered.

Table 1. Descriptive statistics for soil quality indices, ATU Sacalaz, Beregsau Mare, Timis County

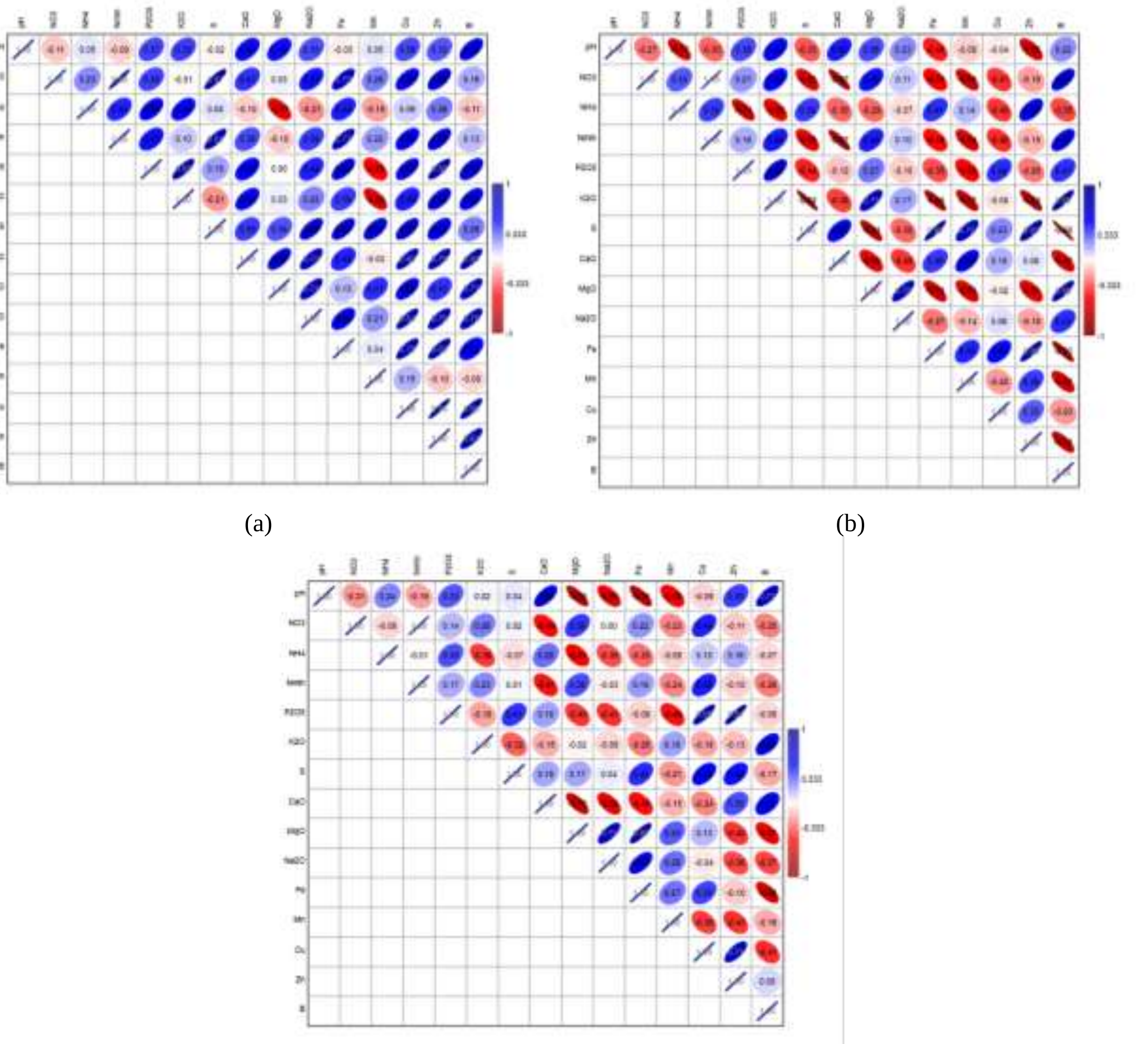
Statistical parameter	Soil quality indices														
	pH	NO_3	NH_4	Nmin	P_2O_5	K_2O	S	CaO	MgO	Na_2O	Fe	Mn	Cu	Zn	B
Valid	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
Missing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mode	7.13	5.26	1.61	7.22	19.21	176.03	14.79	4273.20	604.83	23.59	12.04	5.13	1.96	0.33	0.19
Median	7.33	12.43	1.86	14.38	71.74	334.95	14.05	5970.21	1390.8	49.20	33.80	5.13	1.99	0.47	0.55
Mean	7.21	13.81	2.18	15.99	106.13	324.95	14.01	7017.53	1535.5	57.37	48.38	5.89	1.92	0.57	0.65
Std. Error	0.11	0.94	0.14	0.92	20.18	10.93	0.54	355.94	83.23	4.28	5.78	0.37	0.15	0.05	0.07
Std. Deviation	0.69	5.80	0.87	5.66	124.38	67.36	3.30	2194.18	513.04	26.39	35.62	2.25	0.90	0.31	0.43
Minimum	5.93	5.26	1.21	7.22	19.21	176.03	9.45	4273.20	604.83	23.59	12.04	2.59	0.71	0.29	0.12
Maximum	8.10	26.82	4.17	29.01	712.01	442.02	21.10	11288.2	2595.6	132.16	146.89	11.43	4.84	1.63	1.59
25th percentile	6.70	9.41	1.49	12.10	47.20	298.05	11.33	5032.45	1184.9	40.65	19.91	4.38	1.19	0.37	0.25
50th percentile	7.33	12.43	1.86	14.38	71.74	334.95	14.05	5970.21	1390.8	49.20	33.80	5.13	1.99	0.47	0.55
75th percentile	7.81	17.62	2.60	19.50	123.48	371.78	17.10	9086.92	1777.1	64.53	71.24	7.24	2.25	0.64	1.02

Source: original data.

From the total of 38 soil trials, 11 trials were recorded in the acid pH range (pH = 5.93 – 6.73), seven trials in the neutral pH range (pH = 6.82 – 7.20), and 20 samples in the basic (alkaline) pH range (pH = 7.30 – 8.10).

The mineral elements recorded variable values, descriptive statistical parameters indicating the limits of variation in the case of each soil quality index, considered in the analysis (Table 1).

The degree of agricultural land variability was assessed based on the coefficient of variation, calculated for each soil quality index. Very high variability was registered in the case of phosphorus (CV = 117.1964), followed by iron (CV = 74.6397), boron (CV = 66.8402), zinc (CV = 54.3009), copper (CV = 46.7108), sodium (45.9891). Low value of variability presented the reaction of the soil (CV = 9.5136). In the case of the other indices, intermediate values were recorded, CV = 20.7287 for K_2O, 23.5748 for S, CV = 31.2671 for CaO, CV = 33.4121 for MgO, CV = 35.4255 for Nmin, CV = 38.1529 for Mn, CV = 39.9965 for NH_4, and CV = 42.0332 for NO_3, respectively. The correlation analysis was done on the data series within the three pH domains recorded, with the representation of the correlation coefficient values in Figure 1 (a), (b), (c).



(a) (b)

(c)

Fig. 1. Correlation diagrams between soil quality indices; (a) acid pH conditions, (b) neutral pH conditions, (c) basic (alkaline) pH conditions
Source: Original diagrams, resulted from data analysis.

Predominantly positive correlations were recorded in the acidic pH range, predominantly negative correlations in the neutral pH range, and more balanced correlations (positive, negative) in the basic (alkaline) pH range. In all three pH domains addressed, there were varying levels of intensity of correlations. In some cases, the type and intensity level of the correlation was maintained (e.g. NO_3 with Nmin, r = 0.976 in the acid domain, r = 0.998 in the neutral domain, r = 0.997 in the basic (alkaline) domain), or there were small differences between the intensity level (e.g. P_2O_5 with Zn, r = 0.820 in the acid domain; r = 0.908 in the basic (alkaline) domain).

In most cases, however, the level of correlation between quality indices has changed, in relation to the domain of soil reaction, and the content of mineral elements in the soil, Figure 1 (c).

Considering the large number of indices used in soil quality assessment, the distribution of these indices was analyzed in relation to the main components, according to PCA.

The loading of the quality indices (as factors determining soil quality) in the main components was found, with different values of the correlation coefficient, depending on the importance of each factor in the respective component (Table 2, Figure 2).

Table 2. Component loadings, soil quality indices

Soil quality indices	PC1	PC2	PC3	PC4	Uniqueness
pH	-0.923				0.089
B	-0.883				0.140
Fe	0.782				0.110
CaO	-0.777				0.140
NH_4	0.752				0.283
Zn		0.873			0.194
P_2O_5		0.786			0.210
Cu		0.756			0.064
Nmin			0.960		0.066
NO_3			0.950		0.067
MgO				0.888	0.108
Na_2O				0.881	0.186
K_2O					0.545
S					0.316
Mn					0.286

Source: Original data.

Within PC1, the first position was occupied by soil reaction (pH), with r = -0.923, followed by B (r = -0.883), Fe (r = 0.782), CaO (r = -0.777), NH_4 (r = 0.752), K_2O (r = 0.545), and Mn (r = 0.286), according to Table 2, and Figure 2.

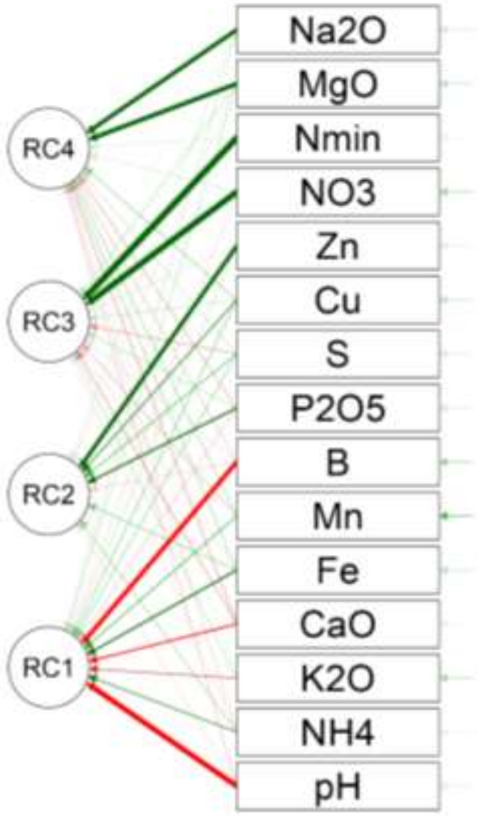


Fig. 2. The graphic representation of the main components and the factors loading (soil indices) on the component
Source: Original figure.

Zinc (Zn) was positioned in PC2, with r = 0.873, followed by P_2O_5 (r = 0.786), Cu (r = 0.756), and S (r = 0.316), according to table 2, and figure 3.

In PC3, with very high values of the correlation coefficient, Nmin with r = 0.960, and NO_3, with r = 0.950, was positioned. In PC4, MgO was positioned with r = 0.888, followed by Na_2O with r = 0.881.

The characteristics of the components, in relation to the analysis mode, are presented in Table 3.

In order to obtain a general distribution of the soil trial (T1 to T38) in relation to the values of the soil quality indices, the PCA multiparameter analysis was applied. According to PCA, the diagram in Figure 3 was generated, where PC1 explained 40.738% of variance, and PC2 explained 17.822% of variance.

The formation of three clusters of points (soil trials) was found, but also the independent distribution of some trials.

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Table 3. Component Characteristics

Components	Unrotated solution			Rotated solution		
	Eigenvalue	Proportion var.	Cumulative	SumSq. Loadings	Proportion var.	Cumulative
Component 1	6.111	0.407	0.407	4.815	0.321	0.321
Component 2	2.673	0.178	0.586	2.712	0.181	0.502
Component 3	2.192	0.146	0.732	2.371	0.158	0.660
Component 4	1.221	0.081	0.813	2.298	0.153	0.813

Source: Original data.

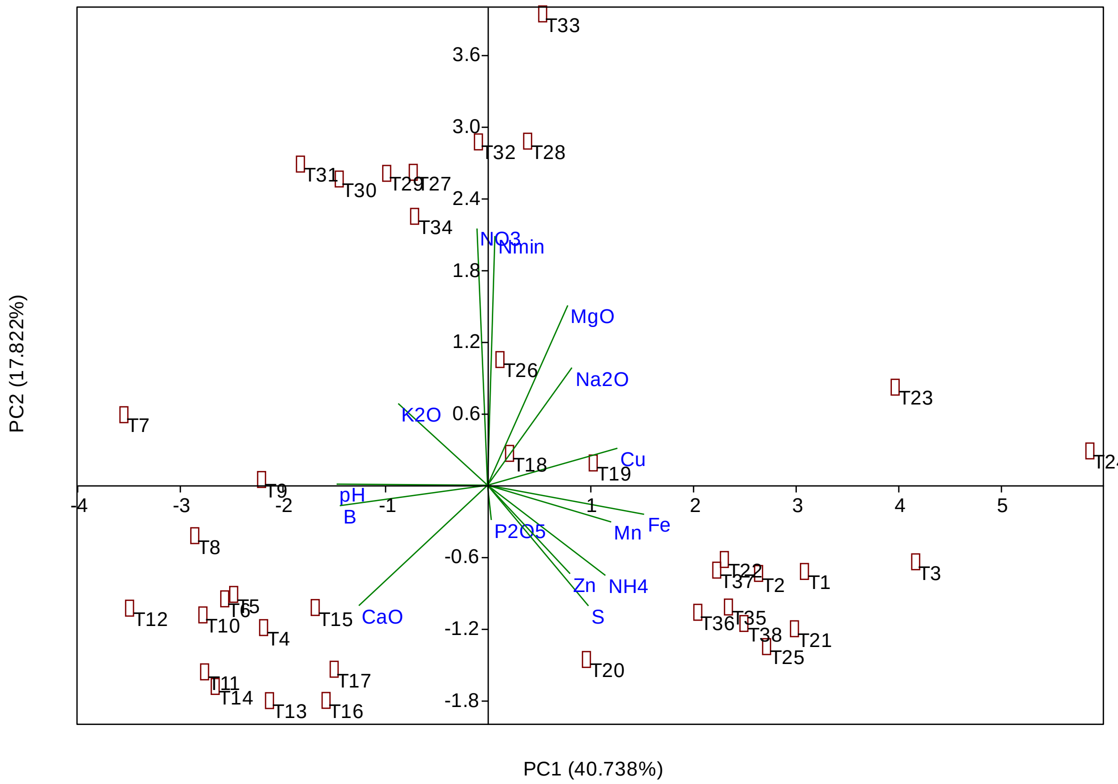

Fig. 3. PCA diagram, based on general soil indices analysis
Source: original diagram, resulting from the data analysis.

Considering the three fields of soil reaction in which the soil trials were included, the PCA multiparameter analysis was applied to obtain the distribution of the indices in relation to the three classification groups.

The diagram in Figure 4 resulted, with the three marked groups that included the soil trials, respectively the acid domain (red color), the neutral domain (green color), the basic (alkaline) domain (blue color). PC1 explained 74.848% of variance, and PC2 explained 25.152% of variance.

According to the PCA, the group of soil trials, indicating acidic soil domain (11 trials), was positioned distinctly (Figure 4).

The other two groups in relation to the soil reaction (neutral soil domain - 7 trials, alkaline soil domain - 20 trials) presented the highest proportion of soil trials as independent (green filled region, blue filled region), but they have a common area, like a transition area (Figure 4). It is an area of interferences, in the conditions of the overall analysis of the soil indices, in the study conditions.

The components presented variable weights, both in the "unrotated solution" analysis version, and in the "rotated solution" version. Thus, in the case of the "unrotated solution" analysis, according to Eigenvalue, Component 1 recorded the value 6.111, Component 2 recorded the value 2.673, Component 3 recorded the value 2.192, and Component 4 recorded the value 1.221, respectively.

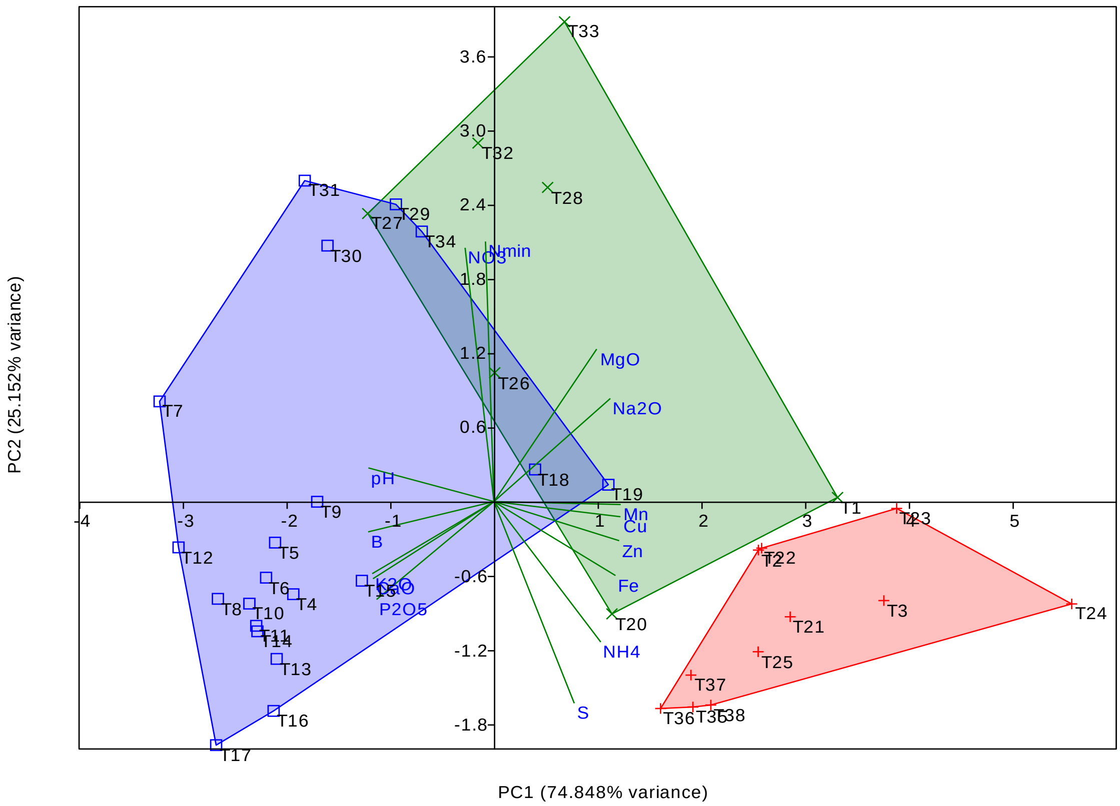

Fig. 4. PCA Correlation Between-group; red color field – acid pH range, green color field – neutral pH range, blue color field – basic (alkaline) pH range
Source: Original figure.

In the "rotated solution" version, and the statistical parameter "SumSq. Loadings", Component 1 recorded the value 4.815, Component 2 recorded the value 2.7112, Component 3 recorded the value 2.371, and Component 4 recorded the value 2.298.

After identifying the classification of indices on the main components, and the levels of correlations between indices by categories of soil reaction, the overall correlation of indices from PC1, especially soil reaction (pH), with indices from the other components (PC2, PC3, and PC4).

At the level of the PC1 component, in the ranking order of the indices, the soil reaction (pH) showed a strong correlation with B ($r = 0.86^{***}$), a strong correlation with Fe ($r = -0.868^{***}$), a strong correlation with CaO ($r = 0.822^{***}$), moderate correlation with NH_4 ($r = -0.714^{***}$), moderate correlation with Mn ($r = -0.695^{***}$), weak correlation with K_2O ($r = 0.461^{**}$) (Figure 5).

At the level of the PC2 component, the soil reaction (pH) showed correlation with Zn at the level of $r = -0.26$, correlation with P_2O_5 at the level of $r = 0.133$, correlation with Cu at the level of $r = -0.558^{***}$, correlation with S at level $r = -0.385^{*}$. At the level of the PC3 component, the soil pH showed a correlation with NO_3 at the $r = 0.107$ level, and with Nmin, $r = 0$. At the PC4 level, the soil pH showed a correlation with MgO at the $r = -0.364^{*}$ level, correlation with Na_2O at the $r = -0.344^{*}$ level. A very strong, positive correlation was recorded between Nmin and NO3, both indices in PC3 ($r = 0.989^{***}$) (Figure 5).

Based on the values of the correlation coefficient recorded between the first index in PC1 and the other indices in PC1, as well as with indices from PC2, PC3, PC4, it was estimated that the level of correlation, therefore also of influence, was variable in the study conditions.

PCA analysis is increasingly used in soil quality assessment, to differentiate the contribution of primary quality indices (physical, chemical, biological) and generate synthetic soil quality indices (e.g. SQI).

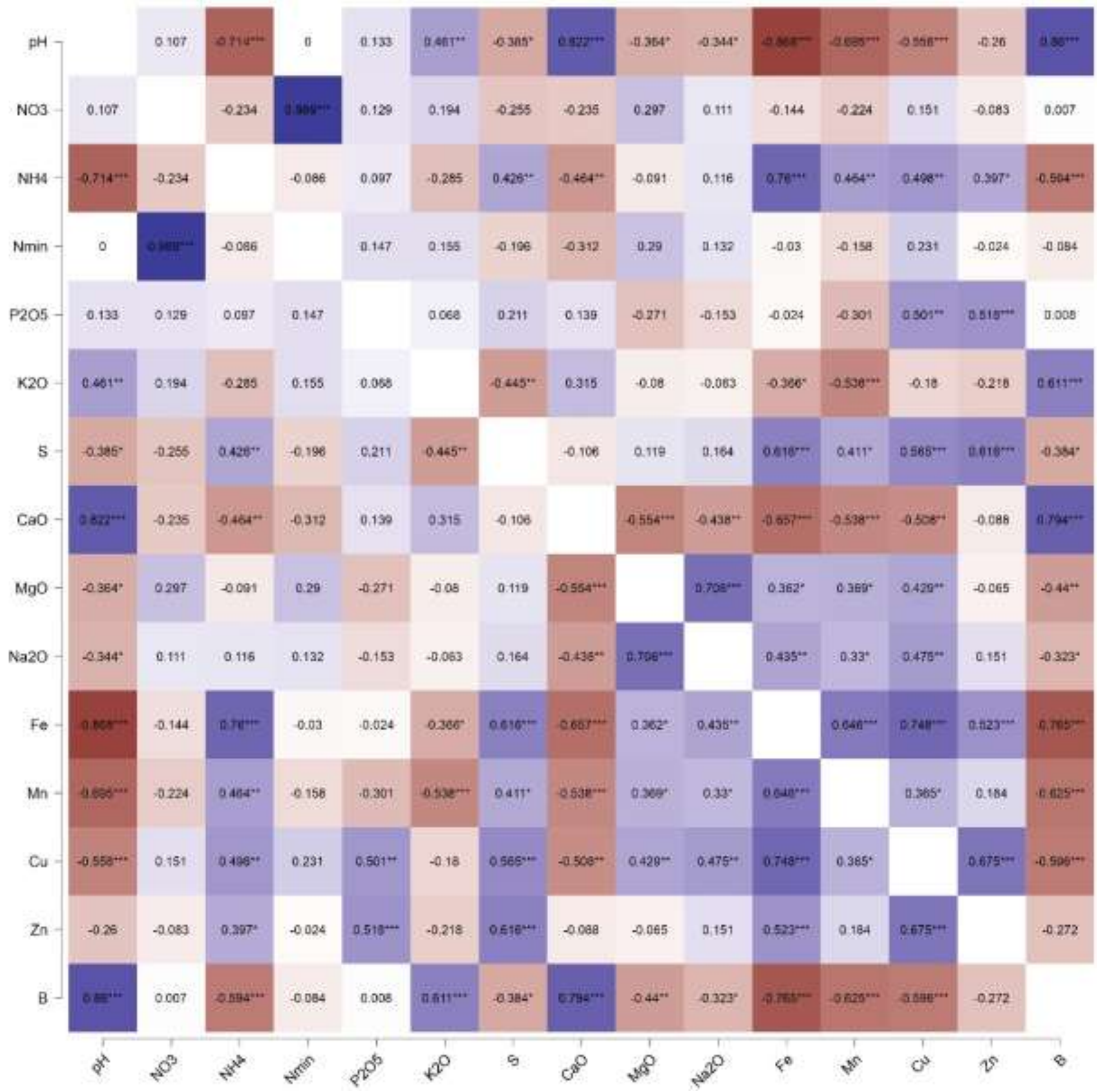

Fig. 5. Correlation heatmap, in the conditions of the overall analysis of the soil quality indices, in the study conditions
Source: Original figure.

Mukherjee and Lal (2014) [16] obtained a soil quality index (SQI-3, according to the authors) that resulted from principal component analysis (PCA) of some soil parameters, obtained from 72 samples. The authors communicated a strong correlation of the SQI-3 index (result through PCA analysis) with crop yield, compared to other indices obtained by other methods.

The variation of some soil quality indices was analyzed in relation to certain agricultural practices, under the conditions of a clay-loamy soil [2]. The authors of the study recorded the decrease in the value of some important indices for soil quality (e.g. soil pH, extractable content of P and K) that influenced soil quality and the yield of wheat and soybean crops. The authors concluded that the indices represented by pH, P and K are representative for the soil, in the study conditions, and require monitoring over time, to evaluate the dynamics of soil quality, fertility and agricultural yields in soybeans and wheat, on the medium and long term.

Lenka et al. (2022) [15] used PCA analysis to define the soil quality index (SQI), in order to find a high correlation with yield in wheat and rice crops. The authors obtained six main components, with 75% of the total variation, of which the first two components (PC1, and

PC2) explained 42.8%.

Damiba et al. (2024) [6] used two methods for evaluating and indexing soil quality, a method based on LDS to find the A-SQI index (additive soil quality index), and a method based on PCA to find the W-SQI index (weighted index of soil quality). Based on the recorded results, the authors appreciated that the method based on PCA, which led to the W-SQI index, was more sensitive and led to more accurate results.

Uthappa et al. (2024) [22] used the PCA method associated with other methods, linear and non-linear, for precise quantification of the contribution or weight of the basic indices in the calculation of the synthetic index (SQI, according to the authors).

In the conditions of the present study, the multiparameter analysis (PCA) led to different results regarding the distribution and explanation of the soil quality indices. Under the conditions of the general analysis of the indices (independent manifestation of the indices), the first two main components (PC1 and PC2) explained 58.56% of variance (Figure 3).

In terms of grouping the indices in relation to the domain of soil reaction, on the three categories recorded in the study conditions (acidic, neutral, and basic or alkaline reaction, respectively), the main components PC1 and PC2 fully explained the variance between the data groups (PC1 and PC2, 100% of variance).

CONCLUSIONS

According to the results of this study, the importance of the aggregation of primary soil indices emerged, in relation to the factor placed in PC1, with the highest action value (soil pH, r = -0.923). The PCA analysis, based on the grouping of the indices in relation to the soil reaction (acidic, neutral and alkaline pH range), fully explained the variance (100%), based on the main components (PC1 and PC2).

According to the coefficient of variation (CV), the soil quality indices showed different variability, phosphorus was found with a high level (CV = 117.1964), and nitric nitrogen, NO_3, was found with a low value (CV = 42.0332), in the case of nutrients.

A positive or negative correlation was found between the quality indices, with different levels of intensity, under conditions of statistical safety.

In the case of some quality indices, the type and intensity level of the correlation was maintained (e.g. NO_3 with Nmin, r = 0.976 in the acid domain, r = 0.998 in the neutral domain, r = 0.997 in the basic domain), or there were small differences between intensity level (e.g. P_2O_5 with Zn, r = 0.820 in the acid domain; r = 0.908 in the basic domain). In the case of most indices, the type and level of correlation in relation to the scope of the soil sample based on the soil reaction have changed.

The study recommends the analysis of the soil quality indices to find out the dominant index as an action in relation to the main components, the framing of the indices on the main components and the generation of a synthetic, convergent result for the assessment of the quality of the soil and agricultural land.

ACKNOWLEDGEMENTS

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PERCEPTIONS, CONSUMPTION PATTERNS, AND PURCHASING BEHAVIOURS OF VEGAN PRODUCTS IN SLOVAKIA: A COMPARATIVE STUDY OF FLEXITARIANS, OMNIVORES, VEGANS, AND VEGETARIANS

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Abstract

The study investigates the factors influencing Slovak consumers' perceptions, consumption, and purchasing behaviors regarding vegan products across different dietary styles. It examines the varying motives behind purchasing decisions among vegans, vegetarians, flexitarians, and omnivores, differences in their consumption and buying frequencies, and the significance of selected factors during the purchase process. Research questions were derived from a literature review, and research gaps were identified. Data were collected via an online questionnaire with criteria including the purchase of vegan products and a minimum age of 18. The final sample included 915 respondents from an initial 2,011 participants. A Likert scale measured motives for purchasing vegan products, consumption patterns, and the importance of various criteria during purchase. Statistical analysis was performed using IBM SPSS Statistics Grad Pack 28.0 and XL Stat version 4.1, employing non-parametric tests like the Kruskal-Wallis test with Dunn-Bonferroni post hoc method, the Friedman test with Nemenyi's multiple pairwise comparisons, and Categorical Principal Components Analysis (CATPCA). Findings revealed that vegans, vegetarians, flexitarians, and omnivores all consume vegan products to some degree, with approximately 38% consuming only vegan products. Vegans and vegetarians strongly endorsed ethical and health reasons for purchasing vegan products, while omnivores and flexitarians cited positive past experiences. All groups disagreed on the financial aspect. The primary factors influencing the purchase of vegan products were taste, based on previous positive experiences, followed by product composition, price, and ecological considerations.

Key words: *vegans, vegetarians, consumer behaviour, rationality and irrationality in purchasing behaviour, consumer perception*

INTRODUCTION

New consumption habits stand out against the idea of a rational consumer and consumer behavior aimed at maximizing utility according to budget constraints [6, 9, 11]. Consumers are the most significant barrier to innovation in the food sector [12]. It has been increasingly acknowledged that food choice is crucial for health and global sustainability [16]. At the same time, ensuring food security - defined as reliable access to an adequate quantity of affordable, nutritious food - is critical not only for maintaining individual health, but also for supporting societal stability [30]. There are various health issues, such as obesity, diabetes, heart disease, cancer, osteoporosis, and dental conditions, that require a specialized diet. Changes in our lifestyle are reflected in a trend towards healthier eating [38], based on natural foods with a reduced calorie content [37]. Vegetarianism is considered an alternative form of nutrition oriented on a plant-based diet. Hargreaves et al. [17] defines the vegetarian diet as “a dietary pattern that excludes meat, meat-derived foods, and, to different extents, other animal products”. Often, the diet is also the living philosophy focused on health care, animal respect and sustainable consumption [39]. Recently, this way of eating has appeared more and more often worldwide, as growing awareness of ethical concerns influences people's dietary choices [52]. Supporters of vegetarianism often point uncritically only to the benefits, and opponents, on the other hand, only to the risks. However, the truth is, as is usually the case, somewhere in the middle. According to Wang et al. [57], vegetarianism has both benefits and risks. Rejection of meat has appeared in various forms throughout human history. Rational reasons may include concerns relating to health, environmental sustainability, animal welfare, and cultural or religious beliefs.Therefore, the consumption of animal meat is being more closely examined because of its impact on ethics, health, and the environment [45].

On the other hand, irrational reasons may include personal preferences or aversions that have little to do with health or ethical concerns, such as not liking the taste or texture of meat or being put off by the sight or smell of animal products. Overall, research suggests that people may be motivated by rational and irrational reasons when choosing a vegetarian or vegan lifestyle. For example, a study by ABCNews [1] found that concerns about animal welfare among Australian adults adopting a vegetarian or vegan lifestyle were the most cited reasons, followed by health and environmental sustainability. These reasons reflect rational incentives for the adoption of a plant-based diet. Other studies have found that personal preferences, taste aversions, and emotional reactions to meat and animal products can also have a role to play in the decision to go vegetarian or vegan. For instance, Hargreaves et al. [18] found that some individuals reported experiencing aversion or disgust towards meat or animal products, which motivated them to adopt a vegetarian or vegan diet. Similarly, a study by Kwasny et al. [26] found that some individuals reported that negative emotions towards meat, such as guilt or disgust, affected their decision to a plant-based diet. However, the fact remains that according to the concept of rational behavior, people consider the future in their current decision-making [32].

Up to the above mentioned and even the term vegetarianism is not "new" (firstly it was used in 1847 by the Vegetarian Society in England, promoting this lifestyle's beneficial effects), an increasing aspiration for a healthy and modern lifestyle (among the centuries) has helped significantly improve recent vegetarian and vegan statistics – global survey carried out in 2021 discovered that 81% consumers tried plant milk, 48% tried other alternatives to dairy products, 44% tried vegan meat alternatives and 25% tried a vegan egg substitute [41]. Despite the growing trend towards vegetarian and vegan lifestyles, these choices still represent a minority of the world's population. However, the growing interest and awareness of plant-based diets indicate a shift in eating habits, consumer preferences, and rational and irrational consumer behavior.

As indicated above, some vegans opt to make the conversion because of diet changes and medical needs, and others because they do not want to add to the cruelty to livestock and the use of animal products. Many people choose a vegan lifestyle due to the environmental consequences of cattle farming, not to overlook its impact on overall climate change [51]. While the preference for vegetarian diets has changed, the popularity of vegetarianism is high nowadays [3, 56]. Consumer use of vegan foods and lifestyles has become increasingly popular, and veganism has increased worldwide. The increased prevalence of those following a vegetarian diet served as an impetus to investigate differences in the behaviors and properties of those who chose a vegetarian diet compared to those who did not. The studies of Segovia-Siapco and Sabaté [49] and Sanchez-Sabate, Badilla-Briones and Sabaté [48] state that in such countries as the U.S. or the U.K., vegetarians make up less than 5% of their population. According to a Gallup poll [14], 5% of U.S. adults identify as vegetarians, and the vegan population in the U.S. accounts for 3% of adults. Currently, the account of those who eat vegetarian or vegan 100% of the time is at 3% of the populace and is rising. Based on Google Trends, interest in veganism reached an all-time high in 2020. This reflects the significant increase in the popularity of plant-based diets and vegan lifestyles [19].

There have even been several studies on consumers' perceptions, consumption, and purchasing behavior concerning vegan products [46, 31, 24, 22, 35] that have investigated various factors such as attitudes towards veganism, health and nutrition beliefs, ethical concerns, taste preferences, and the availability of vegan products in the market; a gap is now opening up, creating a new phenomenon where there is a need to find out how consumers choose to change their lifestyle and approach to life and, most importantly, why. Food consumption is a social token that forms social expressions and ways of life. People are facing a comprehensive variety of options in all spheres of life. Consequently, self-identification is instead governed by people's lifestyles or actual procedures as classical differences, even though the socio-demographic characteristics of consumers could still influence certain areas. The habitual routines that people inducted into the practice are open to change reflexively, which changes their identity. From this viewpoint, food consumption can be seen as a genuine choice in people's lifestyle decisions in the late modern period [53]. Veganism is "a specific style of eating that involves eating only plant-based foods and absenteeism from all livestock products" [53].

The question remains how consumers make decisions and what has the most significant influence on them. At the same time, it is interesting to see how the consumer places himself in the selected group of flexitarians, omnivores, vegans, and vegetarians.

Studies and research were made on the motivation for vegetarianism. A study by Jabs, Devine, and Sobal [23] proposed two rationales for vegetarian dietary choices: health and ethics. Studies, e.g., by Hoffman et al. [20], Radnitz, Beezhold, and DiMatteo [40] and Ruby et al. [47], have shown that the main driving forces for vegetarians are both health and ethics. An overview document by Rosenfeld [44] and by Fox and Ward [13] proposes that since ethical concerns are split into environmental and animal concerns, the more agent vegetarian concerns are environment, health, and animal concerns [25]. Also commonly discussed is veganism, a lifestyle choice and movement that is becoming increasingly popular. The number of people deciding to go vegan is growing, and the decision itself is influenced by several factors [21]: ethical, health, economic, hedonic, empathy towards animals, animal rights, and individual responsibility. In particular, three motifs - empathy for animals, responsibility, and animal rights - are key factors determining consumers' self-identification as vegan-centric subjects. The critical point is that veganism assumes a variety of attitudes and different motifs regarding animal rights, environmental and health aspects, moral/ethical concerns, sustainable lifestyles, spiritual/religious aspects, nutrition, and individual health [15, 50]. Although vegan consumerism can be considered a consumer interest, as per Lawo et al. [27], it is more than just that. It is part of a drive to transform society and consumers into environmentalists or anti-consumerists.

As for omnivores, there was a notable difference between them and vegetarians. When motivated to make food choices, vegetarians scored higher on the factors 'health,' 'ethical concern,' and 'convenience and price.' In contrast, omnivores scored higher on the factors 'sensory appeal' and 'weight control.' For dietary identity, vegetarians scored higher on the factors "complex motivation" and "strictness," while omnivores, on the other hand, scored higher on the factors "out-group respect" and "public respect." Though the reasons differ, the authors validated that vegetarians and omnivores prefer plant-based foods [25].

As Dagevos [10] explained, flexitarianism enters the picture when switching to a diet that reduces overall meat consumption and replaces meat products with those from plants (protein) without the need to become a complete vegetarian and stop eating meat. It can be defined as consuming food where meat is eaten occasionally without altogether avoiding it. Contrary to the original explanation of flexitarians, which is based on vegetarianism - a flexitarian is a vegetarian who occasionally eats meat [43, 44].

However, many factors influence consumers to buy products according to their dietary style. It is essential to understand and recognize them.

For this purpose, the main objective of the present study is to identify the factors influencing the perception, consumption and purchasing process of vegan products among Slovak consumers of different dietary styles, thus pointing differences in purchasing motives across selected dietary types - vegans, vegetarians, flexitarians and omnivores, differences in consumption and purchasing frequency across selected dietary types as well as differences in the significance selected factors under consideration at purchase of vegan products.

MATERIALS AND METHODS

The research aimed to study factors determining the perception, consumption, and purchasing process of vegan products among Slovak consumers of different dietary styles (vegans, vegetarians, flexitarians, and omnivores). Based on the literature review and the existing research gap, the following research questions were formulated:

RQ1: There exist differences in purchasing motives across selected dietary types.

RQ2: There exist differences in consumption and purchasing frequency across selected dietary types.

RQ3: There exist differences in the importance of selected factors when purchasing vegan products.

Research design and data collection

The research was based on prime data from an online questionnaire. In total, 2,011 respondents participated in the survey. The main inclusive criteria were the purchase of vegan products and the minimum respondent's age was 18. Therefore, the final research sample comprised 915 respondents. The mean age of respondents is 25.8 years, and 82.2 % are females. Most respondents have either secondary education (44.8%) or university education (47%). More than 46% have student status or are economically active. Most live in cities with no more than 10,000 inhabitants (40%) or over 50,000 inhabitants (38.4%). The research focused on purchasing behavior, including purchasing motives (ethical, health, financial, social, or others), followed by questions indicating the purchase and consumption of selected vegan products frequent on the Slovak market. Moreover, a survey was oriented on identifying essential factors during the purchase of vegan products, such as budget expenditure, favourite brands, and place of purchase.

Measurements and Analysis:

The Likert scale was applied to identify the motives for purchasing vegan products (5-point scale where 1 = disagree and 5 = agree). Consumption and purchasing patterns were indicated using a 5-point scale (1-I do not consume, 2- occasionally, 3 - a few times per month, 4- every week, and 5 – every day). Furthermore, a 5-point scale was used to examine the importance of selected criteria when purchasing vegan products (1 – very unimportant factor, 5 – significant factor). Statistical analysis was done in IBM SPSS Statistics Grad Pack 28.0 and XLStat version 4.1. Non-parametric tests were applied, such as the Kruskal-Wallis test with the Dunn-Bonferroni post hoc method, the Friedman test with Multiple pairwise comparisons using Nemenyi's procedure and Categorical Principal Components Analysis (CATPCA).

RESULTS AND DISCUSSIONS

The questionnaire survey revealed that vegans, vegetarians, flexitarians, and omnivores consume vegan products to a certain extent. Approximately 38% stated that they consume vegan products only. In comparison, the cases when other family members consume vegan products were indicated by 51% (my spouse/ partner - 24%, my children - 12%, or my parents – 14%). The results showed that, on average, respondents indicated that the main reasons for purchasing vegan products are ethical and health. In contrast, social status and financial aspects do not play essential roles.

Nevertheless, we study results based on different dietary types (omnivores,

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flexitarians, vegetarians, and vegans). In that case, several differences are shown, and applying the Kruskal-Wallis test with the Dunn-Bonferroni post hoc method revealed statistically significant differences across the aforementioned dietary types (Table 1). On average, both vegan and vegetarian groups strongly agreed with the ethical and health aspects of purchasing vegan products. In the case of omnivores and flexitarians, the highest scores indicating favorable agreement were obtained for curiosity and positive previous experiences with vegan products. All four dietary groups indicated disagreement regarding the financial aspect.

Table 1. Motives for purchasing vegan products

Aspects/ Dietary type	**Omnivores (n= 216)**	**Flexitarian (n= 222)**	**Vegetarian (n=274)**	**Vegan (n=203)**	**Overall (n=915)**
Ethical aspect*	3.01^{a}	3.49^{b}	4.46^{c}	4.51^{c}	3.90
Health aspect*	3.25^{a}	3.64^{b}	3.95^{c}	4.10^{c}	3.76
Curiosity*	3.88^{a}	3.90^{a}	3.81^{ab}	3.55^{b}	3.77
Social status*	2.04^{a}	2.15^{ab}	2.44^{b}	2.38^{ab}	2.26
Financial aspect	2.31	2.23	2.29	2.16	2.24
Positive previous experience*	3.68^{ab}	3.72^{a}	3.52^{ab}	3.35^{b}	3.56

** – Significant differences between aspects and dietary types by the Kruskal-Wallis test ($p < 0.05$). Means in the identical row with various subscripts are statistically various by the Dunn-Bonferroni post hoc method ($p \leq 0.05$).*
Source: Results of authors' research.

Furthermore, the research was oriented on consumption patterns related to vegan products. Most respondents consume plant-based milk, plant-based spreads, and tofu afew times a month, followed by plant-based yogurt and hummus. The rest of the vegan food categories were indicated by occasional consumption (Table 2).

Table 2. Consumption frequency

Vegan products/ Dietary type	**Omnivores (n= 216)**	**Flexitarian (n= 222)**	**Vegetarian (n=274)**	**Vegan (n=203)**	**Overall (n=915)**
Plant-based milk*	2.28^{a}	2.77^{b}	3.60^{c}	3.99^{d}	3.02
Plant-based spreads*	2.45^{a}	2.84^{b}	3.53^{c}	3.59^{c}	3.13
Tofu*	2.26^{a}	2.71^{b}	3.54^{c}	3.82^{d}	3.2
Seitan*	1.28^{a}	1.55^{b}	2.06^{c}	2.35^{d}	1.82
Vegan cheese*	1.46^{a}	1.73^{b}	2.00^{c}	2.58^{d}	1.98
Plant-based yoghurt*	2.01^{a}	2.45^{b}	2.83^{c}	2.14^{d}	2.64
Vegan semi-products*	1.52^{a}	1.81^{b}	2.40^{c}	2.45^{c}	2.06
Plant-based ice cream*	1.31^{a}	1.61^{b}	1.80^{c}	1.02^{d}	1.71
Vegan chocolate*	1.55^{a}	1.89^{b}	2.15^{c}	2.66^{d}	2.1
Vegan sausages*	1.45^{a}	1.71^{b}	2.38^{c}	2.35^{c}	1.99
Vegan protein bars*	1.91^{a}	1.95^{a}	2.12^{ab}	2.29^{b}	2.08
Plant-based meat products*	1.46^{a}	1.74^{b}	2.52^{c}	2.47^{c}	2.07
Hummus*	2.03^{a}	2.58^{b}	2.93^{c}	2.05^{c}	2.67

** – Significant differences between vegan products and dietary types by the Kruskal-Wallis test ($p < 0.05$). Means in the identical row with various subscripts are statistically various by the Dunn-Bonferroni post hoc method ($p \leq 0.05$).*
Source: Results of authors' research.

Kruskal-Wallis test with the Dunn-Bonferroni post hoc method revealed statistically significant differences across dietary groups. Vegans evaluated the highest consumption rate> vegetarians > flexitarians > omnivores. Vegans and vegetarians consume plant-based milk, spreads, and tofu weekly, while omnivores consume it only occasionally. Vegans have the highest consumption scores in all vegan food categories, with one exception. In the case of plant-based ice cream, the majority indicated zero consumption.

In addition, purchasing behavior was examined. Generally, vegan products are mostly purchased at retail stores (every week), followed by shops and specialty shops (a few times per month). Respondents indicated that their purchase frequency was similar to its consumption frequency. Most purchase plant-based milk, spreads, tofu, hummus, and plant-based yogurts (a few times a month). Statistically significant differences again exist within dietary groups (Table 3). Vegans and vegetarians purchase these products more frequently (every week or a few times per month), while flexitarians and omnivores only occasionally or not at all. Most respondents (49.73%) stated they spent an average of 5 to 20 euros on vegan products per week. The highest weekly expenses were indicated by vegans (30-20 euros – 26%, 20-11 euros – 33%). Omnivores indicated the lowest expenditure (up to 5 euros). Alpro, Lunter, and private-label K – K-veggie were evaluated as the most favorite vegan brands on the Slovak market.

Table 3. Purchasing frequency of vegan products

Vegan products/ Dietary type	Omnivores (n= 216)	Flexitarian (n= 222)	Vegetarian (n=274)	Vegan (n=203)	Overall (n=915)
Plant-based milk*	2.10^{a}	2.55^{b}	3.01^{c}	3.36^{d}	2.79
Plant-based spreads*	2.27^{a}	2.64^{b}	3.15^{c}	3.21^{c}	2.83
Tofu*	2.15^{a}	2.63^{b}	3.29^{c}	3.45^{c}	2.91
Seitan*	1.26^{a}	1.49^{b}	1.84^{c}	2.09^{d}	1.69
Vegan cheese*	1.44^{a}	1.64^{a}	1.86^{b}	2.32^{c}	1.84
Plant-based yoghurt*	1.91^{a}	2.25^{b}	2.59^{c}	2.90^{c}	2.44
Vegan semi-products*	1.45^{a}	1.67^{b}	2.27^{c}	2.26^{c}	1.93
Plant-based ice cream*	1.31^{a}	1.56^{b}	1.75^{c}	1.91^{d}	1.65
Vegan chocolate*	1.47^{a}	1.76^{b}	1.98^{c}	2.45^{d}	1.95
Vegan protein bars*	1.80^{a}	1.91^{a}	1.98^{ab}	2.17^{b}	1.98
Plant-based meat products*	1.38^{a}	1.75^{b}	2.30^{c}	2.27^{c}	1.94
Hummus*	1.95^{a}	2.35^{b}	2.60^{bc}	2.73^{c}	2.42
Specialty shop*	2.29^{a}	2.49^{b}	2.64^{bc}	2.79^{c}	2.57
Shops*	2.50^{a}	2.57^{ab}	2.75^{b}	2.74^{b}	2.64
E-shop*	2.09^{a}	2.20^{ab}	2.24^{b}	2.20^{b}	2.18
Retail stores*	3.02^{a}	3.38^{b}	3.68^{c}	3.69^{c}	3.68

* – *Significant differences between vegan products and dietary types by the Kruskal-Wallis test ($p < 0.05$). Means in the identical row with various subscripts are statistically various by the Dunn-Bonferroni post hoc method ($p \leq 0.05$)*

Source: Results of authors' research.

Moreover, the paper studies factors that are considered when purchasing vegan products. Respondents used a 5-point scale where 1 represented a very unimportant factor, and 5 represented a significant factor. Friedman test confirmed statistically significant differences in importance evaluation (p-value= 0.0001). Moreover, the Nemenyi test showed specifically where these differences occurred (Table 4). Based on the results, the most critical factors in purchasing vegan products were taste from previous experience, followed by product composition, price, and ecological aspects. Packaging, brand, and producers were indicated as unimportant.

Table 4. Factors considered during the purchase of vegan products

Sample	Mean of ranks	Groups							
Packaging	3.57	**A**							
Brand	4.34		**B**						
Producer	4.45		**B**						
Country of origin	4.99			**C**					
References	5.3			**C**	**D**				
Discount	5.55				**D**	**E**			
Ecological aspect	5.85					**E**	**F**		
Price	6.09						**F**		
Composition	6.85							**G**	
Taste - previous experience	8.01								**H**

Rotated Component Loadings

	Dimension 1	Dimension 2	Dimension 3
Producer	**.835**	-.013	.150
Origin	**.770**	.030	.100
Brand	**.733**	.003	.220
Ecological aspect	**.688**	.240	.109
Product Composition	**.632**	.440	-.113
Price	.070	**.845**	.064
Discount	-.049	**.745**	.236
Taste – previous experience	.246	**.716**	-.045
Packaging	.249	-.081	**.813**
References	.085	.321	**.662**

Variable Principal Normalization.

a. Rotation Method: Varimax with Kaiser Normalization. Rotation failed to converge in 5 iterations. (Convergence =.000).

Source: Results of authors' research.

Furthermore, CATPCA was applied to identify latent components (factors). Results showed three latent components. The first component involves the following factors: producer, origin, brand, ecological aspect, and product composition. All factors are related to overall product quality. The second latent factor comprises price, discount, and taste from previous experience. The last component includes two factors: packaging and references. In addition, respondents stated that references and free sample tasting would attract their attention toward the purchase of vegan products.

As mentioned in the introduction of this article, many studies have been conducted on consumer perception, consumption, and purchasing behavior toward vegan products. These studies have examined various factors such as attitudes towards veganism, health and nutrition beliefs, ethical concerns, taste preferences, and vegan product availability on the open market. Despite the above, there is still a gap in this area, and therefore, this research aimed to investigate the factors determining the perception, consumption, and purchase process of vegan products among Slovak consumers of different dietary styles (vegans, vegetarians, flexitarians, and omnivores). Key international authors in this field include Ruby et al. [46], Kilian and Hamm [24], Ruby and Heine [47], Annunziata and Vecchio [4], and Alcorta et al. [2] for example, who have produced the following findings. Consumers have a growing interest and awareness of veganism and plant-based diets. Many consumers are motivated to choose vegan products because of health, animal welfare, and environmental sustainability concerns. Consumers often perceive vegan products as healthier options compared to animal products. This is because vegan products are often associated with lower fat, calorie, and cholesterol content. Taste is an essential factor in consumer choice, and many consumers associate vegan products with less appealing tastes. However, studies have found that taste perception can be influenced by factors such as preparation method, flavoring, and presentation. The availability and accessibility of vegan products can significantly influence consumer purchasing behavior. Consumers are more inclined to purchase vegan products if they are readily available in supermarkets, restaurants, and other food outlets. Price is an essential factor in consumer purchasing behavior, and many vegan products are perceived to be more expensive than animal products. However, studies have shown that people are willing to pay a higher price for vegan products if they perceive them to be of higher quality or in line with their values. Social norms and influences may also influence consumer behavior towards vegan products. Studies have found that social norms and peer pressure may discourage some consumers from choosing vegan products. In contrast, others may be more likely to try vegan products if they perceive them as a popular or fashionable choice.Other scientific findings on consumer behavior and perceptions of vegan products show that consumers who identify as flexitarian (those who eat a predominantly plant-based diet but occasionally consume animal products) have greater likelihood to purchase vegan products if they perceive them to be healthier, tastier and more convenient than their animal counterparts [7]; while consumers who identify as eco-conscious have greater likelihood to buy plant-based alternatives to meat because they perceive them to be more sustainable than traditional meat products [55]. Another study found that consumers who purchase plant-based meat alternatives tend to value health, ethical considerations, and environmental concerns as their primary motivations rather than taste or price [8]. Ruby and Heine [47] found that consumers who perceive vegan products as expressing their identity or values (e.g., environmentalism or animal rights) are likelier to purchase and consume them.

As mentioned above, rational and irrational factors influence consumer perceptions and behavior towards vegan products. Rational factors include the nutritional advantages of a plant-based diet and the environmental impact of animal production. Conversely, irrational factors may include emotions, social identity, and cultural norms. Evidence of this can be found, for example, in a study published in the Journal of Consumer Research, in which researchers discovered that consumers who identified themselves as environmentally conscious had a greater likelihood to purchase plant-based products. They also revealed that these consumers perceived vegan products as healthier and more ethical than non-vegan alternatives [47]. Another study found that emotions significantly influenced consumers' purchase of vegan products. This study found that consumers experienced feelings of guilt and a moral obligation to reduce animal suffering, which motivated them to choose plant-based alternatives [28]. In addition, Malik and Jindal [29] aimed to investigate the effect of awareness of health, animal well-being, concern for the environment, and personal norms on customer attitudes towards the use of vegan products and its implications for intention for the purchase. Results of their research found that subjective worries do not influence attitudes and that moral concerns are more likely to have the following effect. The approach to vegan consumption positively influences the purchasing intention. Understanding these factors can help businesses and marketers develop effective strategies to promote plant-based alternatives.

Results of the presented research show that in the case of Slovak consumers, the conclusions are almost the same as in the above research - different groups of consumers have different attitudes and behaviors towards vegan products. For example, vegans have a relatively positive attitude towards vegan products, while omnivores have a rather negative attitude. The results showed that Slovak respondents indicated ethical concerns and health as the main reasons for buying vegan products. On the contrary, social status and financial aspects do not play a significant role. On average, both vegans and vegetarians strongly agreed with the ethical and health aspects of buying vegan products. For omnivores and flexitarians, curiosity and positive previous experience with vegan products received the highest scores, indicating favorable agreement. All four dietary groups expressed disagreement with the financial aspect. Most respondents consumed plant-based milk, plant-based spreads, and tofu several times a month, followed by plant-based yogurts and hummus.

Vegans and vegetarians consume plant milk, spreads, and tofu weekly, while omnivores consume it only occasionally. Vegans have the highest consumption scores in all vegan food categories except plant-based ice cream. Generally, vegan products are mainly purchased in retail outlets, convenience stores, and specialty stores. The most relevant factors when buying vegan products are the taste from previous experience, the product's composition, the price, and the organic aspect. Packaging, brand, and manufacturers were identified as unimportant.

CONCLUSIONS

Recently, there has been a growing interest in veganism as a lifestyle, with more people adopting a plant-based diet for ethical, health, and environmental reasons. This has increased the availability and variety of vegan products, from food to personal care. However, the acceptance and consumption of vegan products vary among different consumer groups, including flexitarians, omnivores, vegans, and vegetarians. Consumer perceptions are crucial in determining the purchase behavior and consumption of vegan products. For example, omnivores may perceive vegan products negatively because they are not as tasty or satisfying as animal products [5].

On the other hand, flexitarians may have a more favorable perception of vegan products because they are already familiar with plant-based foods and may seek to reduce meat consumption [54]. Vegetarians and vegans are more likely to positively perceive vegan products because they are already committed to a plant-based lifestyle [46]. In addition, the degree of commitment to a plant-based lifestyle also influences consumption and purchasing behavior. Vegans are most likely to consume and purchase vegan products, while omnivores are least likely. Flexitarians and vegetarians may consume and purchase vegan products to varying degrees depending on their personal beliefs and lifestyle choices [10, 36].

Regarding purchasing behavior, price, and availability are two significant factors influencing consumer decisions [58, 33, 42]. Vegan products can be more expensive than their non-vegan counterparts due to the cost of ingredients and manufacturing processes. This may deter some consumers from purchasing vegan products, especially those on a budget. Availability is also an issue, as vegan products may only be commonly available in certain regions or stores [34]. In conclusion, consumer perception, consumption, and purchasing behavior towards vegan products vary between different groups of consumers, including flexitarians, omnivores, vegans, and vegetarians. Consumer perception is critical in determining the purchase behavior and consumption of vegan products. Price and availability are two essential factors that can influence consumer choice.

This study also offers an interesting starting point for future research on factors influencing the perception, consumption, and purchase process and motives of vegans, vegetarians, flexitarians, and omnivores; in the case of Slovak consumers, further research is needed to investigate the factors influencing consumer behavior concerning vegan products and to develop strategies to increase the acceptance and consumption of vegan products among all consumer groups.

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DIGITAL TRANSFORMATION IN ROMANIA'S AGRICULTURE IN THE PERIOD 2023-2027

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Abstract

The influence of new technologies and digitalization in general on the agriculture sector is a topic of great discussion these days. Digitalization of agriculture and so-called precision farming appear to be the intended answers to a number of problems, like the need for higher output, the desire to become greener, or the declining population. The paper aims to analyze the influence of new technologies and digitization on the agricultural sector, focusing on the opportunities and challenges of precision agriculture. The study will examine how the digital transition can address the challenges of sustainable agricultural production, ecological impact, and human resource management, given the National Strategic Plans implemented by the EU through the post-2020 Common Agricultural Policy (CAP). The main results indicate that the digitization of agriculture has led to a significant increase in productivity (up to 20%), a reduction in the use of environmentally harmful resources (fertilizers and pesticides by 15%), but high initial costs and a lack of adequate infrastructure challenges small farmers over time that financial support and post-2020 CAP mechanisms are essential to accelerate the transition to precision agriculture.

Key words: *digitalization, new technologies, Common Agriculture Policy (CAP), National Strategic Plan*

INTRODUCTION

Since we are living in a digital transition era, the contemporary era is being labelled as one of great transformation. The EU economy and labor markets are being transformed by digitization and accelerated technological progress; an increasing number of EU firms are classified as highly digitalized. We are living in a time of ever-more-capable systems, ever-more-integrated technology, and ever-more-quantified society, which together comprise the digital life world [5]. In agriculture, where technical advancement is matched by machine intelligence that is beginning to surpass human intellect, technological innovation is evolving into a meta-trend that pervades every other element of human life [9]. This led to the debate over the Common Agricultural Policy's overhaul throughout Europe. The talks, which began well in advance of the COVID-19 pandemic, aimed to build a more resilient CAP with the overarching goal of modernizing the industry through knowledge-sharing and stimulation, innovation and digitization in agriculture and rural areas, and adoption of these measures [1].

The European Union began addressing the issue of agricultural resilience in the wake of the COVID-19 epidemic. The issue of the ecological and digital dimensions of resilience was highlighted in the first annual Strategic Foresight Report of 2020, which also highlighted the alarming digital divide between urban and rural regions. This was covered in the Foresight Report for the next year, which discussed the need to use new technology to maintain a robust and sustainable food system.

When the European Commission revealed what should be the main lessons learned from agriculture in terms of digitization in 2022, we finally got a peek at what smarter and greener agriculture will entail.

[12] affirmed that digitization in agriculture needs to "improve the construction of agricultural digitization infrastructure, to pay

attention to the differences in the development degree and demand between regions and to improve the quality of the rural labor force and the input of scientific and technological talents in the agricultural industry.

The purpose of the research is to analyze the influence of new technologies and digitization on the agricultural sector, focusing on the opportunities and challenges of precision agriculture.

MATERIALS AND METHODS

Official EU documents, regulations, and strategies have been analyzed, especially the post-2020 Common Agricultural Policy (CAP) and the member states' National Strategic Plans (NSPs), with an emphasis on Romania. Also, it was evaluated the way in which these legislative and financial frameworks support the digitization of agriculture, with an emphasis on the promotion of agriculture and on adaptation to the national particularities of each member state. Bibliometrics with VOSviewer for digitized agriculture involves using methods and materials to support rigorous and applied research.

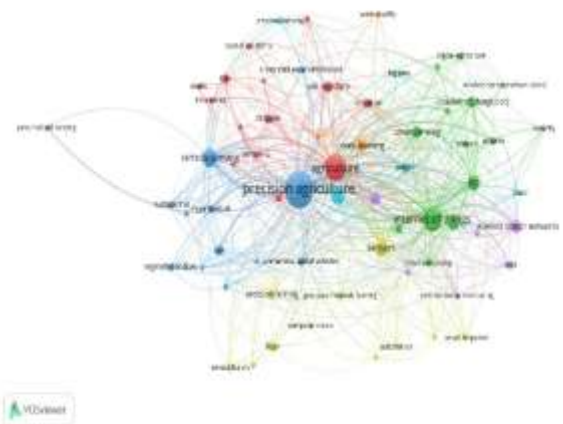

Fig. 1. The directions of digitization in agriculture
Source: Authors' own determination.

Here are some essentials related to the material such as:

-Specialized literature, Books, scientific articles and case studies that address digitized agriculture, emerging technologies and their impact on agriculture.

-Reports and studies of international organizations (FAO, OECD) on trends in the digitization of agriculture.

Coupling using the keywords: precision agriculture and digitization, we found how the directions of digitization in agriculture could be synthesized in Figure 1.

RESULTS AND DISCUSSIONS

This study's foundation is a thorough literature survey and an examination of recent publications and research on emerging technologies and the Common Agricultural Policy.

To do this, we have examined several official European Union papers as well as research and reports written for both public and private organizations.

In light of the epidemic and the conflict in Ukraine, the article aims to first provide the theoretical foundation for understanding how new technologies affect society as a whole and then discuss how the Common Agricultural Policy will evolve beyond 2020. Additionally, consideration was given to the current real-world instances that may support the audience in this endeavour.

One of the most significant developments in the industry is the growing significance of the digitization question. It is also viewed as a potential solution to the central agricultural challenge of "how to produce the most food with the least cost in time, labour, and money." The digitisation of agriculture, or the incorporation of cutting-edge digital technology into the farm production system is one potential solution [4].

Although we still don't completely understand the results, we can already make certain inferences. The effects of digitalization on agricultural knowledge will be one of the effects. The Agricultural Knowledge and Innovation System (AKIS) as a whole will thus be disturbed, although there may be more opportunities than anticipated.

The most important thing to keep in mind while analyzing the effects of new technology is who the major players are and how do they fit into the process.

Thus, these players have been identified and their roles have been summarized in a number of studies. These players all have important roles to play, albeit they are not all the same (Figure 2).

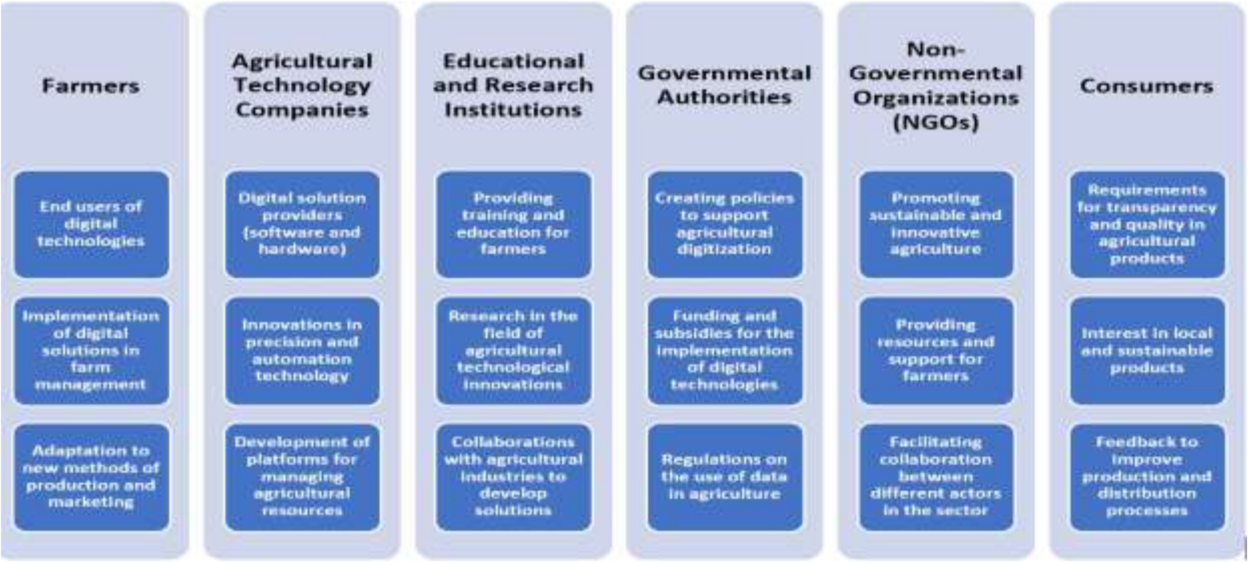

Fig. 2. Key actors in the process of digitalization of agriculture
Source: Authors' own determination.

By 2019, a common declaration of cooperation on digital agriculture, signed by several EU Member States, including Romania, made it clear that progress had been made in that area and that formalization was necessary. The declaration listed the essential actions that needed to be taken, including maximizing impact, building an innovation infrastructure, strengthening research support, and creating a European data space for smart agrifood applications. As can be seen below, this has had a clear and tangible effect on the financing of several European initiatives that looked into how the new technology were affecting agriculture. As a result, the Horizon Europe program has a significant digitalization component that funds several initiatives across the EU.

Arable crops, dairy farming, fruits, meat, and vegetables are the five sectors that comprise the Internet of Food & Farm 2020 (IOF 2020) project, which aims to investigate the possibilities of IoT technology for the European food and farming industry through thirty-three use cases. In addition to its useful daily uses, the project offered several pertinent suggestions for the then-upcoming CAP reform initiative, which was primarily intended to make it easier for farmers to access big data, data platforms, etc [8].

Demeter is a similarly funded initiative that aims to better promote sustainable farming in Europe through the large-scale implementation of interoperable, farmer-driven smart farming IoT-based systems. A further development made by the EU in this regard is the ongoing existence of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), which was established in 2012 with the goal of streamlining the use of funds allocated to research by preventing duplications and optimizing the flow of innovation at the EU level [3].

This platform for sharing knowledge is proving to be very helpful in spreading much-needed information about how to improve the CAP from a digital perspective. For example, it can be used to develop farmers' competencies in the process of digital transition by offering incentives for digital uptake (supporting enhanced connectivity, etc.), incentives for training (more training, more support, etc.), activities for developing skills (digital advisory services, etc.), ecosystem, cooperation, and partnerships. Stronger agricultural knowledge and innovation systems (AKIS), intended to facilitate the development of innovative initiatives, were one of the main outcomes of the new CAP.

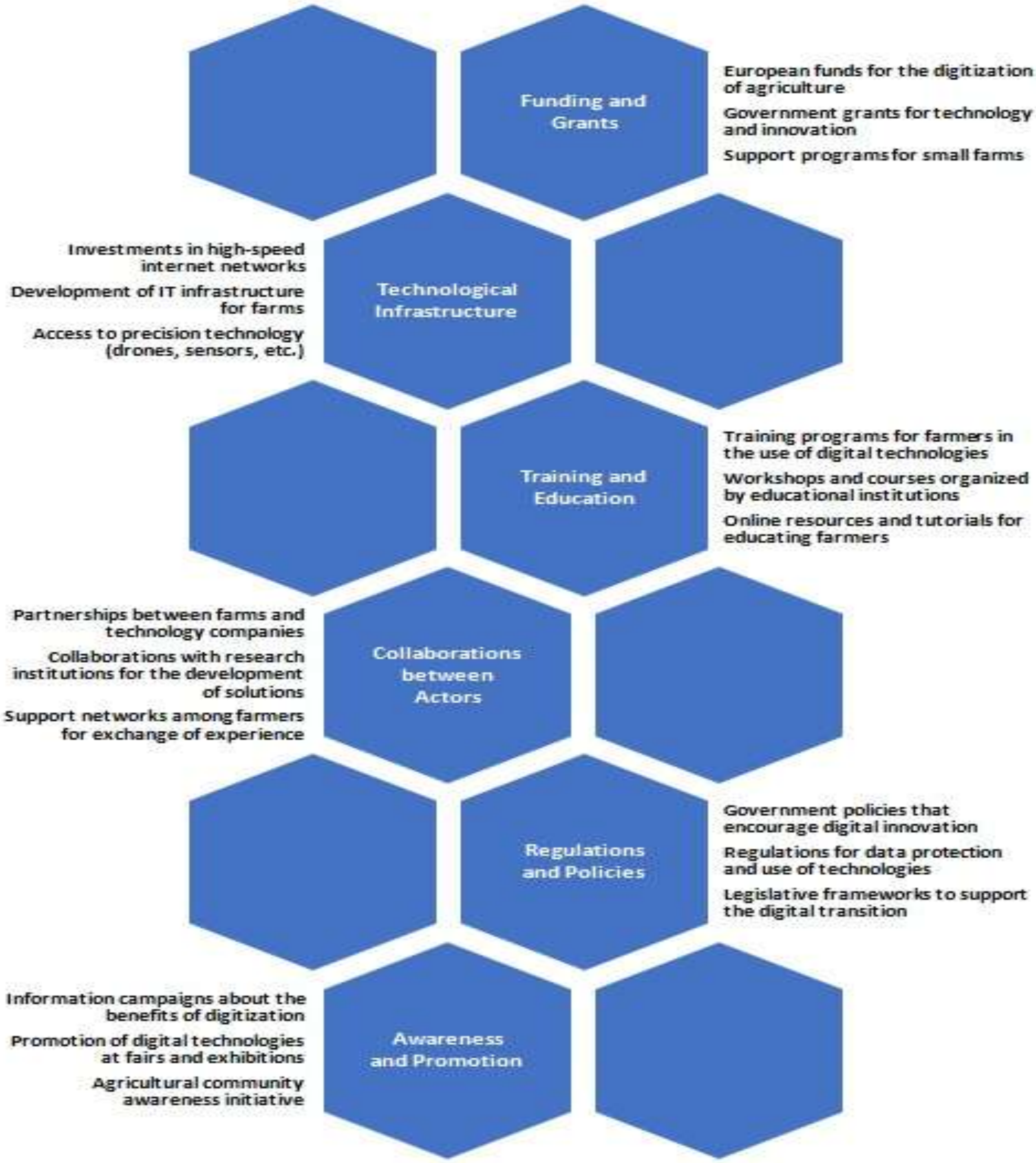

Fig. 3. Support digital transition in agriculture
Source: Authors' own determination.

A number of actions that should be made to assist the digital transformation in agriculture were suggested by the preliminary study [3].
The development of a new methodology and the use of a new instrument, the so-called CAP National Strategic Plan, are what are new to the CAP post-2020. A national CAP strategy plan that integrates money for market measures, rural development, and income assistance must be developed independently by each EU Member State. The ten CAP post-2020 objectives must be the focal point of each of these plans, and in order to guarantee that each goal is carried out on schedule and under the required circumstances, a number of policy measures must be developed for it.

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They should be aware of the country's resources, the laws that are in place there, the ambition of the national government, and the general goals of CAP. The possibility of using EU subsidies to support EU farmers' development of precision farming or precision agriculture is highlighted by the CAP reform after 2022. Therefore, it is anticipated that the National CAP Strategic Plans 2023–2027 would present a range of interventions intended to boost precision agriculture, such as investments in rural development (e.g., machinery), farm consulting services and training, or eco-scheme payments [11].

One notable development, for example, was the introduction of the eco-schemes of an agricultural practice—precision farming and its offshoots—that may be supported by CAP after 2020. The creation of publicly owned platforms for data sharing has advanced, as evidenced by the FaST tool, which aims to build a dynamic data infrastructure that will enable farmers to access a range of digital functionalities (weather forecasts, fertilization advice, integration of static data about the farms, etc.) [6].

The discussion in Europe over the application of new technology in agriculture is not new to Romania, and official governing plans have indicated some paths in this regard. For example, the government has approved a policy to encourage farm-level investments in cutting-edge precision farming technologies. The task of creating a suitable legal framework for the use of agricultural drones, including for plant protection-related activities, is acknowledged. The low level of education and training in rural regions was one issue that Romania's SWOT analysis revealed, which might postpone the adoption of precision farming. The study was conducted in order to design the National Strategic Plan.

Alongside this, there was an increasing gap between large and small farms, and skilled workers were moving from rural to urban regions in pursuit of better prospects. The National Rural Development Network's activation and full utilization, additional educational funding, etc., might be a potential answer. Other potential options include building technology transfer centers, digital hubs, and enhanced communication [2].

The research findings were considered at the government level, and Romania's National Strategic Plan included a number of initiatives aimed at digitalizing farms. Encouraging the growth of digital ecosystems is essential, as is tying counseling and knowledge systems together, enhancing performance via knowledge and creativity, etc. The digitalization of agriculture, which is defined as the proportion of farms that gain from CAP funding for digital technologies, is one important point to note. Throughout the agricultural deliberations held in Romania as part of the Conference on the Future of Europe, similar points were made. Investing in new agricultural technology appears to be one of the primary answers to both the demographic challenge and the need to boost production. Among the proposed solutions that were provided to the general public were a presentation of such technologies, which included semi-autonomous and autonomous tractors, drones for precise treatment, satellite usage in field management, etc. [7].

Thus, among the priorities of Romanian citizens in the framework of the Conference on the Future of Europe was the use of new technology in agriculture.

It should be noted that certain voices of concern have expressed concerns that the new CAP would put further pressure on farmers and that it may be difficult to predict expenses at this time.

Fig. 4. Digitization Barometer 2020 – Agriculture and Food Industry
Source: Authors' own determination.

Some researchers have previously voiced this concern, highlighting the necessity to create a transition mechanism that would assist farmers during this process, even though the change may appear gradual and come with associated expenses.

Furthermore, market research indicates that farmers in Romania are aware of the realities of digitization [5].

Although some of them have not yet been thoroughly investigated in the CAP beyond 2020, precision farming is still not risk-free. One of them—the application of the data gathered—may not seem pertinent to agriculture at all, but it is crucial and has to do with trust. Many farmers have major trust-related concerns, which also include issues with transparency and distribution regarding which stakeholders would have access to and use the data collected from farmers. As a result, these concerns often lead to skepticism regarding the benefits of "smart" technologies [8].

Other authors have also identified a series of dynamic and complex dimensions of precision agriculture that are hindering its development [9]:

(1) data ownership and control (who owns the data produced and who benefits from them?);

(2) the production of technology and data development (the farmers have little input into and control over the development process – is typically directed by big companies);

(3) and data/cyber security (who protects the farmers from hackers and other malevolent actors).

The necessity to approach digitization via social science perspectives has become clear as it transforms agricultural production systems, value networks, and food systems. Because it's not only a technological examination, factors like power, ownership, privacy, and ethics in digitalizing agricultural production systems and value chains are also taken into account. Thus, concerns about the necessity of developing CAP policy responses to address power disparities and the digital gaps brought about by quick, unchecked technology progress. The impact of digital agriculture on animals is another concern. For example, in dairy farming, robotic milking systems are being developed, and technologies are being used to replace animal husbandry tasks [10].

A number of researchers are also examining the design of technology, specifically if the use of Big Data in agriculture does not perpetuate a sequence of production patterns that, for example, provide big agri-food firms with a disproportionate gain.

The expenses of big data and the Internet of Things in the agriculture industry are another topic that comes up after the literature study. The issue of ethics in the global agricultural competition also arises, not only in relation to other regions but also intra-European Union farming, since many small and medium-sized farms in Central and Eastern Europe cannot afford the costs of this precision farming.

This is because data-driven agriculture has high data acquisition costs, and the technical requirements for using the advanced technologies are mostly suited for large factory-like farms such as those in North America and Europe.

How to adapt this is still a functional component of the post-2020 CAP strategy.

The problem of how to teach people about digitalization in agriculture—the so-called "digi-grasp"—and how to implement and understand it in a given agricultural organization remains unsolved, not just in Europe but all across the world.

"Agricultural knowledge and innovation system should better support agricultural knowledge providers in digi-grasping and developing a digitalization strategy, by anticipating possible futures and reflecting on the consequences of these for value propositions, business models, and organisational identities of agricultural knowledge providers," according to research conducted in New Zeeland, for example [10].

CONCLUSIONS

Given the breadth of the subject and the variety of viewpoints to address, this article does not aim to definitively address whether the agricultural sector's digital shift is impacting the CAP after 2020. However, a number of draft concepts emerge, such as the notion that this transitional process is really a continuation of an earlier one that was initiated years ago rather than a completely new one. Additionally, the costs of this shift are frequently too expensive for small and medium-sized farms, which means that EU financial help is required; the post-2020 CAP amendments recognize this fact. The new CAP National Strategic Plans tool is intended to support this process, which is being customized to the unique national characteristics of the Member States. Thus, the digital transition's transversal goal is best suited for implementation. Participating actively in this European bargaining process is Romania as well. It appears that all pertinent parties understand the necessity of a prompt digital shift toward precision agriculture, as well as the advantages and disadvantages this presents for Romanian farmers. We are in the midst of an irreversible transition into an unwritten future. Now is when the seeds and forms of things to come are being formed, and it is up to us if we can build a future where everyone, no matter how big or small, can live in a respectful environment where customs and regional differences are valued, or if we lose this wave of change and end up only being consumers rather than digital producers and shapers.

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RESEARCH ON WORLDWIDE SORGHUM PRODUCTION AND TRADE FOR THE PERIOD 2017-2022

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Abstract

This research reflects a number of aspects regarding the production and trade of sorghum worldwide, in the period 2017-2022. In the paper, several indicators specific to the sorghum production and marketing sector were highlighted and analysed, such as: cultivated area, production, average production and average annual consumption of sorghum and sorghum products per capita; imports and exports. Sorghum ranks 5th in the top of the most cultivated cereals worldwide. Sorghum is cultivated on all continents but the areas occupied vary widely from one region to another. In 2022, Africa accounted for 51.3% of the world's sorghum production. The production of sorghum has a number of uses such as: feeding the population; animal feed and as raw material for industry. The statistical data used in this research were provided by the FAOSTAT website.

Key words*: sorghum, cultivated surface, average production per hectare, total production, imports and exports at the global level*

INTRODUCTION

Sorghum is an herbaceous species that is very similar to corn. It is a cereal that belongs to the Poaceae family and is native to Africa [12].

According to specialists, sorghum and corn have a common ancestor due to polyploidization but also repetitive DNA propagation [8].

Sorghum ranks 5th in the ranking of cereals cultivated worldwide [1]. This situation is due to several factors, the most representative of which are: increased resistance to drought; low production costs; short growing season; increasing interest of farmers worldwide in this crop etc. [2, 5, 6].

Currently, sorghum is cultivated in over 100 countries on all continents, but the largest cultivated areas are found in Africa and Asia [6, 10, 12]. However, there is a decrease in the cultivated areas, as well as the stagnation of the yield per hectare due to changes in the agricultural policy [3].

It should be noted that, due to climate change and its negative impact on representative crops, many farmers are switching to replacing corn with sorghum, which is much more resistant to drought [9].

Sorghum cultivation is of particular importance, as it has many uses, such as: raw material used in the food industry; animal feed; biomass for biofuels; it contributes to the maintenance of biodiversity etc. [7, 9, 13].

In Asia, the use of sorghum as a staple food crop has been found to be declining, as consumption shifts to rice and wheat [11].

Sorghum is a whole grain with numerous nutritional benefits. It is also rich in bioactive polyphenols and other beneficial compounds that have a positive impact on people's health [16].

For developed regions, sorghum was one of the most important sources of feed, but also an important raw material for alcohol and starch [17].

Scientists foresee the potential of sorghum as a staple food in the future, as humanity will be

subject to the negative impact of climate change, and it is more resistant to drought [2].
As regards the global production and consumption of sorghum, it has been observed that there have been no major changes, but there is nevertheless a change in them at continental and regional level [15].

Currently, the largest sorghum producers registered worldwide are: Nigeria; Sudan; United States of America, Mexico, Ethiopia, India, China, Brazil, Argentina and Australia [4, 6].

Sorghum is a competitive crop, especially when the cultivation technology is respected.

In this context, the research aimed to analyse a series of aspects related to the production and trade of sorghum worldwide in the period 2017-2022.

MATERIALS AND METHODS

The most representative indicators were presented and analysed in the paper, as it follows: the area cultivated with sorghum worldwide; global sorghum production; the average production per hectare of sorghum registered worldwide; imports and exports of sorghum worldwide.
The Faostat website was the most important provider of statistical data that contributed to the realization of this research.
Numerous specialized materials were also consulted.
In the paper, the results of the research were presented in a graphic form.

RESULTS AND DISCUSSIONS

Between 2017 and 2022, numerous changes in sorghum production and trade were observed worldwide. As for the area cultivated with sorghum, it was found that it varied from one year to another.
According to the statistical data obtained from Faostat, it can be seen that, in 2018, the largest area with sorghum in the world was cultivated, of 42,040,377 ha.
In 2019, the smallest sorghum area of 39,201,095 ha was cultivated globally.

The area cultivated with sorghum worldwide decreased slightly in 2022, by 0.90% compared to 2022 (Fig.1).

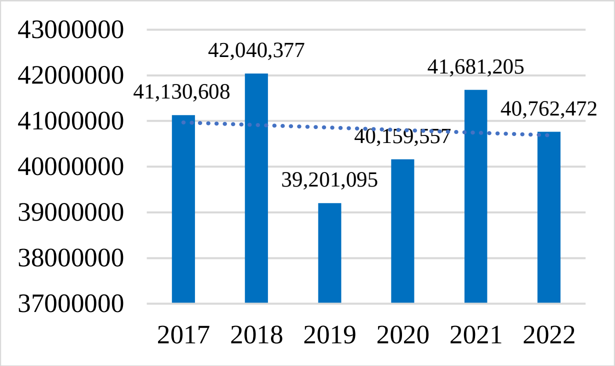

Fig. 1. Area cultivated with sorghum worldwide, in the period 2017-2022 (ha)
Source: Own design based on FAOSTAT database 2024 [4].

During the period under review, global sorghum production recorded different levels According to data on sorghum production at global level, it was found that the highest production was registered in 2021 (62.1 million tons).
The lowest sorghum production obtained worldwide was of 56.7 million tons in 2019 (Figure 2).

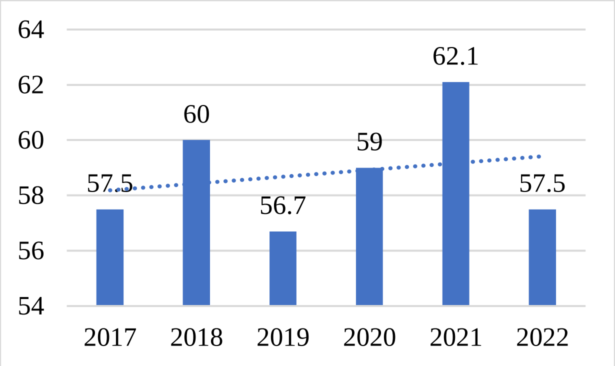

Fig. 2. Total global sorghum production for the period 2017-2022 (million tons)
Source: Graph made based on data processed after Faostat [4].

In 2019, it was found a close correlation between the area cultivated with sorghum worldwide and the total sorghum production achieved. In 2022, sorghum production remained constant, compared to 2017, but different from a region to another.
These differences in production are due to several factors, including: cultivated area;

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yield per hectare; soil and climate conditions; the cost of production; demand level etc.
In 2022, the regional distribution of global sorghum production is shown in Figure 3.
America with a production of 16,373,192.98 tons (28.4% of world sorghum production), was in 2nd place.
Asia, with a production of 8,268,164.04 tons (14.4% of the world production of sorghum), ranks 3rd.
Oceania, with a production of 2,652,953.79 tons (4.6% of world sorghum production), was in 4th place.
Europe with a production of 724,234.13 tons (1.3% of the world production of sorghum), ranks 5th in this hierarchy.

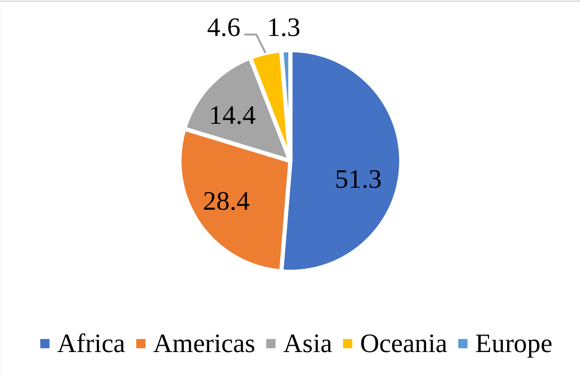

Fig. 3. Share of sorghum production at regional level in 2022 (%)
Source: Own design based on FAOSTAT database 2024 [4].

In 2022, according to statistical data published by Faostat, the top five major sorghum producers registered worldwide were:Nigeria (6,806,370 tons);Sudan (5,248,000 tons);United States of America (4,769,960 tons);Mexico (4,754,169.1 tons);Ethiopia (4,200,000 tons) [4].
The average sorghum production per hectare achieved worldwide has changed from one year to another in the analysed interval.
From the data presented in Figure 4, it can be seen that the highest average production per hectare of sorghum was 1,490.4 kg/ha (2021), and the lowest was in 2017 (1,398.8 kg/ka). In 2022, the average sorghum production per hectare worldwide increased by only 0.98%, compared to 2017.
According to specialists in the field, the yield recorded for sorghum cultivation worldwide during the analysed period was much lower, far below its potential. Under normal conditions, when using improved varieties, yields of 5.0-6.0 tons/hectare can be easily achieved [5].

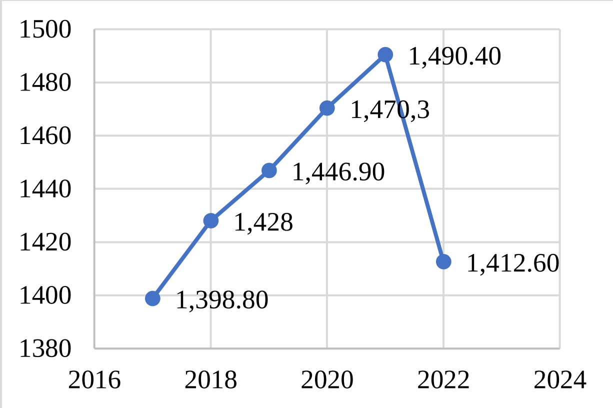

Fig. 4. Average sorghum production per hectare worldwide, in the period 2017-2022 (kg/ha)
Source: Processing and own design based on FAOSTAT database 2024 [4].

Between 2017 and 2022, the average annual consumption per capita of sorghum and sorghum products changed.
The consumption of 4.0 kg/capita in 2022 represented the maximum, and that of 3.49 kg/capita (2019) was the lowest (Figure 5).

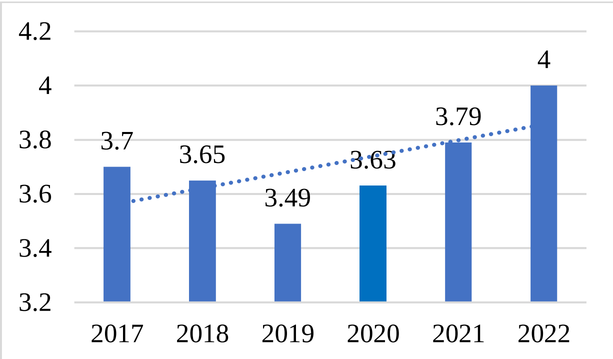

Fig. 5. Average annual consumption of sorghum and sorghum products per capita worldwide, 2017-2022 (kg/capita)
Source: FAOSTAT, 2024 [4].

In 2022, regarding the consumption of sorghum and sorghum products, it was found to have increased by 8.10%, compared to 2017.
This increase is due to several factors, including: the price level and the beneficial effects on food security.

At the global level, about 500 million people from more than 30 countries especially from Africa and China eat sorghum.

Quantitative exports of sorghum and sorghum products globally have changed from one year to the next (Figure 6). In 2021, the quantitative exports of sorghum and sorghum products of 10,955 thousand tons were the highest in the analyzed period. At the opposite pole, the lowest exports were in 2019 (3,919 thousand tons).

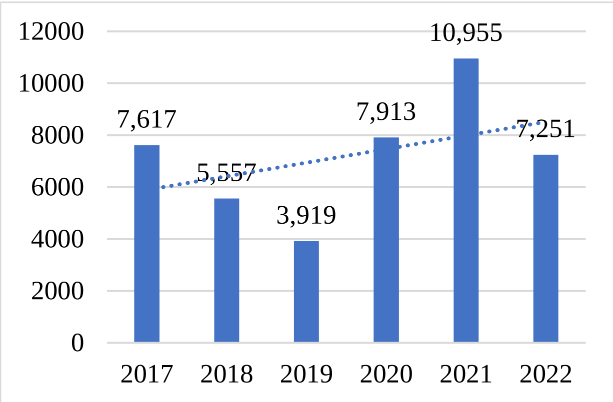

Fig. 6. Global exports of sorghum and sorghum products, 2017-2022 (thousand tonnes)
Source: FAOSTAT, 2024 [4].

Quantitative exports of sorghum and sorghum products worldwide in 2022 decreased by 4.81%, compared to 2017.

In 2022, according to data published by Faostat, the top 5 sorghum exporters that stood out worldwide are:United States of America (6,206,369 tons);Australia (2,212,137 tons);Argentina (1,689,245 tons);France (149,653.2 tons);Ukraine (72,421.6 tons) [3].

Regarding the quantitative imports of sorghum and sorghum products, the data presented show that there were variations from one year to another (Figure 7).

Regarding imports of sorghum and sorghum products globally, the highest were in 2022 (12,024 thousand tons).

In 2019, the lowest imports of only 3,717 thousand tons were observed. Quantitative imports of sorghum and sorghum products made on the international market increased by 56.6% in 2022, compared to 2017.

According to the statistical data published by Faostat for 2022, it was observed that the first major importers of sorghum registered worldwide were the following:China (10,140,198 tons);Japan (265,411 tons);Mexico (230,862.5 tons);Spain (223,418.6 tons);Sudan (122,741 tons) [3].

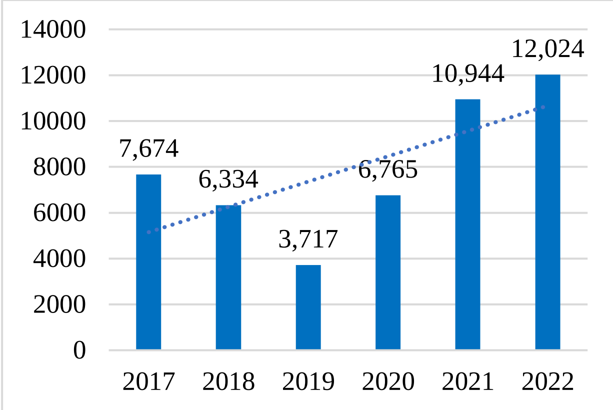

Fig. 8. Global imports of sorghum and sorghum products, 2017-2022 (thousand tonnes)
Source: FAOSTAT, 2024 [4].

According to specialists in the field, an increase in the sorghum market is expected. In perspective, the growth of the global sorghum market will be based on its three-dimensional aspect:

- food for part of the population;
- source for biofuels;
- nutritional component for animal feed.

Sorghum will keep its place on the international market because, on the one hand, it meets the needs of those interested in health (it does not contain gluten), and on the other hand, it can face the challenges related to climate change [6, 14].

CONCLUSIONS

Following the analysis of the most significant indicators related to the production and trade of sorghum worldwide for the period 2017-2022, the following aspects were highlighted:

-The largest area cultivated with sorghum was of 42,040,377 ha (2018);

-In 2021, the most substantial sorghum production of 62.1 million tons was achieved;

-At the level of 2022, Africa obtained the highest sorghum production at the continental

level, being the leader of the ranking with 29,565,397.84 tons;
-In 2021, the highest average production per hectare of sorghum was 1,490.4 kg/ha;
-The highest average annual consumption per capita of sorghum and sorghum products was in 2022 (4.0 kg/capita);
-In 2021, the largest exports of sorghum and sorghum products of 10,955 thousand tons were highlighted;
-In 2022, the largest amount of sorghum on the international market was exported by the United States of America (6,206,369 tons);
−The largest imports of sorghum and sorghum products were 12,024 thousand tons (2022);
-In the year 2022, China was the largest importer of sorghum with 10,140,198 tons.
By 2030, the sorghum production and marketing sector is expected to grow worldwide, on the one hand, due to population growth, and on the other hand, due to its use in different fields of activity.

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CRITICAL AMOUNTS OF PRECIPITATION CAUSING DAMAGES TO SWEET CHERRY FRUITS QUALITY AND HARVEST IN KYUSTENDIL ORCHARD OF THE AGRICULTURAL INSTITUTE, BULGARIA

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Abstract

Present study concerns one of the basic causes for cracking of sweet cherry fruits as a result of increased rainfall, and this amount is different for different soils. The study was done for the soils at the experimental orachard of the Institute of Agriculture – Kyustendil, Bulgaria, which are Chromic Luvisolssoils with acidity pH = 4.5-6.0. This soil is rich of the clay mineral montmorrilonite. As a result of extreme rainfalls the soil in the studied experimental field, the clay mineral montmorillonite starts to separate sodium Na, The area is rich also of chloritized slates which enriched the soil of chlorite Cl as the result is - salinization of the soil, enriching of NaCl.The amounts of precipitation needed for soil salinization, which causes damages - ckracking of cherry fruits. As a result of the present study, the critical amount of precipitations, causing damages – cracking on sweet cherry fruits is estimated on about 28 l/m^2. With these amounts of precipitation, a deterioration in the quality of the crop can be expected and even with forecast amounts of precipitation, it can be counteracted by adding of agricultural gypsum(the mineral gypsum) to the soil, according to the cited reference. In 2024, because of the high precipitations level, the salinity of the soil was very high in NaCl and this was the cause for which the harvest of sweet cherries was lost as many cherry trees died.

Key words: *precipitations, sweet cherry cracking, fruit damages, juice quality, fruit harvest, climate changes*

INTRODUCTION

The climate in the Kyustendil region is transitional-continental with relatively mild winters and warm and dry summers. The climatic conditions in the region are largely determined by its location and its good protection by mountain ranges, which diversify the relief and contribute to some difference in the different micro-regions. The winter is mostly mild and the summer is relatively warm for the altitude [8].

The aim of the study is to investigate the juices of 9 different sweet cherry cultivars and 1 hybrid 5645 for their technological parameters with a focus on Salt content (ppm) and total dissolved solids (TDS, ppm) and to be established the critical amounts of precipitation,causing damages to cherry fruits.

MATERIALS AND METHODS

The research was carried out in an experimental orchard field of the Institute of Agriculture – Kyustendil, Bulgariaduring time period from April to June 2024. The experimental field of the study is 7.7 da. The sweet cherry plantation was grafted onto a prunus mahalebk and were planted in the spring of 1996 at 6 x 5m distances. Each cultivar was represented by 5 experimental trees, with each tree counted as a separate replicate, grown under non-irrigated conditions and formed into a freely growing crown. The object of the study were nine early ripening sweet cherry cultivars and one sweet cherry hybrid 5645 with different genetic origin as follow: Primavera, Superstar, Seneca, Diana, Fabulay, Ranna cherna edra, Tavrichanka, Bigarreau Burlat, Ranna ot Vil.Bigarreau Burlatis used for control cultivar for early ripening sweet cherry. The soil in the experimental plot is highly leached, slightly sandy-clay, *Chromic Luvisols* soils with a low-to medium acid reaction [5].

Stocking with absorbable phosphorus is low to medium, and with absorbable nitrogen very low. The soil surface is maintained in black fallow by periodic shallow tillage during the growing season, and in autumn by plowing to a depth of 15-18 cm. From the established methodology by [9] in Bulgaria, according to the period of ripening, cherry varieties are divided into 3 groups: early ripening (the first 1-2 weeks of sweet cherry ripening), medium ripening (3-4 weeks) and late ripening (5-6 weeks).

The juices of the cherry fruits by varieties were produced by the cold-pressing method with a single-shaft juicer Star Light SJB-150 R in laboratory, unpasteurized, without additives, at temperature 20°C in regular air environment. Minimum 5 measurements of the technological parameters of each cherry variety were done and average value is presented in the Table 1.

Soil survey instrument was used for measurement of the pH value and temperature (t°C) of the soil directly (*in situ*). The EC, TDS, and Salt in the soil were studied after aqueous extract in a ratio of soil: distilled: water=1:1. For this purpose, rain was simulated by adding 100 g of distilled water in 100 g of soil to activate the exchange of cations and for formation of electrolytes, necessary for the measurement [1].

A DigiScope 2.0 digital microscope was used for the microscopic soil studies, using white LED and UV-ultraviolete light.

For determination of the technological parameters of the sweet cherry fruits and their juice and soil aqueous extract, digital instruments were used as follow: Refractometer “Atago-Pal 1”- Australia. Bluetooth compatible water quality intelligent tester “Yieryi BLE-C600”-Chinaand instrument "Lovibond-SensoDirect 150"-United Kingdomwere used for determination of total acidity (pH), electrical conductivity (EC, µS/cm),total dissolved solids (TDS, ppm), total salt content (Salt, ppm,%), Specific Gravity (S.G.), Eh - Redox potential (mV), and temperature (°C).

RESULTS AND DISCUSSIONS

Table 1 shows the results of measurements of the technological parameters of the cherry juice of the different varieties. The content of the total amount of sugars varies from 12.0% to 16.2%. The total acidity varies within a narrow range from 3.35 to 3.75. The redox potential varies from 79 mV to 207 mV. The salinity varies from 0.10% to 0.18%.

Table 1. Results of measurements of the technological parameters of cherry juice from different varieties

No.	Sweet cherry cultivar/ Hybrid	Total Sugar content, Brix %	Acidity pH	Redox potential Eh, mV	Salt, %	Salt, ppm	Total Dissolved Solids TDS, ppm	Electro conductivity EC, µS/cm	Salt+TDS, ppm	Ratio Brix/pH	Ratio EC/TDS	Ratio EC/Salt	Specific gravity S.G.
1	Primavera	12.0	3.37	79	0.15	1,713	1,560	3,160	3,273	3.56	2.03	1.84	1.0
2	Superstar	11.9	3.46	111	0.13	1,140	1,130	2,310	2,270	3.44	2.04	2.03	1.0
3	Seneca	16.2	3.38	138	0.11	1,180	1,170	2,350	2,350	4.79	2.01	1.99	1.0
4	5645	15.3	3.60	132	0.13	1,300	1,290	2,580	2,590	4.25	2.00	1.98	1.0
5	Diana	13.6	3.75	147	0.11	1,110	1,110	2,220	2,220	3.63	2.00	2.00	1.0
6	Fabulay	14.3	3.43	164	0.14	1,480	1,460	2,920	2,940	4.17	2.00	1.97	1.0
7	Ranna cherna edra	14.6	3.41	204	0.11	1,120	1,110	2,230	2,230	4.28	2.01	1.99	1.0
8	Tavrichanka	14.3	3.35	174	0.10	1,040	1,040	2,080	2,080	4.27	2.00	2.00	1.0
9	Bigarreau Burlat	13.6	3.45	207	0.18	1,870	1,840	3,690	3,710	3.94	2.01	1.97	1.0
10	Ranna ot Vil	14.0	3.46	181	0.17	1,750	1,720	3,440	3,470	4.05	2.00	1.97	1.0

Source: Original data from the experiment.

Fig. 1 shows the values of the content of total dissolved salts and the total amount of dissolved solids in the juice, which are almost equal.

From Fig. 2, it can be seen that the values of the electrical conductivity of the juice and the sum of the values of Salt+TDS, ppm by varieties are almost equal.

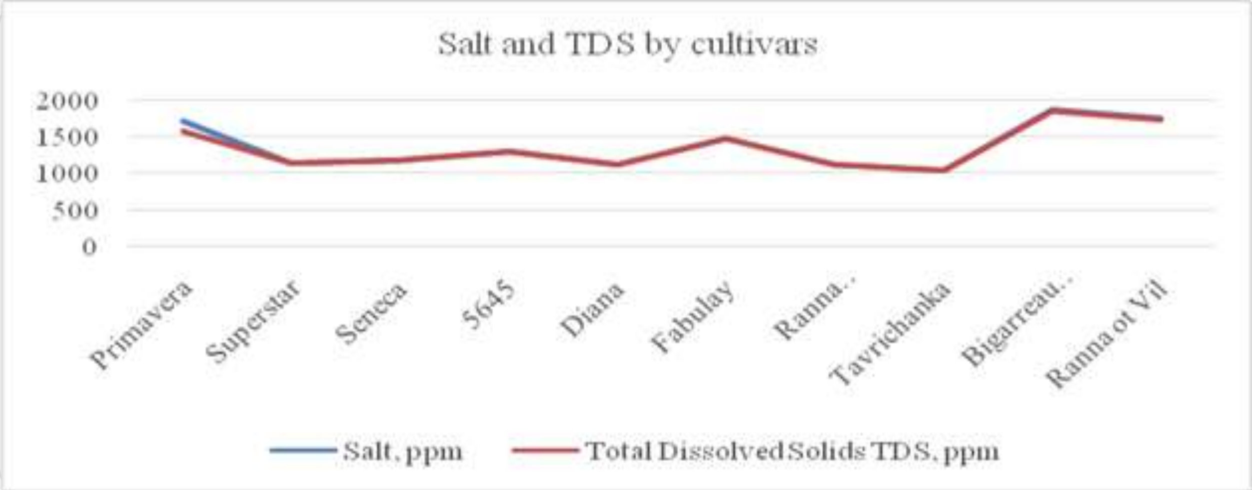

Fig. 1. Values of electrical conductivity of juice and the sum of Salt+TDS, ppm by variety, the lines almost coincide, because the values are very close
Source: Original figure.

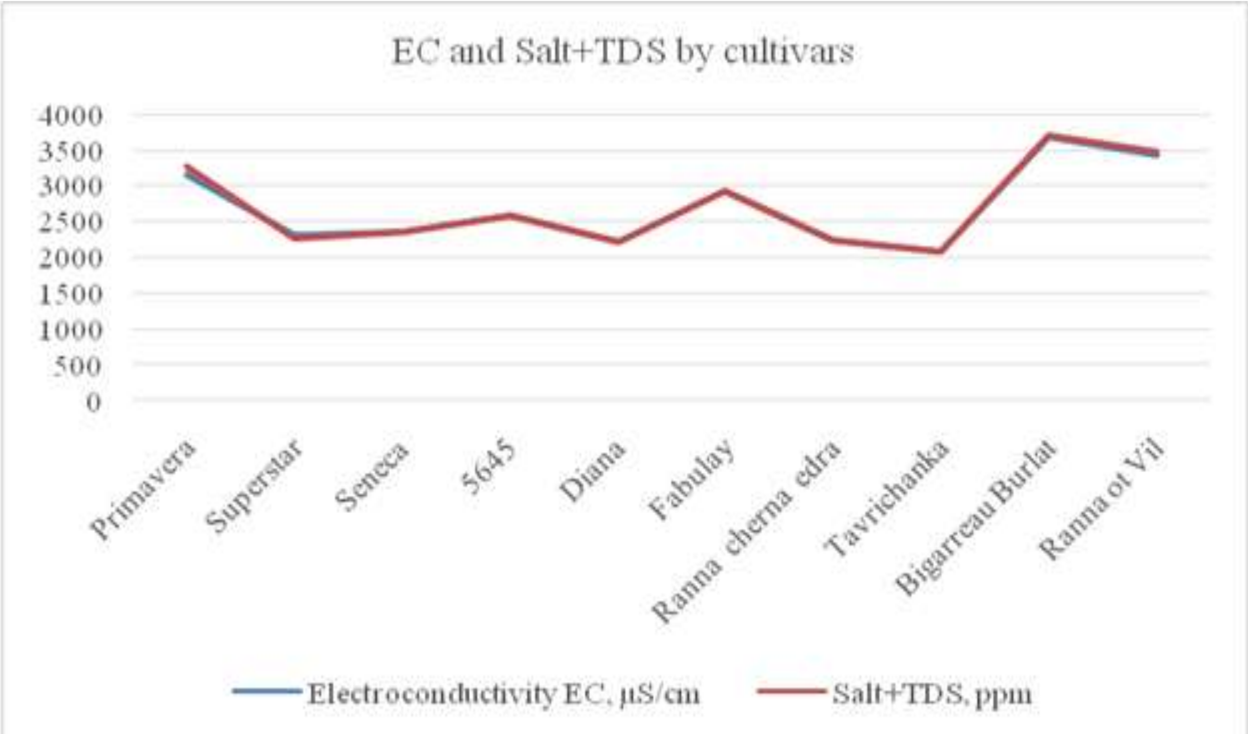

Fig. 2. Values of the content of total dissolved salts and total amount of dissolved solids in cherry juice by variety, the lines almost coincide, because the values are very close
Source: Original figure.

The authors of the present paper have worked on this topic for 5 years and the results are presented in Table 2. Actually, the problem concerns all cherry varieties, conditionally divided of early, medium and late ripening without any differences. During the years 2020, 2021 and 2022 the precipitations were often in smaller quantities, reaching up to 10 liters per sq. m. for a rainy period.

Table 2 shows that for these three years TDS are in greater quantities than Salt in cherry juice in all varieties, both early and late ripening.

Table 2. Average values of the technological parameters of the sweet cherry juices

Year	2020	2021	2022	2023	2024*	2024**
Salt, ppm	1,280	1,400	1,190	1,510	1,367	1,344
TDS, ppm	1,660	1,820	1,560	1,490	1,367	1,286
Ratio Salt/TDS	0.77	0.77	0.76	**1.01**	**1.00**	**1.045**

Source: Original data from the experiments.
Note: Total dissolved solids – TDS (ppm), total salts - Salt (ppm) and the ratio between them Salt/TDS for the last 5years – presented for comparison (previous own data-unpublished) (*-precipitations 28 l/1 sq. m.; **-precipitations more than 28 l/1 sq. m. period 21-26.04.2024).

But in 2023, precipitations of more than 70 liters per square meter was measured, during the ripening period of sweetcherries, as a result of which almost all cherry harvest was damaged, expressed in severe cracking and rotting of the fruits (Fig. 3, Fig. 8).

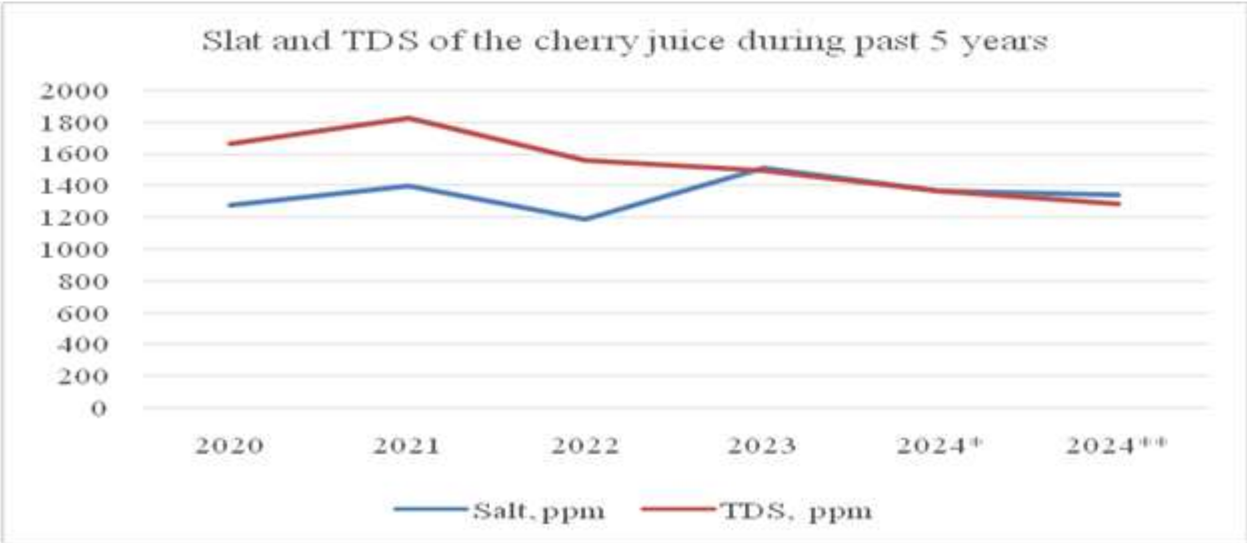

Fig. 3. Measured Salt and TDS content of the cherry juices during past 5 years
Source: Original figure.

In 2024, during the ripening of early sweet cherry varieties, there was precipitation below 20 l/m^2, but alsothere was one period with a total amount of precipitation of about 30 l/m^2, as a result of which it was possible to trace the gradual increase of salt content in the soil and in the fruits of all cherry varieties that ripen at that time Table 3, Fig. 4 and Fig. 5. Figure 4 presents the quantity of precipitation during the ripening period of early ripening sweet cherry varieties 2024, while Figure 5 shows the precipitations during the cherry rippening period season 2023– presented for comparison (previous own data-unpublished).

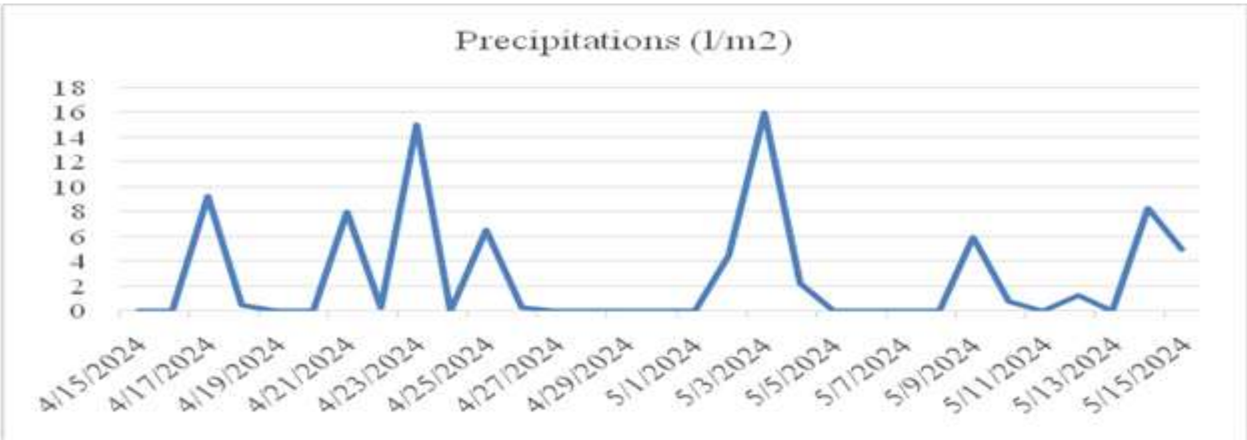

Fig. 4. Quantity of precipitation during the ripening period of early ripening cherry varieties 2024
Source: Original figure.

Table 3 presents the metereological data for the studied period in terms of: maximum air temperature, average air temperature, average air humidity, dew point, precipitations amount, soil moisture at 30 and 70 cm, soil temperature at 30 cm, and foliar moisture.

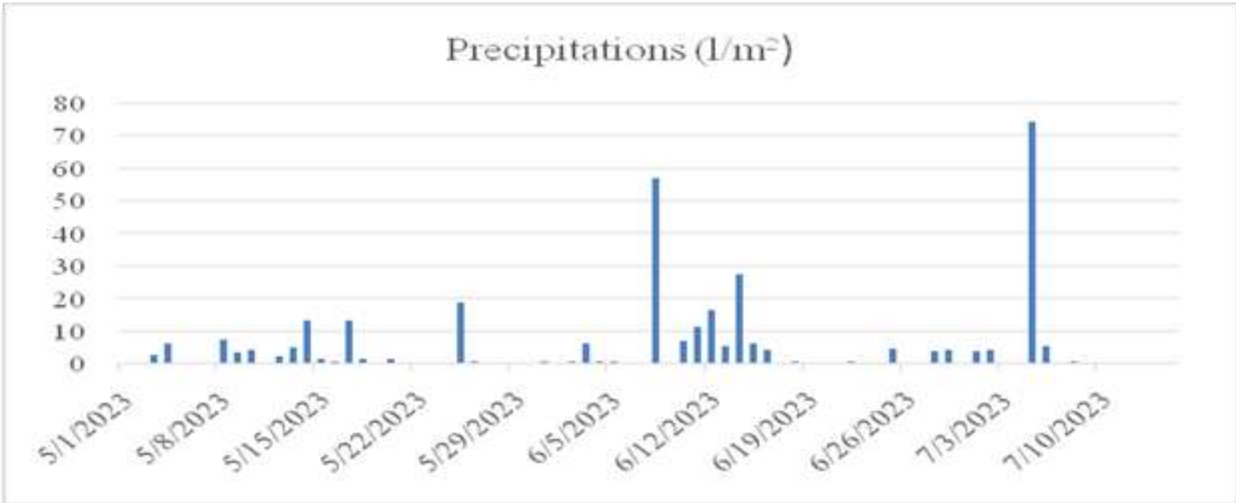

Fig. 5. Precipitations during the cherry rippening period season 2023– presented for comparison (previous own data-unpublished)
Source: Original figure.

Table 3. Metereological data for the studied period

Date	Air temperature max. (°C)	Air temperature average (°C)	Air humidity average (%)	Dew point (°C)	Precipitation (l/m^2)	Soil moisture 30 cm (%)	Soil moisture 70 cm (%)	Soil temperature 30 cm (°C)	Foliar moisture (%)
15.4.24	32.92	17.4	59.6	7.7	0	84.5	99.9	15.8	7.9
16.4.24	28.08	16.7	66.5	9.8	0	84.4	99.9	16	0
17.4.24	19.23	13.1	85.3	10.5	9.25	84	99.9	15.7	12.3
18.4.24	14.16	9.1	74.8	4.4	0.5	83.3	99.7	14.5	3.2
19.4.24	17.36	8.5	67.1	1.8	0	83	99.6	13.6	5.4
20.4.24	20.46	11.2	64.4	4.3	0	83.1	99.6	13.8	0.9
21.4.24	12.77	7.3	90.4	5.7	8	82.8	99.6	13.8	17.5
22.4.24	19.99	9.8	74.3	4.7	0.25	82.5	99.5	13.1	7.3
23.4.24	12.84	10	91.2	8.6	15	82.6	99.5	13.4	14.6
24.4.24	24.43	14.6	72.9	9	0	84.7	99.1	13.4	4.9
25.4.24	12.51	9.6	89.4	7.9	6.5	86	99.1	14.1	17.9
26.4.24	21.44	9.8	79	5.6	0.25	87.9	99.4	13.4	7.3
27.4.24	24.17	11.7	74	6.3	0	90.9	99.8	13.9	14.6
28.4.24	25.61	14.4	67.4	7.2	0	92.5	99.7	14.5	11.7
29.4.24	24.74	15	63.8	7.1	0	92.9	99.8	15.4	10.7
30.4.24	23.35	15.3	67.3	9.1	0	92.3	99.2	15.9	0
1.5.24	22.24	15.9	71.6	10.6	0	92.6	99.6	16.3	0
2.5.24	23.95	15.5	80	11.9	4.5	92.2	100	16.7	6.6
3.5.24	16.25	11.3	89.6	9.6	16	96.4	100	16.3	18.4
4.5.24	19	12.6	82.3	9.5	2.25	100	99.3	15.3	11.6
5.5.24	25.15	15.4	71.1	9.2	0	100	100	15.1	17.7
6.5.24	26.47	15	72.8	9.2	0	100	100	16.2	14.4
7.5.24	28.48	16.5	72.3	10.7	0	100	100	16.8	15.8
8.5.24	23.65	15.6	81.5	12.2	0	100	100	17.4	13.5
9.5.24	23.15	15.3	87	13	6	99.7	100	17.3	13.9
10.5.24	17.66	12.7	81	9.4	0.75	100	100	16.9	2
11.5.24	23.07	15	62.7	6.9	0	100	99.1	16.2	0.5
12.5.24	24.88	12.1	79.2	8.1	1.25	100	100	16.7	18
13.5.24	22.95	15.1	69.2	8.6	0	100	100	16.8	10.1
14.5.24	18.75	11.8	86.1	9.4	8.25	99.3	100	17	11.6
15.5.24	14.77	11.8	94.3	10.9	5	97.4	100	16.2	15

Source: Original data from own metereological station.

Christov and Stoeva (2015) [4] found that in the early-ripening cultivars Bigarreau Burlat, cracked fruits were within 26%, in the medium-ripening Kakianes (80%), Vega (79%), and in the late-ripening Elites 6541 (34%), 6528 (30%) and Regina (8%).

Chivu et al. (2023) published data about sweet cherry fruit cracking as a chronic problem in the era of climate change [3]. They think that the reason for cracking is that “as the fruit develops, the xylem (the only pathway through which calcium is transported) breaks

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the connection with the fruit, and the fruit's needs will be provided by the phloem, which leads to a continuous decrease of calcium in the fruit" [2]. Even if the results are contradictory, the use of calcium-based foliar products is used as a method to reduce sweet cherry fruit cracking".

[7] described the opposite climate effect - drought resistance and its influence on flower formation in sweet cherry.

Actually our investigations shows that the problem is in the soil, after high amount of precipitations. For the studied area – experimental orchard field of Institute of Agriculture-Kyustendil, Bulgaria, this critical amount of precipitations, caused damages on the cherry fruits is calculated aboput 28 liters per sq. m. per a precipitation period (hours or days) as shown in Fig. 5, Fig. 6, and Fig. 7.

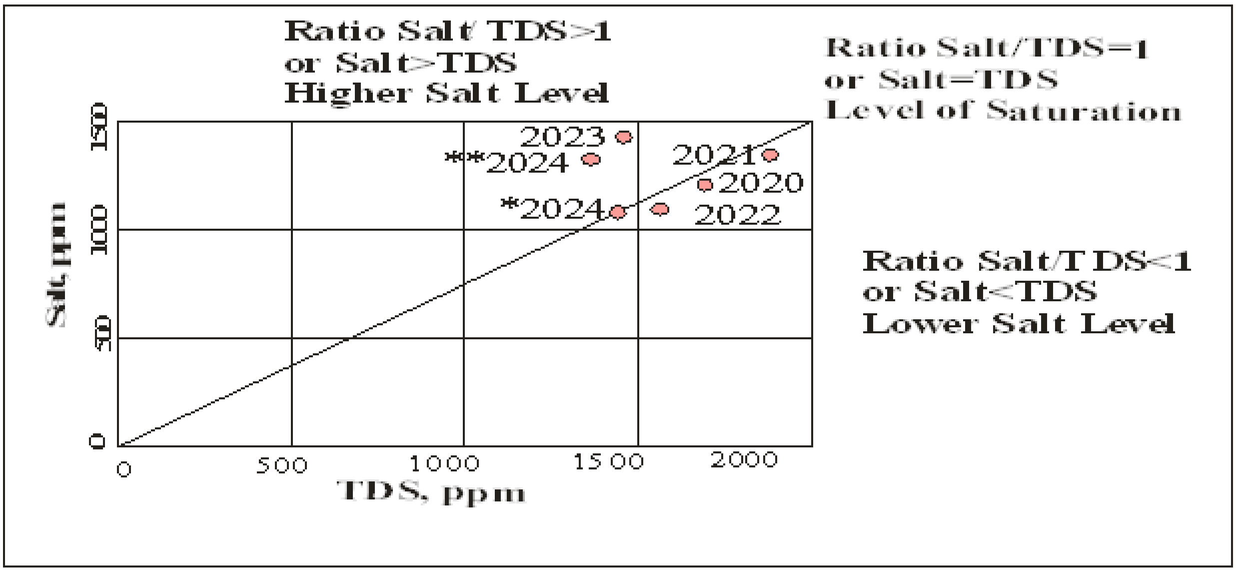


Fig. 6. Ratio Salt-TDS diagram of the cherry juice (*-precipitations 28 l/1 sq. m.; **-precipitations more than 28 l/1 sq. m. period 21-26.04.2024).
Source: Original figure.

Fig. 7. Sweet cherry fruit cracking on variety Ranna ot Vil, May 2024
Source: Original figure.

The soil on the territory of the experimental field of the Institute of Agriculture in Kyustendil is defined as leached *Chromic Luvisols* (FAO-ISRIC-IUSS, 2006) [13], as the soil pH varies from 5.0 to a depth of 0-10 cm and reaches 5.4 at a depth of 100 cm, and the humus is 0.98% at the surface and decreases to 0.40 at 100 cm, according to [14].

Table 4 presents the studied characteristics, related with the soil of the target experimental fields.

As a result of the study was determined that, because of the climatic changes and accompanied abnormal phenomenon as extreme rainfalls, the ordinary soils may become problem soils. As a result of extreme rainfalls the soil in the studied experimental field and especially the clay mineral montmorillonite, according to [10], who started to separate sodium Na, and the area is rich of chloritized slates which enriched the soil of chlorite Cl as the result is salinization of the soil, mainly NaCl.

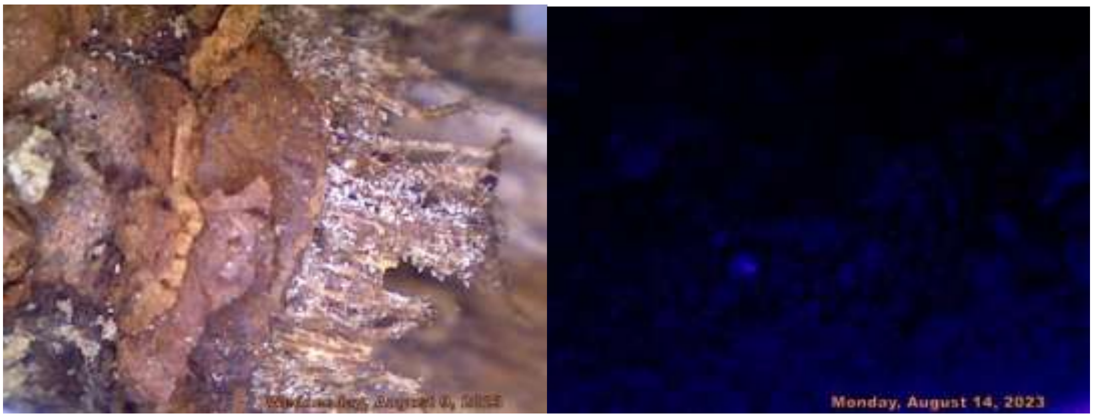
Because of this reason the harvest from cherries was damaged and many cherry trees died in the area. For figuring out the problem soil we suggested using of the mineral gypsum as appropriate method to improve the soil fertility and structure during periods of extreme rainfalls.

Table 4. Summarized results from the measurements of the agroecological and agrotechnological parameters of the soils – distilled water extract and precipitations of the studied area

Measured Parameter	Temperature, °C	pH, Total Acidity	Conductivity (EC), μS/cm	Total Dissolved Solids (TDS), ppm	Salt, ppm	Redox-potential (Eh), mV
Average, 49 samples	7.0	4.5-6.0 Average 4.94	140.00	70.00	68.00	84.00

Source: Original data from experiment.

The classical theory develops the melioration of alkaline soils as a process of ion exchange sweeping of sodium cations on the calcium adsorbent by introducing gypsum materials, which is why this melioration is called gypsum: soil $Na_2+CaSO_4 \Leftrightarrow$ soil $Ca+Na_2SO_4$ [6].
Ratio TDS/Salt is described also by [11] and [12] as usually TDS>Salt when during ripening period rainfalls are less than 28 l/m^2 per a rain period.
Fig. 8 is a microscopic pictures of the mineral halite into roots of died cherry tree after almost 80 l/m^2 rain period during 2023. Fluorescence of the halite was observed with microscope under blue light. The taste of the mineral was salted and bitter.



a) b)

Fig. 8. a) Crystals of the mineral halite (NaCl-salt) in the openings of the roots of sweet cherry tree – reflected light, air environment, magnification x20; b) – The mineral halite as solder between soil grains (the blue grain), ultraviolet light, air environment, magnification x20.
Source: Original figures.

The impact of the precipitations in the year 2024 on the harvest of sweet cherry trees

Due to the climatic changes expressed in terms of extreme rainfalls in the year 2024, the ordinary soils have become problem soils. The high rainfalls have deeply affected the soil in the studied experimental field and especially the clay mineral montmorillonite.
Sotirov (2024a) separated clay mineral montmorillonite, which is rich of sodium Na [6], and because the area is rich of chloritized slates [10], the soil has become enriched by chlorite Cl and, in consequence, it resulted the salinization of the soil, mainly NaCl [1,10].
For this reason, in the year 2024, the harvest of sweet cherries was deeply damaged as many cherry trees died in the area.

CONCLUSIONS

This study concerns the basic causes of cracking of cherry fruits as a result of increased rainfalls during years 2023 and 2024, according to measurements of the Meteo-station "Meteobot", compared with previous years. The study was done for the soils in the cherry plantations, which are *Chromic Luvisols* soils with acidity of pH = 4.5-6.0. This soil is rich of the clay mineral montmorrilonite. As a result of extreme rainfalls the soil in the studied experimental field and especially the clay mineral montmorillonite starts to separate Sodium(Na), and ate the same time the area is rich of chloritized slates which enriched the soil of chlorite Cl as the result is salinization of the soil, mainly with NaCl. The critical amounts of precipitation, which causes soil salinization were estimated of average 28 l/m^2 per a precipitation period. With these amount of rain, a deterioration in the quality of the sweet cherry crop, that reach technological maturity at the same time can be expected and also if there is forecast amounts of precipitation, it can be counteracted by agricultural fertilizer –the mineral gypsum.

The main conclusion of this study is that as a result of a certain amount of precipitation that fell for a short period of time on areas with cherry trees during the technological ripening of their fruits, depending on the type and composition of the soil, soil salinization occurs, which caused damages on the cherry fruits as a result of the disturbed water-salt balance of the solutions in the tree. Accordingly, an imbalance of the osmotic pressure of the fruit cells occurs, which can lead to damage to the cherry harvest.

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ANALYSIS OF THE SUSTAINABLE DEVELOPMENT OF AGRO-TOURISM IN ROMANIA

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Abstract

Agritourism offers rural areas a chance to grow by diversifying the local economy, generating employment, and reviving communities. It also helps to value rural culture, traditions, and natural landscapes while drawing visitors seeking out genuine, environmentally conscious experiences. Agritourism encourages balanced economic development, lowers rural-urban migration, and helps communities become more self-sufficient by boosting local produce and assisting with agricultural endeavors. Agritourism promotes ethical behaviors including waste management, the use of renewable energy sources, and the conservation of natural resources, all of which support environmental preservation and ecological awareness in the framework of sustainable development. Thus, in addition to raising the standard of living in rural areas, agritourism is essential to building a robust and sustainable economy. The research aimed to identify the regions with the greatest growth potential, assess tourist flows and propose recommendations for a more balanced distribution of tourism activities. The methodology included a comparative analysis of statistical data from the period 2020-2023 regarding the capacity and use of guesthouses by region and macro-region, using annual growth indicators to measure the evolution of tourism demand and supply. The data were collected from official sources and interpreted to highlight both growth trends and regions with low potential, with the intention of offering helpful data for the creation of agritourism sustainable development plans. The findings were used to provide a set of conclusions and suggestions for Romania's agritourism industry's growth and diversification.

Key words: *agritourism, sustainable, development, Romania*

INTRODUCTION

The process of sustainable tourism development is intricate and ongoing, requiring the presence of a long-term vision and the conscientious participation of all stakeholders. According to studies, this kind of tourism has positive social and environmental effects in addition to economic ones, helping to preserve and value natural and cultural resources and promote the peaceful growth of visitor communities [2, 11].

Beginning with these factors, it is important to keep in mind that this strategy aims to strike a balance between promoting tourism and protecting the environment. This balance includes policies and practices that minimize adverse effects on resources and the environment while simultaneously maximizing the social and economic benefits for local communities [1, 3, 12]. For the benefit of future generations, the primary goal is to develop a type of tourism that is sustainable over the long run, provided that the natural, cultural, and economic resources are maintained unchanged.

Since sustainable tourism depends on protecting the environment, its operations must guarantee that natural resources are managed properly, that energy and water usage are reduced, that waste is handled appropriately, and that pollution levels are reduced [4, 19].

Numerous tourist sites incorporate renewable energy sources as part of their ecological projects and conservation policies, the creation of recycling programs, ecological education for tourists with the aim of ensuring sustainability [17, 24].

The desire to preserve natural and cultural resources and practice responsible consumption are the cornerstones of the interaction between this type of tourism and the younger generations, so that they remain accessible for the future, considering the increasing awareness of the negative impact on that human activities have on the environment [9, 18, 22]. Sustainable tourism thus responds to the requirement to promote travel practices that respect ecosystems, support local communities and preserve cultural authenticity.

In addition to protecting the environment, the development of sustainable tourism places a strong emphasis on preserving and promoting cultural heritage, by supporting local traditions and crafts that can be included in tourist experiences [13, 14, 21]. Thus, tourists can participate in authentic activities and better understand the local culture, which contributes to preserving the cultural identity of the regions. Instead of mass tourism, they prefer less crowded destinations, where they can contribute directly to the well-being of communities and to protecting the environment, sustainable tourism also becoming a form of education, encouraging a more conscious and responsible lifestyle [10, 23]. By using this type of travel, younger generations can have an impact on how the tourist sector changes and encourage companies to use socially and environmentally conscious practices. Because local communities' participation in tourism activities not only boosts the regional economy but also guarantees steady incomes for the residents of the areas, the local economy in turn plays a significant role in the development of sustainable tourism. This is because local communities engage in conservation practices and create ecological initiatives that use renewable energy. By creating jobs and boosting local businesses, sustainable tourism helps reduce poverty and improve the quality of life in destination communities [15, 16, 20].

Lastly, responsible travel is promoted by sustainable tourism. The long-term viability of this kind of tourism depends on tourists' ecological education, which includes reducing their environmental impact and following travel laws. Encouraging tourists to participate in green activities or contribute to conservation funds is one way to integrate sustainability into their behavior.

Therefore, successfully implementing sustainable tourism must be based on close collaboration between authorities, local communities and the private sector, and government policies must support investments in sustainable infrastructure and provide incentives for businesses that adopt responsible practices.

The purpose of this research is to analyze the regions with a high potential for in agrotourism regarding tourist flows and the capacity and use of guesthouses, reflecting the evolution of tourism demand and supply.

MATERIALS AND METHODS

A quantitative approach was used in the research methodology to analyze the sustainable development of agritourism, which includes analyzing statistical data released by Romania's National Institute of Statistics, and which were collected, processed and analyzed, so that they led us to obtain relevant conclusions regarding the way of evolution and development of agotourism in Romania.

The analyzed indicators, which allowed us to compare the data, were:

The number of visitors and the yearly growth rate, which included analyzing the flow of visitors within the agritourism guesthouses and separating them into Romanian and foreign visitors, may have shown rising or falling trends. We were able to compare the dynamics between years by using the yearly growth rate, which is computed as follows:

$$Percentage\ increase\ (\%) = \frac{Current\ Year\ Value - Previous\ Year\ Value}{Previous\ Year\ Value} x100$$

The average length of stay is the indicator that measures the preferences of tourists and that influences the economic and ecological impact. Analyzing annual variations allowed us to establish seasonal trends and potential for sustainability.

The accommodation capacity and the degree of occupancy are indicators that indicate the available infrastructure and the demand, and the analysis of the variations in the degree of occupancy allows the evaluation of the sustainability and adaptation of the agritourism infrastructure.

RESULTS AND DISCUSSIONS

The examination of how the lodging capacity in agritourism guesthouses has changed over time gives us with information regarding the interest that tourists have in agritourism, as well as its ability to support long-term demand. The indicator reflects both the attractiveness of the region and the level of investment in tourism infrastructure, reflecting local economic development trends (Fig. 1). By monitoring the accommodation capacity, we aimed to evaluate the way in which the development of agritourism is sustainable or influences the local communities. Additionally, the development of this capability shows how agro-tourism guesthouses have adapted to the demands of contemporary guests, incorporated ecological practices into their operations, and helped create jobs in the area.

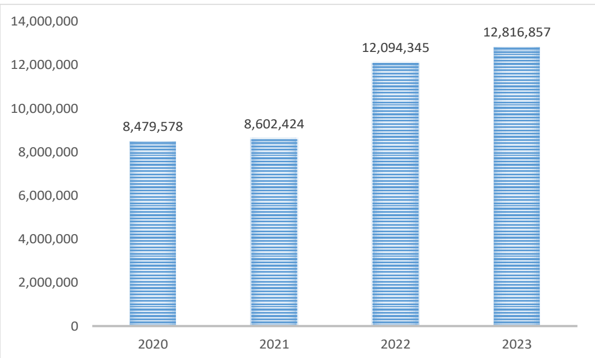

Fig. 1. The growth of hotel capacity in Romanian agritourism guesthouses from 2020 to 2023
Source: own processing (places-days) [5, 6, 7, 8].

An evolution of the lodging capacity of agritourism guesthouses is seen based on data from 2020–2023, with notable fluctuations in the growth rate given that 2020 was the year that the Covid-19 epidemic struck. Consequently, the growth rate in 2021 was a mere 1.45%. In response to the pandemic crisis's aftermath, which increased demand for agritourism and rural travel, it rose at a pace of 40.59% starting in 2022. Although at a lesser rate of 5.97, growth continued in 2023 (Fig. 2). These trends show how the hotel capacity in this sector is dynamically adapting, underscoring the importance of agritourism in Romania.

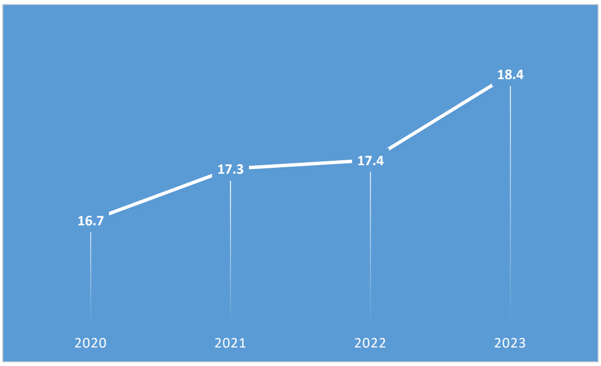

Fig. 2. The shift in the net utilization indices of the lodging capacity of Romanian agritourism guesthouses from 2020 to 2023 (%)
Source: own processing [5, 6, 7, 8].

Between 2020 and 2023, agrotourism guesthouses' visitor capacity utilization index grew gradually. It grew by 3.59% in 2021 compared to 2020. The use increased by 5.75% in 2023 due to the rise in demand for agritourism, particularly for sustainable and nature-based places, but the increase was only low (0.58%) in 2022 (Fig. 3).

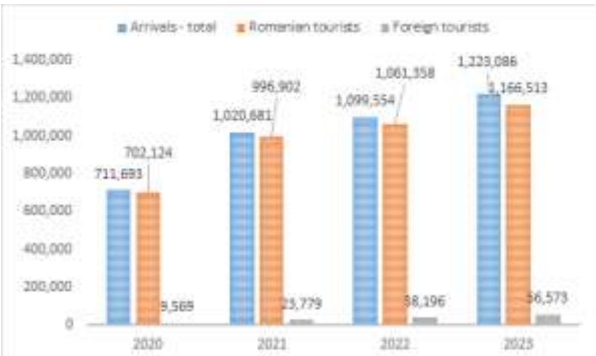

Fig. 3. The change in visitors to Romanian agritourism guesthouses between 2020 and 2023 (no. arrivals)
Source: Own design based on teh data from [5, 6, 7, 8].

In the period 2020-2023, total tourist arrivals increased significantly. In 2021 compared to 2020, the increase was 43.42%, with an advance of 41.98% for Romanian tourists and an increase of 148.50% for foreign tourists. In

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2022, the growth rate stabilized, with total arrivals increasing by 7.73%, this being due to the number of Romanian tourists, which increased by 6.47%, and foreign tourists, which continued to increase (60.63%).

In 2023, the growth rate of total arrivals was 11.23%, due to the growth rate of Romanian tourists of 9.91% and 48.11% for foreign ones. These demonstrate the interest in agritourism and its support from both internal and external tourists.

Fig. 4. The development of overnight stays in Romanian agritourism guesthouses between 2020 and 2023 (number overnight stays)
Source: Owb design based on the data from [5, 6, 7, 8].

The overnight stay growth index for agritourism guesthouses for the 2020–2023 period rose from 37.91% in 2021 to 2020. This resulted from a 36.71% increase in Romanian tourists and a 120.72% increase in foreign tourists.

The overall overnight stays growth rate in 2022 was a mild 7.42%, with a 6.07% increase for Romanian tourists and a 65.66% increase for foreign tourists.

In 2023, the overall growth was 12.44%, with foreign tourists increasing by 55.84% and Romanian tourists increasing by 10.86% (Fig. 4). Foreign visitors' overnight stays are on the rise, however this is during the early aftermath of the Covid-19 pandemic.

Romanian agritourism guesthouses' lodging arrangements throughout the 2020–2023 timeframe exhibit regional variances. With market shares ranging from 33% to 37%, the market leader is unquestionably the Center Region. The North-West Region followed, increasing from 21% in 2020 to 26% in 2023 as a result of the expansion of agritourism.

With weights ranging from 17% to 18%, the North-East Region's contribution was comparatively steady, whereas the South-Mountain Region's varied from a minimum of 6% in 2023 to a maximum of 8% in 2022. The contributions from the South-East Regions, Bucharest-Ilfov, South-West Oltenia, and West were modest but consistent, falling below 8%, with no appreciable fluctuations (Fig. 5).

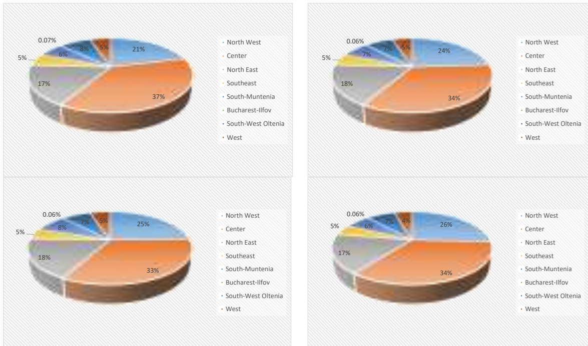

Fig. 5. The distribution of lodging options in Romanian agritourism guesthouses by development regions between 2020 and 2023 (%)
Source: Own design based on the data from [5, 6, 7, 8].

These data demonstrate the role of the Central and North-West regions in Romanian agritourism, but also the growing interest in mountainous and hilly areas, known for their landscapes and rural traditions.

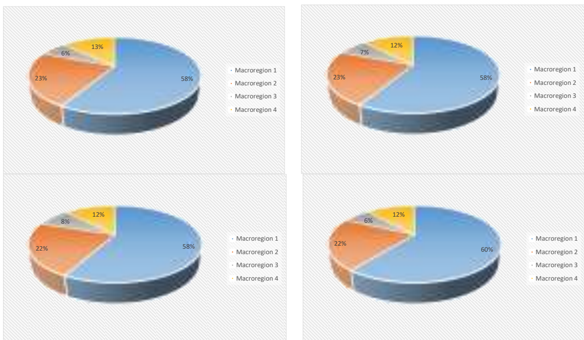

Fig. 6. The distribution of lodging options in Romanian agritourism guesthouses by microregions between 2020 and 2023 (%)
Source: Own design based on the data from [5, 6, 7, 8].

In the period 2020-2023, the structure of accommodation places in agritourism guesthouses in Romania, analyzed by macroregions, shows a clear concentration in Macroregion 1, which had a stable share of 58% in the first three years analyzed and reaching 60% in 2023. Macroregion 2 had a steady contribution, falling from 23% to 22%. The weight held by Macroregion 3 increased

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from 6% in 2020 to 8% in 2022. Macroregion 4 had a weight of 12% in the analyzed period (Fig. 6). The dominance of Macroregion 1 in the practice of agrotourism is thus established, as a result of a well-developed tourist infrastructure and a higher attractiveness for tourists within it.

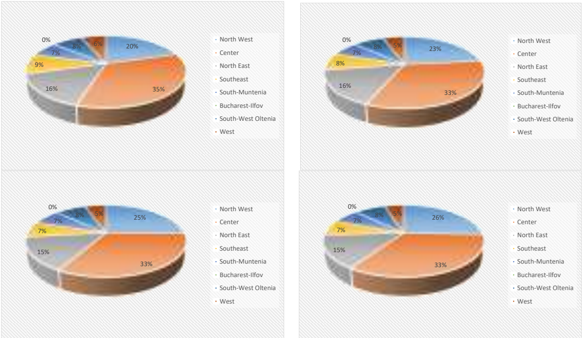

Fig. 7. The distribution of lodging capacity in Romanian agritourism guesthouses by development regions between 2020 and 2023 (%)
Source: Own design based on the data from [5, 6, 7, 8].

In the period 2020-2023, the structure of the accommodation capacity in tourist guesthouses in Romania had a concentrated distribution in a few regions. Thus, the Center Region dominates the market, with shares between 33-35%, The North-West came next, rising from 20% in 2020 to 26% in 2023. The Southeast Region had a decline from 9% to 7%, while the North-East Region saw a decline from 16% to 15%. The Bucharest-Ilfov Region lacked a relevant agritourism capability, whereas the South-Muntenia and South-West Oltenia regions held steady shares of 7% and 8%, respectively. The Western Region's shares ranged from 5% to 6% (Fig. 7).

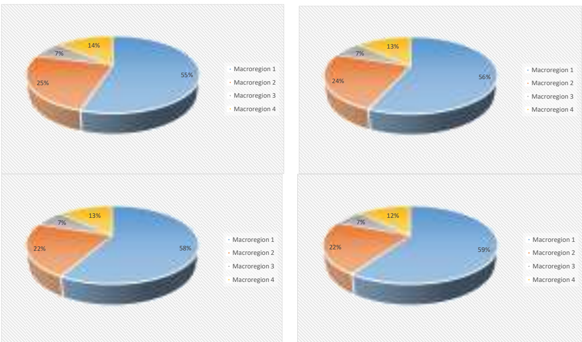

Fig. 8. The distribution of lodging capacity in Romanian microregions' agrotourism guesthouses between 2020 and 2023 (%)
Source: Own design based on the data from [5, 6, 7, 8].

In the period 2020-2023, the accommodation capacity in agritourism guesthouses in Romania was concentrated in Macroregion 1, with percentages between 55% and 59%, confirming the importance of this area for agritourism. Macroregion 2 saw a decrease, from 25% in 2020 to 22% in 2022 and 2023, and Macroregion 3 maintained a constant share of 7%. Macroregion 4 decreased slightly, from 14% to 12%, demonstrating the concentration of accommodation capacity in Macroregion 1 (Fig. 8).

CONCLUSIONS

The analysis of data on the capacity and use of agritourism guesthouses in Romania for the period 2020-2023 shows a constant increase in demand, with a concentration of accommodation capacity and tourist flows in Macroregion 1 and in the Center and North-West regions. Although these regions attract the majority of tourists, both Romanian and foreign, the less developed regions and macro-regions remain stable from the point of view of practicing agritourism. The increase in the number of overnight stays and arrivals, especially from foreign tourists, reflects the growing interest in rural tourism and agritourism, favored by the post-pandemic trends of being close to nature.

By investing in infrastructure and encouraging local initiatives, it may be possible to increase lodging options and tourism in less-traveled areas, like Macroregions 2, 3, and 4, which would help to diversify non-agricultural activities and boost tourism in these areas. Promoting emerging regions could distribute the tourist flow more evenly, lessening the strain on popular destinations and promoting equitable economic growth. Additionally, we believe that incorporating ecological practices and offering a variety of authentic and sustainable tourist experiences could help make agritourism guesthouses more appealing and establish Romania as a destination for ethical and sustainable agritourism.

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WHAT ARE THE MAIN IDENTIFIED NEEDS AND OCCUPATIONAL HEALTH AND SAFETY ISSUES IN WORK ON SHEEP FARMS?

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Abstract

This article fills a gap in the international academic literature, regarding security and safety at work in sheep farms, as well as the main health problems of workers in this type of farms in Romania. The issue of safety and physical and health of sheep farm workers has been little studied in general. The issue of health and safety at work on sheep farms is presented from a multi-actor perspective, promoted within the Safe Habitus project. To identify the main needs and work risks in sheep farms, as well as the causes of workers' illnesses, qualitative research was carried out based on observations, workshops, semi-structured interviews and visits to sheep farms. The main results refer to negative experiences from current activity in sheep farms; needs of the workers; the risks of worker injury and illness and the main health problems. In the current activity of sheep farms, workers (sheep owners or employed staff) face various negative experiences related to work in variable weather conditions, waking up in the morning, early involvement of children in the farm activity, a negative image of shepherds'children. Workers in this activity sector have a large series of specific needs: increased support for small farmers, the lack of labor force, especially the qualified one, lack of identity documents of temporary workers and refusal to work in a legal framework, the distribution of communal pastures in relation to the livestock owned by breeders, lack of school education on occupational safety. The workforce on sheep farms is prone to illness due to hard work and long hours, lack of protective equipment, handling chemicals, outdate equipment and animals, living conditions and poor hygiene. The identified health problems are closely related to lifestyle: alcoholism, rheumatism, digestive problems and diseases of the spine. National and international programs and regulations are needed that also consider the social aspects of sheep farm work, as well as the introduction of farm work safety education at all levels of education.

Key words: *workforce, safety, security, healthy problems, sheep farming*

INTRODUCTION

The issue of health and safety in agriculture and animal husbandry work in Romania should concern researchers in the field, considering that Romania ranks first in the E.U. regarding the large number of people employed in agriculture. Agriculture is one of the employment sectors that involves major health and safety risks in Europe.
The analysis of the structure of the population employed in agriculture in Romania shows an accentuated aging process. Ever since the early 2000s, people aged 55-65 and over represent around 55% of the total number of workers in agriculture [11]. A report from the European Commission shows that there is a marked aging of the agricultural workforce in Romania, respectively, over 44% of people over 65 years old [4].
With 13.5 million hectares of land used for agriculture [4], in Romania, agriculture is an essential part of the rural economy, providing jobs and income for locals and generating food products needed by the entire population [10].
The sheep breeding sector in Romania has a thousand-year tradition, being the source of income for many families, which has determined that the country to be ranked the 2nd in the EU in recent years, from the perspective of the sheep herd owned (10,087,400 heads in 2021) (Figure 1).

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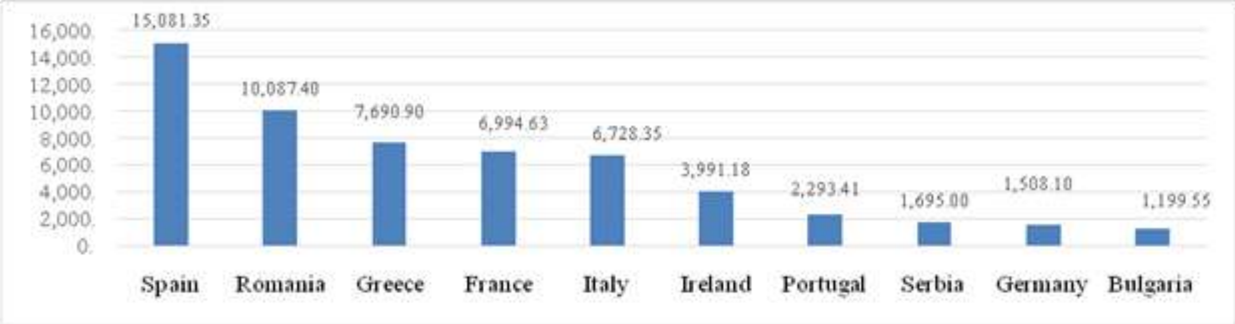

Fig. 1. The number of live sheep registered in 2021 in top 10 EU states (thousand heads animals)
Source: Own design based on [6].

Working on a sheep farm involves diverse and multiple tasks (starting from the production and preservation of fodder, animal care, valorization of production, etc.), which also makes the risks and health problems quite high compared to other fields of activity.

The study published by Coman et al (2024) highlights the general tendency in Romania to reduce the area cultivated with the main agricultural crops and the labor force in agriculture [3].

The most important skills needed by today's agricultural workers are digital skills and knowledge of modern farming practices. In addition, workers must have skills of effective communication, teamwork, environmental protection and knowledge of agricultural legislation [7]. The demand of the agricultural labor market places an increasing emphasis on well-established digital skills, competencies and professional experience [9]. For a sustainable and efficient agriculture, change, innovation and technology are essential [18].

The current age structure of the rural population, the differences in the quality of life between urban and rural areas, as well as the existence of better-paid jobs in urban areas, make the attractiveness of agricultural jobs limited [14,15,17].

Several elements contribute to the employment structure within a country, and opportunity structures certainly influence how people assess the attractiveness or unattractiveness of various employment sectors.

According to the data published by Mărcuță et al (2023), on January 1, 2022, the population employed in agriculture, forestry and fishing in Romania was 846,500 people, predominantly male [12].

Labor productivity in agriculture depends on several factors, such as: land use, farm structure and size, technological equipment, production technologies, demographic structure and demographic changes occurring in rural areas [16]. About 90% of the approx. 3.5 million existing farms in Romania use less than 5 ha and are subsistence farms [4].

The age structure of the total population of 2,887 million people implied in agriculture in Romania indicates an aging population and a very low interest among younger generations in working in agriculture (Figure 2).

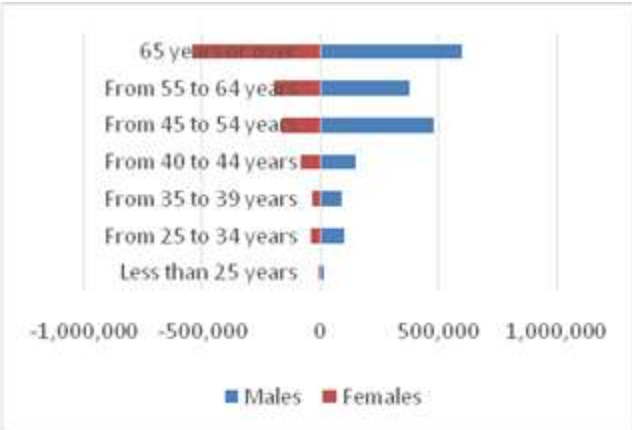

Fig. 2. The age structure of the people employed in agriculture in Romania
Source: own design, after [5].

Choi et al (2024) classified the causes of accidents in agricultural work environments, using an innovative technique, the 4M tool (machine, media, man, management). The purpose of this technique was to suggest the main directions for the creation of prevention measures. The authors pointed out that there are few studies on the causes of accidents in agricultural work. The most common causes identified are: improper handling of agricultural machinery, working in poor conditions, insufficient education and lack of legislation and regulations [2].

Wheeler and Nye (2024) shows that there are very few studies investigating farm accidents or farm health and safety risks among women. Among the causes identified are: long working hours, manual work, work with animals, underestimation of injury risks and lack of training [19].

A study of 313 dairy farms in Ireland to identify factors that contribute to a better working environment for farmers shows that social sustainability on farms is particularly important. It is influenced by the type of farm and its characteristics, the structure of the working day, the attitude of the farmer, the facilities on the farm, current work practices and human resource management [8].

To educate teenagers about farm accident prevention, researchers in Australia have developed an interactive educational game platform that also contains more than 50 lessons. It can be included in the school curriculum, can be completed in the classroom or from home using the mobile phone [13].

The article employs a social science-specific approach to produce empirically based knowledge relevant to understanding the status of safety and security in agricultural work, and the main health issue, with attention given to the sheep farming sector in Romania.

MATERIALS AND METHODS

The research is based on: bibliographic study of the national and international specialized literature on the security and safety of work in farms, as well as the health of agricultural workers; observations of the authors made on the occasion of 3 workshops on the topic of security and safety in work on sheep farms; observations and field visits made to sheep breeding farms in Sibiu County; interviews conducted with members of a community of practice (CoP) which is made up of people representing different stakeholders in this field.

Within the SafeHabitus project, a community of practices (CoP) was established, it includes stakeholders interested in the topic of occupational safety and security, and the health of workers in sheep farms in Sibiu and Brașov counties, Romania. The community of practices includes representatives of local administrations, sheep breeders' associations, farmers, researchers and teaching staff from high school and university education.

To deepen the research regarding work in sheep farms, five semi-structured interviews were also carried out in year 2023 with some of the members of the CoP. The Romanian CoP administrator carried out five interviews with representatives of the CoP CG, including three representatives from the private, one from the public sector, a researcher, and an end user. The interviews were transcribed by two researchers, and the results obtained were analysed, systematized and allowed drawing some conclusions.

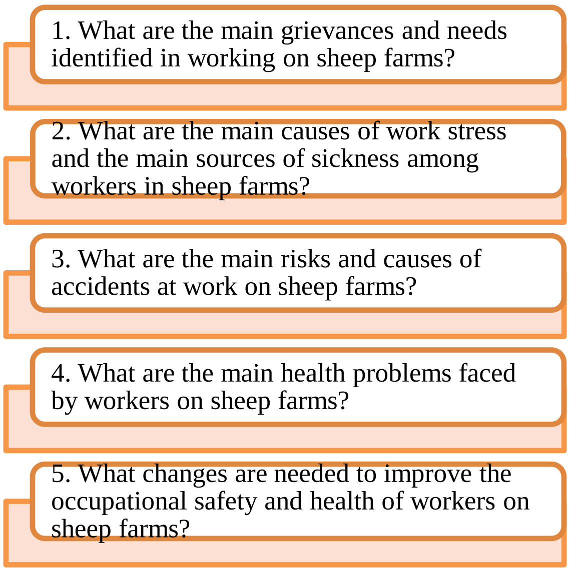

Fig. 3. Research questions
Source: own design.

Several visits were made to sheep farms in Sibiu County, identified in such a way that the number of animals in the farm is greater than 500 heads.

Within this general research framework, we are primarily interested in answering the **research questions** (Figure 3)**.**

RESULTS AND DISCUSSIONS

Results obtained from CoP meetings

Within the CoP meetings, three workshops were organized in the 2023-2024 interval. Some of the main preliminary conclusions drawn during the CoP meetings are presented below.

The main dissatisfactions/negative experiences identified are: the impossibility of capitalizing on wool production; waking up very early in the morning; milking in adverse weather conditions; the involvement of sheep children in farm work from a very young age; the negative perception of the urban community regarding sheep farming and sheep'schildren; the need to stay home during the holidays over the year, while the employees spend the holidays with their families; sheep owners work "continuous flow" and must be permanently present on the farm; sheep owners must put employees first, at the expense of their own family; the best shepherds go to work on farms abroad, where they are paid very well; the risk of being accused of poaching, when defending against the attack of large carnivores; there is an extremely low ratio of children from sheep breeders' families, who choose to continue the family tradition; negative perceptions of association/cooperation due to frequent conflicts between sheep owners or between sheep owners and the local community.

In countries with a high rate of poverty, the use of child labor in farms is a current problem. Various interventions aimed at reducing the proportion of children working in agriculture have been tested. The most effective interventions provided livelihood support, educational programs and public awareness campaigns [1].

The main identified needs are: supporting small farmers, difficulties in finding human resources, lack of qualified workers in the field; the lack of responsibility of the employees, who have to manage significant resources (large herds with high economic value or substantial machinery); inconsistency between the actual number of animals and its reporting; the re-appropriation of communal pastures should be done in proportion to the size of the sheep herd; educating the shepherds to regularly go to the doctor, lack of health insurance and sometimes also of identity documents for employees; lack of education among employees; the reluctance of shepherds to engage with a work contract, which would also lead to the need to assume responsibility at work; the lack of merging of lands makes it impossible to apply rational grazing, parcelled it by using the help of an electric fences; lack of training in general school on issues of labor and fire protection.

Figures 4 and 5 show the main causes of workstress on sheep farms and the main causes of illness.

Fig. 4. Causes of stress in the work carried out on sheep farms
Source: own design based on CoP meetings observations.

Figure 5 presents the situation of illness in work on sheep farms. The main causes are the long work time in the farm during the day and every day of the week, handling chemicals which could affect skin quality, inadequate work equipment, poor hygiene, stress and high risk to contract animal diseases.

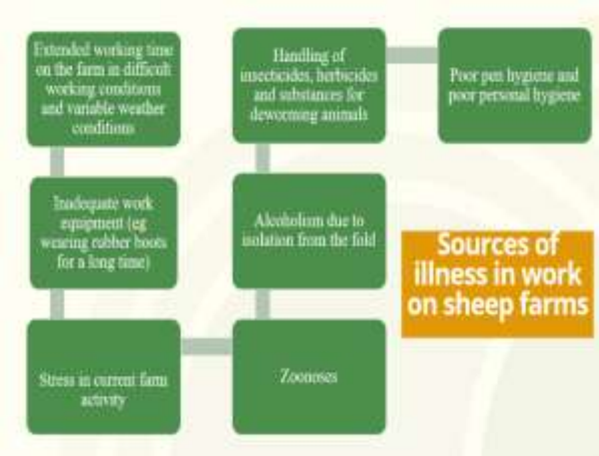

Fig. 5. Sources of illness in work on sheep farms
Source: own design based on CoP meetings observations.

Figure 6 shows the risks and causes of work accidents in sheep farms.

Fig. 6. Risk and causes of work accidents in sheep farms.
Source: Own design based on CoP meetings observations.

The main health problems identified refer to: alcoholism, rheumatism, lung diseases, parasites, digestive problems (ulcers, gastritis), lumbar or cervical disc herniations due to heavy lifting.

In the case of shepherds, who spend a lot of time with the sheep, being isolated from the community, there is a risk of developing behaviours that, in the long term, have a harmful effect on health: alcoholism, excessive smoking and ignoring health problems. In addition to these, living in improper conditions during the grazing season, lack of adequate protective equipment during rainy periods, lack of medical insurance as show in Figures 7, 8, 9, 10, 11 and 12.

Fig. 7. Caravan used by shepherds during sheep grazing (Sibiu County)
Source: own picture based on field study, 2024.

Fig. 8. Shelter for shepherds during sheep grazing (Sibiu County)
Source: Original picture based on field study, 2023.

Fig. 9. Shelter for shepherds during sheep grazing - exterior details (Sibiu County)
Source: Original picture based on field study, 2023.

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Fig. 10. Living conditions during grazing (Sibiu County)
Source: Original picture based on field study, 2024.

Fig. 11. Living conditions during grazing: Interior details (Sibiu County)
Source: Original picture based on field study, 2024.

Fig. 12. Place for rest in the sunny days
Source: Original picture based on field study, 2024.

Types of sheep farms identified are: with continuity over generations; without continuity between generations, in which the children of the shepherds choose to practice other jobs in various fields; with continuity throughout the generations, in which the children of the shepherds choose to study in the agricultural field, to have advantages in accessing European funds.

Fig. 13. Sheltering the sheep in the forest during the afternoon (Sibiu County)
Source: Original picture based on field study, 2024

Fig. 14. Young farmer continuing sheep growing (Sibiu County)
Source: Original picture based on field study, 2024.

Results obtained from the interviews
The main needs identified:

• Many farm workers do not have health insurance, leading to delays in seeking medical care due to financial constraints.
• Emphasizing preventive healthcare through collaboration between GPs and local authorities can help raise awareness and tackle health problems before they escalate.
• Awareness of increasing health and safety issues among farmers, including the importance of health insurance and compliance with legislation. Integrating these topics into school curricula and using different communication channels can raise awareness.
• Improving/renovating machinery and adopting modern farming practices can

significantly reduce health and safety risks. Financial constraints and resistance to change are significant challenges.

• Addressing poor living conditions, especially for pastoralists working in remote areas. Provision of adequate temporary shelters, hygiene facilities and protection from wild animals.

• Improving health and safety education and training programs, including sharing the stories of those with experience in the sector.

• Encouraging collaboration and dialogue between farmers, local authorities and agricultural associations to implement comprehensive solutions and address cultural barriers to change.

The main priorities identified are:

• There is consensus among CoP members that safety and health issues receive inadequate attention in agricultural education. This gap is particularly pronounced in specialized agricultural schools and universities (and primary and secondary schools in communities with many farmers have similar problems).

• Much of the knowledge about safety and health in agriculture comes from hands-on experience, experience on the farm and working with other family members, and interactions within the farming community (prevention culture is lacking at all these levels)

• There is an urgent need for comprehensive training programs covering various aspects such as handling machinery, animal interactions, fire safety and risk assessment.

• Limited financial resources prevent investment in modern equipment and machinery that could mitigate safety risks.

• The nature of agricultural work, including constant contact with animals, working in poor conditions and exposure to extreme weather, presents unique safety and health challenges.

• Resistance to modernization, both in terms of equipment and mindset, is a significant barrier to improving safety standards. Traditional practices are deeply rooted, and convincing older farmers to adopt new methods is a challenge.

• There is a need to raise the general level of health and safety concern among sheep farmers and field workers.

• Awareness campaigns and visits to breeders should be funded and organized to explain the importance of legalizing agricultural work.

CONCLUSIONS

The most important reasons for practicing sheep farming are passion for raising sheep; sheep house breeding efficiency, recorded in large herds; the possibility of exploiting local resources and productions; employees who work for 1-2 years, to accumulate the necessary capital to create their own farm.

Based on the findings from the interviews, the focus of the CoP in Romania seems to be to bridge the gap between traditional agricultural practices and modern safety standards, prioritizing education and the need to adapt school curricula to all levels of education. Thus, in high schools and specialized faculties, it is necessary to train young people in this field and to collaborate to improve the well-being of agricultural workers, respectively, mitigating the occupational risks identified in the agricultural sector, especially in sheep farms. The most severe health risks for workers on sheep farms are possible accidents related to the handling of machinery, risks of animal handling, intensive work regime and varied weather conditions, high volume of physical work and health problems mental. Even though the activity on sheep farms is demanding and there are many dissatisfactions/negative experiences and many identified needs, a generational change is still observed in this field, which determines the change in mentality and openness to the use of new technologies and high-performance equipment. Knowing the specifics of the problems of work in sheep farms can contribute to the development of programs and projects, as well as public policies that lead to the improvement of the quality of life of workers in this field. To increase the attractiveness of the agricultural sector, in the current context of the shortage of personnel in agriculture and the growing need for technology, a social dialogue is necessary on the entire agri-food chain. The future Community Agricultural Policy must pay more attention to the social dimension of agriculture.

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A STUDY OF ROMANIAN CONSUMERS' FOOD PURCHASING, CONSUMPTION BEHAVIOR, AND MOTIVATION TO AVOID AND REDUCE FOOD WASTE

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Abstract

The issue of preventing and reducing food waste (FW) at the household level is of paramount importance and must be analyzed in relation to food purchasing, handling, and consumption habits. This study examines food purchasing and consumption habits in the context of food waste avoidance, among consumers in Romania. An online survey (N = 369, 67.21% women) was conducted to analyze food purchasing and consumption behavior, shopping planning routines, and food waste avoidance behavior. The average age of the respondents was 30.22 years. The collected data was analyzed, processed, and interpreted. Main findings: In 76% of the households surveyed, some of the food needed is produced in the household. The primary source of food supply is the hypermarket, regardless of the food category. About 84.55% of consumers cook at home very frequently and eat meals with their families. The highest scores for shopping planning routines were recorded for the habit of checking food stocks (3.82) and creating a shopping list (3.32). Nearly half of the respondents are responsible for both food purchases and cooking at home. Personal motivation for reducing food waste primarily involves assuming social responsibility (3.92), followed by concern for the environment. Over 87% of consumers believe that a national policy is necessary to implement educational and informational programs and projects aimed at preventing and reducing food waste.

Key words: *consumer behaviour, food purchase, food consumption, food waste, sustainability*

INTRODUCTION

Demographic forecasts suggest that the global population will reach approximately 9.8 billion by 2050. Sustainable Development Goal 12.3 (SDG 12.3) aims to halve food waste (FW) by 2030 in the retail, HoReCa, and consumer household sectors. Many researchers argue that halving food waste, both in retail sales and in households, by 2030 will significantly contribute to meeting humanity's future food needs [14, 36]. In EU in 2022, the global level of food waste was approximately 132 kg per capita per year [43]. FW at the consumer level is a significant issue with substantial environmental, economic, and societal impacts [11,15], with various factors influencing its volume. A study conducted by Dumitru and colleagues (2021) among 991 urban respondents showed that FW decreased from 10.5% in 2016 to 6.5% in 2020 [16].

FW results from a combination of behaviors learned over a lifetime, related to eating habits and food management. The level of FW in households depends on motivational factors and skills related to food acquisition, handling and consumption [42, 44].

Avoiding food waste is closely linked to aspects such as the appearance of food, ease of preparation, taste quality, and health effects. Educating consumers to purchase suboptimal fruits and vegetables, thus contributing to the reduction of food waste, can be achieved using targeted messages [2].

The volume of food waste is most often correlated with the food category (for example, fresh fruits and vegetables generate higher levels of waste due to their external appearance, as perceived by consumers in terms of shape, color, size, perceived freshness, etc.) [46], and the place where the food is purchased (supermarkets, farmers' markets, greengrocers, organic product stores, organic or conventional product stands in supermarkets, etc.) [43].

In developed countries, with a culture based on increasing consumption and where citizens have significant purchasing power, retailer campaigns have a considerable impact on food waste by encouraging excessive purchases [10].The methods used to estimate FW levels must be relevant, representative, and easy to apply [47].The methods used to estimate the volume of FW should also allow for the measurement of interventions aimed at reducing it [45].

In Romania, on March 15, 2024, the Law for the Amendment and Completion of Law No. 217/2016 regarding the reduction of food waste was promulgated. This law provides consumers with the opportunity to purchase food at reduced prices before its expiration date, and it also facilitates the donation of long-lasting food to non-governmental organizations [23].

In addition to national legislation, there are local and regional initiatives aimed at reducing food waste. These initiatives include programs for collecting and redistributing unsold food to disadvantaged people, food waste composting projects, and public awareness campaigns about the impact of FW. Numerous NGOs have implemented projects designed to reduce FWthrough food solidarity programs, educational meetings within local communities to utilize surplus food from markets, shops, or consumers, the redistribution of unsold fresh fruits and vegetables from markets to families with special needs, the operation of social stores, and the information and education of students and local communities [4]. The use of mobile phone applications also contributes to encouraging sustainable consumption habits and reducing FW at the end of the food supply chain [26, 39]. Digitalization at all stages of the food supply chain will help address the challenges the global food system will face by 2050, in the context of food security and safety [18].

The main causes of FW identified in Romania relate to a lack of shopping planning, purchasing excessive amounts of food that end up being thrown away, the lack of selective waste collection and recycling of household waste, and the low impact of current FW prevention campaigns [6].

Reducing FW requires a collective effort from all stakeholders, as it is a sum of individual decisions [9], with targeted actions focused on specific consumer types, considering their eating habits and food waste levels [36]. Wang et al. (2023) draw a correlation between the effect of campaigns promoting healthy diets and the volume of FW, showing that these campaigns only lead to a reduction in food waste among middle-aged consumers [48].

The behavior of Romanian consumers regarding food purchasing and consumption in the context of avoiding FW has been translated into an index that measures the intention to avoid food waste [13], highlighting the need for consumer education and awareness and the absence of a national culture of prevention.

The need for educating and raising awareness among household consumers about the environmental, economic, and social effects of sustainable food consumption and FW is highlighted by other authors as well [9, 24, 25, 28, 37, 38, 39, 41]. A recent study reports the segmentation of household consumers in the context of FW based on different characteristics, such as: gender, age, motivation, involvement, and environmental concern [34].

Any type of educational intervention or consumer awareness campaign requires monitoring and evaluation of effectiveness, through the concrete quantification of FW reduction or changes in behavior aimed at reducing food waste [8].

In the retail sector, there are an increasing number of initiatives to reduce FW, a trend observed in annual sustainability reports [21]. In this sector, most actions undertaken to reduce FW focus on corporate social entrepreneurship [7].

In the public catering sector, the goal is to optimize technological flows so that special attention is given to optimizing portion sizes, dining space, and meal service schedules, with the aim of minimizing the volume of FW associated with each served portion [1, 17, 20, 22].

The aim of this study is to identify the level of knowledge among household consumers regarding FW and their behavior related to food purchasing and consumption to avoid food waste. To achieve this, three objectives were established:

RO1. Identifying the food purchasing behavior and consumption in households.
RO2. Identifying the routines for food planning and purchasing and understanding the respondents' status regarding food purchase and preparation in the household.
RO3. Identification of FW behaviour: categories of FW, quantification and ways of valorisation, attitude towards FW, personal motivation to reduce FW.

MATERIALS AND METHODS

Study Design

The study is based on an online survey, conducted among a sample of over 370 domestic consumers in Romania. The questionnaire used was first distributed to students from the Faculty of Agricultural Sciences, Food Industry and Environmental Protection from the "Lucian Blaga" University in Sibiu. They in turn distributed it to other members of the household of which they are a part. The final sample size was 369 consumers with ages ranging from 18 to over 65 years. The respondents were informed about the study's aim and data protection (GDPR). The survey included socio-demographic data and specific questions about food consumption and the prevention and reduction of FW in the national context. It was developed based on the consultation of specialized literature from the Web of Science Core Collection database, various secondary sources, and based on original research ideas. There is still no tradition in Romania of research on this subject. Most of the questions included a 5-point Likert scale for recording responses, and the questionnaire also collected standard socio-demographic information. For data processing, Excel software, v.365 Microsoft Corporation, Redmond, WA, United States, was used.

Table 1 shows the main and secondary objectives of the study.

Table 1. Main and secondary objectives of the study

Main objectives
O.1. Identifying food purchasing behavior and household consumption
O.2. Identifying food planning and procurement routines and finding out respondents' status related to household food procurement and preparation
O.3. Identification of FW behavior: categories of FW, quantification and ways of valorisation, attitude towards FW, personal motivation to reduce FW
Secondary objectives
O.1.1. Origin of food, frequency of purchase and preferred place of purchase
O.1.2. The preparation of the food and the location of its serving
O.2.1. Food purchase planning routines
O.2.2. Food purchasing routines
O.2.3. Status of the respondent in the family in relation to the purchase and preparation of food in the household
O.3.1. Determining the categories of food wasted and the amount of FW per assortment (self-report)
O.3.2. Capitalizing on FW
O.3.3. Moral attitude towards FW
O.3.4. Subjective norms to FW
O.3.5. Assessment of the intention not to throw away food

Source: own design.

Study Participants

The questionnaire was completed by more than 375 individuals residing in 27 Romanian counties and the municipality of Bucharest. A total of 369 respondents submitted complete responses, which were analysed for this study. Out of the total number of respondents, 221 people (approximately 60%) live in Sibiu County. The analysed sample presents the following socio-demographic data: 67.21% of respondents are female; 68.56% live in urban areas; 76.1% are aged between 18 and 40 years; the average age of respondents is 30.22 years; 53.9% have a secondary education; for 55.28% of respondents, the family consists of 3 or 4 members; the net monthly family

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income for 50.14% of individuals is between 1,000 and 2,000 euros; 49.32% of respondents reported that their monthly spending on food purchases ranges between 200 and 400 euros.

RESULTS AND DISCUSSIONS

RO1. Identifying the food purchasing behaviour and consumption within the household

Origin of the food consumed by the family

As shown in Figure 1, 24% of respondents stated that their family does not produce food. For the remaining 76%, food is produced within the household in varying proportions.

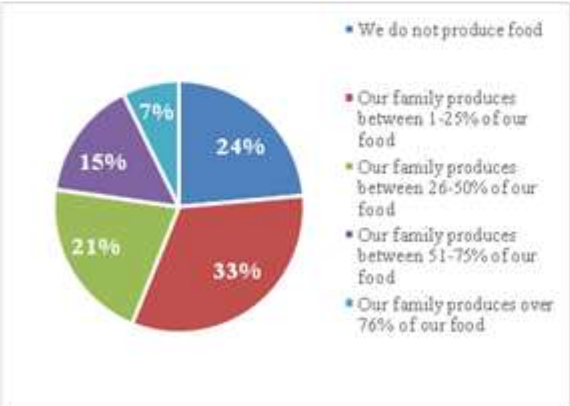

Fig. 1. Origin of food consumed in respondents' households
Source: own design.

In approximately 33% of households, between 1-25% of the current food needs are produced; in 21% of households, between 26-50% of the required food is produced; 15% of households produce between 51-75% of their food; and 7% of households produce more than 76% of the food they consume.

Frequency of food purchases in the household

Approximately 40% of respondents typically purchase food once a week, while 47.70% buy food two-three times during the week. 39.84% used to buy food once a week.

There are also a few respondents (6.50%), who prefer to buy food daily, and also a few individuals who boy food every two weeks (5.96%) (Table 2).

Table 2. Frequency of food purchases in the household

How often do you purchase food for your household?	Frequency (no.)	Proportion (%)
Daily	24	6.50
Once a week	147	39.84
2-3 times/week	176	47.70
Once every 2 weeks	22	5.96
Total	**369**	**100**

Source: own design.

Preferred location for food purchases, by type of product

Although the hypermarket is the preferred place for food purchases, there are differences regarding the purchase location for various food categories. The sources of food, depending on the category, are as follows:

-**Milk and dairy products**: preferred to be purchased from hypermarkets (52.85%), from farms, directly from producers (16.80%), from local producers' shops (10.30%); specialized stores (8.40%); agri-food market (6.78%); neighborhood shop (4.87%);

-**Meat and fish products**: preferred to be purchased from hypermarkets (45.53%), followed by specialized stores (23.31%); local producers' shops (12.74%); from the farm, direct from the producer (10.57%); agri-food market (5.69 %); and neighborhood shop (2.16%);

-**Vegetables and fruits**: preferred to be purchased from hypermarkets (39.57%), from the farmers' market (31.17%), or from farms, directly from producers (9.21%); local producers' shops (7.05%); specialized stores 6.5 %) and neighborhood stores (6.5 %);

-**Bread and bakery products**: mostly purchased from hypermarkets (37.13%), specialized stores (24.39%); local producers' shops (16.53%); neighborhood stores (15.99 %); from the farmers' market (3.25%), or from farms, directly from producers (2.71%);

-**Other food products**: mostly purchased from hypermarkets (75.08%); specialized stores (6.23%); from local producers' shops (6.50%); neighborhood stores (5.42 %); from farms, directly from producers (3.52%); agri-food market (3.25 %).

Where food is cooked and consumed

As expected, 84.55% of respondents stated that they cook at home and frequently eat the prepared food with their family (Figure 2).

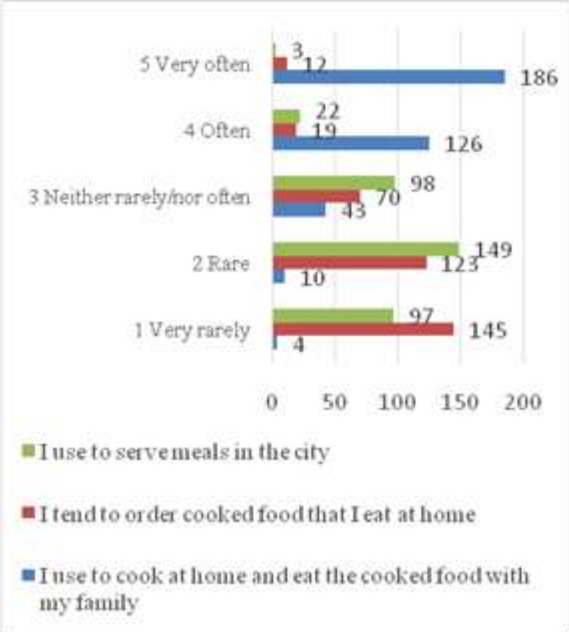

Fig. 2. The place where food is cooked and consumed
Source: own design.

At the same time, 72.62% of respondents stated that they very rarely or rarely order prepared food to consume at home with their family. Generally, prepared food is consumed outside the home rarely or very rarely (66.66%).

RO2. Identifying food planning and purchasing routines and understanding respondents' status regarding food purchasing and preparation in the household

Food purchase planning routines to avoid FW

The assessment of these routines was carried out using a 5-point Likert scale.

As shown in Table 3, the highest score (3.82) was recorded for checking the food stock before going shopping, followed by making a shopping list before going shopping (3.32). On the other hand, it is noticeable that respondents do not usually plan their menu for the following week or purchase food based on this plan (average score of 2.61) as presented in Table 3.

Table 3. Average score recorded for food purchasing routines

Food purchase planning routines	Average Score
How often do you usually make a shopping list before going food shopping?	3.32
How often do you check your household food stock before going shopping?	3.82
How often do you usually plan the menu for the upcoming week before going shopping?	2.61
How often do you think you buy more food than you need when you go shopping?	3.08
When you go shopping, how often do you buy categories of food that you didn't consider necessary?	2.79

Source: own design.

Respondent's Status in the Family Regarding Food Purchasing and Preparation in the Household

Although they are young, 51.76% of respondents stated that they are the person responsible for purchasing food in their own household. Almost half of them (47.96%) are also responsible for preparing the cooked food (Table 4).

Table 4. Average Score Recorded Based on Status Regarding Food Purchasing and Cooking

Respondent's Status Regarding Food Purchasing and Cooking	Average Score
Are you the person responsible for purchasing food in your family?	3.47
Are you the person responsible for cooking meals in your family?	3.14
Are you the person responsible for both purchasing and cooking food in your family?	3.12

Source: own design.

A study conducted among 1,700 household consumers in Australia shows the effectiveness of educational programs aimed at improving cooking and food storage skills at the household level, which can significantly reduce food waste [3].

RO3. Identifying behavior regarding food waste (FW): categories of FW, quantification and ways of valorization, attitude towards FW, personal motivation for reducing FW

Self-reported food waste volume by food category

As shown in Figure 3, the volume of food waste varies weekly depending on the food category:

-**Milk and dairy products:** 40.38% of respondents do not throw away any at all; 39.57% throw away less than 10%; 12.47 % throw away between 11-25 %; 5.15 % throw away between 26-50 %, while 2.43 throw away over 51%.

-**Meat or fish products**: 43.09% of respondents do not throw away any of this category of food; 38.75% throw away less than 10%; 11.92 % throw away between 11 and 25 %; 3.80% throw away between 26 and 50 %; only 2.44% of those surveyed throw away more than 51%.

-**Vegetables and fruits**: More than half of the respondents (50.14%) stated that they throw away less than 10%; 16.80% do not throw away any fruits or vegetables at all; 22.76% throw away between 11 and 25 %; 7.86 % throw away between 26 and 50 %; and 2.44 % more than 51% of the foods in this category.

-**Bread and bakery products**: 20.05 % do not throw away; 43.63% of respondents throw away less than 10% of the leftover bread and bakery products; 20.05% of respondents reported that they throw away between 11 and 25 %; 12.20 % throw away between 26 and 50 %; and 4.07 % throw away over 51%.

-**Cooked food**: 16.53 % do not throw away; 42.82% of respondents throw away less than 10% of leftover cooked food; 25.20% throw away between 11 and 25 % of any cooked food; 10.57% throw away between 26 and 50 % of cooked food; 4.88% throw away more than 51 % of the cooked food.

By food category, respondents do not throw away milk and dairy products at all (40.38%); meat and fish (43.09%); bread and pastries (20.05%); fresh fruits and vegetables (16.80%) and cooked food (16.53%).

At the opposite pole, more than 50% is thrown away by the respondents' families in the case of cooked food (4.88%); bread and pastries (4.07%); respectively, 2.44 % for each of the category's milk and dairy products, meat and fish, respectively, fresh fruit and vegetables.

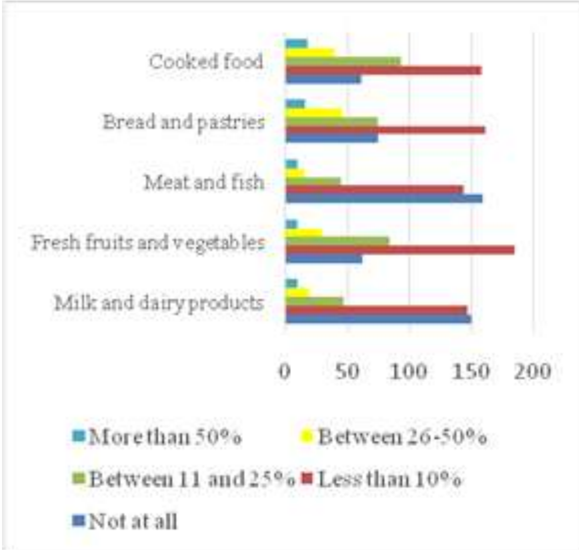

Fig. 3. Quantification of FW by food category
Source: own design

Cooked food, which changes its taste after several days of storage, is thrown away most often (average score 2.44), followed by bread and bakery products (average score 2.37), and fresh fruit and vegetables (average score 2.29). Moroșan et al. (2024) reported the following proportion of food waste by food category: 29.67% for cooked food, 27% for bread and bakery products, and 14.33% for fruits and vegetables [29]. Nijloveanu et al. (2024), following a study conducted among 300 consumers, reported between 0% and 20% of food being thrown away from the total purchased [33].

Valorization of FW

Figure 4 shows what happens to the food that is thrown away. Under a third of respondents (27.64%) state that they throw uneaten food scraps in the trash.

Almost 40% (39.30%) of them use food scraps as animal feed, and 27.10% sort them separately, as biodegradable household waste. Those who convert FW into compost have a low share (5.96%). These results justify us to claim that there is a need for practical demonstrations of composting and using various household waste.

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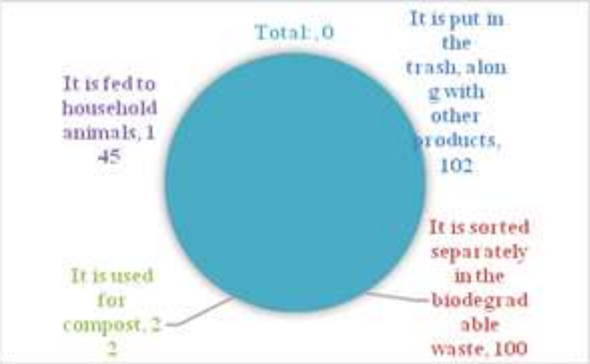

Fig. 4. Utilization of uneaten food (n=369)
Source: own design.

Almost 40% (39.30%) of them use food scraps as animal feed, and 27.10% sort them separately, as biodegradable household waste. Those who convert FW into compost have a low share (5.96%). These results justify us to claim that there is a need for practical demonstrations of composting and using various household waste.

Moral Attitude Towards FW

In Table 5, it is shown on a scale from 1 to 5 that the highest score was accumulated for the statement "I feel guilty when I throw away food," which demonstrates an awareness that wasted and uneaten food ends up being discarded (average score 4.12).

The second highest score (4.11) indicates an awareness that there are people who have nothing to put on the table while others throw food away.

Table 5. Average Score Recorded Regarding Moral Attitude Towards FW

Moral Attitude Towards FW	Average Score
I feel guilty when I throw away food.	4.12
I care about the impact that the food I throw away has on the environment.	3.96
I am concerned about the amount of food I throw away.	3.58
I am concerned that other people don't have enough food, while I throw away food.	4.11
I care about the cost of the food I throw away.	3.88

Source: own design.

Respondents are then somewhat more concerned about the impact of food waste on the environment (3.96) and the cost of discarded food (3.88). The lowest score (3.58) was recorded for concern about the amount of food wasted.

Assessment of Subjective Norms

In Romania, there is a complete lack of a culture of food waste prevention, as evidenced by the subjective norms that can influence it. As shown in Table 6, the average scores recorded for subjective norms are below 3, indicating that respondents are less influenced by the opinions of important people in their lives regarding food waste. Ștefan et al. (2013) conducted the first impact study among Romanian consumers, showing that a change in food purchasing planning routines and buying habits is necessary, with a subsequent effect on food waste reduction [41].

Table 6. Average score recorded regarding subjective norms

Subjective Norms	Average Score
Most of the important people in my life disapprove of the fact that too much food is cooked/prepared in our household.	2.67
Most of the important people in my life disapprove of the fact that food is thrown away in our household.	2.82

Source: own design.

Assessment of the intention not to waste food

The responses regarding the intention not to waste food recorded an average score of 4.13 on a scale from 1 to 5. As shown in Figure 5, over 75% of respondents try not to throw away uneaten food.

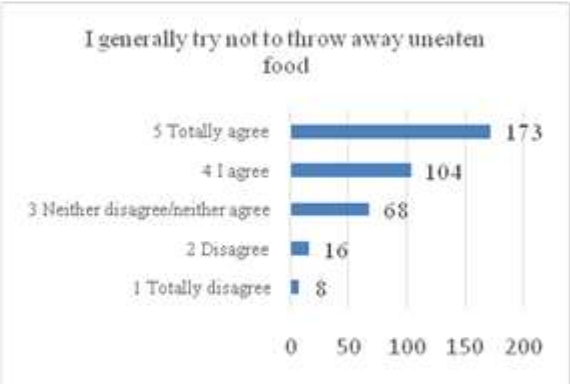

Fig. 5. Assessment of intention not to throw away food
Source: own design.

Approximately 61.52% of respondents stated that they have heard of awareness campaigns

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that teach them specifically what they should do to reduce FW in their households. In 83.20% of households, discussions have been held about the need to reduce FW, and 89.70% said they have considered taking concrete actions to reduce FW in their household.

Personal motivation for reducing FW recorded an average score of 3.97 (on a scale from 1 to 5) in relation to taking on social responsibility, 3.93 in relation to concern for environmental quality, and 3.90 in relation to the potential to reduce food purchasing expenses.

Assessment of the importance of national policies aimed at promoting the reduction of food waste

Most respondents (87.26%) believe that it is important for Romania to implement a national policy to encourage the reduction of food waste (Figure 6).

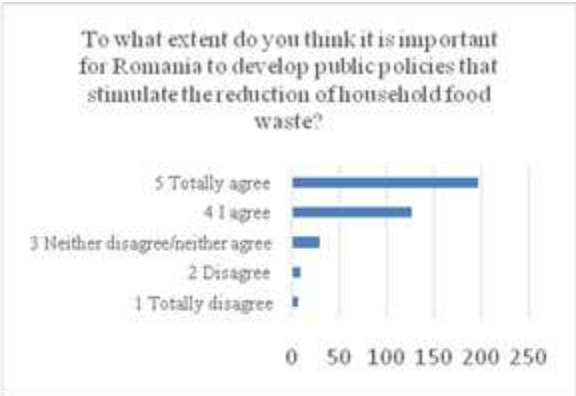

Fig. 6. Assessment of the importance of a national FW reduction policy
Source: own design.

On a scale from 1 to 5, the average score recorded for this item is 4.34.

A recent study published by Baran et al. (2024) shows that, in organizing awareness campaigns on avoiding and reducing FW, it is important to consider environmental concerns and the religion target group [5].

Educational strategies and programmes should highlight aspects related to environmental quality, sustainable food production and consumption behaviours [12,19, 40, 49].

Awareness campaigns on reducing food waste should also promote sustainable production and consumption practices [27], and the role that civil society can play in their implementation is crucial [30]. Additionally, there is a need for easily implementable government policies [32].

The issue of food waste requires a holistic approach and the involvement of various stakeholders [31].

Halving FW in the coming years can contribute to the creation of a "zero waste" societal culture and a circular economy. Preventing FW reduces food insecurity and remains the key to solving the problem [35].

CONCLUSIONS

Moral attitude significantly influences the intention of Romanian consumers to avoid FW, primarily in relation to societal needs, followed by concern for the quality of the environment. This also correlates with the results obtained regarding personal motivation to make efforts to avoid FW. Personal motivation is given by assuming social responsibility through food consumption, thereby reducing global food safety and security issues and negative environmental impact.

Reducing FW requires a holistic approach, integrating all stages of the food supply chain, educating, informing and raising awareness among household consumers and implementing innovations in food production and consumption practices. In order to improve the sustainability and resilience of the agri-food chain, transformative changes in production and consumption practices are needed, based on regional, national and international policies and plans.

To reduce food waste, information campaigns are needed to promote sustainable consumption, focus on the quality attributes of food, and improve consumers' skills in cooking and preserving food, as well as in accurately estimating their own food consumption. Actions aimed at raising awareness among households about the importance of avoiding and reducing food waste should include aspects related to the waste of all inputs used in food production.

In Romania, there is still insufficient data on food loss and waste, highlighting the need for future national studies on this topic.

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ESTIMATING THE IMPACT OF INVESTMENTS IN INNOVATION ON THE PERFORMANCE OF AGRICULTURAL ENTERPRISES: THE CASE OF THE REPUBLIC OF MOLDOVA

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Abstract

The objective of this research is to ascertain how investments in innovations impact the performance of agricultural enterprises in the Republic of Moldova. Based on this analysis, the research will then argue the significance of investments for the economic prosperity of the given branch. In order to achieve the proposed goal, the following tasks were performed: a synthesis study of research in the field of innovation management and its impact on enterprise performance; quantifying the impact of investments in innovation on the gross profit as a relevant indicator of the enterprise performance. From a methodological point of view, it was made a bibliographical study and then it was conducted an opinion survey via semi-structured thematic interviews with a sample of 66 managers and specialists from agricultural enterprises. Also, it was used mathematical modelling of the cause-and-effect relationship between the volume of investments in innovations and gross profit through the application of the linear regression method, and the processes of inference and generalisation. The research findings revealed that 92% of the survey participants have implemented innovations, with 61% of them having invested amounts exceeding LEI one million. The investments are profitable, as evidenced by the fact that each 1 LEI invested in innovations generates an increase in gross profit by 1.37 LEI. The Pearson coefficient value is 0.74 indicating a sufficiently strong correlation between the volume of investment means and the performance of agricultural enterprises.

Key words**:** *agriculture, innovations, performance, profit, correlation.*

INTRODUCTION

It is now widely acknowledged by researchers and practitioners alike that innovations in optimising the potential of enterprises are of significant importance. Consequently, the implementation of a range of innovations, including those pertaining to products and organisational structures, enables enterprises to actualise their potential, facilitate the development of new products, obtain higher income and profit [5] and provide the opportunity to enter new markets, which in turn enhances enterprise performance [9, 10, 15].

The positive impact of innovations on business performance [1, 4, 14, 3] as well as the fact that they are a key factor for the survival of enterprises in today's highly flexible environment [14] and economic growth [4] is irrefutable. This places innovation activity at the forefront of managerial responsibility, necessitating the acquisition of specific skills to overcome existing barriers in the innovation process and ensure the economic performance and competitiveness of enterprises [8].

The rationale pertaining to the significance of innovation is pertinent to all industries and fields of activity, including agriculture, which is currently a subject of extensive debate among researchers and policymakers due to its multifaceted role in achieving sustainable development goals. It has been demonstrated that innovative practices have a beneficial impact on agricultural enterprises [12]. Furthermore, there is a positive association between innovations and the performance of such enterprises [16, 17].

The evidence presented thus far demonstrates that increased R&D costs (for innovations in new products and services) lead to increased company revenues [2] or, by another approach, that the implementation of innovations contributes to faster financial growth [11]. However, the problem of quantifying the impact of financial efforts made in this regard remains particularly important. This provides the necessary economic arguments for justifying investment projects in innovations, as well as for choosing different project variants based on the principle of their efficiency. It is only through the acquisition of data that can be accurately measured and visualised that business managers can develop a tool that will enable them to demonstrate and calculate the contribution of innovations to business efficiency, thereby facilitating the economic case for investment decisions. In this context, however, it should be noted that measuring the effects of concrete investments in innovation is a challenging process, given that business performance indicators are influenced by a multitude of factors, both internal and external, quantifiable and non-quantifiable.

In this context, the paper aimed to assess the effect of investments in innovations on the performance of agricultural enterprises in the Republic of Moldova

MATERIALS AND METHODS

In order to achieve the research goal, the following steps were necessary:

-to investigate the role of innovations in increasing enterprise performance;

-to collect the data regarding the volume of investment in innovations and its impact on the gross profit of agricultural enterprises in the Republic of Moldova;

-to process the data using linear regression equations to quantify the dependence of gross profit on investments;

-to analyze the regression equation, to interpret the results and finally to formulate the conclusions.

At the beginning of the research, it was presented a review of the bibliography on the topic, and then it was conducted an opinion survey using the semi-structured thematic questionnaire.

In order to gather the data required for the application of the linear regression method, a survey was conducted in the period July 2023 – April 2024 on a sample of 66 enterprises. To this end, respondents were invited to participate in a semi-structured interview, based on a series of questions designed to ascertain whether the enterprises had made investments during the period 2021-2022, the specific types of investments, the amounts allocated to each type of investment, and the gross profit cumulatively obtained during that period.

Finally, it was set up a mathematical model using the linear regression method, generalisation and inference. as the most appropriate analytical tool. This method enables the determination of the extent to which a dependent variable – in this case, the gross profit of agricultural enterprises – is influenced by one or more causal variables. The amount of investment in innovation allocated by enterprises was selected as the causal variable for analysis.

A number of scientific publications pertaining to the research topic and the results of the opinion poll were consulted as sources of information.

As a limitation of the research, the low representativeness of the sample included in the survey is highlighted.

RESULTS AND DISCUSSIONS

The results indicated that 61 enterprises (92.4%) had made investments in innovation during the period 2021-2022. The data on the volume of allocated resources are presented in Figure 1.

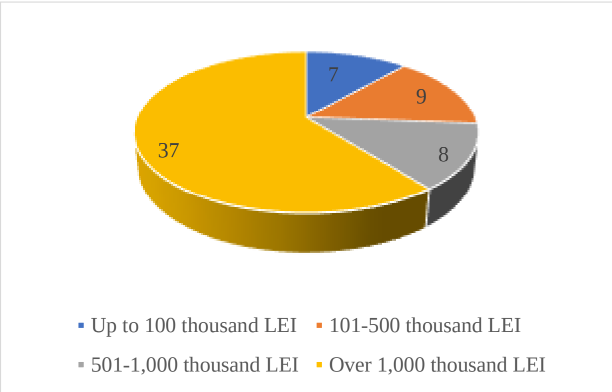

Fig. 1. Sample composition according to the amount of resources allocated to different types of innovations between 2021-2022
Source: Own determination.

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As illustrated in Figure 1, most of enterprises surveyed (60.6%) have invested in innovation amounts exceeding 1 million LEI. Conversely, the fact that almost 40% of the enterprises invested less than 1 million LEI over the two-year period indicates that the level of investment in innovation is insufficient to achieve significant improvements in enterprise performance and competitiveness.

In order to ascertain the extent to which profit is dependent on the amounts allocated to various innovations, the following equation, which characterises the linear relationship between two indicators, was used:

$$Y_x = a + bx \qquad (1)$$

where:

x - factor indicator;

y - outcome indicator;

a and b-the regression equation parameters to be found.

The primary data obtained from the initial processing of the survey results allowed to determine the following sizes of the variables needed for modelling:

$\sum x$ – the sum of the values of the determinant factor –212,737 thousand LEI;

$\sum y$ – the sum of the characteristic values (of the result indicators found in each observation) – 478,046 thousand LEI;

$\sum x^2$ – the sum of the squares of the assets of the determinant factor – 3,308,677,581 thousand LEI;

$\sum xy$ – the sum of the product of the factor and the characteristic value – 5,180,753,546 thousand LEI.

By solving the following system of equations and using the method of least squares, the values of the coefficients a and b were found.

$$\begin{cases} na + b\sum x = \sum y \\ a\sum x + b\sum x^2 = \sum xy \end{cases} \qquad (2)$$

where:

n – the number of observations made.

Upon replacing the data in the formula, the following system of equations is obtained:

61a + 212,737b = 478,046
212,737a + 3,308,677,581b = 5,180,753,646 ....(3)

In accordance with the afore mentioned system of equations, the magnitudes of the parameters a and b were ascertained:

a= 3,092.879665288459
b = 1.368874900739289
.... (4)

The resulting linear regression equation is:

$$Y_x = 3{,}093 + 1.37x \qquad (5)$$

The data obtained can be interpreted as follows:

-the evidence suggests that investments in innovations are profitable. Each LEI invested in innovations is demonstrated to generate an increase in gross profit of 1.37 LEI;

-consequently, the percentage increase in profit relative to the initial investment can be determined as follows:

$$\text{Growth percentage} = \left(\frac{0.37}{1}\right) \times 100\% = 37\% \qquad (6)$$

Thus, a positive linear correlation exists between innovation costs and gross profit. In other words, an increase in investment in innovations is accompanied by a corresponding increase in gross profit for agricultural enterprises.

The subsequent step is to ascertain the correlation coefficient (r) in order to illustrate the significance of innovations in agricultural enterprises. This will enable us to ascertain the strength of the relationship between investment in innovation and the gross profit of the companies in question.

In order to achieve this, we will use the simple linear Pearson correlation coefficient, which is a commonly utilized statistical tool in a multitude of disciplines, including economics, sociology, psychology and medicine, in order to evaluate the interrelationships between the various variables under analysis [6].

The correlation coefficient can vary between 0 and 1. A value closer to 1 indicates a stronger relationship between the factors and the outcome being studied [7]. The results of the correlation coefficient calculation are interpreted as follows:

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- a correlation coefficient of: $0 \leq r < 0.2$ indicates on the lack of correlation between variables;
- a coefficient of $0.2 \leq r < 0.4$ indicates a poor correlation, and a coefficient of $0.4 \leq r < 0.6$ represents a correlation of medium intensity;
- a coefficient of $0.6 \leq r < 0.8$ signifies a sufficiently strong correlation, and a coefficient of $0.8 \leq r < 1$ indicates a very strong correlation [13].

In the context of linear equations, the correlation coefficient is determined through the following process:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{(\sum x^2 n - (\sum x)^2 x(\sum y^2 n - (\sum y)^2)}} \qquad (7)$$

Upon entering the values calculated, the following equation is obtained:

$$r = \frac{61 \times 5{,}180{,}753{,}546 - (212{,}737 \times 478{,}046)}{\sqrt{[61 \times 3{,}308{,}677{,}581 - (212{,}737)^2][61 \times 12{,}518{,}276{,}524] - (478{,}046)^2}} \qquad (8)$$

As a result, we obtain the correlation coefficient:

$$r = \frac{214{,}327{,}894{,}404}{2{,}894{,}473{,}779{,}888} = 0.74 \qquad (9)$$

Because the obtained coefficient is located within the limits of $0.6 \leq r < 0.8$, we may infer that there is a sufficiently strong correlation to conclude that innovations are of significant importance for enterprises. Furthermore, once implemented, they exert a moderately strong impact on the achievement of business objectives and on profit growth.

The impact of innovations on the profitability of the agricultural enterprises under analysis can be observed in Figure 2.

This figure confirms the existence of a positive correlation between the amount invested in innovations and the gross profit obtained.

However, it should be noted that this correlation is not perfectly linear for all the data, as innovations are not the only factor influencing gross profit.

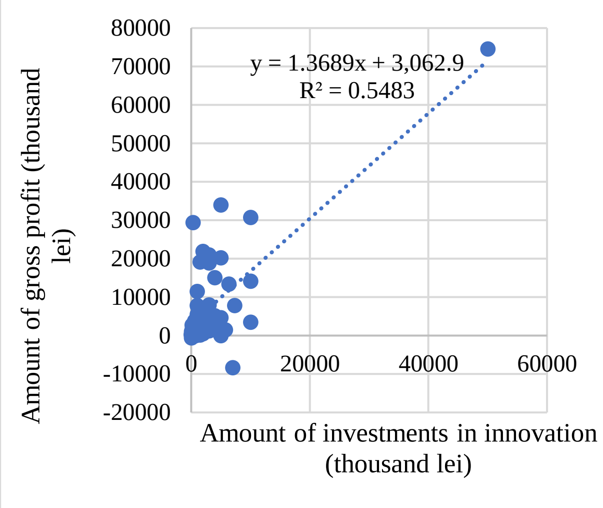

Fig. 2. Structure of the sample of agricultural enterprises according to the amount of resources allocated to various types of innovations in the period 2021-2022
Source: Own determination.

If the coefficient of correlation is squared, the resulting value is the coefficient of determination (R^2), which estimates the degree of dependence of the resulting indicator on the factor under analysis. In this case, the value of R^2 is 0.55, indicating that the gross profit of the surveyed agricultural enterprises is dependent on investment in innovation to the extent of 55%, while other factors account for the remaining 45%. The considerable impact observed can be attributed to the fact that most of the surveyed enterprises (approximately 74%) allocated resources towards process and product innovations. Consequently, by modernizing technologies, diversifying products by including crops with improved properties in their production, streamlining several processes, and so forth, the enterprises were able to achieve a notable improvement in their performance.

CONCLUSIONS

It is evident that innovations play a pivotal role in the advancement of agricultural enterprises. This is a fact that entrepreneurs are keenly aware of, as evidenced by the findings of the survey, in which 92% of managers and specialists participating in the survey indicated that they had invested in the implementation of innovations in their respective companies during the period 2021-2022. Despite the fact that the majority of the surveyed enterprises (60.6%) have invested over one million LEI in innovations between 2021 and 2022, the observation that nearly 40% of the surveyed enterprises have invested less than one million LEI in innovations indicates that the level of investment in innovations is insufficient to achieve significant improvements in the performance and competitiveness of enterprises.

The investments made in innovations in the agricultural enterprises surveyed have yielded profitable outcomes, as evidenced by the fact that each LEI allocated has increased gross profit of 1.37 LEI.

There is a positive linear correlation between innovation costs and gross profit: as investment in innovation increases, the gross profit of agricultural enterprises increases correspondingly.

The Pearson coefficient value of 0.74 indicates a sufficiently strong correlation to conclude that innovations play a pivotal role in enterprise performance. The coefficient of determination of 0.55 suggests that profit is 55% dependent on investment in innovations of various kinds.

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THE EFFECT OF TRANSFORMATIONAL LEADERSHIP ON SHIFTING ATTITUDES AND MOTIVATION OF EXTENSION OFFICERS TOWARDS ICT USE IN AGRICULTURAL EXTENSION IN INDONESIA

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Abstract

The objective of this research is to investigate how transformational leadership influences the shifts in attitudes and motivation of agricultural extension officers (AEOs) regarding the use of Information and Communication Technology (ICT) in agricultural extension. A cross-sectional study was conducted from November 2022 to February 2023 in North Maluku, Indonesia, involving 252 government AEOs as the sample. Data were collected through a survey using a questionnaire that measured transformational leadership, attitudes, and motivation towards ICTs. Linear regression analysis was employed to test the research hypotheses. The results revealed that transformational leadership positively and significantly influenced AEOs' attitudes ($\beta = 0.309$; $p < 0.05$) and motivation ($\beta = 0.416$; $p < 0.05$) towards ICT utilization. However, transformational leadership alone explained a limited portion of the variance in attitudes (14.4%) and motivation (17.6%), suggesting the influence of other factors. These findings highlight the importance of transformational leadership in fostering ICT adoption among AEOs. However, to maximize the potential of ICT in agricultural extension, a multi-faceted approach is necessary, encompassing not only leadership development but also the provision of adequate resources, infrastructure, training, and supportive institutional norms that encourage ICT utilization.

Key words: *transformational, leadership, agricultural, extension, officer*

INTRODUCTION

In the digital age, the agricultural sector is undergoing a profound transformation driven by the rapid advancement of Information and Communication Technology (ICT) [32]. This technology offers unprecedented opportunities to enhance productivity and sustainability in agricultural practices [24] [33]. However, successful integration of ICT into agriculture hinges on the willingness and ability of extension officers to adopt and utilize these tools effectively [15].

Within the landscape of the Agricultural Knowledge and Innovation System (AKIS), extension officers serve as the frontline, acting as intermediaries between research institutions and farmers [23]. Their role is crucial, not only in disseminating knowledge but also as agents of change in facilitating the adoption of new technologies [23, 28]. However, their capacity to embrace ICT and harness its potential for agricultural development is often hindered by various challenges, including resistance to change and low motivation [13].

Previous research on ICT adoption in agricultural extension has identified several factors influencing extension officers' attitudes and behaviors towards this technology. Individual characteristics such as age, education, and experience [2], as well as organizational factors like resource availability and training [26], have proven to be significant. Furthermore, extension officers' perceptions of ICT's usefulness, ease of use, and compatibility with existing work practices are also critical factors of adoption [35].

Nevertheless, these studies often overlook the critical role of leadership in shaping extension officers' perceptions and behaviors towards

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ICT. Transformational leadership (TL), which focuses on inspiring a shared vision, providing individualized support, and encouraging intellectual stimulation[4], has been shown to enhance employee engagement, motivation, commitment, and innovation across various sectors [7, 17, 21]. However, its specific impact on ICT adoption among extension officers remains largely unexplored.

This study aims to address this gap by investigating the influence of transformational leadership on extension officers' attitudes and motivation towards ICT adoption. Specifically, this research seeks to answer the following questions:

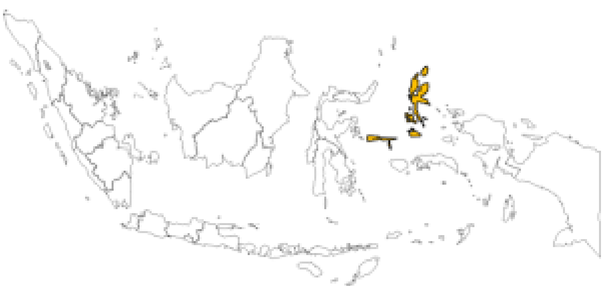
(1)Does transformational leadership (TL) positively influence extension officers' attitudes towards ICT adoption?

(2)Does transformational leadership (TL) positively influence extension officers' motivation to adopt ICT?

By answering these questions, this study is expected to contribute to policymakers and practitioners striving to enhance ICT capacity in the agricultural sector and promote sustainable digital transformation.

MATERIALS AND METHODS

This study employed a cross-sectional design to examine the relationship between transformational leadership and agricultural extension officers' attitudes and motivation towards ICT adoption. The research was conducted in North Maluku, Indonesia between November 2022 and February 2023. This region was chosen due to its unique archipelagic geographical conditions and socio-cultural diversity.



Map 1. Research location in North Maluku, Indonesia.
Source: Own elaboration based on data from Microsoft Excel (2023).

The study population consisted of civil servant agricultural extension officers working within the North Maluku Province jurisdiction. A sample of 252 extension officers was selected using simple random sampling. Data were collected through self-administered questionnaires. The questionnaire instrument consisted of three main sections:

(1)Transformational Leadership: This section assessed the behavior of agricultural department heads using four measurement item components, namely Idealized Influence (II), Inspirational Motivation (IM), Intellectual Stimulation (IS), and Individualized Consideration (IC) [4]. Items were adapted from instruments developed by Kirkman *et al.* [22]and Chen *et al.* [6]. These items utilized a five-point Likert scale ranging from (1)'never' to (5)'Always'.

(2)Attitudes towards ICT Adoption: This section measured extension officers' attitudes towards ICT adoption using items assessing cognitive, affective, and conative aspects. Measurement was conducted using a five-point Likert scale ranging from(1)'strongly disagree' to (5)'strongly agree' [29].

(3)Motivation in ICT Adoption: This section measured extension officers' motivation towards ICT adoption using McClelland's theory, through items assessing the need for achievement (n-ach), need for affiliation (n-aff), and need for power (n-pow) [25]. Motivation measurement employed a five-point Likert scale ranging from (1) 'strongly disagree' (lowest) to (5) 'strongly agree' (highest).

Prior to data collection, the questionnaire underwent validity and reliability testing using Corrected Item-Total Correlation (C-ITC) and Cronbach's alpha (α). The results indicated that all items demonstrated acceptable validity (C-ITC > 0.254), and the instrument exhibited high reliability (Cronbach's alpha > 0.7) for each indicator, confirming internal consistency and the questionnaire's suitability for this research [16], as presented in Table 1.

Table 1. Validity and Reliability of Research Instruments

Variable	Validity Test (Number of valid items)	Reliability Test (Cronbach's alpha)
Transformational leadership	18	0.955
Attitude	18	0.899
Motivation	21	0.947

Source: Primary data analysis (2023).

Data were analyzed using IBM SPSS Statistics version 25. Descriptive statistics were employed to characterize the TL, attitudes, and motivation of the respondents. To determine the overall achievement level, individual scores for each indicator were summed and then standardized to a percentage (0-100 scale) of the maximum possible score, calculated as follows:

*Achievement level (%) = (Total Achieved Score / Total Maximum Score) * 100*

Higher percentages indicate greater achievement.
Linear regression analysis was employed to test the hypotheses regarding the influence of transformational leadership on extension officers' attitudes and motivation towards ICT adoption. The level of statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSIONS

ICT Tools in Agricultural Extension

The study reveals a predominant reliance on smartphones (96.4%) and mobile applications like WhatsApp (95.2%) among agricultural extension workers, highlighting the critical role of mobile technology in their daily tasks (Table 2). The widespread use of smartphones aligns with the global trend of increasing mobile penetration, particularly in developing regions [3]. The versatility of smartphones as multifunctional tools for communication, information access, and data collection makes them invaluable for extension workers serving large numbers of farmers across dispersed areas. The popularity of WhatsApp further underscores the need for accessible, real-time communication platforms that facilitate efficient interaction and knowledge exchange.
While laptops are also utilized to a significant extent (52.8%), likely for more complex tasks such as data analysis and report writing, the limited adoption of other ICT devices like desktop computers and tablets suggests potential barriers to access or perceived relevance. This discrepancy in ICT adoption may hinder the full realization of ICT's potential in agricultural extension.
The observed ICT utilization patterns emphasize the need for transformational leadership to facilitate the broader integration of ICT tools into extension practices. By fostering a culture of innovation and providing support for skill development, transformational leaders can empower extension workers to leverage a wider range of ICT tools, thereby enhancing their effectiveness and contributing to the digital transformation of the agricultural sector.

Table 2. ICT tools used by AEOs

ICT tools	Frequency	Percentage
Smartphone	243	96.4%
Laptop	133	52.8%
Wi-Fi at home	47	18.7%
Computer desktop	18	7.1%
Tablet/Ipad	1	0.4%
WhatsApp (WA)	240	95.2%
Facebook (FB)	194	77.0%
Instagram (IG)	61	24.2%
YouTube	38	15.1%
Telegram	29	11.5%
TikTok	26	10.3%
Twitter	12	4.8%

Sources: primary data analysis (2023).
Multiple responses allowed

Transformational leadership in agricultural extension

Transformational leadership (TL) plays a crucial role in driving digital transformation within organizations [20], including the context of agricultural extension.
Figure 1 provides a nuanced perspective on the prevalence of transformational leadership (TL) behaviors within the agricultural extension organization, as perceived by its

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members. While the leaders demonstrate a strong inclination towards Idealized Influence (II) and Inspirational Motivation (IM), with a majority of respondents indicating these behaviors occur "Often," there is a discernible gap in the consistent application of Individualized Consideration (IC) and Intellectual Stimulation (IS).

The high frequency of "Often" responses for Idealized Influence (43.7%) suggests that leaders are generally successful in embodying the values and ideals they espouse, fostering a sense of respect and trust among their subordinates. Inconsistencies between words and actions, and leaders' lack of adaptability to the digital environment can hinder digital transformation [27]. Similarly, the prominence of "Often" for Inspirational Motivation (42.5%) underscores the leaders' ability to articulate a clear and inspiring vision, motivating their team towards shared objectives.leaders need to further enhance their ability to transmit positive energy and enthusiasm to extension officers to promote their well-being [18].

Fig. 1. Frequency distribution of Transformational leadership behaviors.
Source: primary data analysis (2023).

However, the distribution for Individualized Consideration reveals a more moderate application of this leadership dimension. While leaders do show consideration for individual needs, the relatively high percentage of "Sometimes" (31%) responses indicates a need for greater consistency in providing personalized support and mentorship. This could involve actively seeking feedback, tailoring communication styles, and recognizing individual contributions.Improvement in this aspect can significantly enhance employee performance [17].

The pattern for Intellectual Stimulation is somewhat balanced, with a plurality of respondents reporting that leaders "Often" encourage creativity and critical thinking. Nevertheless, there is room for further development in this area. Leaders could foster a more intellectually stimulating environment by actively challenging assumptions, promoting experimentation, and rewarding innovative approaches.

In essence, while the leaders in this agricultural extension organization demonstrate proficiency in certain aspects of transformational leadership, there is a clear opportunity to enhance their overall effectiveness by focusing on individualized consideration and intellectual stimulation. By nurturing a climate that consistently supports individual growth and encourages intellectual exploration, leaders can further empower their subordinates to embrace ICT and contribute to the ongoing digital transformation of the agricultural sector.

AEOs' attitudes towards ICT utilization

In the context of digitalization, attitudes play a pivotal role in predicting ICT usage behavior [11]. The findings reveal that agricultural extension officers possess a positive attitude (agree) towards utilizing ICT in extension services, with an average achievement of 71.8% (Table 3). This positive disposition is multifaceted, encompassing cognitive, affective, and conative dimensions.

Table 3. Descriptive statistics of AEOs' attitudes

Attitude indicators	**Achievement (%)**	**Category**
Understanding of benefits and experience using digital ICT (Cognitive)	71.7	Agree
Emotional response/satisfaction using digital ICT (Affective)	70.1	Agree
Commitment to utilizing digital ICT (Conative)	74.3	Agree
Average	71.8	Agree

Source: Primary data analysis (2023).

Extension officers perceive ICT as providing numerous benefits, being useful, and relevant to their work in agricultural extension, particularly in enhancing communication, collaboration, information access, and contributing to their professional careers.This resonates with research highlighting the perceived usefulness of ICT as a key driver of adoption among extension professionals [1].

Affectively, the data reveals a favorable emotional response to ICT. The enthusiasm and interest expressed by extension officers suggest a sense of satisfaction and enjoyment associated with ICT use, with an average score of 70.1%.This positive emotional connection can be instrumental in overcoming potential barriers to adoption, such as anxiety or fear of the unknown [10] [34].

Conatively, the strong commitment to utilizing digital ICT is particularly noteworthy. It signifies a proactive intention to not only maintain current levels of ICT use but also to actively seek opportunities to further develop their ICT competencies (74.3%). This proactive stance suggests a recognition of the evolving digital landscape and the importance of staying abreast of technological advancements to remain effective in their roles [19].

AEOS's motivation in utilizing ICT

Motivation serves as the driving force behind individual behavior [14], particularly in relation to ICT usage behavior among extension officers. The results indicate that the motivation of extension officers is relatively high, with an average achievement of 65.4%, suggesting a strong desire to utilize ICT (Table 4).

Table 4.Descriptive statistics of AEOs' motivation

Motivation indicators	Achievement (%)	Category
Need for Achievement (n-Ach)	68.2	High
Need for Affiliation (n-Aff)	68.3	High
Need for Power (n-Pow)	59.7	Moderate
Average	65.4	High

Source: Primary data analysis (2023).

The findings highlight a commendable level of motivation among extension officers towards ICT utilization, particularly in terms of their need for achievement and affiliation. This resonates with previous research emphasizing the significance of intrinsic motivation, encompassing the desire for accomplishment and positive social interaction, in driving ICT adoption among professionals [8]. The strong need for achievement observed in this study suggests that extension officers are intrinsically driven to excel in their roles and view ICT as a tool to enhance their performance and achieve desired outcomes. Furthermore, the high need for affiliation underscores the importance of social connections and collaborative work environments in fostering ICT adoption. This aligns with the theoretical underpinnings of Self-Determination Theory, which posits that relatedness, or the sense of belonging and connection with others, is a fundamental psychological need that fuels intrinsic motivation [9].

The impact of transformational leadership on attitudes and motivation towards ICT adoption

Regression analysis revealed that transformational leadership (TL) has a positive and significant impact on agricultural extension officers' attitudes toward ICT utilization. This is evidenced by the regression coefficient β of 0.309 (p < .,05), indicating that for every one-unit increase in TL, there is a corresponding 0.309-unit increase in positive attitudes towards ICT (Table 5). These findings are consistent with the research by Shal *et al.*, which demonstrated that transformational leadership (TL), known for inspiring, motivating, and fostering innovation, inherently encourages academic librarians to develop capacity, a culture of adaptability, creativity, and openness to change, aligning with the demands of implementing new technologies such as Artificial Intelligence [31]. However, TL only explains 14.4% of the variance in extension officers' attitudes ($R^2 = 0.144$), suggesting the presence of other influential factors in shaping their attitudes towards ICTsuch as individual characteristics, organizational context, and perceived social norms [34].

Similarly, the positive effect between TL and motivation towards ICT use (β = 0.416) resonates with theoretical frameworks that emphasize the motivational power of transformational leaders [4, 5]. By articulating a compelling vision, providing individualized support, and fostering intellectual stimulation, such leaders can ignite intrinsic motivation, empowering individuals to pursue self-determined goals and embrace new challenges [12, 31]. However, the limited explained variance ($R^2 = 0.176$) suggests that motivation is also influenced by a complex interplay of factors, including perceived self-efficacy, perceived benefits, and organizational incentives [30].

While these findings reaffirm the importance of transformational leadership in promoting ICT adoption among extension officers, they also highlight the need for a multi-pronged approach. Cultivating a supportive organizational climate that provides access to resources, training, and recognition for ICT-enabled practices can complement the positive influence of TL. Furthermore, addressing potential barriers such as lack of confidence, fear of technology, and resistance to change through targeted interventions can further enhance the effectiveness of leadership efforts in driving ICT adoption.

Transformational leadership serves as a crucial catalyst in shaping positive attitudes and motivation towards ICT among agricultural extension officers. However, it is essential to recognize the interplay of various factors in influencing technology adoption and to implement a comprehensive strategy that encompasses leadership development, capacity building, and organizational support to facilitate the successful integration of ICT in agricultural extension.

Table 5. Regression analysis

Variables	a	β	R^2	p-value	Sig.
TL ->Attitude	35.154	0.309	0.144	0.000	**
TL ->Motivation	33.371	0.416	0.176	0.000	**

Source: Primary data analysis (2023).
Notes: ** indicates significance at the 0.05 level.

CONCLUSIONS

Transformational leadership has been shown to play a significant role in fostering positive attitudes and motivation among agricultural extension officers towards ICT utilization in North Maluku. While only explaining a portion of the variance in attitudes and motivation, these findings highlight the potential of transformational leadership as a catalyst for ICT adoption.

Therefore, it is recommended that local governments and relevant agencies prioritize the development of transformational leadership training programs for leaders within the agricultural extension sector. Such training would empower leaders to guide their officers through the complexities of technological advancements, ultimately fostering a collaborative environment that maximizes the perceived benefits of ICT in enhancing agricultural extension services and promoting development in emerging economies.Additionally, it is crucial to strengthen supporting factors such as the availability of digital facilities, infrastructure, incentives for extension officers, and supportive norms. Further research is needed to explore other factors that may enhance ICT adoption and develop holistic strategies to maximize the potential of ICT in transforming agriculture in North Maluku, Indonesia.

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BIODIVERSITY IN VEGETABLE CULTURE AND ITS ROLE IN THE SUSTAINABILITY OF AGROECOSYSTEMS. A REVIEW

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Abstract

Biodiversity plays an essential role in vegetable agroecosystems, providing multiple benefits for soil health, natural pest control, and climate change adaptation. This article examines the role of biodiversity in vegetable cultivation and the impact of diversified agricultural practices on the sustainability and health of agroecosystems. The research methods were represented by: studying specialized and scientific literature, structuring the references on the topics of interest, critical evaluation of the ideas belonging to different authors, exposing our own ideas and drawing the main conclusions on the role played by biodiversity in vegetable culture in the sustainability of agroecosystems. The study shows that diversifying vegetable crops through species rotation, intercropping, the use of cover crops, and applying organic mulch is essential for maintaining biodiversity in agroecosystems. These methods contribute to soil health, reduce the need for chemical inputs, and enhance ecological stability. Thus, they represent effective solutions for promoting sustainable agriculture and a healthier, more balanced agricultural environment, offering a solid foundation for resilient and adaptable agriculture.

Key words*: biodiversity, agroecosystems, legumes, cover crops, sustainable agriculture*

INTRODUCTION

The intensification of modern agriculture has led to the adoption of monoculture practices, which has increased the risk of biodiversity loss and affected the stability of agroecosystems [4]. Biodiversity, especially in vegetable cultivation, plays a fundamental role in supporting soil health, attracting natural pest predators, and maintaining a stable ecological balance. Various vegetable species and the use of ecological practices, such as crop rotation and intercropping, contribute to biodiversity conservation and provide a foundation for the development of sustainable agriculture [3], [13].

Plant diversity in vegetable agroecosystems contributes to adaptation and resilience to climate variations. Agricultural systems with a high diversity of species can respond better to climate stress, such as drought or extreme temperatures, through ecological mechanisms that help maintain soil moisture and productivity [18], [85]. The study by [61] showed that crop diversification can enhance agroecosystem resilience, allowing them to adapt more easily to climate variability. For example, cover crops and intercropped crops help maintain lower soil surface temperatures, reduce moisture loss, and protect crops from extreme temperatures. In the long term, implementing diversification practices in vegetable cultivation could reduce dependence on synthetic pesticides and fertilizers, thereby contributing to increased ecological and food security [61].

Vegetable species play an essential role in maintaining and enhancing the biodiversity of agroecosystems. They contribute to soil health, natural pest control, and support balanced ecosystems through complex nutrient cycles and beneficial interactions with microorganisms and local fauna. The diversity of vegetable species includes not only traditional varieties but also legumes, cover crops, and crops with increased genetic resistance, all of which contribute to a sustainable agricultural system.

Biodiversity in agroecosystems helps conserve water and prevent soil erosion by providing permanent ground cover and improving soil structure.

Cover crops and intercropped plants help safeguard soil from wind and water erosion, enhancing water retention and minimizing nutrient loss through runoff.

[20] study demonstrated that cover crops like clover and mustard effectively mitigate soil erosion and enhance water retention, promoting long-term soil fertility and stability.

Another study, conducted by [58], highlights the benefits of biodiversity in reducing soil erosion and conserving water, showing that better-structured soil has a greater capacity for water infiltration, thus preventing soil degradation and preserving water resources.

Aromatic and medicinal plants, such as rosemary (*Rosmarinus officinalis*) and lavender (*Lavandula* spp.), are particularly valuable for attracting natural predators and pollinators, thereby contributing to pest control and improving vegetable productivity. These plants have a high content of essential oils that deter many harmful species while attracting beneficial insects, such as bees and parasitic wasps. According to the research by [92], adding aromatic plants to vegetable crops increases faunal biodiversity and may help reduce the need for pesticides.

A study by [67] showed that the use of organic mulch in vegetable cultivation supports a greater diversity of beneficial soil organisms, such as bacteria and fungi. Organic mulch also contributes to stabilizing nutrient levels and improving soil health, thus facilitating long-term productivity.

The purpose of this paper is to examines the role of biodiversity in vegetable cultivation and the impact of diversified agricultural practices on the sustainability and health of agroecosystems.

MATERIALS AND METHODS

Information sources were represented by specialized and scientific publications on innovative technologies, reports, projects and studies at both national and international levels were consulted.

The studied literature was structured based on the topics of interest and the authors' ideas have been critically evaluated and commented.

The content of this research work includes the results of the bibliographic analysis focused on specific vegetable farming practices, such as crop rotation, the use of cover crops and the application of organic mulch, with the aim of synthesizing best practices and their impact on sustainability.

RESULTS AND DISCUSSIONS

Legumes and their contribution to biodiversity conservation

The production of legumes provides numerous ecosystem services, facilitating land use diversification and supporting biodiversity in agroecosystems due to their ability to fix atmospheric nitrogen in the soil.

In the European Union, protein crops occupy only 1.5% of arable land, compared to 14.5% globally [101]. A relatively small percentage of peas (*Pisum sativum* L.) (11–15%) and fava beans (*Vicia faba* L.) (9–14%) cultivated in Europe are designated for human consumption, with the majority being allocated for animal feed, a less efficient method of protein production for human diets [17]. In Northern Europe, peas (*Pisum sativum* L.) and fava beans (*Vicia faba* L.) have long been integral crops in agricultural practices [94]. Protein-rich crops such as fava beans (*Vicia faba* L.), peas (*Pisum sativum* L.), chickpeas (*Cicer arietinum* L.), lupins (*Lupinus albus* L.), and soybeans (*Glycine max* L.) possess the unique ability to fix atmospheric nitrogen, making them essential for low-input farming systems that aim to lower greenhouse gas emissions [60].

These crops can provide significant amounts of nitrogen to subsequent crops in the rotation, reducing the need for mineral fertilizers [101]. In addition, they improve soil health and support crop protection [51]. Other studies have shown that adding legumes to cereal rotations has positive effects on cereal yields and gross margins, compared to monocultures [102].

[71] demonstrate that intercropping maize (*Zea mays* L.) with legumes increases N uptake. Additionally, nitrogen fixation

provides significant residual benefits, enhancing the productivity of subsequent maize crops [1].

Recently, legume crops have gained importance due to rising prices for animal feed and food proteins, fertilizers and fuel, in addition to sustainability concerns. The impact of introducing legume (*Vicia faba* L.) into dominant cereal crop production systems, typical of southwestern Finland, was investigated by [98].

Traditional varieties and indigenous species of vegetables

The wide array of traditional crops once cultivated on a sustainable scale in various regions of the world has been replaced by a limited selection of major crops grown in large-scale monocultures [49]. This shift has significantly reduced the diversity of species upon which global food security depends [96]. Over the past 50 years, reliance on commercial hybrids and advanced cultivars, coupled with the marginalization of traditional local species, has drastically diminished horticultural and agricultural biodiversity. Additionally, factors such as habitat loss, climatic changes, and evolving cultural practices have further narrowed the spectrum of non-commercial crops commonly utilized by humans. Globally, vegetable genetic resources are being lost at an estimated rate of 1%–2% annually [25], primarily due to changes in how the human population exploits the world's edible plant resources [86].

There is a need of investment in research breeding and cultivar development in traditionally open-pollinated cultivars and in the minor and so-called “forgotten” vegetables. More investments in this area will mean cheaper cultivars for growers to choose from and more preservation of vegetable biodiversity.

Indigenous and traditional vegetables exhibit remarkable biodiversity, thriving in specific marginal soil and climatic conditions with minimal reliance on external inputs [28], [48]. Incorporating these traditional vegetables into current production systems enhances their heterogeneity, which in turn improves resilience to both abiotic and biotic stresses [74].

[61] highlights examples where diverse agroecosystems successfully suppressed pests and diseases while buffering against climate variability.

Several solanaceous crops, including species of Solanum, Capsicum, and Physalis, are cultivated beyond their original centers of domestication. Recently, there has been growing interest in novel Solanaceae crops for European cultivation [79], [87], [89], [88], [68], [69]. This emerging focus underscores the potential of lesser-known species, warranting further exploration and research. As climate change continues to shift environmental parameters, many of these crops could potentially expand beyond their traditional climatic zones [86].

The initial step in launching new breeding programs for indigenous vegetable crops is their thorough characterization, a process that should begin promptly across various countries. The assumption that these crops are inherently and permanently "resistant to pests and diseases" compared to conventional or globally cultivated vegetable crops is likely a misconception. When indigenous crops transition to mainstream production, they will inevitably face a broad spectrum of pests and diseases, potentially undermining farm productivity. To ensure sustainable and profitable cultivation, defensive strategies such as selective breeding, grafting, integrated pest management, and robust agronomic practices will be essential to achieve high-quality and sufficient crop yields [55].

Cover crops

Cover crops, such as red clover (*Trifolium pratense* L.) and rapeseed (*Brassica napus* L.), are essential for soil protection against erosion and improving microbial biodiversity. These crops provide constant soil cover, preventing nutrient runoff and offering a favorable habitat for beneficial microorganisms and insects. In a study conducted by [19], it was shown that the use of cover crops reduces the need for chemical inputs and supports soil structure by increasing microbial activity.

Cover crops also contribute to pest control by stimulating populations of natural predators and pollinators, thus maintaining an ecological balance within the agroecosystem [59].

Cover crops are plants grown between production cycles of main crops to protect the soil from erosion, increase organic matter content, and improve soil fertility or as feed for animals. They also provide habitat for a wide range of beneficial organisms, including predatory insects, bacteria, and fungi.

The decomposing residues of brassica cover crops, through the release of glucosinolates, aid in the control of parasitic nematodes [81]. In addition, during the same phase, they can cause chemical and physical changes in the soil and facilitate root penetration of the next crop and act as a buffer for the soil [50]. Several studies confirm that the use of legume cover crops in crop rotations, such as clover (*Trifolium pratense* L.) and alfalfa (*Medicago sativa* L.), and graminaceous cover crops, such as ryegrass (*Trifolium pratense* L), oat (*Medicago sativa* L.), and barley (*Hordeum vulgare* L.*)*, enhance the yields of the following cash crop [52], [64], [24].

Studies conducted by [19], demonstrate that cover crops such as red clover (*Trifolium pratense* L.) and mustard (*Brassica napus* L.) improve soil health by enriching it with nutrients, reducing the need for chemical fertilizers, and helping regulate pest populations. Additionally, [59] emphasized that the use of cover crops increases biodiversity by attracting pollinators and through biological pest control.

There are various crop alternatives to be used as vegetative cover, such as grains, legumes, root crops and oil crops. All of them are of great benefit to the soil, however some cover crops have certain attributes, which need to be kept when planning a rotation scheme [2], [23]. It is important to start the first years of conservation agriculture with cover crops that leave a lot of residues on the soil surface, which decompose slowly (because of the high carbon/Nitrogen ratio, an indicator for nitrogen limitation of plants and other organisms). The adoption of cover crops in agro-ecosystems provides multiple benefits to the agro-ecosystems.

To maximize the agro-ecological functions, complementing and synergizing the effects, cover crops are usually cultivated in a mixture. Very important, in the constitution of these mixes is to use the functional complementarity of the species [21]. The potential application of crop mixtures (involving cereal, legume, and even crucifer cover crops) is an issue of strategic interest when designing low-C cropping systems such as in Mediterranean areas.

In addition, Brassicaceous over crops are chosen to improve soil penetration resistance due to taproot growth but are also used as a highly effective catch crop [11]. For example, mixing radish with rye can mitigate both soil compaction and soil erosion risks due to the bio-drilling potential of radish and abundant aboveground biomass cover produced by rye [22], [82].

Radish (*Raphanus raphanistrum* subs. *sativus*), a widely used and highly beneficial cover crop, catch soil nutrients, especially nitrogen [93]. In that sense, the use of cruciferous species as cover crops could allow the natural control of potential diseases.

[99] showed that radish (*Raphanus raphanistrum* subsp. *sativus*) or brown mustard (*Brassica juncea* L.) as a biofumigant crop could be effective against plant-parasitic nematodes without compromising on soil health or changing the structure of the nematode community. Furthermore, [6] revealed that using radish (*R. sativus*) and arugula (*Eruca sativa*) as winter cycle plants before plants that are susceptible to the root-knot nematode *Meloidogyne arenaria* would help to reduce gall index, egg masses and consequently damage and also increase crop yields. Last, leguminous vover crops are recognized as the most effective when maximizing nitrogen (N) input becomes the priority [35]. Indeed, leguminous cover crops can deposit significant amounts of N in the soil during growth and have the ability to acidify the rhizosphere by facilitating the uptake of insoluble phosphorous into the soil [72], [100]. According to [91], the presence of *Trifolium subterraneum,* for three consecutive years, determined a considerable increase in ammoniacal nitrogen, nitric nitrogen, and the N cycle bacteria.

Furthermore, [39] revealed that the mitigation effect of the legume (vetch) cover crops mainly due to the reduction of synthetic N inputs in the subsequent cash crop as well as a decrease in indirect N_2O emissions from NO_3^- leaching and an increase in C sequestration due to an intensive photosynthetic activity.

[29] have observed that the specific use of *Trifolium repens* and *Vicia villosa* as cover crops can improve soil quality and yield in apple orchards. In long-term cropping systems such as orchards, cover crops have economic benefits because, in addition to protecting soil against water and wind erosion, they can contribute, through residue deposition, to nutrient recycling, increased soil health and reduced mineral fertilization needs [27]. This could be useful on vineyard and olive tree systems that are generally affected by erosion due to the high loss of organic matter and excessive tillage operations [7]. Other tree systems that have the same issues are those consisting of almond [65], apricot [56] and persimmon orchards [83]. Several studies showed that the cultivation of cover crops is an effective solution to minimize soil erosion in these orchards caused by intensive tillage, excessive mineral fertilizer applications and herbicide use and, therefore, preserve soil from the risk of desertification [54], [8].

[36] observed that the use of cover crops could reduce soil losses by 3.8 to 0.7 Mg ha^{-1} in a vineyard.

[76] showed that using cover crops reduces by 27% annual water runoff and can be used as an agronomic strategy for improving water use efficiency.

Aromatic and medicinal plants

Intercropping medicinal and aromatic plants with various horticultural crops plays a significant role in reducing post-harvest yield losses, preserving fruit quality, and extending shelf life during storage. Additionally, the essential oil content, yield, and composition of medicinal and aromatic plants are influenced by the interspecific competition present within the intercropping system. [32], [77].

According to the experimental result of [57] intercropping of some aromatic plants with tomato (*Solanum lycopersicum* L.) protect the infestation of *Tuta absoluta* on tomato. The inclusion of rosemary (*Rosmarinus officinalis* L.) with onion elevated yield advantage and competitiveness over sole planted crop per unit area as indicated by higher LER and relative crowding coefficient. This enables to prevent the insect pest attack on onion [5]. Planting marigolds (*Calendula officinalis L.)* between tomatoes protects the tomato plants from harmful root-knot nematodes in the soil and increase the marketable fruit yield of tomato by trapping different insects and pest attack and the like [31]. Marigold repels nematodes, tomato worm, slugs and general garden pests [38] found that intercropping of tomato with African marigold (*Tagetes erecta* L.) reduced early blight (*Alternaria solani*) of tomato (*Solanum lycopersicum* L.). Intercropping marigold (*Tagetes erecta* L.) for nematode management also appeared to reduce numbers of aphids and whiteflies, and resulted in lower levels of virus in tomato [103].

Tomato (*Solanum lycopersicum* L.) and basil (*Ocimum basilicum* L.) are common pairs that are intercropped [70]. Several studies reported the performance of intercropping of aromatic and medicinal plant species with selected major horticultural crops in different countries as cited by [70], the experimental results of [73], [75]. [37] reported intercropping of onion (*Allium cepa* L.) with basil (*Ocimum basilicum* L.) at a 1:1-row arrangement could provide farmers with the best yield advantage and income over sole planting of component (onion) crops. Basil and tomato are companion plants that have similar lighting and watering needs, some even say tomatoes (*Solanum lycopersicum* L.) taste better when they neighbour basil (*Ocimum basilicum* L.) [12].

Application of organic mulch

The application of organic mulch is an effective technique for conserving soil moisture, reducing weed growth, and improving soil structure [80]. Organic mulch helps increase soil biodiversity by providing a habitat and a constant source of organic matter for soil organisms. It can also contribute to maintaining soil temperature and improving water retention capacity.

Numerous studies have demonstrated that intercropping and living mulches can positively influence pest and disease management as well as weed control [40], [41], [45], [46], [47], [53], [90] . However, this outcome cannot be universally applied and must be evaluated on a case-by-case basis [66]. The effectiveness of these practices often depends on various factors, including the cropping systems and the arthropod species involved in the experiments.

[30] highlight the overall positive impact of the living mulch technique on plant-soil systems, evidenced by increased soil biodiversity and the absence of significant negative effects on pest abundance.

In the study by [30], the effects of a 'cover crop–vegetable cash crop' intercropping system on arthropod dynamics and biodiversity were analyzed across four European countries: Italy, Denmark, Germany, and Slovenia. Soil arthropod fauna served as an indicator for comparing the ecosystem services provided by living mulch systems versus sole crop systems. The findings revealed that the living mulch technique had no adverse effect on the infestation of cabbage caterpillar (*Pieris* spp.), a key pest of cabbage [14], [15], [16].

In Denmark, aphid populations were notably higher in the sole crop system compared to the living mulch system. In Italy, a high rate of larval parasitization was observed, with parasitization levels reaching 88% in living mulch systems versus 63% in sole crop systems during one year of the study. Additionally, the living mulch positively influenced the activity density of Carabid beetles, enhancing species diversity and evenness in Italy and Slovenia and increasing the activity density of specific taxa in Slovenia and Denmark.

Overall, the results demonstrate that living mulch techniques contribute positively to arthropod biodiversity in plant-soil systems, enhancing soil biodiversity and showing no detrimental effects on the density of canopy pests. These findings suggest that living mulch can provide valuable ecosystem services while maintaining effective pest control [26], [33], [63].

In conclusion, a notable finding from our study is that the use of living mulch in cauliflower cultivation did not lead to an increase in pest infestation, demonstrating the absence of any detrimental effects associated with this technique.

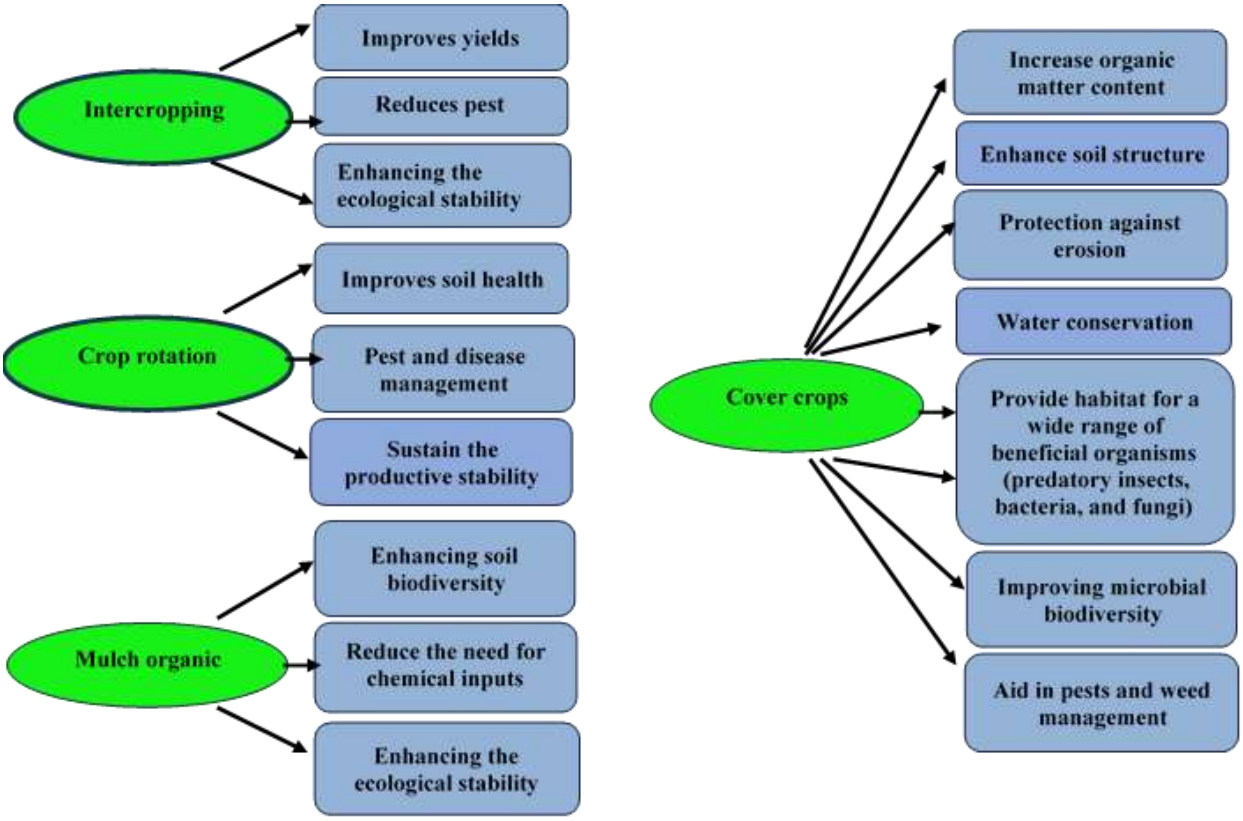
When vegetables are undersown in living mulches or row intercropped with cover crops or other vegetable crops, they are found to reduce herbivorousinsects and damage caused by them [42], [43], [44], [97], [104].

These systems (living mulches, intercropping) create diverse habitats that are generally less favorable for herbivores and/or more conductive for natural enemies [84].

However, herbivore response to diverse habitats could not be explained by a single ecological theory and may depend on the behavior of herbivores (host finding, host acceptance, etc.) to the specific habitat type [44].

The primary mechanisms behind the pest-suppressive effects of living mulches and intercrops are attributed to the disruption of host-plant detection, chemically-based repellency, impacts on insect pests and their natural enemies, and potential competition between the cash crop and adjacent non-crop vegetation [34], [62]. Although these techniques can function independently as pest management strategies, their effectiveness is enhanced when integrated with other approaches, including chemical controls (used selectively, such as in trap cropping), cultural practices, and biological control methods [9], [10] [78]. Below, we discuss the main mechanisms underlying the effects of living mulches and intercrops on pest suppression [95].

Further development of such methods, as shown in Figure 1, promote biodiversity and provide favorable conditions for agriculture based on ecological principles are expected to reduce chemical inputs (e.g., insecticides) (a), thus impacting positively the society and the environment to move towards sustainability in vegetable production systems (b).



(a) (b)

Fig. 1. Methods of diversifying vegetable crops for the sustainability of biodiversity in agroecosystems (a) and The ecological and economic impact of using these methods (b)
Source: Authors' own conception.

The economic impact of the use of various methods for diversifying vegetable crops

The use of a large variety of crops gives a new chance to farmers to develop their agri-business in terms of a higher production, diversification of the products obtained, improving the acquisition price at the farm gate, raising their incomes and profit.

Consumers will have at their disposal more alternatives from which to choose the most suitable one to cover their needs.

Industry will benefit of a large range of raw materials to transform them into new products which will enlarge the domestic market and also could become an object for commercialization on the international market.

In the rural communities, where agriculture plays the main role, new opportunities of jobs could be created by extending and diversifying the cultivated crops.

The new crops could increase value-added, create market niches and generate income streams along the value chain.

The implementation of a large range of vegetal crops and enlarging the use of various the methods to cultivate them in a friendly manner with the environment will contribute to production diversification, to the increase of revenues, to the reduction of the market dependence on commodity crops, and to the enhancement of the competitiveness of farmers in global markets [13].

CONCLUSIONS

There is a lot of scientific evidence that supports the adoption of cover crops as a valid solution for allowing the ecological transition of modern and intensive systems toward sustainable farming systems. Several beneficial effects could be accounted for following the cultivation of cover crops, such as the improvement of soil health, enhancement of nutrient cycling, carbon sequestration and reduction of greenhouse gas emissions, reduction of synthetic fertilizers, and economic returns [82]. Therefore, the introduction of cover crops into agricultural systems can sustain the productive stability of cash crops and increase soil fertility through organic matter accumulation. Furthermore, cover crops may enhance soil structure, water conservation, and aid in pests and weed management.

Agricultural practices such as crop rotation, intercropping, the use of cover crops, and the application of organic mulch are essential for maintaining biodiversity in agroecosystems. These methods contribute to soil health, reduce the need for chemical inputs, and enhance ecological stability. Thus, they represent effective solutions for promoting sustainable agriculture and a healthier, more balanced agricultural environment, providing a solid foundation for resilient and adaptable farming.

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QUANTIFYING FOOD LOSS AND WASTE: A BIBLIOMETRIC ANALYSIS FROM 1970 TO 2023

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Abstract

This study conducts a bibliometric analysis of food loss and waste (FLW) research from 1970 to 2023, aiming to map key trends, influential authors, and foundational papers. Using Scopus and Web of Science databases, quantitative citation and co-citation analyses were employed to identify core themes and research clusters. The analysis revealed a significant increase in FLW publications post-2015, indicating heightened global awareness. China, the USA, Italy, and India emerged as leading nations in FLW research. The study highlights key journals, with "Waste Management" and "Bioresource Technology," are identified as central to disseminating influential research. Keyword analysis reveals "food waste" and "anaerobic digestion" as the most recurrent terms, indicating significant research focus areas. This study not only maps the current state of FLW literature but also identifies critical gaps and suggests future research trajectories. It underscores the imperative for interdisciplinary collaboration, integrating technological, ecological, and socio-economic perspectives to address the multifaceted challenges posed by FLW.

Key words: *food loss and waste, FLW, food supply chain, bibliometric analysis, sustainability*

INTRODUCTION

There has been a global increase in food waste and loss trends, especially in China and Asia. Research on energy-value systems utilizing food loss and waste (FLW) has risen since 2010 [18]. Parfitt et al. [30] provided crucial insights into food waste within food supply chains (FSCs) and strategies to address it by 2050, establishing a foundational basis for further research. The Food and Agriculture Organization (FAO) reports that 1.3 billion tons of food, or one-third of the food produced for human consumption, is wasted annually. This waste includes 45% of fruits and vegetables, 35% of fish and poultry, 30% of cereals, and 20% of meat and dairy products, resulting in 3.3 billion tons of CO_2 emissions and financial losses exceeding $800 billion [10]. Food losses (FL) involve crops and livestock removed from the supply chain due to various methods, while food waste (FW) includes food and inedible components removed from the human FSC through various waste disposal methods [39].

The primary determinants of FLW include macroeconomic conditions, policy frameworks, socio-cultural norms, urbanization trends, infrastructure investments, globalization dynamics, industry consolidation, and prosperity. These factors influence all stages of the FSC, contributing to inefficiencies and pressures that significantly cause FLW. Additionally, infrastructure adequacy, waste management services, cultural identity, health considerations, and lifestyle choices at the retail and consumer levels further drive FLW [35]. Recognizing the urgent environmental, social, and economic concerns of FLW, multiple sectors, including governments, businesses, NGOs, academia, and the public, are increasingly collaborating to address these challenges [24]. Raising public awareness and providing education on the issue of food waste are essential tactics in tackling the problem of FLW [26].

Up to the present time, there is no universally accepted definition of FLW [1], making it challenging to quantify FLW, carry out related research, and establish specific policy goals. Various terms, such as food waste, food loss, post-harvest loss, spoilage, food and drink waste, bio-waste, and kitchen waste, are utilized interchangeably [33]. These terms may represent distinct concepts. A significant issue arises when translating such terms into another language, particularly from the original language of the author to English for global dissemination [33]. Nonetheless, numerous organizations have introduced and employed their own definitions in their research endeavors.

The definitions are similar in conveying the reduction in the quantity or quality of food intended for human consumption. Nonetheless, variations exist in the consideration of external factors and in defining the connection between Food Waste (FW) and FL [19]. As per the FAO, FL occurs in the initial three stages of the FSC, while FW denotes the wastage at the concluding stage. Under this definition, FW is associated with the behavior of retailers and consumers [12]. In the context of FUSIONS EU, all losses and waste are categorized as FW without the use of FL terminology. Food Use for Social Innovation by Optimising Waste Prevention Strategies EU (HLPE) identifies FL as a decline in the initial four stages of the FSC, with FW referring to a decrease solely in the final stage, linked exclusively to consumer behavior [17]. United States Department of Agriculture (USDA) views FW as a subset of FL, with FL representing a reduction in food across the FSC [6].

Despite valuable insights into FLW quantification, several knowledge gaps and future research directions remain. Comprehensive and standardized methods for quantifying food waste across FSC stages are needed. Understanding the socio-economic and cultural determinants of FLW is crucial for developing targeted interventions. Future research should also explore technological innovations, supply chain optimizations, and policy interventions to reduce FLW.

Generally, FL is a greater concern in developing nations, while FW is more common in industrialized nations [11], indicating that in developed nations, the primary emphasis ought to be placed on the reduction of food wastage, while in developing countries, the focus should be on the minimization of food losses [29]. A 2008 U.S. study estimated FL at retail and consumer levels cost $165.6 billion, translating to 124 kilograms of food lost per person [7]. In the hospitality industry, 20% of prepared meals were wasted, with an average of 192 grams per person per meal in Finland, Germany, Sweden, and Norway [24]. Household FW per person was approximately 136 grams in the UK, 50 grams in Germany, and 76 grams in Italy [14], [22], [23].

Five primary clusters associated with patterns of behavior regarding food waste were identified through a study in Romania via statistical analysis. These clusters show differences in eating habits and various factors studied [27]. These findings provide valuable insights for policymakers and stakeholders to develop targeted interventions for specific demographic groups [27].

The focus on FLW has greatly impacted low to middle-income nations, emphasizing the need to reduce harvest and post-harvest losses. This focus has led to incentives to minimize consumer waste. Research and international bodies are developing frameworks, methodologies, and policies to reduce FLW. The Malabo Declaration and the 2030 Sustainable Development Agenda aim to halve post-harvest losses and reduce global FW by 2030 [9]. Economic growth, rising incomes, and a declining Engel coefficient have contributed to increased FW, while sustainable development demands emphasize reducing FW and utilizing waste resources [20].

FW prevention studies and initiatives focus on the final stages of the supply chain, addressing household FW practices and policy implications [4], [30], [32]. The UN's 17 Sustainable Development Goals (SDGs) include Goal 12, focusing on responsible consumption and production, aiming to reduce FL and FW along the production and supply chains by 2030 [38]. Collaborative efforts across governments, businesses, civil society, and individuals are crucial to achieve these targets, impacting other SDGs like ending hunger and tackling climate change. This study maps specialized literature on FLW, identifying key research trends and features.

MATERIALS AND METHODS

A bibliometric analysis was conducted using resources from Scopus [34] and Web of Science (WoS) [40] databases, employing quantitative approaches to citation and co-citation evaluations. This technique relies on the idea that citations indicate intellectual communication between scholars and academic organizations [2]. Coauthorship is highlighted as a significant form of scholarly cooperation [42]. The methodology includes designing the research, gathering data, analyzing data, and visualizing findings to identify publication clusters, authors, and journals [3].

The analysis utilized Microsoft Excel and RStudio with the Bibliometrix package [3], which supports researchers by transforming data into R data frames and facilitating structured data management. The analysis involved descriptive analysis of publication datasets, co-citation, coupling, and collaboration analyses using matrices for network analysis, factorial analysis, and multidimensional scaling. These methods help examine and visualize relational structures within scholarly datasets, enhancing understanding of academic interconnections and collaborative patterns. Co-word analysis was also performed to explore relationships and thematic trends within the textual data.

The search criteria for this study included parameters such as subject area, publication language, geographical region, publication timeframe, and literature type. The focus was on English-language literature covering environmental, economic, and societal aspects, with a timeframe from 1970 to December 2023. Keywords used in the search included "food waste," "food loss," and "FLW", applied to the title, abstract, and author keywords. Additional keywords such as “measur*”, “report*”, “quanti*”, “estimat*”, “account*”, and “assess*” ensured coverage of articles addressing the quantification of FLW.

The OR disjunctive logic connector was used to broaden the search, capturing a wide range of relevant articles. This resulted in 6,387 articles from the Scopus database and 6,324 articles from the WoS database, ensuring a comprehensive collection of literature relevant to the research topic.

The search outcomes from Scopus and WoS were exported in "bibtex" format for examination in Bibliometrix. Of the 12,711 articles found, 3,841 duplicates were removed using the "remove.duplicated" function in Bibliometrix. Further refinement using Biblioshiny eliminated 350 articles published in 2024 and 23 articles with missing data, resulting in 8,497 articles available for analysis.

RESULTS AND DISCUSSIONS

To address the research questions on food loss and waste (FLW), the data analysis was organized into key segments, focusing on: publishing year (Q1), associated authors' countries (Q2), the leading authors (Q3), most relevant sources (Q4), and most cited papers (Q5).

Up until 2002, the annual publication rate on food loss and waste (FLW) was low, peaking at 13 papers in 1997 (Fig.1), with some years, such as 1978 and 1985, having no publications. From 2002 to 2014, the annual publication count varied between 22 and 168 papers. A significant increase began in 2015, with publications rising from 306 to 1,348 papers in the year 2023. This indicates that 2015 marked a notable rise in FLW research, with over 1,000 papers published annually after 2020.

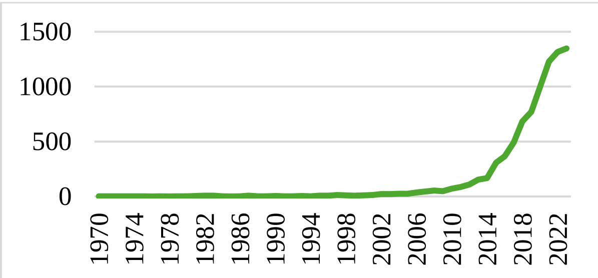

Fig. 1. Annual scientific production spanning from 1970 to 2023
Source: Own calculation on the basis of data from Scopus and WoS [34, 40].

It is important to note that a corresponding author's affiliation, including their country, can change over time. For this research, the submission and/or acceptance date of the paper was used as a reference point, as it is often closely related to the research funding. By analyzing the data based on the corresponding author's country of origin (Fig. 2), it was possible to map out a global perspective on where FLW research is most concentrated. This analysis offered valuable insights into the geographical distribution of academic interest and expertise in the field.

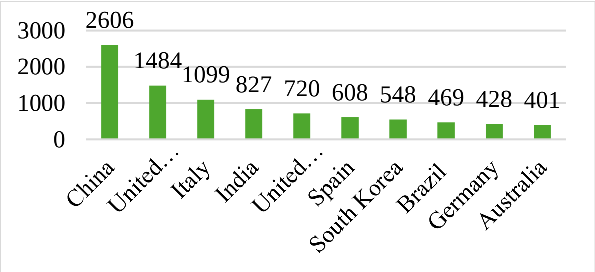

Fig. 2. Top 10 scientific production by country
Source: Own calculation on the basis of data from Scopus and WoS [34, 40].

As a result, when examining the criterion of the corresponding author's country, it was observed that with 2,606 publications, China has the highest number of scientific publications, suggesting a significant investment in the field of FLW, followed by USA (1,484), Italy (1.099), India (827), the United Kingdom (720), Spain (608), South Korea (548), Brazil (469), Germany (428) and Australia (401).

In the domain of FLW, scholars such as Li Y., Zhang Y., and Wang Y. (Table 1) have distinguished themselves through their prolific scholarly output, as evidenced by the enumeration of articles attributed to them.

Table 1. Top 10 most productive authors

Author	No. of Articles
Li Y.	125
Zhang Y.	102
Wang Y.	99
Liu Y.	96
Wang X.	75
Chen Y.	69
Li X.	67
Liu X.	64
Wang J.	63
Kim S.	59

Source: Own calculation on the basis of data from Scopus and WoS [34, 40].

The prevalence of such surnames intimates a possible geographical concentration of these academics in regions commonly associated with these surnames, potentially alluding to a robust contribution to the field emanating from nations such as China. This supposition is corroborated by the data presented in Fig. 2, which denotes China as the preeminent nation in terms of scholarly publications within this research area.

Fig. 3 provides a longitudinal depiction of scholarly productivity within the realm of FLW, showcasing the publication trajectories and the accrued citations annually for a cohort of eminent researchers. The durational breadth of the dataset implies a sustained academic tenure for the authors in question. Notably, the scholar Wang Y. manifests the genesis of their publishing efforts in the year 1997 [8] within the databases under analysis, culminating in a prolific zenith in 2023 with a total of 17 articles and a citation tally of 18 for that year. In a similar vein, the academic Li Y. reached an apogee in scholarly output in 2020, with 21 articles and an impressive citation count of 160,6 for the year, indicative of significant influence and recognition in the field.

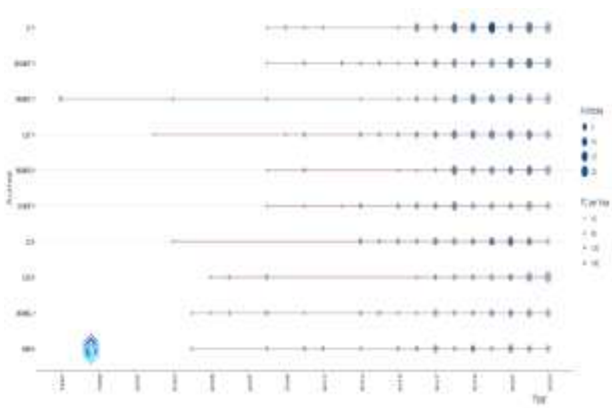

Fig. 3. Authors' production over time
Source: Visualization using Biblioshiny on the basis of data from Scopus and WoS [34, 40].

The temporal aggregation of the publication peaks across the top 10 authors, particularly within the years 2020 to 2023, suggests a crescendo in FLW research output. This surge aligns temporally with the promulgation of global sustainability objectives, which have galvanized academic inquiry into FLW, emphasizing the nexus between food waste management and overarching environmental and sustainability imperatives.

The analysis of Scopus and WoS databases identified the most prominent journals in FLW research (Table 2). A few journals dominate the field, with "Waste Management" leading with 437 papers, highlighting its prominence and influence. This is followed by "Bioresource Technology" with 404 papers, "Journal of Cleaner Production" (395), "Sustainability Switzerland" (287), "Science of the Total Environment" (242), "Resources, Conservation and Recycling" (172), "Journal of Environmental Management" (164), "Foods" (114), "Sustainability" (113), and "Waste Management and Research" (94).

Table 2. Top 10 most relevant sources

Journal	No. of Articles
“Waste Management”	437
“Bioresource Technology”	404
“Journal of Cleaner Production”	395
“Sustainability (Switzerland)”	287
“Science of the Total Environment”	242
“Resources, Conservation and Recycling”	172
“Journal of Environmental Management”	164
“Foods”	114
“Sustainability”	113
“Waste Management and Research”	94

Source: Own calculation on the basis of data from Scopus and WoS [34, 40].

The variety of these journal titles, such as "Bioresource Technology," "Journal of Cleaner Production," and "Science of the Total Environment," indicates that FLW research is interdisciplinary, encompassing technology, environmental science, and sustainable practices.

Focusing on citation counts provides insight into the influence and reach of specific articles in the field of FLW (Table 3). It highlights key contributions that have shaped the discourse and research, as well as the most recognized and referenced papers by the academic community. By identifying these highly cited articles, we gain a clearer understanding of the pivotal research and seminal works driving advancements in FLW quantification.

The paper “Options for keeping the food system within environmental limits” by Springmann et al. [36] tops the list with 1,561 citations. It is followed by “Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use” by Kummu et al. [21] with 843 citations, and “Characterization of food waste as feedstock for anaerobic digestion” by Zhang et al. [41] with 823 citations. The highest citation counts come from "Nature" (1,561 citations), "Science of the Total Environment" (843 citations), and "Bioresource Technology" (823 citations), indicating the significant impact and relevance of these journals in the research community.

Table 3. Top 10 most frequently cited articles

Scopus titles	Authors	Citations
“Options for keeping the food system within environmental limits” [36]	Springmann, M. et al. (2018)	1,561
“Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use” [21]	Kummu, M. et al. (2012)	843
“Characterization of food waste as feedstock for anaerobic digestion” [41]	Zhang, R. et al. (2007)	823
“The food waste hierarchy as a framework for the management of food surplus and food waste” [28]	Papargyropoulo, E. et al. (2014)	785
“Hydrogen production from agricultural waste by dark fermentation: A review” [15]	Guo, X.M. et al. (2010)	658
“Determinants of consumer food waste behaviour: two routes to food waste” [37]	Stancu, V. et al. (2016)	618
“Diversification practices reduce organic to conventional yield gap” [31]	Ponisio, L.C. et al. (2014)	537
“The Food Systems in the Era of the Coronavirus (COVID-19) Pandemic Crisis” [13]	Galanakis, C.M. (2020)	523
“Importance of food-demand management for climate mitigation” [5]	Bajželi, B. et al. (2014)	514
“The Progressive Increase of Food Waste in America and Its Environmental Impact” [16]	Hall, K.D. et al. (2009)	505

Source: Own calculation on the basis of data from Scopus and WoS [34, 40].

There is an overlap between the top 10 most relevant sources and the journals listed in the top 10 most cited papers. Specifically, "Bioresource Technology" with 404 papers, "Journal of Cleaner Production" with 395 papers, "Science of the Total Environment" with 242 papers, and "Foods" with 114 papers are on both lists. The most cited articles cover themes such as the environmental impact of food waste, sustainable food systems, food waste hierarchy, and food-demand management. This diversity emphasizes the blend of environmental, technological, and socio-economic perspectives in FLW research. The international authorship of these papers signifies global concern and collaborative efforts in addressing FLW.

Aria and Cuccurullo [3] proposed a mathematical framework for analyzing bibliometric networks, which is instrumental in understanding various relational aspects in bibliometric studies. Their approach is encapsulated in several equations, each tailored to analyze a different type of bibliometric network:

Equation for coauthorship/collaboration network (B_{coll}):

$B_{coll} = A \times A^t$ [3]......................................(1)

Here b_{ij} demonstrates the quantity collaborations between countries *i* and *j*, highlighting coauthorship networks.

Equation for keyword co-occurence network (B_{coocc}):

$B_{coocc} = A \times A^t$ [3].....................................(2)

where:

A and A^t are matrices of the type "Document x Word", where "Word" may be terms taken from the titles or abstracts, authors' keywords, or keywords. The element b_{ij} shows the quantity of occurrences between words *i* and *j*, hence mapping the network of co-occurrences of keywords.

These equations are fundamental in bibliometric analyses for constructing and interpreting various bibliometric networks, such as bibliographic coupling, cocitation, collaboration, and keyword co-occurrence networks. They offer a quantitative way to analyze and visualize the relationships and interconnections within a set of documents, authors, or keywords.

The concept of a scientific network of authors, where nodes represent specific authors grouped by criteria such as country or institution [25]. Links between these nodes indicate collaborative relationships, typically shown by coauthorship on research papers. In this study, coauthorship analysis was conducted to illuminate collaborative links between authors across different countries. Using Biblioshiny, 8,497 records were examined to map the international landscape of author collaborations. The analysis identified authors from 123 countries, with 50 countries chosen for representation, showing the strongest interconnections in collaboration.

The analysis revealed (Fig. 4) that authors from China, the USA, the UK, and Italy have the highest levels of international collaboration. Four author collaboration clusters were identified:

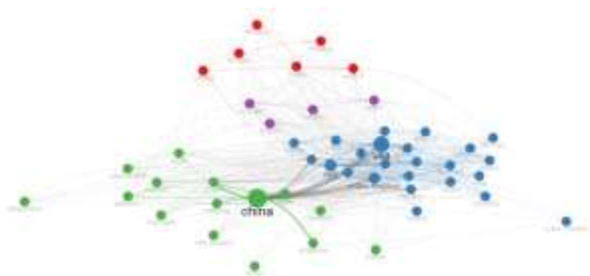

Fig. 4. Countries collaboration
Source: Visualization using Biblioshiny on the basis of data from Scopus and WoS [34, 40].

Green cluster: China, India, Thailand, Singapore, Finland, New Zealand, South Korea, Pakistan, Bangladesh, Saudi Arabia, Egypt, Indonesia, and Malaysia.

Blue cluster: USA, UK, Italy, Ireland, Netherlands, Switzerland, Austria, Belgium, Japan, Australia, Spain, Canada, Colombia, Sweden, Mexico, Norway, France, Denmark, Germany, Chile, South Africa, Nigeria, and Iran.

Red cluster: Poland, Romania, Lithuania, Serbia, Slovenia, and Croatia.

Purple cluster: Portugal, Brazil, Greece, and Hungary.

This study's keyword co-occurrence analysis aimed to explore and highlight relationships between essential keywords used by authors in research papers, referred to as Author Keywords (AKs). Unlike other bibliometric analyses that start with bibliographic references, this analysis focused directly on these keywords. The co-word network visualization showed how frequently certain keywords appeared together, creating a network of related terms.

The primary goal was to define the conceptual framework for the FLW topic. By analyzing patterns of keyword co-occurrence, core themes and subthemes were identified within the field. The study examined keywords in the 8,497 articles indexed in Scopus and WoS, selecting the top 50 most used keywords for representation.

Within this scholarly context, "food waste" and "anaerobic digestion" emerged as prominent terms (Fig.5), indicating key themes and subjects frequently explored by authors. Two main keyword clusters were identified:

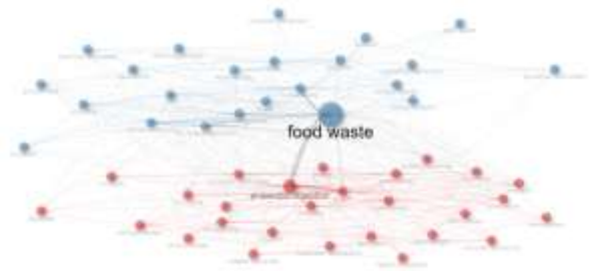

Fig. 5. The occurrence of keywords
Source: Visualization using Biblioshiny on the basis of data from Scopus and WoS [34, 40].

Blue cluster: food waste, waste, carbon footprint, household food waste, plate waste, consumer behavior, food loss, environmental impact, Covid-19, food, food security, sustainability, agriculture, food supply chain, food loss and waste, climate change, environment, recycling, waste management, circular economy, life cycle assessment (LCA), and biodiesel.

Red cluster: anaerobic digestion, biowaste, municipal solid waste, compost, bioenergy, composting, sewage sludge, kitchen waste, organic waste, optimization, microbial community, biogas, biochar, methane, biohydrogen, anaerobic co-digestion, fermentation, biomass, biomethane, co-digestion, hydrogen, volatile fatty acids, digestate, biorefinery, energy, and renewable energy.

These clusters encapsulate the principal investigative interests and thematic concentrations of FLW research.

The study has illuminated the evolution of FLW research, noting a substantial increase in scholarly interest and publication volume starting from 2015. This trend underscores a growing recognition of the socio-economic and environmental implications of FLW, reflecting heightened global awareness and academic engagement.

The analysis identified China, the United States, Italy, and India as the leading nations in FLW research, indicating their pivotal roles and investment in addressing FLW challenges. These countries host established research communities and collaborative networks, making them focal points for future funding and cooperative efforts.

Prominent authors such as Li Y., Zhang Y., and Wang Y. have made substantial contributions to the FLW discourse, shaping the academic landscape with their prolific research output. Their work, along with the key journals like "Waste Management," "Bioresource Technology," and "Journal of Cleaner Production," highlights the interdisciplinary nature of FLW research, integrating technological, environmental, and socio-economic perspectives.

Highly cited papers, such as Springmann et al. [36] study on environmental limits, have significantly influenced the field, covering diverse themes including the environmental impact of food waste, sustainable food systems, and food-demand management. These foundational works provide critical insights and directions for future research.

The coauthorship analysis revealed strong international collaborations, particularly among researchers from China, the USA, the UK, and Italy. This network of collaborations underscores the global effort and interconnectedness in tackling FLW issues.

The identified collaboration clusters demonstrate the presence of robust national and international research networks dedicated to FLW.

Keyword analysis further defined the conceptual framework of FLW research, with "food waste" and "anaerobic digestion" emerging as central themes. The identified keyword clusters encompass a broad range of research topics, reflecting the comprehensive scope of FLW studies.

CONCLUSIONS

The bibliometric analysis of quantifying food loss and waste (FLW) has successfully addressed the research purpose by responding to five key questions, producing a comprehensive bibliographic mapping of FLW studies with significant socioeconomic implications. The study identified a limited number of literature reviews on FLW in Scopus and WoS databases, highlighting the need for further comprehensive analyses.

Key contributions of the study include identifying gaps and new directions for future research. Providing a roadmap for navigating the complex FLW research landscape. Guiding researchers in identifying potential collaborators and understanding geographic distribution of research activity. Outlining main research areas, key publications, and influential authors to shape future research focus and methodologies.

The analysis focused on rigorously reviewed and indexed research papers, ensuring academic credibility. However, this methodology limits the study to sources in Scopus and WoS, suggesting future studies should include a broader range of sources for a more comprehensive understanding of FLW.

The study advocates for an integrative research agenda spanning technological, ecological, and socio-economic domains. Future research should leverage big data and AI, emphasize waste valorization, foster consumer awareness, and implement scalable policy-driven solutions. Strengthening dialogue between developed and developing nations is essential for sustainable global food systems, requiring cross-disciplinary collaboration and innovation.

In summary, this bibliometric analysis has mapped out the primary trends and features of FLW research, offering valuable insights for academics, policymakers, and stakeholders. It underscores the need for continued interdisciplinary and international collaboration to effectively address the multifaceted challenges of FLW. Future research should focus on refining quantification methods, exploring socio-economic determinants, and leveraging technological innovations to reduce FLW and promote sustainable food systems.

Additionally, a systematic appraisal of FLW studies is recommended to enhance understanding of theoretical developments and ensure future research is built on a robust analytical foundation.

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ECONOMIC ANALYSIS OF GRAIN MAIZE PRODUCTION: A CASE STUDY IN TÜRKİYE

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Abstract

The main purpose of this study is to determine the level of input use, cost and profitability for farmers and entrepreneurs by making an economic analysis of grain maize production in Izmir province of Türkiye. The data of the study was collected by survey method from 93 farmers with proportional sampling. First, the socio-economic characteristics of the farmers were examined. Then, the activity results of the farmers regarding maize production were analyzed. Variable cost items in maize production were labour and machine costs, material (seed, fertilizer, pesticide, water, etc.) costs and interest on the total costs. Fixed cost items were land rent and management costs. To calculate the net return obtained from maize, production costs were subtracted from the gross production value. The average age of the farmers and average education period were determined as 46.47 and 7.81 years, respectively. The average maize land in the farms was 9.90 hectares. The average total production cost per hectare for maize was 27,953.30 TL. Farmers obtained an average of 15,885.16 TL/ha gross return and 11,406.71 TL/ha net return from maize production in the relevant period. The study results show that maize production in the region can be done economically.

Key words: *maize growing, maize costs, maize marketing, profitability analysis*

INTRODUCTION

Different purposes can be considered when determining the crop pattern in the farms. Farmers are looking for ways to obtain the highest income when determining the crop pattern. One of the most important alternatives for farmers in irrigable lands is maize [14]. The origin of maize (*Zea mays L.*) is the Andean Region of Central America. It is one of the most important grains for human and animal nutrition. In terms of global production, maize was the third most important food crop after rice and wheat. Demand for maize is increasing both as a fresh and processed food [20]. Maize is currently also grown for the biodiesel market by many ethanol plants. Maize, which has a very important place in the market with its agricultural products, production and trade, is an important food source due to the valuable nutrients it contains [1, 5].

According to FAO's 2022 data, 1,163 million tons of maize were produced in 203.5 million hectares of land in the world. Maize ranks second in the world after wheat in terms of growing area and first in terms of production. The most important countries in world maize production are USA (30%), China (24%), Brazil (9%), Argentina (5%) and India (3%) [19]. Many studies have been conducted on the economic aspects of maize production in different countries of the world [24, 27, 34, 36, 2, 3, 23, 37, 29, 17, 33]. These studies have shown that maize production can be done profitably in different climate and soil conditions.

According to TURKSTAT data, 8.5 million tons of grain maize were produced in 911,885 hectares of land in Türkiye in 2022. 74% of the total maize production was obtained from main crop maize. 30% of the maize produced in 2022 was provided from Western Anatolia Region, 22% from the Mediterranean Region, 21% from Southeastern Anatolia Region, 11% from Eastern Marmara Region and 7% from the Aegean Region. Maize yield in Türkiye may vary from region to region. The average maize yield per hectare in Türkiye in 2022 is 9,321 kg [39]. In the same year, the world average maize yield was 5,718 kg and Türkiye were well above this yield level [19].

The increasing trend in maize production in recent years is a positive development in terms of meeting domestic demand with domestic supply and reducing the increase in imports. However, in the future, it is necessary to preserve and further develop the current production structure and ensure continuity in production. From this perspective, the premium application and the purchases of the Turkish Grain Board are important. On the other hand, the most important factor in increasing maize production is increasing the yield level [38].

Many studies have been conducted on the cost and profitability analysis of maize in Türkiye [9, 12, 16, 13, 6, 32, 11, 26, 22, 15, 7, 40]. These studies have shown that maize is an important alternative for irrigated lands in terms of increasing farmer income. However, these studies need to be repeated over time and in different regions. Because changes in economic and ecological conditions can affect production costs and income levels.

One of the provinces of Türkiye with significant agricultural potential is Izmir province. In this province, farmers mostly grow potatoes, cotton, tomato (paste), pepper, cucumber, watermelon, green beans, maize, wheat and some forage crops on irrigated lands. In recent years, declines and fluctuations in cotton, tomato and wheat income have led farmers in Izmir to turn to maize production. Ecological and economic conditions may have an impact on the income provided by maize farmers. Therefore, farmer practices, input selection and usage levels, cost and income items in maize production need to be determined over time and through local research. The research results can be a guide for farmers in determining the crop pattern, as well as contribute to the control of production costs, preparation of production plans, and the creation and implementation of appropriate agricultural policies.

The main purpose of this study is to determine the level of input use, cost and profitability for farmers and entrepreneurs by making an economic analysis of grain maize production in Izmir province of Türkiye.

MATERIALS AND METHODS

Study data was obtained by face-to-face survey method from maize farmers in Menderes district of Izmir province (Map 1). In addition, the results of previous studies and statistical data published by relevant institutions were also used.

Map 1. Menderes districts in Izmir province
Source: [4].

Approximately 2% of grain maize production in Türkiye is provided by Izmir province. Menderes district is one of the important districts in maize production in Izmir province. This district provides approximately 20% of the maize production in the province. For this reason, it was planned to include Menderes district. According to the information received from the Menderes District Directorate of the Ministry of Agriculture and Forestry, Cileme, Tekeli, Cakaltepe, Karakuyu, Gölcükler and Develi neighbourhoods, which produce approximately 90% of maize production in the district, were included in the scope of the study. The total number of farmers registered in the Farmer Registration System in these neighbourhoods was determined as 742. Some of these farmers were included with proportional sampling. At this stage, the following formula was used [30]. It is seen that this formula has been used in many similar studies [18, 21, 11].

$$n = \frac{Np(1-p)}{(N-1)\sigma^2_{px} + p(1-p)} \quad (1)$$

In the formula:
n = Sample size
N = Total number of farmers

p = Proportion of farmers producing maize (0.5 was taken for maximum sample size)
$\sigma^2 px$ = Variance.

In the study, calculations were made based on a 90% confidence interval and an 8% margin of error, and the sample size was determined as 93. In determining the number of farmers to be interviewed in each neighbourhood, the shares of the neighbourhoods in the total number of farmers were taken as basis. The farmers to be interviewed in the neighbourhoods were determined using the random numbers table. Study surveys were conducted in March-April 2022.The study was found ethically appropriate with the decision of Ege University Scientific Research and Publication Ethics Committee numbered E.668908/2022.

In the analysis of data, farmers are divided into 3 groups according to the size of their maize land. The first group is farmers with maize land of less than 5.0 hectares (36 farmers), the second group is farmers with maize land of 5.0-9.9 hectares (27 farmers), and the third group is farmers with maize land of 10.0 hectares and more (30 farmers) were formed.

First, the socio-economic characteristics of the farmers were examined. At this stage, the age, education period, household size, land size, family labour potential, capital availability and organizational characteristics of the farmers were determined.

In the study, the activity results of the farmers regarding maize production were analyzed. Variable cost items in maize production; labour and machine costs, material (seed, fertilizer, pesticide, water, etc.) costs and interest on the total costs.

Fixed cost items are land rent and management costs. Half (5%) of the interest rate applied by Ziraat Bank (State Agriculture Bank) for subsidized crop production loans in 2021 was used in interest calculations. In calculating the management costs, 3% of variable costs was taken.

The following formulas were used to calculate the gross and net return obtained from maize production [25].

Gross Return = Gross Production Value – Variable Costs..(2)

Net Return = Gross Production Value – Production Costs...(3)

Farmers' opinions about the economic aspects of maize growing and their tendencies to sustain it in the future are revealed. At this stage, a five-point Likert scale was used [8].

In the study, it was also tested statistically whether there was a difference between the farm groups. For continuous variables, first the Kolmogorov-Smirnov test and the normal distribution test were applied, and variables with or without normal distribution were determined. Analysis of variance (ANOVA) was performed for normally distributed variables. For variables that do not show normal distribution; the Kruskal-Walli’s test was used [31].

RESULTS AND DISCUSSIONS

Information on the socio-economic characteristics of farmers is presented in Table 1.

The average age of the farmers and average education period were determined as 46.47 and 7.81 years, respectively. The education period of the farmers in the third group is longer. However, the difference between groups is not statistically significant ($p>0.05$).

The average experience period of farmers in maize production was determined as 15.90 years. In a study conducted in Kahramanmaras province, Türkiye, the average maize production experience of farmers was found to be 11 years [32].

The average household size in farms was found to be 3.49. 49.23% of the total population in farms is women, and 47.12% is the population in the 15-49 age group.

Family labour potential was calculated as male labour unit (MLU) and it was determined as average 2.46 MLU.

Table 1. Socio-economic characteristics of farmers

Characteristics	Farm groups			
	Group 1 (<5.0 ha)	Group 2 (5.0-9.9 ha)	Group 3 (≥10.0 ha)	General
Age of farmers	46.31	48.48	44.87	46.47
Education period of farmers (year)	7.42	7.15	8.87	7.81
Maize experience of farmers (year)	15.33	16.74	16.00	15.90
Household size	3.08	3.89	3.63	3.49
Family labour potential (MLU)	2.22	2.75	2.48	2.46
Land size (ha)	93.39	112.00	343.67	179.53
Equity rate (%)	90.99	93.72	95.52	93.02
Cooperative partnership rate (%)	75.00	55.56	73.33	68.82

Source: Results of this study.

The average agricultural land cultivated by farms is 179.53 decares. 64.27% of the total land consists of self-owned lands. 97.27% of the active capital owned by farms is land assets. Soil assets constitute 82.24% of the land assets. In liabilities, the most important element is equity capital with 93.92%. 68.82% of the farmers stated that they were partners in any cooperative. In a study conducted in Konya province, Türkiye, it was found that 87.77% of maize farmers were partners in an agricultural cooperative [11].

The average maize land in the farms was determined as 9.90 hectares. 67.07% of the land where maize is produced in farms consists of self-owned lands. When the farm groups are examined, it is seen that the highest proportion of self-owned land is in the third group (68.95%) (Table 2). In a study conducted in Kahramanmaras, Türkiye, the average maize production land was found to be 8.15 hectares [32]. In a study conducted in Konya, Türkiye, it was determined as 10.40 hectares [11].

Table 2. Ownership characteristics of maize lands

Farm groups	Land ownership			
	Self-owned land (ha)	Jointly operated land (ha)	Rented land (ha)	Total land (ha)
Group 1 (<5.0 ha)	1.69	0.51	0.79	2.99
Group 2 (5.0-9.9 ha)	4.67	1.09	1.22	6.98
Group3 (≥10.0 ha)	14.37	4.07	2.40	20.84
General	6.64	1.83	1.43	9.90
%	67.07	18.49	14.44	100.00

Source: Results of this study.

The average maize production amount in the farms was determined as 143,787.47 kg. Maize yield based on the average production area is calculated as 14,523.99 kg/ha. It is seen that the yield is higher in the first group of farms (Table 3).

The varieties used and timely irrigation and maintenance play an important role in yield level.

The difference between groups is not statistically significant (p>0.05).

Table 3. Yield obtained from maize production

Farm groups	Maize production land (ha) (1)	Total production quantity (kg) (2)	Yield (kg/ha) (2/1)
Group 1 (<5.0 ha)	2.99	43,958.33	14,701.78
Group 2 (5.0-9.9 ha)	6.98	99,990.74	14,325.32
Group3 (≥10.0 ha)	20.84	302,999.50	14,539.32
General	9.90	143,787.47	14,523.99

Source: Results of this study.

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In studies conducted in different provinces of Türkiye, it has been determined that the average maize yield varies between 7,000 and 15,032 kg/ha [35, 13, 10, 32, 11, 26, 41, 22, 15].

76.13% of the maize produced in the farms was marketed (Table 4).

It is seen that some of the maize is reused in the farms, and some is given to the workers.

The marketing rate of maize in the third group of farms is higher than the others (76.89%).

Table 4. Marketed quantity of maize

Farm groups	Total production quantity (kg)	Total quantity of marketed (kg)	Total quantity used in the farms (kg)	Total quantity given to workers (kg)
Group 1 (<5.0 ha)	43,958.33	32,777.78	10,972.22	208.33
Group 2 (5.0-9.9 ha)	99,990.74	74,472.22	25,185.19	333.33
Group3 (≥10.0 ha)	302,999.50	232,976.17	69,500.00	523.33
General	143,787.47	109,462.74	33,978.49	346.24
%	100.00	76.13	23.63	0.24

Source: Results of this study.

72.06% of the maize marketed in farms was sold to merchants-brokers. It is seen that farmers also market to maize processing companies and livestock enterprises (Table 5).

The rate of marketing maize to merchants-brokers is higher in the third group of farms than in others (73.26%).

Table 5. Maize marketed channels

Farm groups	Marketing channels			
	Merchants-brokers (kg)	Maize processing companies (kg)	Livestock enterprises (kg)	Total (kg)
Group 1 (<5.0 ha)	23,194.44	4,166.67	5,416.67	32,777.78
Group 2 (5.0-9.9 ha)	51,137.04	14,444.44	8,890.74	74,472.22
Group3 (≥10.0 ha)	170,680.00	48,666.67	13,629.50	232,976.17
General	78,882.80	21,505.37	9,074.57	109,462.74
%	72.06	19.65	8.29	100.00

Source: Results of this study.

The average maize price received by farmers in the examined farms was calculated as 2.71 TL/kg. It is seen that farmers in the third group obtain higher maize prices. However, the difference between groups is not statistically significant ($p>0.05$). Considering the yield per hectare and the average price received by the farmers, the average gross production value obtained from maize is calculated as 39,603.01 TL/ha (Table 6).

Table 6 . Gross production value obtained from maize production

Farm groups	Yield (kg/ha) (1)	Average maize price (TL/kg) (2) (*)	Gross production value (TL/ha) (1x2) (*)
Group 1 (<5.0 ha)	14,701.78	2.67	39,253.75
Group 2 (5.0-9.9 ha)	14,325.32	2.70	38,678.36
Group3 (≥10.0 ha)	14,539.32	2.77	40,273.92
General	14,523.99	2.71	39,360.01

*1 US$ = 8.88 TL in 2021
Source: Results of this study.

The inputs used by farmers for maize production and their average usage amounts are shown in Table 7. Seed usage per hectare was determined as 30.10 kg, labour usage was 60.00 hours, and machine power usage was 38.70 hours. The most used corn varieties were DEKALB DKC 6761, DEKALB DKC 6980, Syngenta (SY Prosperic, Gladius,

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Fuerza) and May 7575. Farmers use pesticides for weeds, leafworms, earworms and spider mites. It was determined that farmers used 12 kg of herbicide and 2.8 kg of insecticide per hectare.

Table 7. Inputs used in maize production

Inputs	Farm groups			
	Group1 (<5.0 ha)	Group 2 (5.0-9.9 ha)	Group 3 (≥10.0 ha)	General
Materials				
Seed (kg/ha)	29.70	30.40	30.30	30.10
Fertilizer (kg/ha)				
N	444.40	429.60	481.70	452.10
P_2O_5	177.80	161.10	191.70	177.40
K_2O	70.80	63.00	81.70	72.00
Pesticides (kg/ha)				
Herbicide	9.20	13.30	14.30	12.00
Insecticide	2.40	3.03	2.80	2.80
Labor (h/ha)	57.40	61.40	62.00	60.00
Soil preparation	11.40	12.20	12.00	11.80
Planting	2.50	3.00	3.00	2.80
Fertilization	3.30	3.30	3.30	3.30
Pesticide application	3.10	3.70	3.70	3.40
Irrigation	23.60	24.10	24.30	24.00
Hoeing	7.20	8.10	8.00	7.70
Harvest	4.40	4.80	4.70	4.60
Transportation	1.90	2.20	3.00	2.40
Machine power (h/ha)	35.30	39.30	42.30	38.70

Source: Results of this study.

Table 8. Maize production costs (TL/ha)

Cost items		Farm groups			
		Group 1 (<5.0 ha)	Group 2 (5.0-9.9 ha)	Group 3 (≥10.0 ha)	General
1. Labor and machine costs	Soil preparation	2,736.10	2,685.20	2,783.30	2,736.60
	Planting	944.40	925.90	966.70	936.20
	Fertilization	888.90	851.80	933.30	882.50
	Hoeing	1,097.20	1,074.10	1,133.30	1,092.10
	Irrigation	1,527.80	1,463.00	1,616.70	1,527.60
	Pesticide application	1,166.70	1,185.20	1,233.30	1,183.50
	Harvest	3,263.90	3,037.00	3,266.70	3,188.90
	Transportation	1,194.40	1,092.60	1,266.70	1,188.20
	Total	12,819.40	12,314.80	13,200.00	12,735.60
2.Material costs	Seed	2,083.30	2,018.50	2,166.70	2,081.40
	Fertilizer	3,138.90	2,963.00	3,166.70	3,086.80
	Pesticide	1,263.90	1,333.30	1,366.70	1,317.20
	Electric diesel	2,361.10	2,351.80	2,433.30	2,381.70
	Others	694.40	777.80	816.70	754.30
	Total	9,541.60	9,444.40	9,950.10	9,621.40
3.Interest on variable costs (5%)		1,118.05	1,087.96	1,157.50	1117.85
4.Total variable costs (1+2+3)		23,479.05	22,847.16	24,307.60	23,474.85
5.Fixed costs	Management cost (3%)	704.37	685.41	729.23	704.25
	Land rent	3791.70	3,759.20	3,766.70	3,774.20
	Total	4,496.07	4,444.61	4,495.93	4,478.45
Total production costs (4+5)		**27,975.12**	**27,291.77**	**28,803.53**	**27,953.30**

Source: Results of this study.

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Farmers use compound fertilizers (15-15-15, 18-18-18, 20-20-20), Ammonium Nitrate (26%), DAP (18-46), Ammonium Sulphate, Urea, Potassium Sulphate and uses leaf fertilizer.

The average total cost per hectare for maize production in farms was calculated as 27,953.30 TL (Table 8). Variable costs constitute 83.98% of total production costs. Total production costs are higher in the third group of farms. 54.25% of variable costs consist of labour and machine costs. The cost items that have the highest share in total production costs are land rent (13.50%), harvest costs (11.30%), fertilizer costs (11.04%) and electric-diesel costs (8.52%). Studies conducted in different provinces of Türkiye have found that the share of variable costs in production costs varies between 65.45% and %83.72 [35, 13, 10, 32, 41, 26, 15].

When the total production cost per hectare for maize in farms was divided to the yield, the unit maize cost was calculated as 1.92 TL/kg. In the third group of farms, unit costs are higher. However, the difference between groups is not statistically significant (p>0.05). Average gross return and net return obtained from maize in farms were calculated as 15,885.16 and 11,406.71, respectively. The gross and net return in the third group of farms is higher (Table 9). The difference between groups is not statistically significant (p>0.05).

Table 9. Profitability level of maize production in farms

Economic results	Farm groups			
	Group 1 (<5.0 ha)	Group 2 (5.0-9.9 ha)	Group 3 (≥10.0 ha)	General
Yield (kg/ha) (1)	14,701.78	14,325.32	14,539.32	14,523.99
Average maize price (TL/kg) (2)	2.67	2.70	2.77	2.71
Gross production value (TL/ha) (3=1x2)	39,253.75	38,678.36	40,273.92	39,360.01
Variable costs (TL/da) (4)	23,479.05	22,847.16	24,307.60	23,474.85
Production costs (TL/ha) (5)	27,975.12	27,291.77	28,803.53	27,953.30
Unit maize cost (TL/kg) (6=5/1)	1.90	1.91	1.98	1.92
Gross return (TL/ha) (7=3-4)	15,774.70	15,831.20	15,966.32	15,885.16
Net return (TL/ha) (8=3-5)	11,278.63	11,386.59	11,470.39	11,406.71

Source: Results of this study.

According to the study results, when the proportional return is calculated, that is, when the gross production value is divided by production costs, it is determined as 1.41. In other words, 1.41 TL production value is obtained for 1 TL cost in maize production in farms. In studies conducted in different provinces of Türkiye, it was determined that the relative return obtained from maize varied between 1.16 and 1.74 [35, 10, 32, 26; 15].

The government also provides support for grain maize production.

Table 10. Farmers' opinions on the economic aspects of maize growing

Opinions	Participation level*
Maize production provides a good income level	4.10
High yield is obtained from maize production	3.83
Maize has a high price advantage	3.84
Maize has a cost advantage	4.13
Maize has ease of marketing	4.04
Maize production is storable	4.12
Maize is suitable for contract production	4.07
Supports for maize production is sufficient	2.39
I would like to continue maize production in the future	4.04

*1: Strongly disagree, 2: Disagree, 3: Undecided, 4: Agree, 5: Strongly agree
Source: Results of this study.

In 2021, maize farmers were provided with 270 TL diesel fuel and 80 TL fertilizer support per hectare. In addition, 0.03 TL/kg was paid to maize farmers as a difference payment (premium) [28].

When fertilizer and diesel support (350 TL/ha) and premium support (435.72 TL/ha) are added, the average net return obtained from maize in the farms reaches 12,192.43 TL/ha.

In the study, farmers were asked about their opinions on the economic aspects of maize growing. According to the answers, it is possible to say that the farmers are satisfied with the yield and income level of maize and do not experience marketing problems. However, it is understood that they do not find government support sufficient (Table 10).

CONCLUSIONS

In this study, the economic aspects of grain maize production were analyzed with data collected from 93 farmers in Menderes district of Izmir province. According to the study results, farmers achieved an average maize yield of 14,523.99 kg/ha. Maize was marketed at an average price of 2.71 TL/kg and an average gross production value of 39,360.01 TL/ha was obtained. The average total production cost per hectare for maize was 27,953.30 TL. Farmers obtained an average of 15,885.16 TL/ha gross return and 11,406.71 TL/ha net return from maize production in the relevant period.

The study results show that grain maize production in the region can be done economically. As a matter of fact, farmers think that the yield is at the desired level, marketing of maize is easy, and the net return obtained from maize is sufficient. While the high-water demand of maize is a disadvantage, the low labour demand and the use of machine power at all stages may be a reason for preference for farmers. Farmers have a positive approach to contract maize production. Farmers do not find government support sufficient. However, farmers tend to sustain mostly maize production.

It would be beneficial to take some measures to increase grain maize production and ensure sustainability both in the region and throughout Türkiye. Maize has a high price in the domestic market. This is due to high input costs. Local and cheap input supply can be ensured through policies regarding input costs, price policies and credit opportunities for farmers can increase the attractiveness of maize production and reduce costs. Increases in input prices increase production costs. For this, field-based input support should be increased. Additionally, taxes paid on inputs should continue to be reduced. Most farmers find government support insufficient. Increasing the difference payment for maize production is one of the most important expectations of farmers. Support in this direction should be increased and support payments should be planned on time. Maize is a crop that requires a lot of irrigation. Farmers are having difficulty covering water costs. Therefore, farmers should be informed about the use of alternative irrigation techniques and encouraged through financial methods. Turkish Grain Board should announce the guaranteed crop price early to support farmers, and the necessary financial means should be created to make the necessary payments on time. For farmers to obtain input at lower prices, cooperative and union activities should be increased, and the organization of farmers should be encouraged.

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THE ROLE OF INVESTMENTS IN THE MODERNIZATION AND DEVELOPMENT OF THE VITIVINICULTURAL SECTOR

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Abstract

The paper presents the analysis of the investment flow in the vitivinicultural sector and the prospects for the development of the sector, and a SWOT analysis was developed to have a conjugate vision of the sector. The paper reflects the role and importance of investment in the modernization and development of the sector by increasing competitiveness, economic performance of enterprises, market growth and diversification. In Moldova, the vitivinicultural sector is at the heart of the harmoniously developed social and economic life, due to the favorable conditions, also wines can be considered as the visiting card of the Republic of Moldova. The methodology applied includes systemic analysis methods, quantitative and qualitative methods, economic and financial analyses specific to the production and marketing activity. The results of the research revealed the connection between investments in modernization-innovation and sustainable growth of the vitivinicultural sector through: improvement of technological processes, improvement of working and living conditions of the involved population, especially those in rural areas, effects of new technologies on the environment.

Key words*: *vitivinicultural sector, investment, sustainable development, modernization, innovation

INTRODUCTION

The vitivinicultural sector is the most important part of the agricultural sector, and the wine industry represents about 3% of the GDP and about 8% of the country's exports [6] and are exported to more than 70 countries. Wine is also strategically important for the positioning of the Republic of Moldova as a country, being the first reason why tourists visit the country. The image and position of Moldovan wine on foreign markets can help shape the way the Republic of Moldova is perceived in the world. Vine plantations occupy 7% of the total agricultural land in Moldova and 3.8% of the total surface of the country, demonstrating the highest density of vineyards in the world.

The wine sector is an important source of income for the country's population, especially for people living in rural areas. The development of this sector will reduce poverty in rural areas and improve living standards. For the development and modernization of the wine sector, investments and modern and efficient technologies are needed, this would be one of the reasons why the population, especially young people, stay in rural areas.

Over the years, the wine sector has gone through several major crises with negative consequences. In order to recover the situation in the sector and its revitalization, several restructurings were necessary, adapting to the new paradigms and market development trends. Thus, in order to ensure a sustainable development, it is necessary that the modernization and development strategies of the wine sector are supported by concrete and well-motivated measures and actions, by coordinated and effective involvement both at the level of sectoral policies and at the level of the wine business. The modernization of the sector must be supported by investment strategies coupled with the need to modernize through modern techniques, technological development, digitization, innovations and also through the establishment of vineyards with new, productive and competitive varieties that will have an impact on the quality of the wine, which is the calling card of the country.

A solution regarding the restructuring and modernization of the viticultural sector can be through investments, subsidies being a tool applied by the authorities to stimulate this process. The authors, Timofti E. and Șargo [15] emphasize that: "the investments have a pronounced innovative character for the development of agriculture, which creates material conditions necessary for the promotion of technical progress and the results of scientific research in the field of agriculture, a fact that ensures the improvement of the means of production, of technologies, forms of production organization".

The aim of this research is to study and analyze investments aimed at modernization and development of the wine sector. At the same time, it was carried out the diagnosis of the wine sector from the economic and investment perspective to highlight the need and importance of implementing modern technologies.

MATERIALS AND METHODS

The informational support for this work was the significant scientific publications, legislative acts and policy documents, reports and publications of the National Bureau of Statistics, Ministry of Agriculture and Food Industry, Reports of the National Office of Vine and Wine, Reports of the Agency for Intervention and Payments for Agriculture. Research methods such as: the documentary method, the synthesis method, the graphic and table method, as well as the analysis by the comparative method were used to create this article.

In order to identify the strengths and weaknesses within the wine sector, the authors applied SWOT analysis.

RESULTS AND DISCUSSIONS

Studying and mapping a sector from an economic and investment perspective allows highlighting the existing investment potential, identifying intervention solutions that would accelerate development, orient businesses towards important investment objectives, strengthen strategies calibrated to sustainable growth trends [14].

In this paper we applied SWOT-analysis method, which allows us to analyze the current situation in the winemaking sector (Table 1) in order to outline specific directions and measures aimed at the development and modernization of the winemaking sector [5].

Table 1. SWOT analysis of the vitivinicultural sector

Advantages	Favorable climatic and pedological conditions for the development of the vitivinicultural sector. The existence of the wine industrial potential. Rich traditions in the production of quality wine. Capitalizing on sloping land. High overall economic efficiency and satisfactory profitability. Making investments in the development of the sector. Ensuring a decent living in the rural area. Increasing the surface area of grapes. Entering new markets. ***Wine Day*** holiday. The emergence of new partners.
Disadvantages	Lack of a positive image formed. Varieties with low productivity. Increased competition. Price changes. Current production technologies do not allow the production of quality and competitive grapes for export. High costs of harvesting, storage and packaging. Lack of knowledge and experience in intensive production technologies. Modern technologies insufficiently applied. Lack of professional training and retraining of the workforce. Poorly developed tourist infrastructure.
Opportunities	Implementation of innovative technologies. The existence of the market. Implementation of modern technologies. Increasing the export of wines. Attracting personnel (national/international), financial resources regarding the development of the vitivinicultural sector. Increasing interest in production in the vitivinicultural sector.
Threats	Climate change. Migration of qualified young people. Price changes. Increasing taxes. Increased competition. Reduced capacities to access financial resources. Low capacity of the local business environment to make investments for development. The instability of the economic-political environment. Lack of an effective system of professional training and retraining of the workforce.

Source: Elaborated by the authors.

Effective cooperation between authorities and entrepreneurs in the wine sector is necessary for the modernisation and dynamic, balanced and sustainable development of the wine sector. The Ministry of Agriculture and Food Industry is an important component in promoting a balanced and sustainable policy leading to the development and modernization of the wine sector, aimed at strengthening the wine segment and promoting the Republic of Moldova as a wine country. Thus, MAIA's objective is "to modernize the wine sector, to solve structural problems in the wine industry and to contribute to the creation of favorable conditions for the production of quality wines (with protected geographical indication (PGI) and protected designation of origin (PDO)"), thus contributing to increasing competitiveness on the internal and external market [9]. Thus, we can mention that the modernization and development of the wine sector can be remedied through investments. Also, in the National Strategy for Agricultural and Rural Development 2023-2030 is mentioned, through specific objective 1.1. "Actions to stimulate investments in the primary infrastructure of agricultural holdings for viable and competitive growth" which aims to stimulate investments to "modernize infrastructure and the agricultural production sector", "increase agricultural competitiveness and productivity in a sustainable way" [13]. Attracting investments in the wine sector will allow the modernization of qualitative and competitive production processes, which will be able to be aligned with EU standards. Following this research, authors can mention that a solution regarding the restructuring and modernization of the wine sector can be carried out through investments, subsidies being a tool applied by the authorities to stimulate this process. And to achieve these goals, it is necessary to find the most successful sources of financing.

The starting points that were the basis for the development of the research refer to the effects of investments on the modernization of the vitivinicultural sector and its development. The importance of investments in the modernization of the vitivinicultural sector, the re-technologization of production processes, the transition to new forms of agriculture (intensive and super-intensive) is an indisputable necessity to ensure the development of this sector. Therefore, for the vitivinicultural sector, investments represent an important strategy and the most effective method of reducing poverty in rural areas. The investment increases production productivity, increases the availability of food in the market and helps keeping prices low by making agricultural products more accessible to rural and urban consumers. Investments also reduce the vulnerability of the food supply to shocks, contributing to the stability of consumption. The vitivinicultural sector has suffered and continues to suffer as a result of a long-term lack of investment at both the macro and micro levels [5, 6]. Thus, we can mention that the economic engine for achieving performance in the field is based on advanced technologies, the technological and digital modernization of the sector will generate both an increase in the quantity and quality of grapes, and the catalyst for performance and development are investments in the technological chain of the targeted field.

Agriculture is one of the last sectors to move towards modernization/digitalization. And the impact of environmental economic conjecture factors has emphasized the need to integrate modern technologies in the vitivinicultural sector. The vitivinicultural sector needs modern solutions for specific problems against which classical methods do not have the expected effect.

Aligning the vitivinicultural sector with EU standards involves increasing the degree of modernization by procuring modern equipment, in order to obtain quality products, increasing competitiveness and integration on the global market.

In order to achieve these objectives, the enterprises in the vitivinicultural sector are forced to find the most successful sources of financing, increasing the advantages of each type of financing and reducing their negative effects, is of major importance (Figure 1).

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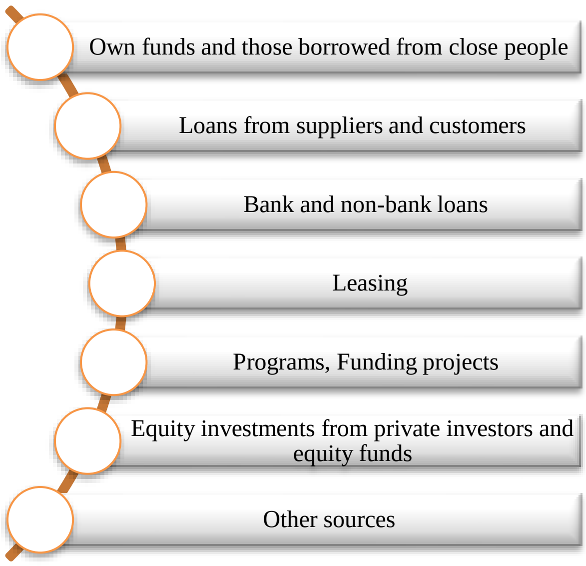

Fig. 1. Funding sources for the modernization of the vitivinicultural sector
Source: Elaborated by the authors.

From the strategic point of view of the national economy, the wine sector is an important branch. Thus, we can mention that any financial support, both investments, subsidies and programs/projects, is an effort, a rationally managed expense in a set period of time, which generates for investors the achievement of added value as a result of modernization and development.

Agricultural subsidy is a government support given to farmers and agricultural enterprises to supplement their income, stimulate the delivery of agricultural products, as well as to influence the cost of these products. In the Republic of Moldova, subsidizing the agro-industrial sector and rural development is carried out on the basis of Law no. 276, "on the principles of subsidies in the development of agriculture and the rural environment [8]. The subsidy process is regulated by the Regulation on the distribution of the means of the fund for subsidizing agricultural producers, which was approved by Government Decision no. 455/2017, [3]. Additionally, the financial resources allocated from the sources of the National Fund for the Development of Agriculture and the Rural Environment (NFDAR), the vitivinicultural sector benefited from financial support through various projects and investment programs with external financing. Thus, from the sources of the "Filiera Vinului" Viticulture Sector Restructuring Program, about 44.3 million euros were capitalized out of the total of 75 million euros available, and in the case of the Restructuring Program of the Horticultural Sector "Livada Moldovei" approximately 38.3 million euros were attracted from the total of 120 million euros available, the Grants Program for the Promotion of Moldovan Wine Export comes to support the diversification of export markets, with a budget of 13 million MDL [10].

The value of the NFDAR in the analyzed period 2017-2021 increased by about 3.2 times, or 1,072 mil. MDL, constituting about 63% of the total expenses allocated from the state budget for agriculture. During the given period, an increase of 1.4 times (or by 621.5 mil. MDL) was registered in the expenses for agriculture. FNDAMR, in 2021, constituted 1535 mil. MDL, with only 94.2% of AIPA being capitalized, i.e. 1446.4 mil. MDL (Figure 2) and 88.6 mil. MDL being uncapitalized [2].

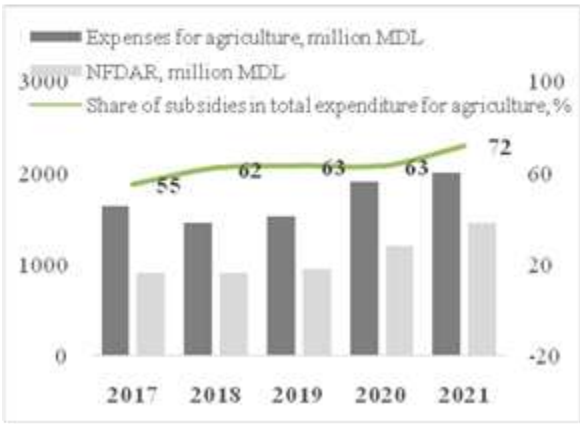

Fig. 2. Evolution of the subsidy fund for agricultural producers, in the period 2017-2021, million lei
Source: Elaborated by the authors [2, 11].

Following this analysis, we note that the allocations for the agricultural sector constitute 2.1% of the total expenses. Thus, in the period 2017-2020, these allocations registered an upward trend from 1.6 billion MDL to 1.89 billion MDL. In 2021, 2.0 billion MDL were provided for the agricultural sector. [1].

One of the most important measures to modernize the vitivinicultural sector was the Vitivinicultural sector Restructuring Program

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"*Filiera Vinului*". For the realization of this Program, the European Investment Bank granted the Republic of Moldova a loan of 75 million euros, in the period 2011-2017, for the financing of 75 projects. For several reasons, this program was extended until the year 2020. Thus, during the period 2016-2020, investments of around 45.97 million euros were allocated, which constitutes a share of 38.31% of the total value of investments of 120 million euros. In this analyzed period, about 189 projects were approved for financing [9, 10, 6, 12]. During the analyzed period, investments in the vitivinicultural industry varied. In 2020, investments amounted to 404 million MDL, being 26.7% less compared to 2019 and by 15.4% more compared to 2018 (Figure 3).

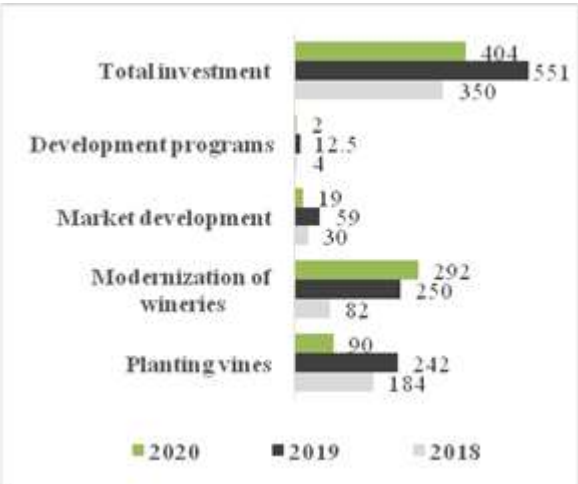

Fig. 3. Investments in the vitivinicultural sector by direction, mln. MDL in the period 2018-2020.
Source: Elaborated by the authors [9, 6, 10, 12].

In 2019, the wine sector attracted the most investments, worth about 551 million MDL, in 2020 the value of investments was 404 million MDL. being about 27% less compared to 2019. These investments were directed towards several branches of the wine sector, namely, about 292 million MDL were directed towards the modernization of wineries, and at the opposite pole are the development programs for which only 2 million MDL were allocated. 90 million MDL were allocated for planting vines with new and productive varieties and 19 million MDL were allocated for the diversification and development of markets (Figure 3) [12].

In order to solve the problems registered in the wine sector, actions and measures aimed at improving the investment activity are needed, namely, the subsidies in the wine sector must be oriented towards: efficient management, to implement the good practices of the partner countries; planting vines with new, productive and competitive varieties; diversification of export markets; the implementation of modern technologies throughout the value chain of the wine sector; encouraging and supporting winegrowers who want to invest in re-technology, modernization of the sector, including the establishment of small wineries and the development of wine tourism. Education and science that allow the transfer of knowledge and technologies to farmers/businessmen are also important for the wine sector. Natural calamities are becoming more and more unpredictable, complicated in form and proportion and costly in impact, therefore it is necessary to create a fund regarding risk insurance in the sector.

The first steps in the modernization of the vitivinicultural sector took place since 2006, making considerable progress. The first steps were taken towards the modernization of the Vine and Wine Law [7] and the creation of the National Vitivinicultural Organization (ONVV). In 2013 took place a structural reform of the sector setting new and transformational standards for quality, regulation and marketing. A number of innovative projects were supported by foreign donors, including the creation of a register of vineyards, modernization of facilities and equipment in laboratories and nurseries, support for small producers. These initiatives have provided a strong platform for the vitivinicultural sector to develop/modernize and adapt to climate conditions [12].

The most important role in the modernization of the vitivinicultural sector is played by the authorities, which ensure financing and the selection of priorities in the sphere of innovation, strategic planning, determining the list of goods and services that can become the object of a state order, creating self-organization mechanisms in the sphere of innovation, promoting capital for participating in innovative projects.

In our view, *the implementation of modern technologies in the vitivinicultural sector* represents a chance for the entire sector, having a major impact, coming to represent one of the defining elements of contemporary agriculture, bringing with it a transformation that will bring productivity, profitability and sustainability (Figure 4).

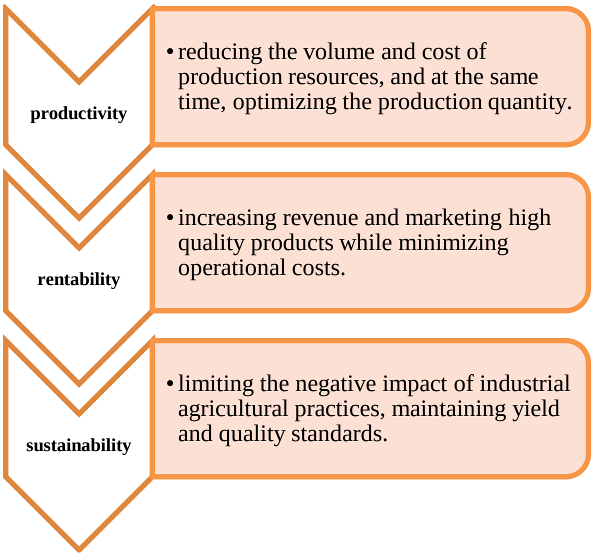

Fig. 4. Advantages of the modern technologies in the vitivinicultural sector
Source: elaborated by the authors [16].

However, it can be concluded that the modernization of the vitivinicultural sector represents a significant and essential step for increasing the efficiency of agricultural activities, for increasing production and controlling costs, maximizing profits and protecting the environment. Thanks to the evolution of technologies and IT solutions that have taken place in recent years, they are able to manage the complete flow, starting from tracking specific activities in the vineyard to obtaining and commercialization of the wine. The modernization of the vitivinicultural sector will bring major benefits throughout the different stages of the value chain. Everyone involved in the value creation chain, starting with winegrowers, supervisory authorities and ending with analytical laboratories, wholesale and retail distributors and even pubs and restaurants manage their data in digitized form [4].

Thus, we conclude that the level of development and modernization of the vitivinicultural sector can be stimulated by investments, and investments for the vitivinicultural sector are the key factor of modernization, development and sustainable economic growth, and through the correct use of investment resources, new places of work can be created, the yield per hectare can be increased, labor productivity and the quality of life in rural areas can be increased.

CONCLUSIONS

The analysis of the importance of investments in the modernization of the vitivinicultural sector, demonstrated that, *investments* in the retechnologization of production processes, the transition to the form (intensive and super-intensive) is an indisputable truth, a necessity of the time. Therefore, investments have an important role in promoting the modernization of the vitivinicultural sector, namely of the technical progress by equipping economic objectives with machines, equipment, tools that lead to the improvement of technological processes.

The financing of the vitivinicultural sector has increased significantly in recent years, especially due to funds allocated by external donors, programs and projects that support the development and modernization of the sector. It is important to note that with the increase in the volume of financing of the vitivinicultural sector, the efficiency of the use of funds must also increase. And the implementation of the new programs, the strategic planning of investments and their prudent capitalization will drive modernization and increase the impact both at the business level and at the sector level.

The research shows that the modernization of the vitivinicultural sector is still at a low level of maturity, but the recorded rates and the potential are increasing. The modernization of the vitivinicultural sector through investments will strengthen and increase the recorded trends, will allow the timely capitalization of the existing potential will benefit already launched businesses ensuring the resilience of the value chain, through the improved yields of the vineyards; increased productivity by exploiting digital data; using technologies such as artificial intelligence and reducing supply costs by implementing smart storage.

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THE AGROECONOMIC VALUE OF COMMON MILLET, *PANICUM MILIACEUM*, UNDER THE CONDITIONS OF THE REPUBLIC OF MOLDOVA

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Abstract

Common millet, Panicum miliaceum, is one of the world's oldest cultivated crops. This research was aimed at evaluating the quality indices of fodders and substrates for biomethane production from common millet crop. The cultivar 'Marius' of Panicum miliaceum, created at the National Agricultural Research and Development Institute Fundulea, Romania, cultivated in the experimental sector of the "Alexandru Ciubotaru" National Botanical Garden (Institute) MSU Chişinău served as subject of the research. The results revealed that the dry matter of Panicum miliaceum 'Marius' whole plants contained: 10.62% CP, 2.81% EE, 30.96% CF, 47.60% NFE, 8.01 % ash, 0.30% Ca, 0.23% P with 18.21 MJ/kg GE, 9.29 MJ/kg ME and 5.23 MJ/kg NEl. The prepared silage is characterized by pleasant smell and color, the dry matter nutrient and feed energy values were: 11.07% CP, 4.01% EE, 36.65% CF, 38.61% NFE, 9.66 % ash with 18.38 MJ/kg GE, 8.61MJ/kg ME, 4.69 MJ/kg NEl. The common millet hay contained 13.40% CP, 2.37% EE, 32.22% CF, 42.29% NFE, 9.72 % ash with 18.02 MJ/kg GE, 8.66 MJ/kg ME, 4.84 MJ/kg NEl. The common millet substrates for anaerobic digestion for renewable energy production had optimal carbon to nitrogen ratio and the estimated biochemical methane potential reached 303-305 l/kg organic matter. The Panicum miliaceum 'Marius' grain contained 140.0g/kg CP, 47.5 g/kg EE, 137.0 g/kg CF, 627.4 g/kg NFE, 48.0 g/kg ash, 0.9 g/kg Ca and 0.6g/kg P. The cultivar is characterized by optimal productivity, can be used in monoculture or as a component of the mix of annual legume crops, and the harvested green mass may be used as forage for livestock as natural fodder, hay, fermented fodders, also as substrate in biogas reactors via anaerobic digestion for renewable energy production.

Key words: *biochemical composition, biomethane potential, grain, green mass, hay, nutritive value, Panicum miliaceum 'Marius', silage*

INTRODUCTION

A solution to a lot of problems associated with food security, healthcare and raw material supply for industrial purposes would be the diversification of crops by cultivating neglected and underused crops on a larger scale, as well as new species.

Global warming and altering precipitation patterns affect crop water requirements, cause a decrease in crop productivity, while raising the cost of irrigation. Under these conditions, switching to alternative crops that require minimal water input, are tolerant to abiotic stress, provide high yields may be an effective measure of coping with water scarcity in agriculture.

In particular, sorghum and millet crops are gaining popularity due to their high resilience against the effects of climate change and acceptable productivity and nutritional value.

Panicum L. is a genus in the family Poaceae, with nearly 450 species of annual or perennial grasses, occurring in areas with tropical and warm temperate climate. Many representatives of this genus are popular agricultural and horticultural crops, due to their economic significance and ornamental value.

Panicum miliaceum L. is one of the most commonly cultivated millet species as grain and forage crops. This species, commonly known as proso millet or common millet, is one of the world's oldest cultivated crops, and has also been cultivated in our region. It is a summer annual plant, the stems are light green, erect, sometimes branched at the base, and grow 0.5-1.5 m tall, with bright green leaves, compact panicle, the grains are round, about 3 mm long and 2 mm wide, and enclosed in a smooth hull, which is typically white or creamy-white, yellow, or red, but also may be gray, brown or black. Plants have shallow, fibrous root systems and produce few tillers. It is a short growing, summer season crop (60 to 100 days) with unique agronomic properties such as high tolerance to heat and drought conditions. *Panicum miliaceum* could be a viable alternative to main summer forages in areas where cultivation of corn or Sudan grass is restricted because of a longer growing season or poor agricultural conditions [10; 13; 16; 23; 24; 27, 28; 20].

The goal of this research was to evaluate the quality indices of the harvested green mass, prepared silage and hay, collected grain from common millet, *Panicum miliaceum*, for feeding farm animals, as well as substrates for anaerobic digestion of the production of biomethane as renewable energy.

MATERIALS AND METHODS

The cultivar *'Marius'* of common millet, *Panicum miliaceum*, created at the National Agricultural Research and Development Institute Fundulea, Romania, cultivated in the experimental sector of the “Alexandru Ciubotaru” National Botanical Garden (Institute) Chişinău served as subject of the research. The cultivar *'Napoca 2'* of tall fescue *Festuca arundinacea* created at the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, România, hybrid *"SAȘM-4"* of sorghum and Sudan grass – *Sorghum bicolor* × *Sorghum sudanense* – created at the Institute of Genetics, Physiology and Plant Protection of Republic of Moldova and the hybrid *‘Porumbeni 374’* of corn, *Zea mays*, created at the Institute of Crop Science "Porumbeni", Republic of Moldova, were used as control variants. The proso millet, tall fescue and sorghum x Sudan grass hybrid plant samples were collected in the pre-flowering stage and corn – in wax stage of grains. The prepared hay from proso millet and tall fescue was dried directly in the field. The silage was prepared from green mass cut into small pieces, compressed in well-sealed glass containers, stored at ambient temperature (18-20 °C) for 45 days, to allow complete fermentation to occur. Following the 45-day fermentation period, each glass container was opened and the content was visually examined, the color and the aroma were recorded. The dry matter content was detected by drying samples up to constant weight at 105°C. For biochemical analysis, the samples were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with diameter of openings of 1 mm. The pH of the samples of silage was measured immediately after removal from the containers. After seed formation, proso millet panicles from five plants on each plot were protected with paper bag to prevent grain loss. Hand-harvesting was carried out at full maturity, the common millet panicles were threshed and the grains were cleaned by sieves and a wind separation system. The evaluation of chemical composition: crude protein (CP), crude fat (EE), crude cellulose (CF), nitrogen-free ex-tract (NFE), soluble sugars, starch, ash, calcium (Ca), phosphorus (P), carotene content were carried out in the Laboratory of Nutrition and Forage Technology of the Scientific-Practical Institute of Biotechnology in Animal Husbandry and Veterinary Medicine, in accordance with the methodological indications. The gross energy (GE), metabolizable energy (ME) and net energy for lactation (NEl) were calculated according to standard procedures.

The carbon content of the substrates was determined using an empirical equation according to Badger et al. [3]. The biochemical biomethane potential was calculated using the methane potential of degradable nutrients according to Baserga [4], and the digestibility index of nutrients – according to Medvedev & Smetannikova [16], Coșman et al. [9].

RESULTS AND DISCUSSIONS

The biochemical composition and fodder value of the green mass from *Panicum miliaceum* 'Marius' are presented in Table 1. The comparative analysis of the nutrient concentration of the harvested green fodder showed that common millet fodder was characterized by a significantly higher content of proteins than sorghum x Sudan grass and corn green mass fodders. The level of crude fat content in whole plants of the studied species did not differ significantly. The content of crude cellulose in common millet green fodder was lower than in sorghum x Sudan grass and tall fescue fodder, but higher than in corn whole plants. The common millet green fodder is characterized by optimal amount of nitrogen free extract, but much lower than in corn whole plants. In common millet, the ash content is lower than in tall fescue, but there is a much higher concentration of ash, calcium and phosphorus than in sorghum x Sudan grass and corn fodder. The energy supply of the feed from whole common millet plants reached 9.29 MJ/kg metabolizable energy and 5.23 MJ/kg net energy for lactation, being higher than in the forage produced from sorghum x Sudan grass and tall fescue plants, but lower than in corn plants. It was found that the level of carotene in common millet green mass was significantly higher as compared with corn green mass.

Different results regarding the biochemical composition and the nutritive value of the harvested mass from millets species are given in the specialized literature. Burlacu et al. [8] indicated that the green forage from *Panicum miliaceum* plants contained 230 g/kg DM with 91.3% OM, 14.0 % CP, 4.7% EE, 27.1% CF, 45.5% NFE and 18.5 MJ/kg GE, but *Sorghum bicolor × Sorghum sudanense* green mass 200 g/kg DM, 90.0% OM, 9.4 % CP, 3.1 % EE, 29.7% CF, 47.8% NFE and 17.8 MJ/kg GE, respectively. Piłat et al. [20] reported that the forage quality of *Panicum virgatum* was 274.9 g/kg DM, 92.84% OM, 10.46 % CP, 32.60% CF, 48.30% NFE, 72.33% NDF, 39.23% ADF. Avetisyan [1] revealed that the dry matter content and the nutritive value of green mass from proso millet was 200 g/kg DM, 9.8% CP, 38.9% CF, 6.2% sugar, 9.7 MJ/kg ME and from Sudan grass 250 g/kg DM, 7.6% CP, 30.5% CF, 8.0% sugar, 8.8 MJ/kg ME, respectively. Mohajer et al. [17] mentioned that the common millet whole plants contained 134.8 g/kg DM, 8.88% CP, 43.28% CF, 6.81% WSC, 29.48% ADF and 64.24% DMD [14]. Svirskis [22] reported that the forage quality of harvested common millet cultivars was characterized by the following indices 12.6-19.6 % CP, 28.0-35.6% CF, 56.6-65.3% NDF, 25.3-33.1% ADF, 4.56-11.39 % WSC and 48.4-65.3% DMD.

Zhang et al. [28] revealed that the forage produced from proso millet whole plants harvested at 12 weeks after emergence contained 12.8% CP, 73.3% NDF, 40.8% ADF; while maize forage contained 10.8% CP, 66.1% NDF, 42.89% ADF and Sudan grass forage – 12.0% CP, 62.7% NDF and 42.8% ADF, respectively.

Kertikov & Kertikova [13] stated that forage productivity of true millet *Panicum miliaceum* as non-traditional forage crop was 541.8 kg/da dry matter and crude protein feed is equal to 57.1 kg/da.

Tran [24] revealed that *Panicum miliaceum* aerial part contained 7.9% ash, 10.1% CP, 73.7 % NDF, 36.0% ADF, 4.5 % lignin, 3.6 g/kg Ca, 1.6 g/kg P, 58.5 % DOM. Maksimova et al. [15] determined that forage quality indices of *Panicum miliaceum* cv. *Baganskoye 88* was 0.56 feed units/kg DM, 107.17-126.23 g/kg DM digestible protein, 8.3-8.4 MJ/ kg DM metabolic energy, 17.5-17.6 MJ/ kg DM gross energy.

Avetisyan et al. [2] mentioned that the nutritive value of forage from studied cultivars of *Panicum miliaceum* was 0.23 feed units/kg fresh mass, 24 g digestible protein/kg fresh mass, and 10.3-10.4 MJ/kg DM exchange energy, while that from *Avena sativa* plants - 0.21 feed units /kg fresh mass, 23 g digestible protein/kg fresh mass, 10.0 MJ/kg DM exchange energy.

Park et al. [18] reported that feed values of green forage from *Panicum miliaceum* cv. *Native* was 5.7-10.4% CP, 63.1-65.4 % NDF, 36.3-37.0% ADF, 59.7-60.2% TDN and RVF=86-89, but feed values of green forage from *Panicum coloratum*, cv. *Selection*, respectively 12.0-12.4% CP, 57.8-62.2 % NDF, 30.3-31.7% ADF, 63.9-64.9% TDN and RVF=95-105.

Van Die & Entz [26] indicated that the nutritional value of forage biomass from *Panicum miliaceum* cv. Crown Proso was 8.0-10.0 % CP and 64.8%TDN, while that from

Zea mays 6.0-6.7 % CP and 65.1-69.2%TDN, but from *Sorghum bicolor* × *Sorghum sudanense* plants 4.7-4.8 % CP and 63.3-64.3% TDN.

Table 1. The biochemical composition and the fodder value of the green mass from the studied *Poaceae* species

Indices	*Panicum miliaceum*	*Festuca arundinacea*	*Sorghum bicolor × Sorghum sudanense*	*Zea mays*
Crude protein, % DM	*10.62*	*10.81*	*8.47*	*7.26*
Crude fats, % DM	*2.81*	*2.67*	*2.75*	*2.83*
Crude cellulose, % DM	*30.69*	*32.79*	*37.61*	*18.40*
Nitrogen free extract, % DM	*47.60*	*40.64*	*45.19*	*67.92*
Soluble sugars, % DM	*7.31*	*6.30*	*10.56*	*7.55*
Starch, % DM	*2.67*	*1.97*	*1.50*	*22.79*
Ash, % DM	*8.01*	*13.09*	*5.99*	*3.59*
Calcium, % DM	*0.30*	*0.30*	*0.20*	*0.24*
Phosphorus, % DM	*0.23*	*0.25*	*0.13*	*0.22*
Gross energy, MJ/ kg DM	*18.21*	*17.34*	*18.27*	*18.46*
Metabolizable energy, MJ/ kg DM	*9.29*	*8.96*	*8.13*	*11.13*
Net energy for lactation, MJ/ kg DM	*5.23*	*5.01*	*4.63*	*6.34*
Carotene, mg/kg	*32.92*	*28.35*	*32.92*	*14.30*

Source: Own calculation.

The hay yield and its nutritional value mainly depends on the botanical family, species and varieties, the growing period at which these plants have been harvested, on haymaking equipment, on conditions of its storage and on many other factors. Analysing the results regarding the biochemical composition of the hay prepared from proso millet and tall fescue, Table 2, we would like to mention that its dry matter contained: 10.06-13.40 % CP, 2.37-2.79% EE, 32.22-33.79% CF, 40.15-42.29% NFE, 9.72-13.25% ash, 0.23-0.32% Ca and 0.22-0.27% P with 17.33-18.02 MJ/kg GE. The hay prepared from common millet, *Panicum miliaceum*, is characterized by high level of crude protein, nitrogen free extract, calcium, phosphorus and low level of crude fats, crude cellulose, ash, but optimal gross energy value. Several literature sources describe the quality of the hay prepared from *Panicum* species. Burlacu et al. [8] mentioned that the quality indices of the hay prepared from millet plants harvested after flowering stage were: 850 g/kg DM, 92.6% OM, 5.8% CP, 2.1% EE, 33.5% CF, 51.2% NFE and 17.9 MJ/kg GE.

Berhane et al. [7] reported forage quality of hay from *Panicum miliaceum* was 17.3% CP, 72.5 % NDF, 37.4% ADF, 2.2% ADL, but hay from *Panicum coloratum* respectively 11.4% CP, 83.5 % NDF, 35.9% ADF, 2.8% ADL.

Dağtekin et al. [10] mentioned that the quality indices of the hay prepared from millet plants was 16.3-20.5% CP, 28.7-36.3% ADF, 60.0-70.6 % NDF, 0.373 - 0.434% P, 0.58 - 0.824% Ca, 0.270-0.393 % Mg, 3.174- 3.964% K.

Tan et al. [23] reported that *Panicum miliaceum* hay obtained in variant without fertilization contained 12.39% CP, 58.40% NDF, 36.05% ADF, but in the variants with the application of different doses of nitrogen fertilizers, the respective values were obtained: 13.16-14.24 % CP, 58.09-60.02 % NDF, 35.73-36.10 % ADF.

Jimoh et al. [12] mentioned that the nutrient content of *Panicum maximum* forage was 9.70-9.88% CP, 7.88-8.90% EE, 47.63-54.11 % ADF, 65.44-73.58% NDF, 17.80- 19.27 HC, 41.47-45.02% Cel, 9.19- 9.58% ash.

Tran [24] reported that dry matter concentration of nutrients and fodder value of hay from common millet plants were 7.9% ash, 12.5% CP, 2.5% EE, 33.9% CF, 72.3 % NDF, 39.9% ADF, 5.9 % lignin, 6.6% ash, 59.3% DOM, 18.9 MJ/kg GE, 10.7 MJ/kg DE, 8.6 MJ/kg ME.

Table 2. The biochemical composition and the fodder value of the hay from the studied *Poaceae* species

Indices	***Panicum miliaceum***	***Festuca arundinacea***
Crude protein, % DM	*13.40*	*10.06*
Crude fats, % DM	*2.37*	*2.79*
Crude cellulose, % DM	*32.22*	*33.79*
Nitrogen free extract, % DM	*42.29*	*40.15*
Ash, % DM	*9.72*	*13.25*
Calcium, % DM	*0.32*	*0.23*
Phosphorus, % DM	*0.27*	*0.22*
Gross energy, MJ/ kg DM	*18.02*	*17.33*

Source: Own calculation.

Stybayev et al. [21] stated that the proso millet hay had 947.3 g/kg DM with nutrient content 9.07% CP, 2.76% EE, 30.32% CF, 3.32% sugar, 9.25% ash, 1.11% Ca, 0.23% P, but hay from Sudan grass plant 952.2 g/kg DM, 10.17%

CP, 2.75% EE, 30.49% CF, 8.83% sugar, 4.51% ash, 0.97% Ca, 0.23% P, respectively.

The conservation of fodder crops is a traditional way of reducing seasonal variations in feed availability for farm animals. The silage is an important source of nutrients for the dairy production sector in the autumn - middle spring period.

Silage plays an important role in the nutrition, wellbeing and productivity of animals. It can help solving some problems in the animal husbandry sector by providing a balanced diet for livestock with an appropriate amount of protein and fiber. When opening the glass containers with proso millet silage, there was no gas or juice leakage from the preserved mass. As for the organoleptic properties, the silage prepared from *Panicum miliaceum* had yellowish-green stems and leaves with pleasant smell of pickled apple; the texture of the plants stored as silage was preserved well, without mold and mucus. It has been determined that pH =4.0, most organic acids were in fixed form, butyric acid not was detected and lactic acids constituted 86% of organic acids. The nutrient content of the prepared silages is shown in Table 3.

Table 3. The biochemical composition and the fodder value of the silage from the studied *Poaceae* species

Indices	*Panicum miliaceum*	*Festuca arundinacea*	*Zea mays*
pH index	4.00	4.38	*3.92*
Crude protein, % DM	11.07	6.65	*7.28*
Crude fats, % DM	4.01	2.44	*3.94*
Crude cellulose, % DM	36.65	36.87	*19.02*
Nitrogen free extract, % DM	38.61	41.53	*66.22*
Soluble sugars, % DM	1.03	0.46	*0.91*
Starch, % DM	0.62	0.58	*24.54*
Ash, % DM	9.66	12.51	*3.55*
Calcium, % DM	0.31	0.24	*0.27*
Phosphorus, %	0.27	0.18	*0.27*
Gross energy, MJ/ kg	18.38	17.23	*18.72*

Source: Own calculation.

It was found that during the process of ensiling, the concentrations of crude protein, soluble sugars and starch decreased. In comparison with the initial mass, in the prepared silage from *Panicum miliaceum* the level of crude fats and crude cellulose increased substantially, but nitrogen free extract, soluble sugars and starch – decreased, crude protein and ash did not change essentially. The dry matter of proso millet silage contained a high amount of crude protein, crude cellulose and ash, but very low amount of nitrogen free extract, soluble sugars and starch, as compared with the corn silage. The ensiled fodder from *Panicum miliaceum* was characterized by optimal gross energy concentrations, but lower than corn silage. The silage from tall fescue had low concentration of crude protein and gross energy.

Some authors mentioned various findings about the quality of the silage prepared from *Panicum* species. Paziani et al. [19] reported that the fodder value of *Panicum maximum* silages had the following indices: pH =4.7-4.9, 8.5-11.0% CP, 38.7-46.4% ADF, 49.8.8-69.4% NDF, 8.3-11.2 % ash. Piłat et al. [20] found that the quality of *Panicum virgatum* silage was characterized by 204.4 g/kg DM, pH =4.57, 1.19% lactic acid, 0.71% acetic acid, 0.08% butyric acid, 91.61% OM, 11.84 % CP, 33.91% CF, 42.87% NFE, 74.57% NDF, 43.22% ADF, but the silage with chemical supplements and microbial additive – 238.8-254.4 g/kg DM, pH =4.31-4.60, 1.25-1.26% lactic acid, 0.65-0.671% acetic acid, 0-0.06% butyric acid, 91.49-92.14% OM, 11.43-12.64 % CP, 33.62-35.76% CF, 40.22-41.29% NFE, 70.30-71.72% NDF, 39.24-41.01 % ADF. Wei et al. [27] reported that ensiled mass from proso millet had 266.8 g/kg DM with nutrient content 5.96% CP, 33.00 % ADF, 58.60 % NDF but corn ensiled mass 264.1 g/kg DM, 5.30% CP, 24.15 % ADF, 44.55 % NDF and ensiled mass from sorghum-Sudan grass plants 178.4 g/kg DM, 4.61% CP, 41.32 % ADF, 63.50 % NDF, respectively. Maksimova et al. [15] stated that silage from *Panicum miliaceum* cv. *Baganskoye 88* had pH =5.0, 0.55 feed units/kg DM, 39.0 g/kg DM digestible protein, 8.21 MJ/ kg DM exchange energy, 17.3-17.6 MJ/ kg DM gross energy and 72.5 g digestible proteins/ feeding unit. In our previous research [25] found that dry matter nutrient content of ensiled fodder from common millet plants was 13.3% CP, 11.5% ash, 37.0% CF, 37.1% ADF, 63.0% NDF, 2.0% ADL, 6.8% TSS, 35.1% Cel, 23.7% HC with fodder and energy value 600 g/kg DDM, RFV=92, 11.87 MJ/kg DE, 9.75 MJ/kg ME, 5.76 MJ/kg NEl.

On the basis of our observations, *Panicum miliaceum 'Marius'*, under the soil climatic conditions of the Republic of Moldova, reached seed maturity in end August, 28 days earlier than corn hybrid *'Porumbeni 374'*. The *Panicum miliaceum* '*Marius*' grain dry matter contained 140.0 g/kg CP, 47.5 g/kg EE, 137.0 g/kg CF, 627.4 g/kg NFE, 48.0 g/kg ash, 0.9 g/kg Ca and 0.6g/kg P, 10.7 g/kg soluble sugars, 313.7 g/kg starch. Medvedev & Smetannikova [16] revealed that the *Panicum miliaceum* grain contained 10.4-15.5% CP, 2.5-3.3% minerals, 7.8-10.5% CF, 2.6-4.2% EE, 57.8-63.9% NFE, 0.93-1.1 feed units/kg DM.

Increasing biomass usage leads to the reduction of greenhouse gas emissions, as compared with the use of fossil fuels. In recent years, the considerations for the use of *Poaceae* species for bioenergy have increased considerably, it can be used as biomass feedstock for the production solid fuel, lignocellulosic bioethanol, synthetic natural gas or synthetic biofuels, and in particular for biogas production. The C_4 grasses are considered as a potential feedstock for biogas production, due to their low water consumption as compared with other crops, and the fact that they can be cultivated in non-arable lands, avoiding the direct competition with food crops. Biogas is a product of anaerobic fermentation of organic products. Among the fuels from plant biomass, biogas has a great importance and can successfully replace fossil fuels to obtain electric power and heat. The quantities of biogas and the methane content depend mainly on carbohydrates, fats and proteins, the biodegradability and ratio of carbon and nitrogen (C/N) from the substrates. The results of the determination of the quality of substrates of green mass and prepared silages are presented in Table 4.

Table 4. Biochemical methane production potential of green and ensiled mass substrates from leguminous species

Indices	***Panicum miliaceum***		***Festuca arundinacea***		***Sorghum bicolor x Sorghum sudanense***	***Zea mays***	
	green mass	silage	green mass	Silage	green mass	green mass	silage
Organic dry matter, g/kg	*919.0*	*903.4*	*869.1*	*874.9*	*894.4*	*964.1*	*964.5*
Digestible matter, g/kg	*662.3*	*646.7*	*560.5*	*556.6*	*640.5*	*678.0*	*686.9*
Digestible proteins, g/kg	*80.7*	*84.0*	*69.2*	*42.1*	*59.2*	*42.1*	*42.2*
Digestible fats, g/kg	*17.4*	*24.9*	*14.2*	*12.9*	*12.3*	*19.2*	*26.8*
Digestible carbohydrates, g/kg	*564.2*	*537.8*	*477.1*	*501.6*	*569.0*	*616.7*	*617.9*
Carbon, g/kg	*510.6*	*501.9*	*428.8*	*486.1*	*496.9*	*535.6*	*535.8*
Nitrogen, g/kg	*17.0*	*17.7*	*17.3*	*10.6*	*13.6*	*11.6*	*11.7*
Ratio carbon/nitrogen	*30.0*	*28.4*	*24.8*	*45.9*	*36.5*	*46.2*	*45.8*
Biochemical methane potential, L/kg DM	*278*	*275*	*235*	*230*	*265*	*281*	*288*
Biochemical methane potential, L/kg OM	*303*	*305*	*270*	*263*	*296*	*291*	*299*

Source: Own calculation.

It is a commonly known fact that methanogenic bacteria need a suitable ratio of carbon to nitrogen for their metabolic processes, ratios higher than 30:1 were found to be unsuitable for optimal digestion, and ratios lower than 10:1 were found to be inhibitory, because of low pH, poor buffering capacity and high concentrations of ammonia in the substrate. The C/N ratio is more favorable in proso millet substrates as compared with the other substrates. The digestible organic matter concentration in the tested substrates ranged from 556.6 to 686.9 g/kg, the methane potential of the digestible organic matter varied from 230 to 288 l/kg dry matter or specific methane yield – from 263 to 305 l/kg organic matter. The lowest results were achieved in tall fescue substrates, with rather low concentration of digestible matter. The biochemical methane potential of studied millet substrates ranged from 303 to 305 l/kg organic matter, being about the same as in corn and sorghum x Sudan grass substrates.

According to Battista et al. [5], the methane yield of *Panicum miliaceum* substrate was 253 L/kg, *Zea mays* substrate – 289 ± 86 L/kg, *Triticum aestivum* substrate – 351 ± 5 L/kg, *Hordeum distichon* substrate – 290 ± 83 and *Sorghum* spp. substrate – 313 ± 73 L/kg.

Baute et al. [6] reported that the methane potential of *Panicum virgatum* harvested in July reached 186.5 L/kg VS, but – harvested in October – 160.1 L/kg VS, respectively. Holder et al. [11] found that the biochemical methane potential of the substrate from guinea grass, *Panicum maximum*, was 250 l/kg DM. Kupryś-Caruk et al. [14] remarked that *Panicum virgatum* control silages had methane yields 310 l/kg ODM, while the inoculated silage had a yield of 380 l/kg ODM.

CONCLUSIONS

The forage value of *Panicum miliaceum 'Marius'* whole plants is 10.62% CP, 2.81% EE, 30.96% CF, 47.60% NFE, 8.01 % ash, 0.30% Ca, 0.23% P, with 18.21 MJ/kg GE, 9.29 MJ/kg ME, 5.23 MJ/kg NEl.
The ensiled mass is characterized by pleasant smell and color, the dry matter nutrient and feed energy values are: 11.07% CP, 4.01% EE, 36.65% CF, 38.61% NFE, 9.66 % ash, with 18.38 MJ/kg GE, 8.61 MJ/kg ME, 4.69 MJ/kg NEl.
The common millet hay contained 13.40% CP, 2.37% EE, 32.22% CF, 42.29% NFE, 9.72 % ash with nutritive energy value 18.02 MJ/kg GE, 8.66 MJ/kg ME and 4.84 MJ/kg NEl.
The *Panicum miliaceum 'Marius'* substrates used for renewable energy production by anaerobic digestion had optimal carbon to nitrogen ratio and the estimated biochemical methane potential reached 303-305 l/kg organic matter.
The *Panicum miliaceum 'Marius'* grain contained 140.0g/kg CP, 47.5 g/kg EE, 137.0 g/kg CF, 627.4 g/kg NFE, 48.0 g/kg ash, 0.9 g/kg Ca and 0.6g/kg P.
The cultivar 'Marius' of Proso millet is characterized by optimal productivity, can be used in monoculture or as a component of the mix of annual legume crops, and the harvested green mass may be used as forage for livestock as natural fodder, hay, haylage, and also as substrate in biogas reactors via anaerobic digestion for renewable energy production.

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THE QUALITY INDICES OF FODDERS FROM *SESAMUM INDICUM* L. GROWNING UNDER THE CONDITIONS OF MOLDOVA

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Abstract

The main objective of this research was to evaluate the quality indices of fodders prepared from the non-native ecotype of sesame Sesamum indicum, grown in monoculture in the experimental plot of NBGI, Chisinau, Republic of Moldova. We found that the dry matter of sesame whole plants harvested in flowering period contained 190 g/kg CP, 114 g/kg ash, 239g/kg CF, 296 g/kg ADF, 479 g/kg NDF, 72 g/kg ADL, 224 g/kg Cel, 183g/kg HC with 10.6 MJ/kg ME, 6.52 MJ/kg NEl. The fermentation characteristics and quality indices of sesame haylage was: pH =4.33, 0.67% acetic acid, 3.45% lactic acid, 0.02% butyric acid, 161g/kg CP, 151g/kg ash, 212 g/kg CF, 285 g/kg ADF, 520 g/kg NDF, 70 g/kg ADL, 210g/kg Cel, 235 g/kg HC with 66.7% DMD, RFV= 120, 9.75-11.73 MJ/kg ME, 6.75 MJ/kg NEl. It has been determined that the sesame plant residue contained 104 g/kg CP, 110g/kg ash, 411g/kg CF, 83 g/kg ADL, 363 g/kg Cel, 175g/kg HC with 8.90 MJ/kg ME, 4.90 MJ/kg NEl. The fodders from Sesamum indicum have optimal nutrient content and energy value of forage, can be used as alternative forages for livestock

Key words: *green mass, haylage, nutrient content, plant residue, Sesamum indicum*

INTRODUCTION

Livestock farming is an indispensable sector for contributing considerably to food security and sustainable development of agriculture of any country. Under the conditions of climate aridization, in order to provide farm animals with feed, it is necessary to diversify the range of fodder crops, by adding plants with high adaptive and productive potential.

Sesame *Sesamum indicum* L. is the earliest known oleaginous plants, belonging to the *Pedaliaceae* family, which originated in Africa, but has been cultivated in many areas of the world. It is an annual herbaceous plant; the stem is erect, quadrangular, stout, branched, bright pale green, covered with short soft hairs, reaching up to 2.0 m in height. The leaves are hairy, ovate, 7.5–12.7 cm long and 1-7 cm broad, and dull green in colour. White to pale pink bell-shaped flowers develop at the leaf axils along the stems. Flowers are mostly self-pollinated. The fruit is a deeply grooved capsule, 2.5-3.5 cm long, parallelepipedic in shape and containing 8 rows of seeds. The seeds are flattened ovoid, 2-3 mm in diameter, 0.5-1 mm thick, are variable in colour, yellow, white, brown or black. Sesame is deep-rooted and will scavenge nutrients from below most crop root zones. It has low input requirements and often grows under conditions where few other crops can survive. Sesame is a short-day plant, crops require 90 to 120 frost free days and warm conditions above 23 °C favor its growth and yield. Sesame is one of the most valuable oilseed plants due to the special quality of the oil in the seeds for human health, high in antioxidants such as sesamolin and sesamin, which keep them from becoming rancid, unsaturated fatty acids constitute 80% of the total fatty acids, oil meal is a protein rich by-product, a valuable protein and energy source for ruminants [10, 15, 21, 22, 25].

Currently, *Sesamum indicum* is studied as fodder plant in several research centers [3, 4, 5, 6, 9, 12, 19, 23, 24, 26].

The main objective of this research was to evaluate the quality indices of green mass, prepared haylage and collected plant residue from sesame, *Sesamum indicum* cultivated under the conditions of the Republic of Moldova.

MATERIALS AND METHODS

The non-native ecotype of sesame, *Sesamum indicum,* which was cultivated in the experimental plot of the National Botanical Garden (Institute) of Moldova, Chişinău, N 46°58′25.7″ latitude and E 28°52′57.8″, served as subject of research and the traditional crop alfalfa, *Medicago sativa,* common oat *Avena sativa* and corn, *Zea mays*, were used as control variants. The experimental design was a randomised complete block design with four replications, and the experimental plots measured 10 m^2. *Sesamum indicum,* was sown in the middle of May, at 45-cm row spacing and a rate of 1 g/m^2, at a depth of 2-3 cm. The sesame green mass was harvested manually at 5 cm cutting height, in the flowering period. The alfalfa green mass samples were collected in the second growing season, the first cut – in the flowering stage, common oat plant samples were collected in the pre-flowering stage, corn plants were collected in the wax stage of grains. The corn silage was prepared from harvested fresh mass. The sesame, alfalfa and common oat haylages were produced from wilted whole plants, cut into small pieces and compressed in glass containers. The containers were stored for 45 days, and then, they were opened and the organoleptic assessment and the determination of the organic acid composition of the persevered forage were done in accordance with the Moldavian standard SM 108*. The sesame and common oat plant residue were collected after harvesting the seeds. The dry matter content was detected by drying samples to constant weight at 105°C. For biochemical analysis, the fresh and ensiled mass were dried in a forced air oven at 60°C, milled in a beater mill equipped with a sieve with mesh diameter of 1 mm and some of the main biochemical parameters, such as crude protein (CP), crude fibre (CF), ash, acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin (ADL), were determined by near infrared spectroscopy (NIRS) using PERTEN DA 7200. The concentration of hemicellulose (HC), cellulose (Cel), digestible energy (DE), metabolizable energy (ME), net energy for lactation (NEl), digestible dry matter (DDM) and relative feed value (RFV) were calculated according to standard procedures.

RESULTS AND DISCUSSIONS

As a result of the study on the biological peculiarities of sesame, *Sesamum indicum,* the emergence of the seedlings was observed on the 3rd-4th day after sowing, the development of the stem – in 10-12 days after seedling emergence, the growth rates were faster at the middle of June and during July, the formation of the flower buds occurred in the end July, the flowering period lasted 28-31 days, ripening of the seeds occurred in the middle September.

At the harvested period, the sesame plants reached 152.6 cm, the green mass productivity was 55.9 t/ha green mass or 12.3 t/ha dry matter with 59.7 % leaves and flowers.

The fact that green fodder plays a major role in the supply of natural feed for animals, and the quality of animal products (meat, dairy) is considerably determined by the nutritional value of forage, thus, the evaluation of quality is necessary and mandatory. The biochemical composition, nutritive and energy value of the harvested green mass from sesame, *Sesamum indicum,* is presented in Table 1. We would like to mention that the dry matter of sesame whole plants contained 190 g/kg CP, 114 g/kg ash, 239g/kg CF, 296 g/kg ADF, 479 g/kg NDF, 72 g/kg ADL, 224 g/kg Cel, 183g/kg HC with 10.6 MJ/kg ME, 6.52 MJ/kg NEl. The content of acid detergent lignin in sesame fodder was higher than in fodders from control variants. The sesame green fodder, as compared with the traditional forage crop alfalfa, is characterized by a higher content of crude protein and lower content of minerals, crude fibre, hemicellulose and cellulose. As compared with common oat green forage, the sesame forage stands out due to its higher concentration of crude protein and minerals, low level of crude fibre, hemicellulose and cellulose, which has a positive effect on relative feed value and energy concentration. The green corn forage is characterized by lower amount of crude protein, acid detergent fibre and minerals, but high amount of hemicellulose and cellulose, higher energy supply than sesame forage.

Little information is available about the chemical composition and nutritional value of *Sesamum indicum* whole plants. Mbaebie al. [18] mentioned *that* chemical composition of *Sesamum indicum* whole plants was 21.44% CP, 8.80% CF, 4.54% EE, 58.86% carbohydrates, 6.68% ash, 0.46% P, 2.41% Ca. Amorim et al. [4] compared the forage quality of green mass and remarked that sesame green forage contained 251.7g/kg DM, 11.77 % CP, 10.54 % EE, 56.24 % NDF, 15.35 % NFC, 36.99 % ADF, 3.14 % ADL, 33.85 % Cel, 19.25 % HC, 56.41 % TDN, 6.08 % ash, but corn green forage – 404.5 g/kg DM, 6.67 % CP, 1.65 % EE, 69.99 % NDF, 15.92 % NFC, 34.17 % ADF, 2.76 % ADL, 31.41 % Cel, 35.82 % HC, 45.90 % TDN, 5.75 % ash.

Table 1. The biochemical composition and the nutritive value of the harvested green mass of the studied species

Indices	*Sesamum indicum*	*Medicago sativa*	*Avena sativa*	*Zea mays*
Crude protein, g/kg DM	*190*	*182*	*95*	*84*
Minerals, g/kg DM	*114*	*138*	*65*	*52*
Crude fibre, g/kg DM	*239*	*352*	*356*	*248*
Acid detergent fibre, g/kg DM	*296*	*361*	*374*	*271*
Neutral detergent fibre, g/kg DM	*479*	*557*	*627*	*474*
Acid detergent lignin, g/kg DM	*72*	*43*	*46*	*48*
Cellulose, g/kg DM	*224*	*318*	*328*	*336*
Hemicellulose, g/kg DM	*183*	*196*	*258*	*223*
Digestible dry matter, g/kg DM	*658*	*608*	*598*	*678*
Relative feed value	*128*	*102*	*89*	*133*
Digestible energy, MJ/ kg	*12.91*	*11.96*	*12.00*	*13.28*
Metabolizable energy, MJ/ kg	*10.60*	*9.82*	*9.85*	*10.90*
Net energy for lactation, MJ/ kg	*6.52*	*5.83*	*5.88*	*6.91*

Source: Own calculation.

Ensiled fodder, haylage, is an important component of livestock diets and can be an excellent source of nutrients particularly in the autumn - middle spring period, but also throughout the year. The haylage prepared from *Sesamum indicum* was distinguished by dark olive leaves and yellow stems with pleasant specific smell, the consistency was retained, in comparison with the initial plant green mass, without mould and mucus. The fermentation profile, the nutrient composition of the haylage prepared from sesame plants is shown in Table 2. The fermentation profile of prepared sesame haylage was pH =4.33, 7.8 g/kg free lactic acid, 2.8 g/kg free acetic acid, 26.7 g/kg fixed lactic acid, 3.9 g/kg fixed acetic acid, 0.2 g/kg fixed butyric acid. It was determined that the pH of the sesame haylage is lower than alfalfa haylage, but higher than in common oat haylage and corn silage. In sesame haylage, the concentration of total organic acids is lower, as compared with alfalfa haylage and corn silage. The acetic acid content in sesame haylage is low in comparison corn silage, but much higher than in common oat haylage. In sesame haylage, butyric acid was detected in fixed form, in very small quantity, at the same level as in corn silage. The concentrations of nutrients in the sesame haylage dry matter were: 161g/kg CP, 151g/kg ash, 212 g/kg CF, 285 g/kg ADF, 520 g/kg NDF, 70 g/kg ADL, 210g/kg Cel, 235 g/kg HC with nutritive and energy values 66.7% DMD, RFV= 120, 9.75-11.73 MJ/kg ME, 6.75 MJ/kg NEl. As compared with the green mass fodder in the *Sesamum indicum* haylage, a reduction in the crude protein content, cell wall fractions (NDF, ADF, ADL) was noticed, and an increase in the content of minerals and hemicellulose. The dry matter digestibility and energy concentration is higher in sesame haylage than in sesame green mass fodder. We would like to mention that sesame haylage is characterized by an optimal content of crude protein, low content of crude fibre, cellulose and high content of acid detergent lignin and hemicellulose as compared with the control – corn silage. Sesame haylage had high concentration of crude protein, acid detergent lignin and minerals, reduced content of neutral detergent fibre than common oat haylage. It has been found that the concentration of crude protein, cell wall fractions (NDF, ADF, ADL), and minerals in sesame haylage is higher, but the relative feed value, metabolizable energy and net energy for lactation is lower than in corn silage.

Several studies have evaluated the quality indices of ensiled mass from *Sesamum indicum*. Medeiros et al. [19] reported that silage nutrient content from whole sesame (S*esamum indicum* L.) plants harvested in different phenological stages were 172-260.9 g/kg DM, 11.13-13.93 % CP, 2.01-7.62 % EE, 49.76-53.59 % NDF, 23.28-25.13 % NFC, 35.83-40.27% ADF, 12.68-13.41 % HC, 57.53-60.98 % TDN, 5.32-8.54 % ash. Amorim et al. [5] found that sesame silage is characterized by pH=4.07, 326.5g/kg DM, 10.13 % CP, 13.03 % EE, 62.74 % NDF, 9.61 % NFC, 37.44 % ADF, 2.55 % ADL, 34.89 % Cel, 25.30 % HC, 51.44 % TDN, 4.47 % ash and corn silage – pH=4.21, 429.4 g/kg DM, 5.92 % CP, 1.85 % EE, 73.26 % NDF, 13.64 % NFC, 34.95 % ADF, 2.68 % ADL, 32.27 % Cel, 38.31 % HC, 43.41 % TDN, 5.31% ash. Galeana et al. [12] reported that sesame silage is characterized by pH=5.22, 217.5g/kg DM, wilted silage is characterized by pH=4.91, 364.3g/kg, but 50% sesame +50% corn silage pH=3.96, 255.3g/kg.

Table 2. The fermentation profile, the nutrient composition of the ensiled fodder from the studied species

Indices	*Sesamum indicum*	*Medicago sativa*	*Avena sativa*	*Zea mays*
pH index	*4.33*	*4.65*	*4.10*	*3.77*
Content of organic acids, g/kg DM	*41.4*	*56.2*	*44.7*	*48.6*
Free acetic acid, g/kg DM	*2.8*	*2.2*	*2.5*	*5.1*
Free butyric acid, g/kg DM	*0*	*0*	*0*	*0*
Free lactic acid, g/kg DM	*7.8*	*10.3*	*10.7*	*17.0*
Fixed acetic acid, g/kg DM	*3.9*	*4.4*	*3.4*	*5.2*
Fixed butyric acid, g/kg DM	*0.2*	*0*	*0*	*0.2*
Fixed lactic acid, g/kg DM	*26.7*	*39.2*	*38.1*	*21.1*
Total acetic acid, g/kg DM	*6.7*	*6.6*	*5.9*	*10.3*
Total butyric acid, g/kg DM	*0.2*	*0*	*0*	*0.2*
Total lactic acid, g/kg DM	*34.5*	*49.5*	*38.8*	*38.1*
Acetic acid, % of organic acids	*16.18*	*11.75*	*13.20*	*21.19*
Butyric acid, % of organic acids	*0.48*	*0*	*0*	*0.41*
Lactic acid, % of organic acids	*83.34*	*85.25*	*86.80*	*78.40*
Crude protein, g/kg DM	*161*	*169*	*102*	*80*
Crude fibre, g/kg DM	*212*	*297*	*393*	*245*
Minerals, g/kg DM	*151*	*107*	*78*	*59*
Acid detergent fibre, g/kg DM	*285*	*321*	*413*	*258*
Neutral detergent fibre, g/kg DM	*520*	*481*	*699*	*469*
Acid detergent lignin, g/kg DM	*70*	*55*	*40*	*37*
Cellulose, g/kg DM	*215*	*266*	*373*	*221*
Hemicellulose, g/kg DM	*235*	*160*	*281*	*211*
Digestible dry matter, g/kg DM	*667*	*639*	*567*	*688*
Relative feed value	*120*	*122*	*76*	*136*
Digestible energy, MJ/ kg DM	*13.07*	*12.46*	*11.28*	*13.45*
Metabolizable energy, MJ/ kg DM	*10.73*	*10.23*	*9.26*	*11.04*
Net energy for lactation, MJ/ kg	*6.75*	*6.34*	*5.29*	*7.06*

Source: Own calculation.

Crop residues are important feed resources for livestock. The availability of these feeds depends on type of agroecosystem, cropping patterns and intensity, type and concentration of animal species, and prevailing animal production systems. The quality indices of residual *Sesamum indicum* biomass after seed harvesting are presented in Table 3. We would like to mention that sesame plant residues are characterized by high content of crude protein and minerals and lower – of structural carbohydrates, as compared with common oat plant residues, which had a positive effect on the digestibility, nutritional value and energy supply of the feed.

Several publications have documented the chemical composition and nutritional value of *Sesamum indicum* crop residues. Mesgaran et al. [20] found that sesame stover forage contained 96.4% OM, 6.7% CP, 75.7% NDF, 46.2% ADF, 54.48% OMD and 7.8MJ/kg ME.

Yaşar et al. [27] identified in sesame stalks monosaccharide carbohydrate: 0.60% rhamnose, 18.97% xylose, 1.49 % arabinose, 1.11% arabinose, 45.70% glucose, 1.87% mannose and 23.64% Klason lignin.

Table 3. The biochemical composition and the nutritive value of the crop residues

Indices	*Sesamum indicum*	*Avena sativa*
Crude protein, g/kg DM	104	62
Crude fibre, g/kg DM	411	467
Minerals, g/kg DM	110	82
Acid detergent fibre, g/kg DM	446	499
Neutral detergent fibre, g/kg DM	621	800
Acid detergent lignin, g/kg DM	83	56
Cellulose, g/kg DM	363	443
Hemicellulose, g/kg DM	176	301
Digestible dry matter, g/kg DM	542	500
Relative feed value	81	58
Digestible energy, MJ/ kg	10.84	10.09
Metabolizable energy, MJ/ kg	8.90	8.28
Net energy for lactation, MJ/ kg	4.91	4.30

Source: Own calculation.

Malekkhahi et al. [17] found that sesame residual components including more than 40% leaves, capsules and stems contained 963 g/kg DM, 88.3% OM, 9.4% CP, 36.1% NDF, 29.1% ADF,11.3 MJ/kg ME, but in low leaves sesame plant residues there was 964g/kg DM, 88.4% OM, 5.9% CP, 55.4% NDF, 36.00% ADF, 8.44 MJ/kg ME, respectively. Aregawi et al. [6] reported that sesame stover forage is characterized by 6.61-7.32 % ash, 4.14-4.69 % CP, 64.0-66.0 % ADF, 69.8-71.1 % NDF and 38.5-41.7 % IVOMD. Hamed & Elimam [13] studied the biochemical composition of plant residues of various crops and remarked that sesame straw contained 965.7 g/kg DM, 1.57% EE, 4.52% CP, 40.01% CF, 7.84% ash, 46.05 % NFE, 67.50 % NDF; sorghum stover – 975.3 g/kg DM, 2.7% EE, 5.72% CP, 30.44% CF, 11.13% ash, 51.44% NFE, 73.00% NDF; millet straw – 968.7 g/kg DM, 0.50% EE, 5.21% CP, 39.99% CF, 10.80% ash, 43.50% NFE, 79.00% NDF. Malekkhahi & Mesgaran [16] reported that the nutritive value of sesame stover was 882.5g/kg DM, 3.6% ash, 6.7% CP, 75.75% NDF, 46.20 % ADF, 575.8g/kg IVND. Bonos et al. [8] mentioned that the chemical composition of sesame seed hulls was: 11.6% CP, 94.9% OM, 13.84% EE 17.63% CF, 12.70% ADF, 17.07% NDF, 16.4 MJ/kg ME. Kumar et al. [14] remarked that sesame stover contained 22.80% of cellulose, 37.76% of hemicellulose, and 7.35% of lignin. Desta et al. [11] found that the nutrient content in fresh sesame residue was 34.55 g /kg TN, 9.6 g /kg S, 5.2 g/kg P, 23 mg/kg Zn, 130.23 mg/kg Fe, 17–6.2 mg/kg Cu and 10.67mg/kg B. Abdullahi et al. [1] mentioned that chemical composition of sesame chaff was: 942 g/kg DM, 89% OM, 13.65% CP, 83.62% NDF, 48.00% ADF, 38.32 % HC. Adeola et al. [2] remarked that after harvest of sesame, residues contained 89.8 % OM, 8.20 % EE, 9.30 % CP, 56.41 % NDF, 52.68 % ADF, 17.53 % NFE, 5.10 % ash. Bagudu [7] reported that sesame seed capsule contained 935.7 g/kg DM dry matter, 75.41% carbohydrate, 3.59 % EE, 4.32% CP, 12.01% CF and 4.77% ash.

CONCLUSIONS

The *Sesamum indicum* plants develop well under the climatic conditions of Moldova.

The productivity of studied ecotype of sesame, *Sesamum indicum* achieved 55.9 t/ha green mass or 12.3 t/ha dry matter, 2.34 t/ha crude protein, 196.8 GJ/ha metabolizable energy and 80.2 GJ/ha net energy for lactation.

The prepared haylage from *Sesamum indicum* plants is characterized by high concentration of crude protein (161 g/kg DM) and hemicellulose (235 g/kg DM), low content of crude fibre (212 g/kg DM) and cellulose (215 g/kg DM) as compared with the traditional fodder – corn silage.

As compared with *Medicago sativa* haylage, the haylage from *Sesamum indicum* plants had similar concentration of crude protein, low crude fibre, high level of digestible dry matter and energy supply.

Sesame haylage had high concentration of crude protein, metabolizable energy and net energy for lactation than common oat haylage.

The sesame plant residues after harvesting the seeds are characterized by high content of crude protein and minerals and lower concentration of structural carbohydrates, as compared with common oat plant residues, which had a positive effect on the digestibility, nutritional value and energy supply of the feed.

The green mass, prepared haylage and collected plant residues of studied ecotype of sesame, *Sesamum indicum* have optimal feed value and can be used as alternative forages for livestock, of partial replacement of traditional fodder crops, in the conditions of climatic change and aridification.

Thus, in order to reduce the negative influence of climatic change (insufficient precipitation and uneven distribution during the vegetation period, drought and heat, soil salinization, etc.) on the formation of the fodder base, widening the spectrum of fodder crops used in feeding farm animals to ensure the well-being and manifestation of the productive potential of farm animals, it is necessary to continue and deepen scientific investigations in the field of the average cost of fodder production per hectare, the proportion in which these fodders can be included in rations for different species and categories of farm animals, the level of milk production or average weight gain that can be ensured by rations with the participation of the non-traditional fodder crops *Sesamum indicum*.

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INFLUENCE OF HYDRO-COOLING AND PACKAGING ON THE STORABILITY OF ROSEMARY PLANTS

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Abstract

Rosemary plants are regarded as one of Egypt's most valuable medicinal and aromatic herbs because they are used in a variety of food and medical industries. Because of medicinal and aromatic herbs are quickly affected by temperatures, the initial cooling process procedure is an essential stage in the treatment of these herbs. This process is carried out immediately after harvesting plants to remove the field heat and reduce microbial activity. Also, it keeps the final product fresh for a long period. Here, we investigated the influence of Hydro-cooling, packaging materials and storage temperatures on the quality and active components for rosemary plants. The plants were immersed in a mixture of ice and water at 5°C for 10 min and stored in two various bags (polyethylene – polyvinyl chloride shrink at 5 and 23°. The quality of rosemary plants such as fresh weight loss, chlorophyll content, respiration rate, volatile oil percentage and its compounds were measured. The obtained data showed that Hydro-cooling, packing in polyethylene bags and storage at 5 °C were the most suitable treatments when compared to the other treatments, as notified by the values of fresh weight loss, chlorophyll content, respiration rate, volatile oil % and its compounds. Hydro-cooling and storage at 5 °C decelerated leaf water loss, reduced respiration rate, and increased oil content, thus increasing the shelf life of rosemary plants by up to 28 days.

Key words: *hydro-cooling, Rosemary, storage, shelf life, volatile oil*

INTRODUCTION

Medicinal and aromatic herbs are very important in Egypt due to their various uses, including cooking and treating a variety of ailments. As a result, their productivity must be increased by increasing the area of agricultural land. Since these plants are sensitive to high temperatures, they must be handled with care after harvest. The field heat of medicinal and aromatic herbs and freshly harvested crops is ordinarily elevated and must be taken away as soon as possible before transportation, processing and storage to increase their shelf life and be available on demand whenever required. Precooling of agricultural crops shortly after harvest is a paramount component of the cool series, which ultimately influences the product's shelf life. Pre-cooling is typically viewed as a separate process that requires particular facilities but is complimentary to low temperature storage. Because impairment is proportional to the time agriculture products are risked to high temperatures, pre-cooling is effective even when produce is later reverted to ambient temperature [10]. Most highly perishable horticultural products, especially leafy and flowering vegetables, deteriorate faster when field heat is not removed before being stored in low temperatures [6]. Storage deteriorating after harvest is the major source of vegetable losses, resulting in substantial financial losses [30]. Leafy vegetables are very perishable and susceptible to water loss, which can be exacerbated by inappropriate temperature and air humidity management during store and trade areas, resulting in shorter usable life and higher end product costs for customers [2]. As a result, it's either consumed right away or used conservation strategies to reduce metabolic activity and extend shelf life. Postharvest wastage control methods are used to slow or minimize product impairment through various storage, shipping, and treatment processes, whereas hydro-cooling is useful for fresh vegetables [31]. Hydro-cooling is a process that uses ice or cold water and is simple, practical, and effective to reduce the temperature of vegetables before packing and refrigerating them. This approach eliminates heat from freshly harvested crops in the field, slowing metabolism and reducing crop degradation [12]. The freshness of most fruits and vegetables is influenced by water loss during storage, which is dependent on the temperature and relative humidity of the storage conditions. According to [16], Low temperature storage is the most effective way to preserve the quality of fruits and vegetables because it reduces respiration, ethylene production, ripening, senescence, and mold development. They also demonstrated that elevated temperatures increment the difference of vapor pressure between the fruit and its surroundings, which has the potential to accelerate moisture transport from the fruit to the atmosphere around it. Packing films have been demonstrated to extend the shelf life of perishable goods, creating a modified in-pack atmosphere with low O_2, elevate CO_2 and decreasing water loss [29]. The MA response of fresh Cymbopogon citrates was studied by [25] in relation to film packing and storage temperatures. At 5 and 0 degrees Celsius, fresh weight loss was substantially smaller than at higher temperatures. Many medicinal and aromatic plants' essential oil content and compounds were influenced by the period of store [4]. Most herbs, like mint, oregano, rosemary, thyme, and sage, preserved their apparent quality after keeping at 0°C for up to 4 weeks, whilst basil suffered from chilling harm, inclusive flavour loss, after stored period of 5 to 7 days at 7.5°C and just 2 days at 2°C, as indicated by [7].

The aim of this research is to study the effect of hydro-cooling, packing in two types of bags, and storage at 5 and 23 °C on fresh weight loss, chlorophyll content, respiration rate, volatile oil content, and its compounds for rosemary plants.

MATERIALS AND METHODS

This research was achieved at Horticulture. Department of the Faculty of Agriculture, Kafr El-Sheikh University to study the influence of Hydro-cooling and storage bags at storage temperatures 5 and 23 °C on the storability of *Rosmarinus officinalis*, L. plant in 2022. The quality of herbs was analyzed at the laboratory of the faculty.

Plants used in this study

Rosemary plants were acquired from the research farm of the Horticulture Department, Faculty of Agriculture, Kafr El-Sheikh University, in March 2022 and transported immediately to the laboratory. Plants were selected without any marks of fading, yellowing or the incidence of mold. The plants were divided in two groups (hydro-cooling and non-cooling). Hydro-cooling was adjusted at 5°C where plants were immersed in a blending of ice and water for 10 minutes and stored in two different bags (polyethylene and polyvinyl chloride shrink), then stored at two temperatures (23–5°C). Each bag contained 200 g of plants.

Measurements

Safe storage duration (days)

The parameters in which precooled and non-precooled fresh plants maintained acceptable quality until they began to deteriorate were measured. The following parameters have been included:

Fresh weight loss

The weights of the samples were measured by a digital balance with an accuracy of 0.01g and the proportion of fresh weight loss of each replicate was calculated in relation to its original weight according to the equation:

$$\frac{\text{First weight} - \text{plant weight on storage date}}{\text{First weight}} * 100 \quad \text{...(1)}$$

Respiration rate

Plants weighing 100 grammes were placed in a dissector and linked to a tube holding 25 ml of 1.0 N KOH; CO_2 free air was introduced into the dissector via the KOH for one hour. KOH was titrated with 1.0 N HCL using thymol blue indicator, and CO_2 generation was measured as mg CO_2 $Kg^{-1}h^{-1}$ as described by [15].

Total chlorophyll

Each week, five plant samples were selected randomly from each packaging at each storage temperature; chlorophyll was measured using chlorophyll meter equipment, model Minolta SPAD 502.

Volatile oil content and its components

The volatile oil has been extracted from fresh herbs samples (50g) using Clevenger hydro-distillation devices, as indicated by the [26]. The volatile oil concentration was measured for each treatment on a weekly basis until each treatment's shelf life ended. The volatile oil extracted from the plants was analysed using gas liquid chromatography (GLC) to determine its constituents.

Plants temperature

Temperature changes in plants throughout the pre-cooling procedure was measured using a digital global temperature meter with a copper-constantan thermocouple.

Statistical analysis

The experiment was coordinated in a completely randomized block design and included eight treatments with three replicates for each treatment. All data were analysed statistically by analysis of variance (ANOVA) using CoStat version 6.303. The means of treatments were compared using Duncan's test.

RESULTS AND DISCUSSIONS

Fresh weight loss

Table 1 revealed that plants held at room temperature lost their fresh weights more quickly than those stocked in the refrigerator. According to [9], who evidenced similar results, fresh sweet basil and spearmint preserved at a higher temperature of 20 ºC lost more weight than those kept at 0 or 5 ºC. Furthermore, it is apparent that the Hydro-cooling process and storage temperatures have a significant impact on fresh weight loss. Using hydro-cooling and lowering the storage temperature from 23 to 5 °C produced a decrease in the loss of fresh weight for rosemary in general.

Similar results were achieved by [23] in coriander and [12] in parsley, which manifested that hydro-cooling lowered fresh leaf weight loss during storage. It was found that the non-hydro-cooling treatments resulted in the largest fresh weight loss compared with the hydro-cooling treatments, which recorded the lowest fresh weight loss.

Additionally, raising the storage temperatures from 5 to 23 °C resulted in a greater fresh weight loss. After 21 days, only hydro-cooling at 5 °C resulted in improved leaves turgescence.

This finding shows the relevance of hydro-cooling treatment, which is very efficient due to water's strong thermal conductivity, as well as the uniform contact between water and the product's surface, which enhances quick temperature decrease [32].

However, maintaining the cold chain extends the shelf life of the product by lowering the temperature difference between the plant and the environment, hence reducing water losses.

Also, we can notice that plants in two packages continued to lose their fresh weight as the duration of storage increased but this fresh weight loss was greater in storage temperature 23 °C than 5 °C.

This consequence can be attributable to the final condensation and water collecting within the package, which generate a high-moisture atmosphere.

The same result was found by [1], as he discovered considerable water collecting within the packages and ascribed it to high levels of transpiration in the leaves at room temperature.

Polyvinyl chloride shrink bag was recorded the highest fresh weights loss with and without hydro-cooling at storage temperature 23 °C for all storage periods compared with polyethylene bags in which storage continued, with a decrease in weight loss, up to 28 days at storage temperature 5 °C.

According to [34], who reported that the decrease in the proportion of quotidian fresh mass loss in the leaves was due to the increase and keeping of the border layer, the depression in the vapour pressure deficit between the leaves and the atmosphere surrounding the produce, and the formation of an adjusted atmosphere within the package.

Table 1. Influence of Hydro-cooling, packaging materials and storage temperatures on weight loss % of *Rosemarinus officinalis* plants

Packaging materials	Storage temperatures, °C	7 days		14 days		21 days		28 days	
		Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling
control	23	23.25 a	18.23 b	29.98 a	25.54 b	-	-	-	-
polyvinyl chloride shrink	5	2.76 g	0.02 h	5.23 g	1.05 h	7.19 e	3.03 f	9.35 e	5.15 f
	23	12.56 c	10.11 d	23.79 c	19.22 d	27.06 a	24.03 b	29.94a	26.08b
polyethylene	5	0.22 h	0.21 h	0.24 h	0.23 h	0.75 g	0.29 g	1.91 g	1.01 g
	23	10.01 e	8.56 f	15.5 e	12.6 f	21.79 c	17.31 d	24.73c	20.99d

Note: Data were expressed by mean as means in a column that are followed by the different letters indicate significant differences at the ($P \leq 0.05$) level.
Source: Own results.

Respiration rate

Table 2 exhibited that the respiration rate of the rosemary plant upgraded with the storage period increment at 5 and 23 °C, as it was noticed that the large increase was at 23 °C while it slowed down by the low storage temperature of 5 °C. This result was in line with [22], who mentioned that low temperature storage slows down respiration rates in most products, but in chilly-sensitive produce, lower temperatures that cause chill injury will raise the rates of respiration. Also, the respiration rate at room temperature is higher than 5 °C and this is due to the cooling reduces the respiration rate and ethylene production. According to [17], who reported that cooling decreases the rate of respiration, ethylene generation, the degree of senescence, and microbial activity. On the other hand, it can be observed that the respiration rate of the untreated plants was higher than that of the plants treated with hydro-cooling, and this is due to the fact that the hydro-cooling process is an effective approach to decreasing the plant's metabolic activity, which slows the rate of respiration, resulting in a longer storage duration. According to [13], hydro-cooling was found to be a quick method for cooling minimally treated spinach in spring, reduced the rate of respiration , and improved quality in comparison with other cooling methods like traditional room cooling, forced-air cooling and vacuum cooling. In addition to packaging material had significant effect on respiration rate for rosemary plants at 5 and 23 °C.

Table 2. Influence of Hydro-cooling, packaging materials and storage temperatures on respiration rates CO_2 $Kg^{-1}h^{-1}$ of *Rosemarinus officinalis* plants

Packaging materials	Storage temperatures, °C	7 days		14 days		21 days		28 days	
		Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling
control	23	143.23a	133.62b	165.85 a	153.62 b	-	-	-	-
polyvinyl chloride shrink	5	123.65 d	83.63 h	138.32 d	87.06 h	148.65 b	98.79 g	162.45a	105.65c
	23	131.22bc	126.65c	140.63 c	138.52 d	157.88 a	146.33 c	-	-
polyethylene	5	90.65 f	72.22 i	106.52 f	76.23 i	136.23 d	81.35 h	152.41b	84.33d
	23	97.26 e	87.33 g	111.51 e	104.65 g	127.65 e	123.02 f	-	-

Note: Data were expressed by mean as means in a column that are followed by the different letters indicate significant differences at the ($P \leq 0.05$) level.
Source: Own results.

Respiration rate values of polyvinyl chloride shrink bags were higher than polyethylene bags at 5 and 23 °C. [33] reported that when the temperature rises, the O_2 level in the package decreases while the CO_2 level grows, since the permeability of the package film to O_2 and CO_2 gases does not increase at the same extent as the produce's respiration rate, the low O_2 and high CO_2 concentrations are harmful to fresh fruit, producing physiological harm and bad flavours.

Total chlorophyll (SPAD)

Total content of chlorophyll reduced during the storage duration at 5 and 23 °C with or without hydro-cooling as illustrate in Table 3. The control herbs which preserved without packaging at room temperature lose the storability after storage period of 14 days but they listed the highest values of total chlorophyll content compared with treated herbs. This same findings was noticed in a peppermint investigate conducted by [3], who stated that the SPAD values in hydro-cooled branches were much lower than those in control branches, owing to the increment water in the tissues during the pre-cooling process, which effectively diluted the chlorophyll concentration. The highest values of chlorophyll content were observed at 5°C of the storage temperature. The result agrees with [28], who mentioned that samples stored in refrigeration at 5 ºC exhibited a higher SPAD index, as the low temperature prevented chlorophyll breakdown and resulted in green leaves at the end of storage. According to [2], pre-cooling followed by 5°C on parsley leaves (*Petroselinum crispum*) did not cause chlorophyll breakdown, as measured by the SPAD index. The extension of storage periods decreases total chlorophyll, which is probably attributable to some breakdown in plant tissues as storage duration increases [21]. The results also, illustrated that packaging materials had significant effect on total chlorophyll content. In accordance with [2], imperforated plastic packaging might cause CO_2 cumulation and minimise O_2 in the package, affecting the atmosphere and decreasing the formation and activity of ethylene and the enzymes that cause chlorophyll breakdown. In addition, our findings are similar to [20, 21], stated that using different packing materials under similar cooling temperatures influenced the total chlorophyll content, likewise influenced by different cooling temperatures under the same packaging materials. The highest values of total chlorophyll content recorded by using polyethylene bags at low temperature.

[12] reported similar results, as they attributed the keeping of chlorophyll in the leaves of lettuce to chilled packaging. Polyethylene bags are superior to polyvinyl chloride shrink bags in delaying degradation of chlorophyll, possibly due to their improved influence on CO_2 and O_2 inside the package.

Table 3. Influence of hydro-cooling, packaging materials and storage temperatures on total chlorophyll (SPAD) of *Rosemarinus officinalis* plants

Packaging materials	Storage temperatures, °C	7 days		14 days		21 days		28 days	
		Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling
control	23	1.39 a	1.23 b	1.25 a	1.14b	-	-	-	-
polyvinyl chloride shrink	5	1.13 d	0.84 f	1.09 c	0.65 h	0.97 b	0.53 f	0.92 b	0.49 e
	23	1.02 ef	0.82 g	0.99 e	0.63 i	0.81 c	0.51 g	0.42 f	0.31 h
polyethylene	5	1.21 c	0.85 f	1.15 b	0.76 f	1.03 a	0.64 d	0.96 a	0.58 c
	23	1.06 e	0.83 g	1.01 d	0.71 g	0.96 b	0.61 e	0.50 d	0.39 g

Note: Data were expressed by mean as means in a column that are followed by the different letters indicate significant differences at the ($P \leq 0.05$) level.
Source: Own results.

Volatile oil content

Hydro-cooling treatment showed the highest oil % compared with non cooling treatment for rosemary plants throughout storage period as shown in Table 4. Volatile oil content at 5 °C was higher than at 23 °C. As mentioned by [19], low temperature slows down changes in physiological, chemical and physical composition of the produce. According to [5], high temperature have an impact on respiration rates of product, organic matter breakdown, transpiration losses, exterior quality characteristics and the decrease in inactive components. In regard to the packaging types, the data revealed that the differences in oil content among the packaging types were negligible at the different storage periods. Whereas, the storability of control herbs was for only 14 days, which gave a slight increase in oil content over the other treatments. Also, the content of oil in different packaging was higher at a temperature of 5 °C as mentioned by [18] who showed the impact of packaging types on the oil quality of sweet basil and he found that oil quality was best by storage at 4 °C in plastic bags.

Table 4. Influence of hydro-cooling, packaging materials and storage temperatures on the volatile oil content % of *Rosemarinus officinalis* plants

Packaging materials	Storage temperatures, °C	7 days		14 days		21 days		28 days	
		Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling	Without cooling	With cooling
Control	**23**	0.21bc	0.23a	0.22bc	0.25a	-	-	-	-
polyvinyl chloride shrink	**5**	0.18ef	0.20cd	0.20 de	0.21cd	0.21bc	0.22ab	0.22cd	0.24ab
	23	0.17f	0.19de	0.18e	0.20de	0.20cd	0.21bc	0.22cd	0.22cd
polyethylene	**5**	0.19de	0.21bc	0.21cd	0.22bc	0.22ab	0.23a	0.23bc	0.25a
	23	0.18ef	0.19de	0.19ef	0.21cd	0.21bc	0.22ab	0.22cd	0.23bc

Note: Data were expressed by mean as means in a column that are followed by the different letters indicate significant differences at the ($P \leq 0.05$) level.
Source: Own results.

Volatile oil components

The data in Table 5 demonstrate that 14 compounds accounted for 91.99% of the aromatic oil of rosemary herb after harvest (control). Compounds identified included α-pinene (12.33%), β-pinene (8.14%), limonene (4.21%), ρ-cymene (11.18%), camphene (8.24%), α-terpinolene (9.25%), 1,8 cineole (7.12%), linalool (6.61%), B-carophyllene (7.29%), borneol (4.56%), thymol (5.22%), camphor (3.19%), Eugenol (1.74%), and Bornyl acetate (4.52 %). [24] found similar findings, the oil of rosemary contains α-pinene, β-pinene, limonene, ρ-cymene, camphene, eugenol, linalool, borneol, and terpineol.

In general, the total proportion of oil components in samples treated with or without hydro-cooling declined after storage in comparison with the control. Total proportion of oil compounds for hydro-cooling treatments were higher than non cooling at different storage temperatures as they were 41.07 and 31.1 % at 23°C and 61.75 and 54.86 % at 5°C, respectively.

Table 5. Influence of hydro-cooling on volatile oil components (%) of rosemary after storage period (21 days) at different storage temperatures and polyethylene bags

Components	Control	21 days			
		Without cooling		With cooling	
		23 °C	5 °C	23 °C	5 °C
A – pinene	12.01	5.31	7.88	6.33	8.25
B – pinene	8.14	1.54	3.95	2.89	4.42
Limonene	4.21	0.99	1.89	1.16	2.65
ρ- cymene	11.18	4.21	6.69	5.89	7.65
Camphene	8.24	3.51	6.84	5.32	7.21
γ- terpinene	9.25	3.01	5.22	9.61	10.12
Thymol	5.22	1.79	2.98	2.75	3.65
1, 8 cineole	7.12	0.75	2.33	1.02	2.65
Linalool	6.11	2.94	4.98	3.56	5.02
Eugenol	1.74	0.42	1.36	0.55	0.89
borneol	4.06	1.13	2.01	4.47	5.31
B-carophyllene	7.00	3.66	4.94	4.03	5.12
camphor	3.19	0.62	1.23	0.84	1.63
Bornyl acetate	4.52	1.22	2.56	1.65	3.89
Total	91.99	31.1	54.86	50.07	68.46

Source: Own results.

In addition, the temperature of storage also influenced the percentages of oil components, as they were higher at 5 °C than at 23 °C. The findings are consistent with [7] observation that most herbs, including rosemary, keep acceptable quality after being kept for up to four weeks at a temperature of 0 °C.

In summary, regarding the global economic crises, we must look for ways to reduce post-harvest processes costs to obtain a product for marketing over longer distances with high quality and a longer shelf life at the lowest costs. Economic gains arise for precooling of fruit and vegetables from reduced spoilage and extended shelf life as precooling methods impact both quality and economics, making them critical considerations in the postharvest supply chain comparing with the lake of cooling [8, 27, 14]. Additionally, precooling minimizes food waste during long-distance transport. Also, hydrocooling is regarded as efficient because of the low application cost and high energy efficiency compared with other precooling methods. Moreover, hydrocooling is capable of cooling large quantities of fruit while disinfecting the fruit surface, as mentioned by [11]. This increases the economic return for both local and international market traders.

CONCLUSIONS

Hydro-cooling improved the shelf life of rosemary plants, mainly by minimizing fresh weight loss and maintaining a greater amount of water in the leaves throughout refrigerated storage. In addition to plastic packaging proved successful at maintaining relative water content. Polyethylene containers efficiently kept the leaves from fading for a long duration of time. The most effective treatments for quality upkeep postharvest rosemary were hydro-cooling, polyethylene bags and storage at 5 °C as they decreased the loss of fresh weight, increased the total chlorophyll, maintain respiration rates, oil content and its components.

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METHODOLOGICAL ASPECTS OF ELABORATION OF COST RATES APPLIED IN THE AGRICULTURAL SECTOR OF THE REPUBLIC OF MOLDOVA

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Abstract

Entrepreneurial activity in the agricultural sector requires activities that, initially, involve a certain volume of financial resources. The correct planning and management of these expenses can only be executed following the analysis of a set of economic indicators that reflect consumption and production costs in the given sphere. Currently, through the use of some groups of technical procedures, both consumption and production costs in it represents cost rates, used in the process of planning technological production activities. The purpose of the given work is to reflect the methodology for developing the respective indicators, highlighting the main technical aspects of forming cost rates and the principles of using the given methodology. At the same time, the standard cost of agricultural and animal husbandry products is determined by means of the cost tariffs - an indicator that reflects the expenses for obtaining a plant/animal husbandry production unit on a certain area of land/head. In addition to the theoretical part of the given methodology, where the methods of determining the tariffs applied in the given sector are presented, the work also contains a practical demonstration of the use of tariffs in determining production costs for autumn wheat and autumn barley. In conclusion, the methodology of developing cost tariffs applied in the agricultural sector reflects the entire agricultural production process, is explicit and easily usable by agricultural entrepreneurs and serves as a reference for planning production processes in the sector.

Key words: *agriculture, cost tariffs, production costs*

INTRODUCTION

Through the land reform, implemented in the period 1998-2000 in the Republic of Moldova, the goal was to redistribute agricultural land plots and the assets of former collective farms among active members of the respective entities.

Later, the given action was followed by the formation of different types of households with agricultural activities, such as: peasant households, individual enterprises, joint-stock companies, limited liability companies, etc. [1].

The main purpose of these households was and still is to obtain income from the cultivation of agricultural crops and/or the breeding of animals and birds, from the provision of various agricultural services.

The economic efficiency of this activity is ensured only by the production and efficient marketing of agricultural products, the optimal management of land resources, the creation of means of production and services, capital and labor [17].

The result of these actions represents the difference between the value of global production and the amount of production and marketing consumption of agricultural products or services.

Currently, the stage of correct estimation of production consumption, as well as the development of standard costs for obtaining a production unit, represent an impediment for most domestic agricultural entrepreneurs [16].

In the given context, in order to overcome this obstacle, the methodology for the objective identification of these costs was elaborated, the measure being reflected in the form of tariffs.

Cost levels represent the clarification of the production consumption of agricultural products and services for various types of companies in the field and are reflected in the form of indicators of the current expenses required for the production process.

MATERIALS AND METHODS

The informational framework necessary for the development of cost tariffs in agriculture is represented by: legislative acts, sectoral cost norms, developed by specialized institutions, cost standards obtained as a result of specialized studies.

The basic method for calculating cost rates is the predictive method, which consists in determining the normalized costs in accordance with technological and economic standards. Also, the expertise method and the method of specialized studies will be used - methods that will be applied to the determination of the prices of raw materials purchased by agricultural households, the assessment of the amount of expenses for marketing agricultural products, etc.

Various methods are used to determine consumption related to basic products (residual value method, related cost distribution method).

The cost rate calculation method operates with a number of indicators, such as: production costs; fixed costs; global costs; variable costs; selling costs; standard (planned) costs.

When determining the cost elements, methods taken from the accounting standards of the Republic of Moldova are applied. Additionally, the taxes and fees involved in the formation of production costs are determined by the current legislation

RESULTS AND DISCUSSIONS

The development of cost tariffs in agriculture represents an extensive process of actions involving a wide spectrum of economic indicators. Once determined, the rates represent a reliable source of accessible data for use by agricultural entrepreneurs in the process of planning the respective activity. Cost rates represent consumption of production and agricultural services, and represent a group of economic indicators of current expenses directed towards ensuring the production process. Applying the respective methodology allows obtaining a relevant database that reflects different types of costs for a wide range of agricultural products and services. Material costs are based on current prices in the local market, and the evolution of the rates in question does not involve including various types of financial losses.

The determination of production and marketing costs is carried out in accordance with the rules of cost grouping, the listed items aim to ensure the inclusion of the costs borne by the respective economic agents (Table 1).

Table 1. Direct consumption items included in the standard cost of agricultural products

The name of the articles	Crop	Zootechnics
1.Total variable costs, including		
1.1Seed material	+	-
1.2Fertilizers	+	-
1.3 Chemical preparations	+	-
1.4 Veterinary services and preparations	-	+
1.5 Feed	-	+
1.6 Mechanized operations	+	+
1.7 Manual operations	+	+
1.8 Other consumptions	+	+
2. Total constant (fixed) costs, including		
2.1 Depreciation of fixed assets	+	+
2.2 Taxes and duties	+	+
2.3 Lease payments	+	-
2.4 Other direct fixed consumption	+	+
3. Indirect costs	+	+
4. Standardized cost	+	+

Note: „+” – the existence of the article, „-” – its absence.

Source: Author's synthesis based on regulations in force.

The total of variable costs results in the total variable cost and changes depending on the production volume. This indicator is calculated based on the ratio between total variable cost and physical production obtained, expressed in the variable cost per unit of product obtained or service provided. [3].

In turn, variable consumption is divided into material consumption and consumption in the form of services. Material consumption has a significant weight in the structure of production consumption. Since the absolute size of these consumptions is directly proportional to the cultivation area (livestock), they are part of the group of variable consumptions.

In the phytotechnical sector, the main components of material consumption are:

seeds, planting material, mineral fertilizers, chemical fertilizers, pesticides.

In the zootechnical sector, these consumptions are simple and compound feeds, veterinary medicinal preparations [8].

The consumption of seeds and planting material is a mandatory component in the given structure, it represents the normed consumption for sowing or planting a unit of agricultural surface. The volume of consumption of mineral and organic fertilizers is directly proportional to the volume of the expected harvest, their cost may also vary depending on the chemical and technical characteristics of the fertilizing product.

The initial data for calculating the consumption of mineral fertilizers are as follows:

1.The volume of mineral fertilizers on main nutrient elements, incorporated in the soil or administered on the foliar part of the plants are expressed in kg of active substance per ha;

2. The mass of organic fertilizers, which will be introduced into the soil on one agricultural hectare, is 3.5 tons annually;

3. The market price of fertilizers at wholesale warehouses, including transport costs to the relevant household;

4.The rules for introducing mineral fertilizers into the soil are determined according to the pedological conditions and the expected yield per hectare.

The quantity of fertilizers needed to obtain a production unit depends on the agricultural crop being cultivated. For optimal standardization of the fertilizer quantity, it is necessary to determine the export of active substance by agricultural crops in the physiological process, as well as the agrochemical characteristics of the soil. [14].

The protection of agricultural crops involves the use of phytosanitary products. The use of these chemical means is an important technological element for both conventional and sustainable agriculture.

The use of phytosanitary products and chemical fertilizers in the agricultural production process is regulated by a set of laws adopted at the national level. The consumption of chemical products is determined by the physiological specificities of each crop, taking into account the initial economic objectives. The applicative aspect of the initial pesticide use information is established based on expert judgment. Thus, the volume of consumption of phytosanitary preparations depends on the applied protection methods. When developing these methods, the following aspects will be taken into account:

1.Reducing or optimizing the number of treatments;

2.Alternation of products with active substance for a more effective diversification;

3. Application of the treatment in the periods most sensitive to pathogens and pests [9];

4. The use of the most effective phytosanitary preparations to reduce the given type of consumption.

The consumption of phytosanitary and veterinary preparations is a basic component in the structure of production costs, with an essential contribution to the formation of the quantity and quality of the expected product [7].

In the animal husbandry sector, the basic weight of the consumption is the cost of feed. The principles of rational feeding involve understanding issues such as the nutritional value of feed and rations, feed resources and their nutritional characteristics, the feed requirements, which vary according to age category, physiological condition, and production status [18]. Being the result of the activity in the phytotechnical sector, different types of feed for animals and birds pass, in one way or another, through technological processes of cultivation, harvesting, primary processing, transport, storage, etc. Subsequently, those expenses are reflected in the cost of this type of product. At the same time, a significant part of fodder is manufactured and realized as commodity production. Therefore, the share of this type of fodder in the structure of material fodder consumption differs considerably, depending on the correlation of different factors, such as: species of animals and birds; the final destination of the livestock production to be obtained. Nutrition and feeding directly and obviously influence not only the level of animal production, but also reproduction, growth and development processes, the health status of animals, and, last but not least, economic efficiency - a decisive objective in carrying out activities in animal husbandry [13].

In the composition of production costs, the share of received services occupies up to 40%, in some cases, such as the production of apples - it can reach the level of 70% [6].

The services provided in the production process in both phytotechnics and animal husbandry are differentiated into mechanized services, with the involvement of machinery and mechanized techniques, and manual services – directly involving manual labor. The main component of expenses for mechanization works is the cost of diesel, gasoline and other petroleum products. The method of determining the market prices of these products is developed in accordance with the Methodology of the formation and application of prices for petroleum products. The volume of consumption (in natural units) of diesel, gasoline, etc. at the execution of each separate technological operation, it is determined by applying the technological data sheets, the type of consumption norms, the technical passports of the tractors, combines, vehicles, etc.

The market price of a conventional unit (Pp) of petroleum products is calculated according to the formula:

$$Pp = P_m \frac{1}{G} + K_1P_{um} + K_2P_{ut} + K_3P_s \text{ (MDL/kg)}\text{...,,,}(1)$$

where:
P_m – market price of 1 liter of diesel (MDL);
G – specific gravity of diesel (G=0.86);
K_1;K_2;K_3 – engine oil, transmission oil and solid oil usage ratio;
P_{um}; P_{ut}; P_s – the market price of a liter of motor oil, transmission oil and solid oil.

For each technological process, the production capacity in one exchange (Wsch) of used aggregates is calculated, the calculation being carried out according to the formula:

$$W_{sch} = 0.1 \times B_1 \times V_1 \times T_e \text{ (ha/hour)}\text{.................}(2)$$

where:
B_1- working width of the aggregate (m);
V_1 - working speed of the aggregate (km/hour);
T_e -actual working time.

The amount of expenses for the execution of mechanized works calculated for a surface unit (Cm) or for a conventional surface unit is calculated according to the formula:

$$C_m = Q_{petr} + P_m + A_t + R_t + N \text{ (MDL/ha)}\text{......}(3)$$

where:
Q_{pet}–cost of fuel consumption, MDL/ha;
P_m –labor payment (including taxes and breakdowns in the social fund), MDL/ha;
A_t –depreciation of fixed assess, MDL/ha;
R_t –current repairs, technical services and storage costs, MDL/ha;
N –other types of planned expenses (taxes, administrative expenses, lease expenses, etc.), and unplanned expenses (advertising, landscaping, ecological measures, etc.)

The cost of the mechanical services is established with the formula:

$$P_p = C_m \times K_{prof}\text{..}(4)$$

where:
C_m –unitary cost of the mechanized services;
$K_{prof.}$ –coefficient of profitability of mechanization works [11].

The agricultural sector is characterized by a massive involvement of manual labor. The degree of use in one type of process or another depends on the complexity of the work performed, the level of automation and mechanization of production technologies, and the specifics of the agricultural sector.

As an example, in the normalized cost structure for the production of winter wheat, the cost of mechanized services represents 35% and manual services - about 5%, while in the production of currants, mechanized expenses represent 4.7% and manual operations represent 64% of the total production consumption [2].

If the cost of mechanized services consists of several components (reflected previously), then only salary expenses are used as the basis for the formation of operational consumption and are developed based on the pricing of manual production works. Therefore, the salary represents the remuneration of the providers, an action that is carried out through the tariff system [4].

The labor remuneration tariff system represents by itself the totality of norms with the help of which the differentiation and regulation of the level of remuneration of various jobs and categories of workers in the branches of agricultural production is carried out depending on the quality of work, the level of qualification of the worker, the working conditions [15]. The composition of the salary includes the so-called basic salary (tariff salary for workers and position salary for other collaborators) and various financial supplements.

As the main wage component for calculating the rates of expenses for services and agricultural products, this methodology provides for the use of the basic tariff wage, established for the fulfillment of a work norm and differentiated depending on the tariff categories of the agricultural work. The salary includes the so-called base salary (tariff salary for workers and position salary for other employees) and various financial supplements [12].

The tariff grid, approved by the Decision of the Government of the Republic of Moldova (no. 743 of 06.11.2002) provides for six qualification categories for agriculture, with the general growth coefficient at the level of 2.00(category VI in relation to the first category) and is updated annually. Manually executed works are assigned to category I, II, III, IV, difficult works belong to category V-IV. For the livestock sector, categories III-IV are mostly assign. The monthly tariff salary is determined by multiplying the tariff salary for one hour by the total number of hours worked during a month (169 hours).

In the agricultural production process, some variable consumptions are carried out that are not part of the previously examined compartment and are represented by the following items: Irrigation expenses; Insurance premiums, related to certain agricultural crops (animal species); Expenses for guarding cultivated agricultural land, expenses for design services, extension, etc.

Fixed costs represent all consumption independent of production volume (depreciation of fixed assets, taxes, lease payments, etc.).But changing the volume of production after some limits can generate the reduction or increase of fixed expenses. Thus, fixed costs can become conditionally constant costs, with the discrete change of its values depending on the change in production volume after some limit [5].

The wear and tear of fixed assets represents the decrease in value of fixed assets in the production process or the loss of some capacities, properties and qualities of fixed assets as a result of their operation, their value being gradually transferred to the cost of manufactured production. Depreciation is calculated on each group and object of fixed assets depending on their initial value and duration of use. Lease payments are a specific component and represent a way of redistributing the agricultural surplus. Although in most cases the lease payments are made in kind, in the present methodology they are calculated in their monetary equivalent, resulting from the size of the market prices of the respective products on the date of making the calculations.

Taxes and duties consist of land tax (single tax) and value added tax (VAT).The amount of the land tax is established annually by the representative authorities of the local public administration, within the limits of the maximum quotas specified in the Fiscal Code and other normative acts.

Other direct consumption will include: Insurance premiums; consumption related to combating and liquidating the consequences of natural disasters, etc.; the cost of small value items that can be attributed to a specific agricultural product.

Indirect costs represent all expenses related to the management and servicing of the entity's production subdivisions.

Summing up the total variable costs, the fixed fixed costs and the indirect ones gives you the total global cost of production, expressed as a monetary unit at a unit of measure.

A study case- calculation of production costs per 1 ha for winter wheat and barley in a vegetal farm of Moldova

For a clearer explanation of the process of developing cost tariffs in agriculture, we will provide a demonstration with real data. For this example, we will consider two cereal crops - autumn wheat and autumn barley. Following the application of the methodology for determining the standardized cost, the following result was obtained (Table 2).

Table 2. Standard cost of autumn wheat grains and autumn barley grains. MDL/ha

Specification	Autumn wheat yield 30 quintals/ ha	Autumn barley yield 25 quintals/ ha
1. Total variable costs, including	**7,700**	**8,271**
1.1 Seeding material	1,666	1,520
1.2 Fertilizers	2,335	2,000
1.3 Chemical preparations	1,050	1,731
1.4 Mechanized operations	2,180	2,485
1.5 Manual operations	245	295
1.6 Other expenses	224	240
2. Total fixed costs, including	**1,194**	**1,211**
2.1 Depreciation of fixed assets	100	100
2.2 Taxes and fees	170	170
2.3 Rent payments	693	693
2.4 Other direct fixed expenses	231	248
3. Direct consumption, total	**8,894**	**9,482**
4. Indirect costs	267	286
5. Standard cost	**9,161**	**9,768**

Source: Author's calculations based on the methodology used.

In order to determine the standardized cost of wheat and barley production, the following consumption indicators were initially calculated:

Calculation of variable costs

(1)***Seed material***. For sowing one hectare of winter wheat, 300 kg of seed material are needed, for barley - 220 kg. By multiplying by the selling price of one kilogram of seed material, the total value of the respective indicator was obtained.

(2)***Fertilizers***. Usually, due to the lack of organic fertilizers, the determination of the respective consumption will be based only on the value of chemical fertilizers. Depending on the need for N;P;K in the soil and according to the technological sheet, the indicator given for wheat is 2,335 MDL/ha, for barley - 2,000 MDL/ha.

(3)***Chemical preparations*****.** These represent chemical plant protection products. In our case, the value of this consumption is determined by the content of the preliminary protection program for each individual crop, but it can vary in case of unforeseen conditions. In our case, the expenses are: for wheat - 1,050 MDL, barley - 1,731 MDL.

(4)***Mechanized operations*****.** It includes the entire set of mechanized works according to the technological sheet. Mechanized operations are calculated based on the initially developed rates for mechanized works. The total mechanized expenses incurred during the production process are reflected as an indicator and included in the respective table. For wheat - 2,180 MDL, barley - 2,485.

(4)***Manual operations*****.** In our case, manual force is used for loading and unloading the seed material and chemical fertilizers, servicing the seeding equipment. Expenses are calculated based on the hours worked, with remuneration being executed depending on the wage rate category. The value of manual operations used in cultivating one hectare of wheat is 245 MDL, for barley - 295 MDL.

(5)***Other expenses*****.** These are unforeseen expenses in the process of agricultural crop production, which can vary depending on the applied technologies and the morphological specificity of the crop. In the case of cereal crops grown in the conditions of the Republic of Moldova, these expenses represent 3-4% of the total variable costs.

Calculation of fixed costs

(1)***Wear and tear of fixed assets***. It is calculated using the method of production units, which involves calculating depreciation as the product of the depreciation rate per unit of product (service) and the volume of products manufactured (services provided) in the management period. When determining the depreciation of tangible fixed assets, the economic useful lives and conditions of use are taken into account [10]. Both for autumn wheat and barley, the wear and tear of physical means is estimated at 100 MDL per hectare.

(2)***Taxes and fees.*** For activity in the agricultural sector, central authorities have established a flat tax. Similarly, for both crops, the respective tax amounts to 170 MDL/ha.

(3)***Lease payments*****.** Most large agricultural enterprises have significant portions of leased agricultural land. Following field research, it has been determined at an expert level that currently, the average payment for one hectare of leased agricultural land is on average 693 MDL.

(4)***Other direct fixed expenses***. Includes unplanned expenses related to various local taxes, variations in the calculation of fixed asset depreciation, rent payments. In our case, a margin of 20-24% of total fixed expenses was chosen.

Calculation of Direct consumption costs is the sum between variable costs and fixed costs, which in case of winter wheat accounts for 8,894 Lei/ha and in case of barley for 9,482 Lei/ha.

Calculation of Indirect costs

Indirect costs include administrative expenses, security expenses, logistics and constitute 3% of the total production costs. Thus, for wheat this type of expenses is 267 MDL/ha, for barley - 286 MDL/ha.

Calculation of standard costs

The determination of the total standard cost for both crops is done by summing up all consumption and production costs. As a result, cultivating one hectare of wheat, with an estimated yield of 30 quintals per hectare (average productivity in autumn wheat production in the Republic of Moldova), the standard cost will be 9,161 MDL or 305.3 MDL per quintal of production. For autumn barley, the standard cost for one hectare of crop is 9,768 MDL or 390.7 MDL per quintal of production.

CONCLUSIONS

The cost of production in agriculture represents the value expression of labor consumption directed towards the realization of an economic process completed with obtaining a unit of agricultural product. At the same time, the respective indicator forms the basis of the prices for the production obtained or the service provided.

In determining production costs in agriculture, consumption or production expenses represent the resources used for the production of agricultural products or the provision of services, and the value of these expenses is reflected in the form of tariffs. The development of cost tariffs in agriculture involves the systematization of a large set of economic, social and technological data. Once established, they separately reflect the amount of expenses to be included in the production cost.

Cost tariffs in agriculture constitute a basic element regarding the planning and self-control of production expenses in the agricultural sector. They serve as an information base for making managerial decisions regarding the formation of the optimal production structure for agricultural production, making investments in the production process, etc. In order for the effect of the development and practical use of the tariff system in the agro-food sector to be reflected in all areas of economic activity, it is necessary to expand the tariff base throughout the value chain: from the producer's farm to the consumer's table.

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EXPLORING THE DETERMINANTS OF ADOPTION BEHAVIOR IN COCOA PRODUCTION: A CASE STUDY OF INTEGRATED PEST MANAGEMENT IN CROSS RIVER STATE, NIGERIA

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Abstract

A comprehensive Integrated Pest Management (IPM) is an ecosystem approach to control insect and disease pests to minimize the use of pesticides. Cross River State was purposively selected based on training done by International Institute of Tropical Agriculture (IITA) through Sustainable Tree Crop Programme. The study explored the determinants of adoption behaviour. A systematic sampling technique was used to select a total of 108 IPM trained respondents. Structured questionnaire was used to gather information on farmers'socio-economic factors affecting IPM Adoption, determine the IPM adoption behaviour of farmers and ascertain the constraints experienced from IPM adoption. Male respondents were 81.5% while the females were 18.5%. Majority (65.1%), were between the age range of 41 and 60 years which is an indication that they were still in their prime age. Majority (94.4%), of the respondents were educated and majority (97.2%) of the farmers own small farms between 1 and 5 ha. Most of the respondents rated inaccessibility to market information as the highest constraint affecting IPM adoption with a Weighted Mean Score of 0.8. Majority (79.6%) had high level of intensity of IPM adoption while most of the respondents rated both pest monitoring and planting resistant varieties as the highest rate of adoption with a score of 2.9. A significant relationship exists between sex (X^2 =42.815, $p<0.05$), age (X^2 =65.148, $p<0.05$), education (X^2 = 40.426, $p<0.05$), years of experience (X^2 =110.333, $p<0.05$), and adoption behaviour. The contingency coefficient (CC) shows very strong relationship of sex 0.5328, age 0.6134, marital status 0.7758, education 0.5218 and years of experience 0.7108 with adoption behaviour. Farmers need to be encouraged in adopting IPM through marketing information that would reduce extortion of the farmers by local buying agents.

Key words: *exploring the determinants, adoption, cocoa, Integrated Pest Management training, marketing information*

INTRODUCTION

Cocoa was first located in Mexico and in other areas of centralAmerica thousands of years ago [38]. Cocoa was grown in many ancient south American cultures, the Aztecs and Mayans being the most well-known indigenes [42]. Cocoa trees were found growing wild in some areas of the Amazon and in current times, cocoa cultivation has spread and it can be located in West Africa, Asia, Central America and South America with each of them having different cocoa variety [38]. About 60% of the world's cocoa is grown in West Africa, it has been the largest cocoa producer since the end of World War 1 and in recent times is the international center of production [39].

The foremost cocoa farms in Nigeria were in Bonny and Calabar in the 1870s but the area was not suitable for cocoa cultivation [29]. The relevance of cocoa to Nigeria can be examined based on its contribution to the economy of the nation.

Nigeria used to be the second leading world producer of cocoa in the 70s but currently the world's fourth largest producer after Ivory Coast, Indonesia and Ghana. The drop in production has been due to diverse factors such as ageing cocoa farmers and cocoa trees which occupy a large proportion of established plantations, government neglect of agriculture due to huge investments in the oil sector and inadequate fund to acquire inputs [12, 32]. Also, the deterioration in cocoa production in Nigeria is mainly due to the incidences of insect pests and diseases along with other factors [6]. The major insect pests of cocoa are Brown mirids (*Sahlbergella singularis*) and Black mirid (*Distantiella* *theobroma*) which could cause an estimated loss of 100,000 tons. The main disease of cocoa is the ‘Black pod’ caused by *Phytophthora palmivora* and *Phytophthora megakarya* which results to 100% total loss [40].

According to the United States Department of Agriculture-Agricultural Research Service [35] Integrated Pests Management (IPM) is a sustainable, science-based, decision-making process that combines biological, cultural, physical, and chemical tools to identify, manage, and reduce risk from pests and pest management tools and strategies in a way that minimizes overall economic, health, and environmental risks.

The concept of integrated pest management (IPM), a sustainable strategy for managing pests, has been in practice for a long time. Although multiple sources define IPM in different ways, previous models primarily focused on the ecological, and to some extent on the evolutionary, aspects of pest management [28].

Integrated pest management is a complementary and necessary feature of sustainable agriculture, which aims to assure equitable, secure, sufficient and stable flows of both food and ecosystem services [34]. Agriculture will achieve sustainability only if the agro-ecosystem maintains stable productivity while resisting major disturbances including pest ravages [7].

A comprehensive IPM is an ecosystem approach to control insect pests that uses all available tools and combines different management strategies and practices to maintain the quality of stored products, enhance the sustainability (environmental, economic, and social) of stored product ecosystems, and minimize the use of pesticides in an effective, economical, and environmental way. There are usually six main elements in an IPM program [11] and any element of an IPM approach should use the knowledge of insect movement. Notwithstanding its low adoption rate in developing countries, IPM potentially offers the best route to economically efficient crop protection that increases and sustains farm productivity while minimizing threats to humans and the environment.

Even though insect controls are affected by macro-economics, business decisions, and policy factors, integrated pest management (IPM) has been gradually adapted to insect control decisions in most countries. The IPM is ecologically-based and the operational plan of an IPM has at least two key elements: monitoring-based decision making and applications of multiple pest control tactics [11]. If the foundation of an effective IPM program is to understand pest ecology, then understanding insect movement should be at the core of any IPM decision.

Several reports indicated that IPM implementation depends on numerous factors including the level of education, economic and social conditions, environmental awareness, rational thinking, moral values, regulatory aspects, government policies, availability of IPM tools, extension education, consumer preference, and retail marketing [27, 17, 15 and 30]. Several other definitions also focus on minimizing or eliminating the reliance on chemical control options, adopting a number of other options with the emphasis on environmental and human health. However, some practitioners interpret IPM as rotating chemicals from different mode of action groups to maintain pest control efficacy and reduce pesticide resistance with an emphasis on reducing pest damage. These definitions and interpretations represent a variety of objectives and strategies for managing pests including vertebrate and invertebrate pests, diseases, and weeds. IPM is not a principle that strictly and uniformly applies to every situation, but a philosophy that can guide the practitioner to use it as appropriate for their situation. IPM is an approach to manage pests in an economically viable, socially acceptable, and environmentally safe manner.

Justification of the study

The Cocoa Transformation Agenda was introduced by the Federal government of Nigeria to revitalize cocoa production in the country. There is great need for the success of this programme, though a major hindering factor that could affect this transformation programme is the incidence of pest and disease infestation of cocoa. This major problem could be reducedusing Integrated Pest Management. In view of the above, this study becomes appropriate in evaluating and examining Nigerian cocoa farmers' IPM adoption practices so as to provide a baseline information from which to assess advancement towards increasing IPM adoption.

Objectives of the research

The objectives of the study are to:

1. Identify socio-economic factors affecting the adoption of IPM by cocoa farmers in the study area,
2. Describe the enterprise characteristics of the farmer,
3. Determine the behavior of farmers towards IPM adoption,
4. Profile the constraints experienced from adoption of IPM.

MATERIALS AND METHODS

The Study Area

Cross River State is a coastal state in South-South geopolitical zone of Nigeria. Its capital is at Calabar, and it is named from the Cross River (Oyono), which passes through the State. Cross River is one of the 36 States of Nigeria and was formed from the eastern part of the Eastern Region on 27 May 1967. It borders to the north through Benue State, to the west through Ebonyi State and Abia State, and to the southwest through AkwaIbom State, while its eastern border forms part of the national border with Cameroon.

The present Cross River State is made up of parts of old Calabar and Ogoja Provinces divided into 18 administrative units called Local Government Areas. The Local Government Areas include Obanliku, Obudu, Bekwara, Ogoja and Yala in the North Senatorial District, Boki, Ikom, Etung, Obubra, Abi and Yakurr in the Central District and Biase, Akankpa, Odukpani, Calabar Municipality, Calabar South, Akpabuyo and Bakasi in the Southern Senatorial District. Ejagham and Efik are major languages of the State.

The State is situated within the tropics with total land area of 20,156 km^2. It lies between latitudes 5°32' and 4°27' North and longitudes 7°50' and 9°28' East. The Obudu and Obanliku Plateau with an altitude of 1,575.76 meters above sea level enjoys a climate typical of the temperate regions of the world.

Cross River State is an agricultural state and its economy relies partially on crops, such as cocoyam, rubber, oil palm, yam, cocoa, cashews and plantain, as well as fishing. Agriculture employs about 80% of the state's labor force, and contributes about 40% to the Gross Domestic Product (GDP). The state has modern agricultural estates and several smallholder farms in the local government areas. The climate allows the growing of a wide variety of crops. Export crops are the focus of agricultural production and research of the state with livestock, fishing and forestry as pillars of the economy.

Smallholder farmers account for a greater proportion of farm holdings in Cross River State. These farmers are the backbone of the agricultural sector in the state. Boki, Ikom and Etung are the three Local Government Areas known for the largest production of cocoa in the State.

Data collection and analysis

Sampling population and sample size

A purposive selection of Cross River State from the South-South zone,was based on the training centers of the STCP/IITA. A systematic random sampling technique was used in selecting a total of 108 IPM trained respondents from the list of STCP/IITA Farmers Field School (FFS) in the state.

Structured questions administered through questionnaire were used in collecting both quantitative and qualitative data from the selected cocoa farmers. Questions asked were categorized as: identify selected personal characteristics, identify enterprise characteristics, determine the behavior of farmers towards IPM adoption compared to their conventional practices, determine the constraints experienced from IPM adoption. The adoption of various practices was explained by the potential variables used and this included information in four broad categories: economic, social, management and institutional factors. Some specific variables included farmer's age, education, farm size, farming experience, and farm yields.Descriptive statistics was used for data presentation while Chi-square was used to test hypothesis 1.

Hypotheses

HO_1: There is no significant relationship between the socio-economic characteristics and adoption behavior of the trained cocoa farmers.

RESULTS AND DISCUSSIONS

The socio-economic characteristics of the respondents

Sex of Respondents

The male respondents were 81.5% while the females were 18.5%. This is an indication that more males were involved in IPM adoption in cocoa farming than the females. In Nigeria, most agricultural culture limit women in acquiring land for tree crops cultivation which however affects gender issues in agricultural production and technology adoption. This finding is in line with [1], who opined that rural women farmers are constrained by adoption of modern technologies. Such factor could limit rural women's ability to improve agricultural production and the well-being of their families (Table 1).

Age of respondents

The result reveals that few (25.9%) of the respondents' ages were between age 21-40 years while 9.0% fall between age 61-80 and majority (65.1%) were between the age range of 41 and 60 years. This indicates that most of them are still in their prime age and would be ready to learn and apply the skill of IPM techniques in their farms. Few youths are involved in cocoa farming which could affect IPM techniques adoption negatively as some of the techniques are labor intensive. This study supports the findings of [36] who stated that most of the farmers trained on IPM were still in their prime age and would be ready to adopt IPM (Table 1). Also, [37] described the challenges of the adoption of IPM technology in cocoa production in Nigeria.

Marital Status of Respondents

The result reveals that most (77.7%) of the respondents were married while 13.9% were single. This implies that large family size will create labor for IPM adoption. The high proportion of married respondents shows that more members of the farm family are likely going to be available for IPM adoption in the study area. This also corroborates the age distribution result that few youths are involved in cocoa production. According to [24] most married cocoa farmers relied on family labor, reducing the requirement for hire labor to carry out some IPM activities and thereby reducing their financial obligations. According to [26] the implication of this similar study is that farmers in the study area were matured and could effectively take crucial decisions jointly with their spouses. Marital status is a crucial factor in shaping social rural participation and acceptance of innovation. Farmers need a large family to reduce the cost of adopting IPM labor and maintain good farming practices in their farm especially for tree crop like cocoa (Table 1).

Table 1. Distribution of respondents by socio-economic characteristic (n = 108)

Variables	Frequency	Percentage
Sex		
Male	88	81.5
Female	20	18.5
Age		
21-40	28	25.9
41-60	60	65.1
61-80	10	9.0
Marital status		
Single	15	13.9
Married	84	77.7
Divorced	3	2.8
Widowed	6	5.6
Years of Farming experience		
1-10	22	20.4
11-20	48	44.4
21-30	30	27.8
31-40	8	7.4

Source: Field survey, 2021.

Farming experience of the respondents

The result in Table 1 revealed that many (44.4%) of the respondents had between 11 and 20 years of experience in cocoa farming while only 7.4% had between 31 and 40 years. Farmers with longer farming experience are

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expected to have higher inclination in adopting IPM technology.

[20] in his study ascertained that an increased farm productivity,farmers' education count less than farming experience while [21] opined that the tendency to adopt new innovations such as IPM depends on age of farmers, long time of farming business and access to capital (Table 1).

Educational qualification of respondents

The result shows that majority (94.4%) of the respondents were educated with primary (27.8%), adult education (4.6%), secondary (30.5%) and Tertiary (31.5%) while 5.6% had no formal education (Figure 1).

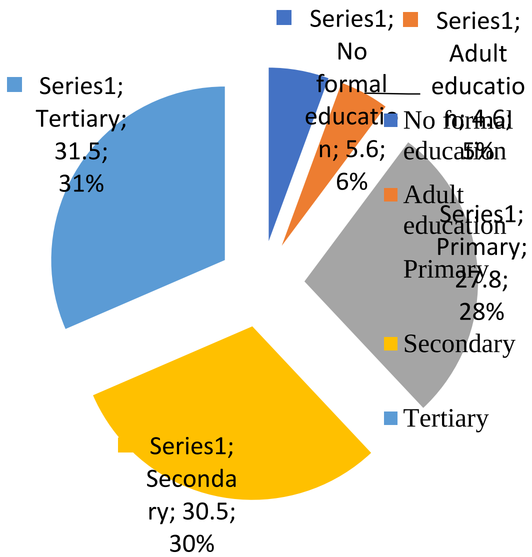

Fig. 1. Educational qualification of respondents
Source: Field survey, 2021.

The outcome of this study revealed that majority of the respondents were literate which has positive influence on adoption of IPM innovation and supports the findings of [25] who posited that highliteracy level will predispose farmers to adopt and use improved farm practices. Also, [19] opined that education empowers individual to be receptive of the modern technologies in terms of decision making, problem solving and adaptation to change. The formal education of farmers is very vital in technology adoption as it helps in quick assimilation of the innovation such as IPM technologies.

Farm size

Figure 2 shows that majority (97.2%) of the respondents had farm size between 1 and 5 ha, while only 2.8% had 6-10 ha. This implies that majority of the farmers own small farms, which could facilitate high adoption of IPM technologies based on less cost in adoption covering small areas. The farm size distribution of the cocoa farmers showed that most cocoa farmers were smallholders growing cocoa on less than 10 hectares of farmland. This could be ascribed to land tenure system in Nigeria which favors land disintegration through inheritance. Cocoa farm size is expected to have a positive effect on adoption since as the farmer devotes more of his total available land to IPM in cocoa cultivation, there is the likelihood that cocoa output and income would increase, enhancing the probability of technology adoption [22] posited that 75.5% of the cocoa farmers in Nigeria were either small or medium scale farmers which is in line with the findings of this study. [31] had a contrary view and resolved that size of farm is not a determinant of Integrated Pest Management (IPM) adoption regardless of farmers' scale of operation.

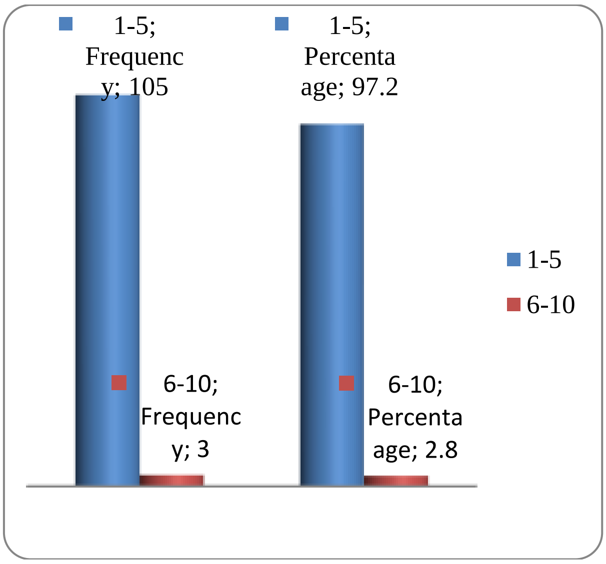

Fig. 2. Distribution of respondents based on farm size
Source: Field survey, 2021.

Cocoa yield in respondents' farms

The yield of cocoa beans is measured in terms of kilogrammes harvested in the last cropping season as presented in Table 2. The result shows that many (57.4%) of the respondents produced between 1-1,000kg while 32.4% produced 1,001-2,000kg, 7.4% produced

2,001-3,000kg, 1.9% produced 3,001-4,000kg while very few (0.9%) produced more than 4,000kg. The level of cocoa production in this study could be due to their small size of farm and moderate adoption of the IPM technology by the respondents.

Table 2 Distribution of respondents based on yield (kg/ha)

Yield	Frequency	Percentage
<1,000	62	57.4
1,001-2,000	35	32.4
2,001-3,000	8	7.4
3,001-4,000	2	1.9
>4,000	1	0.9
Total	108	100.0

Source: Field survey (2021).

The result corroborates the findings of [10] who posited in his study that most cocoa farmers don't produce at maximum level which could be as a result of farm age, insect pests and disease incidences and not adhering to recommended practices but controverts [8] whose report proved that yield of majority farmers was high with plots treated with IPM technology when compared with controls.

Adoption of IPM technology favors high yield and would have a multiplier effect on high revenue obtained by farmers.

Constraints of the respondents

Weighted mean score was used in ranking the constraints experienced in adoption of IPM technology as rated by the respondents. Most of the respondents rated inaccessibility to market information as the highest constraint affecting IPM adoption with a score of 0.8 followed by other off farm activities and inadequate labor which scored 0.7. Age of farm scored 0.6, inadequate credit facilities scored 0.5, Household size 0.4 while Contact with Extension agents and Membership of cooperative association scored the least with 0.3.

Inadequate marketing facilities and structure is a barrier to accessing marketing information. This problem can be solved by developing infrastructure of the existing market in the state and also by encouraging farmers in forming marketing co-operatives which will increase their capacity to negotiate with buyers. Farmers could also be trained on how to access market price information both locally and internationally.

Inadequate labor and other off farm activities were rated second in ranking with a score of 0.7 it is also a very severe constraints which could be as a result of rural urban drift of the youth in search for white collar jobs and riding motor bike and tricycle to earn daily income. Encouraging farm mechanization may be an option to overcome the problem of inadequate labor.

The third highest severe factor affecting IPM adoption is inadequate credit facilities with a score of 0.5. This could be as a result of inability of the farmers to obtain loan from financial institutions due to their inability to provide collateral (Table 3).

Table 3. Distribution of respondents based on constraints to IPM adoption

Constraints	Very severe		Severe		Not severe		Weighted Mean score
	Freq	%	Freq	%	Freq	%	
Age of farm	21	19.4	25	23.2	62	57.4	0.6
Other off farm activities	14	13.0	47	43.5	47	43.5	0.7
Access to Market Info	34	31.5	16	14.8	58	53.7	0.8
Inadequate labor	12	11.1	51	47.2	45	41.7	0.7
Household size	8	7.4	25	23.2	75	69.4	0.4
Inadequate credit facilities	23	21.3	12	11.1	73	67.6	0.5
Contact with Extension Agents	6	5.5	15	13.9	87	80.6	0.3
Membership of farmers/cooperative association	13	12.1	9	8.3	86	79.6	0.3

Source: Field survey, 2021.

Lack of capital due to seasonal liquidity and poor access to credit facilities makes technology utilization amongst poor farmers challenging thereby threatening sustainability of IPM adoption.

[9] opined that farmers' inaccessibility to credit contributes to lack of fund due to government inability to provide soft loan to farmers.

Household size which is the fifth constraint with a score of 0.4 could be due to large family size and inability to cope with little revenue to feed many mouths and maintain the family upkeep. The provision of adequate financial support to cocoa farmers will increase credit facilities that will assist the farmers in coping with their household expenditure. This could also encourage the farmers toaccess more communal land for cocoa production.

[41] also reported that Ghana reduced rural poverty by 24% between 1990 and 2005, principally as a result of empowering small-scale farmers through adoption of improved technologies. This could be encouraged in Nigeria through the use of Farmers Field School (FFS) in training cocoa farmers on IPM throughout the cocoa producing States in order to empower the small-scale farmers and reduce poverty.

Adoption behavior

Intensity of adoption

Intensity of adoption is a measure of the percentage of total land on which the cocoa farmers implemented IPM practices in their cocoa farms as compared with the total area of land they used for cocoa growing. It refers to the level of use of a given technology in any time period.

Table 4 revealed that majority (79.6%) had high level of intensity of adoption, 17.6% had medium while 2.8% had low level. This implies that the respondents implemented IPM in high proportion of their total cocoa farm land.

[13] defined intensity of adoption as the level of adoption of a given technology (for instance the number of hectares planted with improved seed or the amount of fertilizer applied per hectare). Intensity of adoption has been measured in several ways in literature. [18] defined intensity as the number of technologies adopted.

Other researchers such as [5] defined intensity of adoption as the proportion of area under the improved varieties.

Table 4. Distribution of respondents based on intensity of adoption

Intensity Categories (Ha)	Frequency	Percentage
1-2	86	79.6
3-4	19	17.6
5-6	3	2.8
Total	108	100.0

Source: Field survey, 2021.

Rate of adoption

Rate of adoption refers to the relative speed with which farmers adopt an innovation. It is usually measured by the length of time required for a certain percentage of members of a system to adopt an innovation.

The rate of adoption was ranked using Weighted Mean Score as rated by the respondents. Most of the respondents rated both pest monitoring and planting resistant varieties as the highest rate of adoption with a score of 2.9. Weeding 2-3 times a year and appropriate use of recommended pesticide scored 2.8, followed by pruning of basal chupons and routine sanitation of farm (such as removal of mistletoe, climbers, lichen, moss) which both scored 2.7.

Also, water management androutine destruction of infected cherelles scored 2.6 each while fertilizerand soil management scored 1.9 and biological control scored 0.7. Pest monitoring and planting resistant varieties are the highest adopted IPM technology which may be due to the training received from Cocoa Research Institute of Nigeria (CRIN) on improved cocoa varieties, accessibility to the varieties and pest management.

According to [3] Integrated pest management (IPM) is a potentially effective method that makes use of many non-chemical means to control pests, but its adoption is low. Biological control scored the lowest due to its complexity in IPM technology. Despite the expected benefits of many agricultural technologies, farmers often adopt them at a slower pace than might be expected in developing countries [33].

Table 5. Respondents' rate of IPM adoption n=108

	Year 1		Year 2		Year 3		Year 4		Year 5		WMS
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	
Pruning of basal chupons	15	13.9	9	8.3	31	28.7	33	30.6	20	18.5	2.7
Fertilizer and soil management	13	12.0	22	20.4	23	21.3	19	17.6	31	28.7	1.9
Water management	26	24.1	9	8.3	35	32.4	24	22.2	14	13.0	2.6
Weeding 2-3 times a year	17	15.7	17	15.7	24	22.2	27	25.1	23	21.3	2.8
Routine destruction of infected cherelles	17	15.7	12	11.1	27	25.0	25	23.2	27	25.0	2.6
Routine sanitation of farm such as removal of mistletoe, climbers, lichen, moss	12	11.0	14	13.0	26	24.0	28	26.0	28	26.0	2.7
Biological control	20	18.5	19	17.6	20	18.5	21	19.5	28	25.9	0.7
Pest monitoring	19	17.59	12	11.1	30	27.8	35	32.4	12	11.1	2.9
Planting resistant varieties	13	12.0	18	16.7	33	30.6	28	25.9	16	14.8	2.9
Appropriate use of recommended pesticide	7	6.5	16	14.8	25	23.1	34	31.5	26	24.1	2.8

Source: Field Survey, 2021
WMS: Weighted Mean Score
Grand Mean Score: 2.5

Scale of adoption

Findings presented in Table 6 concern the scale of adoption which had some implications for the future direction of IPM practices. The study measured the number of technological components that were tried after the respondents were trained. The result revealed the Weighted Mean Score of all the IPM techniques that were tried by the respondents as follows: pruning of basal chupons 1.9, weeding 2-3 times a year 1.9, routine destruction of infected cherelles 1.8.

Table 6. Distribution of respondents based on scale n=108

IPM Technologies	Full trial		Some trial		Never tried		WMS
	Freq	%	Freq	%	Freq	%	
Pruning of basal chupons	-	-	98	90.7	10	9.3	1.9
Fertilizer and soil management	15	13.9	32	29.6	61	56.5	1.2
Water management	1	0.9	71	65.7	36	33.3	1.6
Weeding 2-3 times a year	-	-	101	93.5	7	6.5	1.9
Routine destruction of infected cherelles	-	-	86	79.6	22	20.4	1.8
Routine sanitation of farm such as removal of mistletoe, climbers, lichen, moss	-	-	101	93.5	7	6.5	1.9
Biological control	23	21.3	21	19.4	64	59.3	0.8
Pest monitoring	-	-	84	77.8	24	22.2	1.8
Planting resistant varieties	-	-	88	81.5	20	18.5	1.8
Appropriate use of recommended pesticide	-	-	93	86.1	15	13.9	1.9

Source: Field survey, 2021.
WMS-Weighted Mean Score
Grand Mean=1.6

Routine sanitation of farm such as removal of mistletoe, climbers, lichen, moss 1.9, pest monitoring 1.8, planting resistant varieties 1.8 and appropriate use of approved and recommended pesticides 1.9 which are higher than the grand mean of 1.6 and are regarded as high trials while water management had 1.6, fertilizer and soil management had 1.2and Biological control had 0.8 which are equal or below the grand mean score of 1.6 and are regarded as low trials. The result indicates that the respondents had higher trials of the IPM technologies.

This finding is similar to the findings of [16] who reported that durian growers had high level of IPM trial. According to [2] certain research technologies, which are deemed to improve farm production, may be beyond the understanding of rural farmers, even with the interpretation of extension agents especially when it is more costly than their local techniques.

Association of socio-economic relationship and IPM adoption

Table 7 reveals that significant relationship exists between sex (X^2 =42.815, $p<0.05$), age (X^2 =65.148, $p<0.05$), marital status (X^2 =163.333, $p<0.05$), education (X^2 =40.426, $p<0.05$), years of experience (X^2 =110.333, $p<0.05$), and adoption behavior. The null hypothesis is rejected as all variables show significant relationship. The contingency coefficient (CC) shows strong relationship of the variables with adoption behavior; sex 0.5328, Age 0.6134, marital status 0.7758, education 0.5218 and years of experience 0.7108.

Table 7. Association of socio-economic relationship and IPM adoption

Variables	Df	X^2	P	CC	Decision
Sex Age	1 33	42.815 65.148	0.000 0.001	0.5328 0.6134	S
Marital status	3	163.333	0.000	0.7758	S
Education	4	40.426	0.000	0.5218	S
Years of experience	29	110.333	0.000	0.7108	S

Source: Field survey, 2021.

This finding is supported by the study of [14] who posited that Education expands individual scope of inference and paradigm, whereas training re-enforces individual's experience and up-grade the skills for effective implementation of any novel technology. Education enhances individual farmer's ability to access and process agricultural information, and the application of information in improving on-farm activities. Educational status is assumed to influence cocoa production technologies positively because with higher level of education the farmers would be in a position to technically and economically assess the new crop or technology to clear doubts and uncertainties associated with it and enhance its adoption. The significant relationship of sex implies that men and women have roles to play in the adoption of IPM in cocoa farms. However, cocoa farming is labor intensive which is confirmed by [23] findings that men are more decisive, aggressive, logically ambitious and have strength to withstand the rigors of farming.

According to [4] since cocoa farming is dominated by male farmers, it is expected that more male cocoa farmers would adopt technologies than their female counterparts, other things being equal. This is because women have less access to credit and land as collateral when compared with men,as well as relying mostly on hired labor which is scarce due to migration of the rural youth to the urban areas to seek for jobs with relatively better remuneration.

Adoption of IPM by cocoa farmers have economically impacted farmers in a number of ways including increase in cocoa yield which invariably translates to increased income and profit. Also, increased yield encourages the creation of more efficient market and export opportunities. In addition, there is a substantial reduction in the quantity of pesticides applied to cocoa farms which leads to reduced input cost and lowering of hazards that are associated with food poisoning through gradual intake of chemically produced cocoa beans. Other economic benefits of IPM adoption are reduction of insects and disease pests attack and improved cocoa beans quality.

CONCLUSIONS

The findings of this study inferred that majority of the respondents were literate which has positive influence on adoption of IPM innovation which is very vital in technology adoption as it helps in quick assimilation of the innovation. Majority of the farmers own farm size less than 10 hectares which showed that the cocoa farmers were smallholders who could be ascribed to land tenure system in Nigeria which favors land disintegration through inheritance. This is also reflected in their cocoa yield. Marketing information is a problem which can be solved by developing structure of the existing market in the state and also by encouraging farmers in forming marketing co-operatives which will increase their capacity to negotiate with buyers.

Farmers could also be trained on how to access market price information both locally and internationally.

The result on adoption behavior of intensity, rate and scale revealed that most of the respondents were early adopters and had a higher scale of adoption.

More youth should be encouraged by the government to take up cocoa farming to enhance sustainability of IPM adoption.

The farmers are constrained financially, so they need to be supported with soft loan to enhance increase in their hectare of cocoa farms.

Yield improvement programme such as rehabilitation programme in agronomic practices should be initiated in order to increase cocoa yield of farmers.

Women should be encouraged to grow cocoa and they should be given access to farm land for tree crops.

Way forward

There is need to bring up policies that will enhance sustainability of continuous use of IPM to boost production among farmers in the study area. The time of paradigm shift from the farmers' primitive ways of controlling insect pest and diseases to a more effective and efficient methods of control is now.

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THE DYNAMICS OF THE AGRICULTURAL SECTOR IN ROMANIA BY NUTS 2 REGIONS

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Abstract

This paper analyses the evolution of the agricultural sector in Romania at the level of NUTS 2 Regions (Development Regions) in the period 2010-2020. The study of the farms' number evolution, the agricultural area used and the simple and derived indicators of agricultural performance are basic elements in characterizing this area of interest, identifying the most appropriate sectoral strategies and formulating the directions of action both by the agricultural policymakers and the farmers. The data required for the calculations were subtracted from the Eurostat platform and processed using graphical and tabular elements. The results identified the importance of the agricultural sector in Romania for the regions analyzed in relation to the European Union average, highlighting the dynamics of the number of farms, agricultural land use, labour productivity, economic size and production value. The analysis focuses on the regional level but makes connections and comparisons with the national and EU levels, the conclusions indicating the differences and explaining the trends.

Key words**:** *agricultural sector, farm, agriculture dynamics, NUTS 2 Regions, agriculture performance*

INTRODUCTION

Due to the large number of farms caused by the excessive fragmentation of agricultural land and the presence of traditional agriculture in subsistence and semi-subsistence farms, Romania is often seen as a country whose agricultural sector is inefficient. According to the data, the agriculture sector has experienced a noticeable and positive growth rate. The results and economic indicators reveal an improved level of performance in various areas, compared to the EU average. A substantial reduction in the number of farms means an increase in the share of large farms [4] and following the review and analysis of the literature, it was found that an increased interest in the cooperation in agriculture is developing in the last decades [21].

Considering the fact that the performance of agriculture is given by several determinants and particular factors that establish relationships of conditioning, complementarity or competitiveness [7] the data indicate the need to continue and intensify efforts to modernize and improve efficiency in the agricultural sector in many regions of the EU [24], in particular by using dedicated financing instruments [5]. The results were reflected by the absolute and relative indicators that describe the growth in the scale of farming and agricultural output across the farming types [23], the basic unit for agriculture development being the farm.

The farm, which consists of agricultural land, buildings, storage facilities, agricultural machinery and equipment, other outbuildings, livestock and poultry and associated utilities that support agricultural activities, is the fundamental economic unit for agricultural production [6].

Agriculture has become the major land use activity in the world and in Romania as well, farming becoming more intensive in order to raise productivity [22] even if this is not necessarily a sustainable solution for economic development [1].

Agricultural systems supply the national economy with several vital products and agricultural production differs in many

respects from other sectors of the economy in terms of the complexity of farming systems and methods, as well as the multiple correlations between the factors involved in the technological processes [3], agriculture representing the primary source of supply for the food processing industry [9] and, as one of the most important branch of the national economy, agriculture, is called upon to provide quantitatively and qualitatively raw materials for the food industry [26] even if it's contribution to GDP as at present in Romania, is still smaller compared to industry and services [19].
There are many farms in Romania and the European Union, with diverse agricultural activities that form a complex reality [2]. However, the current stage of development of Romanian agriculture shows a low level of agricultural production that is mostly dependent on the evolution of natural conditions [20]. Regional development in Romania has become one of the most important policy, because its actions affect an entire range of fields, including economic, social and environmental [25]. Regarding agriculture in general some regions in Europe are already highly dynamic, others are locked-in, and still others are struggling to stay viable and as a consequence major transformations are needed to address sustainability issues and policymakers should regionally differentiate their strategies [8].
In order to discover the best solutions based on the unique characteristics of each region's agricultural sector and to generate a more detailed picture from the general to the particular, a regional approach to agriculture is required.

MATERIALS AND METHODS

Statistical data sources associated with EUROSTAT were used to illustrate the selected theme. Particular intermediate data series from 2010 to 2020 were used, with 2020 being the final year for which data were available for all the indicators examined.
In order to analyze and comprehend statistical indicators, it was necessary to determine the fundamental series and compute the relative difference between the final year and the first year of the series under consideration, as demonstrated by the results that were displayed in graphical and tabular form. An extensive characterization of the dynamics of the agricultural sector was made possible by calculating the derived indicators using the identified basic indicators, and a comparative analysis which revealed evolutionary gaps at the level of development region in Romania.

RESULTS AND DISCUSSIONS

The agricultural sector's dynamic value and percentage growth, as indicated by the Gross Domestic Product (GDP) for Romania (Table 1) highlights the sector's continued high importance when compared to the European Union average values.

Table 1. GDP (at current market prices) and share of Agriculture in GDP evolution for EU and Romania

Region	2010	2013	2016	2020
GDP (million euro)				
EU - 27 (from 2020)	10,980,485	11,516,211	12,548,706	13,461,156
	100.0	104.9	114.3	122.6
Romania	128,278.9	142,928.9	167,494.3	220,486.7
	100.0	111.4	130.6	171.9
Percentage of GDP represented by Agriculture, forestry and fishing (%)				
EU - 27 (from 2020)	1.6	1.7	1.6	1.6
	100.00	106.25	100.00	100.00
Romania	5.2	5.5	4.3	4.2
	100.00	105.77	82.69	80.77

Source: Own calculation using Eurostat Database [18].

Romania's GDP increased in 2020 related to 2010 with 49.3% more than the EU average, with GDP per capita increasing by more than 60% (Table 2). During the period under review, the share of agriculture in GDP fell by 19.23%, being in 2020 2.6 times higher than that of the EU even though in 2020 the level of GDP per capita was 2.6 times lower than the EU average.

Table 2. The GDP evolution (Euro/inhabitant) for NUTS 2 Regions

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	24,900	26,000	28,200	30,000	20.48
Romania	6,300	7,200	8,500	11,400	80.95
North-West	5,400	6,200	7,600	10,700	98.15
Center	5,800	6,700	8,100	10,900	87.93
North-East	3,700	4,500	5,200	7,500	102.70
South-East	4,800	6,400	7,100	9,000	87.50
South-Muntenia	4,900	5,700	6,800	8,600	75.51
Bucharest-Ilfov	14,300	16,800	19,900	26,200	83.22
South-West Oltenia	4,500	5,300	6,100	8,800	95.56
West	6,800	7,400	9,000	11,500	69.12

Source: Own calculation using Eurostat Database [17].

Since 2010 there have been significant increases for this economic indicator for all 8 NUTS 2 regions in Romania, the highest being 102.7% (North-East). The structural changes in Romanian agriculture impact the economy [10] through the purchase of land by foreigners [6], farms number or efficiency. At the European, national and regional levels, a decrease in the number of farms can be identified (Table 3), which is, in fact, a positive element in the economic development and especially of agriculture, indicating a lower degree of fragmentation for the utilized agricultural areas and, obviously, a higher number of agricultural associations and cooperatives.

Table 3. NUTS 2 farms number (2010-2020)-thousands

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	12,055.3	10,650.7	10,270.6	90,67.3	-24.79
Romania	3,859.0	3,629.7	3,419.2	2,887.1	-25.19
North-West	528.5	499.9	478.1	443.1	-16.16
Center	394.7	358.5	330.6	318.5	-19.30
North-East	790.8	754.5	719.8	593.0	-25.01
South-East	460.3	433.0	409.9	324.1	-29.60
South-Muntenia	800.8	753.6	694.1	522.0	-34.82
Bucharest-Ilfov	33.5	25.3	21.0	17.2	-48.55
South-West Oltenia	576.6	557.9	539.2	466.5	-19.09
West	273.9	247.0	226.6	202.8	-25.97

Source: Own calculation using Eurostat Database [14].

The North-East Region accounts for 20.54% of all farming units, with South-Muntenia having the second-highest percentage at 18.08%. However, it should be noted that the structure of farms by development region does not serve as a major indicator of differentiation because each region has unique physical and geographical characteristics that directly influence the number of farms.

A country's agricultural sector has developed to a greater extent when the number of associative forms with high levels of technology and increased productivity increases, which is shown by a decline in the number of farms.

Fig. 1.Evolution indices related to NUTS 2 average (%)
Source: Own design based on the data from Eurostat [14].

Given that the Bucharest-Ilfov region is a smaller area with a substantially increasing urbanization index, it records the highest deviation (21.24%) compared to the national average percentage decrease in the number of farms, while the North-West region records the lowest value (Fig. 1).

Given the limitations of area, landform, and climatic conditions that can determine the practice of agricultural activity in a certain area, Utilized Agricultural Area (UAA) is an indicator that cannot show significant variations, nor can there be significant changes from one year to the next considering the current availability (Table 4).

Table 4. UAA evolution (2010-2020) - thousands ha

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	159,089.9	157,008	150,171	155,093	-2.51
Romania	13,306.1	13,055.9	11,016.5	12,762.8	-4.08
North-West	1,808.4	1,783.2	1,549.1	1,788.9	-1.08
Center	1,627.3	1,694.0	1,267.7	1,606.1	-1.30
North-East	1,940.2	1,937.1	1,698.0	1,834.0	-5.47
South-East	2,194.4	2,092.5	1,853.6	2,173.3	-0.96
South-Muntenia	2,333.7	2,251.0	1,932.4	2,283.3	-2.16
Bucharest-Ilfov	62.5	75.6	63.0	78.8	+26.10
South-West Oltenia	1,608.4	1,574.2	1,379.5	1,484.2	-7.72
West	1,731.4	1,648.4	1,273.2	1,514.3	-12.54

Source: Own calculation using Eurostat Database [11].

The data show a slight decrease in UAA for most of the development regions except Bucharest-Ilfov, while at the national level there is a decrease of 4.08%, 1.6 times the EU average. An indicator showing the efficiency of agricultural land use and the degree of land aggregation in relation to existing farms is the UAA per farm, whose national level increase is close to the EU average (Table 5).

Table 5. UAA/farm evolution (2010-2020) - ha

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	13.20	14.74	14.62	17.10	+29.61
Romania	3.45	3.60	3.22	4.42	+28.21
North-West	3.42	3.57	3.24	4.04	+17.99
Center	4.12	4.73	3.83	5.04	+22.30
North-East	2.45	2.57	2.36	3.09	+26.06
South-East	4.77	4.83	4.52	6.71	+40.69
South-Muntenia	2.91	2.99	2.78	4.37	+50.11
Bucharest-Ilfov	1.86	2.98	3.00	4.57	+145.10
South-West Oltenia	2.79	2.82	2.56	3.18	+14.05
West	6.32	6.67	5.62	7.47	+18.14

Source: Own calculation using Eurostat Database [11, 14].

Fig. 2. UAA/farm distribution per NUTS 2 Regions in Romania
Source: Own design based on the data from Eurostat [11, 14].

Romania, the country with the largest number of farms in the EU, has managed to increase this indicator slightly from 3.45 ha/farm in 2010 to 4.42 ha/farm in 2020, even though it continues to possess the lowest value of the indicator.

From a regional point of view (Fig. 2), the highest values are recorded in 2020 in the West (7.47 ha/farm) and South-East (6.71 ha/farm) and the lowest value is for the North-East Region (3.09), which is less than half the value recorded in the West.

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Out of a total of 2.887 million farms, Romania has only 16,010 over 100 hectares (5.5%) (Table 6) while in the EU this percentage is 3.6%.

Table 6. NUTS 2 Regions farms number per UAA category (2020) -ha

Region	Zero ha	Over 0 ha to less than 2 ha	From 2 to 4.9 ha	From 5 to 9.9 ha	From 10 to 19.9 ha	From 20 to 29.9 ha	From 30 to 49.9 ha	From 50 to 99.9 ha	100 ha or over
EU - 27 (from 2020)	126,500	3,733,420	1,925,520	1,121,510	789,040	341,690	353,530	349,630	326,470
Romania	45,570	2,042,630	519,440	161,020	56,200	18,160	16,890	11,150	16,010
North-West	1,800	264,950	115,760	39,770	11,590	2,950	2,680	1,840	1,730
Center	4,380	191,260	70,510	30,490	11,530	3,400	3,200	1,910	1,800
North-East	5,370	458,920	90,250	20,990	8,140	3,100	2,820	1,390	2,020
South-East	6,720	240,640	44,370	14,600	6,700	2,750	2,640	2,060	3,590
South-Muntenia	16,220	422,340	56,420	12,810	5,370	2,110	1,960	1,470	3,260
Bucharest-Ilfov	350	15,100	1,120	230	140	50	60	50	140
South-West Oltenia	8,630	334,910	93,130	19,540	4,920	1,480	1,370	870	1,660
West	2,110	114,510	47,880	22,590	7,810	2,340	2,160	1,560	1,810

Source: Eurostat Database [16].

For all levels of analysis, the 0-2 ha category had the highest weight in total (Fig. 3).

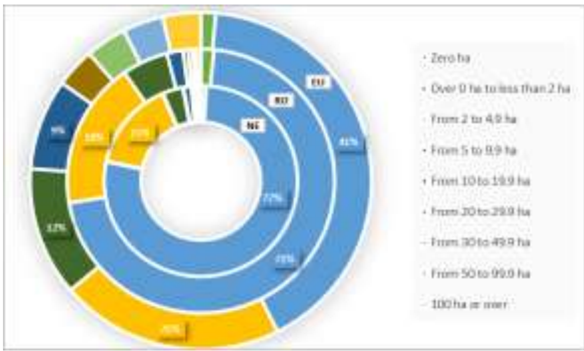

Fig.3. Farms number structure by UAA/farm (2020)
Source: Own design based on the data from Eurostat [16].

The segmentation group 0-4.9 ha has the biggest proportion at both the regional and national levels, accounting for 92% in the North-East Development Region, 88% in Romania, and 62% in the EU.

The group 5-19.9 ha, which accounts for 21% of the EU, makes up the difference; in Romania it represents just 8%, and in the North-East Region it represents 5%.

One crucial factor in the classification of farms is the economic size of the holding, which can be stated in either standard

Table 7. NUTS 2 Regions farms number by economic size (2020) – euro (S.O.)

Region	0	0-2,000	2,000-3,999	4,000-7,999	8,000-14,999	15,000-24,999	25,000 -49,999	50.000-99.999	100,000-249,999	250,000-499,999	over 500,000
EU - 27 (from 2020)	75,640	3,345,990	1,353,950	1,172,660	842,290	547,230	591,690	445,010	398,640	175,290	118,910
Romania	28,280	2,064,190	395,920	215,790	90,140	38,640	29,270	12,910	7,520	2,580	1,850
North-West	7,500	288,340	69,090	44,610	18,330	7,240	4,930	1,890	780	210	150
Center	3,790	217,910	41,920	26,760	12,810	6,320	5,390	2,240	970	240	130
North-East	2,520	447,850	78,380	36,460	13,720	6,220	4,530	1,800	1,030	300	210
South-East	1,670	233,590	39,430	22,720	10,890	5,550	4,860	2,460	1,780	680	430
South-Muntenia	4,870	408,040	55,600	28,020	12,290	4,950	3,690	1,930	1,450	620	500
Bucharest-Ilfov	260	14,250	1,280	740	300	110	110	60	60	40	20
South-West Oltenia	3,220	327,050	80,250	35,830	11,680	3,890	2,410	1,120	660	220	170
West	4,450	127,160	29,970	20,650	10,120	4,360	3,350	1,410	790	270	240

Source: Eurostat Database [15].

According to the economic size study, which shows the standard value of agricultural production, Romania and the EU differ significantly in 2020. While the percentage of farms above 500,000 SO is 1.31% at EU level, in the same category Romania has only 0.06% of the total number of farms. Also at the national level, the 0-3,999 SO group makes up 85.21% of the total, whereas the share in the EU is just 51.83% (Fig. 4).

Fig. 4. Farms number structure by economic size (2020)
Source: Own design based on the data from Eurostat [15].

Fig. 5. Structure of farms by NUTS 2 Regions for the 0-2,000 S.O. category (%)
Source: Own design based on the data from Eurostat [15].

Without a doubt, Romania's vast array of small farms exerts a substantial effect on the farms structure within the EU. At the regional level, 21.7% of the largest group (0-2,000 S.O.) is found in the North-East Region (Fig. 5). West Development Region holds the lowest proportion in this category, at 6.16%, a percentage that's 3.5 times lower than North-East Region, with the exception of Bucharest-Ilfov Region, that stands out due to particular features.

In terms of economic size per farm, the dynamics of values show similar increases on the three levels (regional, national and European). From a value point of view, however, the differences are significant, Romania having an average economic size 9.47 times lower than the EU average, with the South-West Oltenia Region recording the lowest level, standing at 74.43% of the national average (Table 7).

Table 8. Economic size/farm (2010-2020) - euro (S.O)

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	23,855.9	29,039.1	33,018.9	39,677.4	+66.32
Romania	2,558.8	3,303.2	3,423.8	4,188.8	+63.70
North-West	2,399.6	3,168.9	3,295.4	3,745.7	+56.09
Center	2,836.1	3,831.1	3,932.9	4,530.7	+59.75
North-East	2,084.4	2,730.2	2,783.8	3,167.0	+51.93
South-East	3,642.5	4,569.2	4,799.2	6,271.4	+72.17
South-Muntenia	2,311.1	2,924.6	3,076.0	4,121.1	+78.32
Bucharest-Ilfov	2,881.6	3,619.8	3,751.5	4,013.8	+39.29
South-West Oltenia	2,092.0	2,602.4	2,662.2	3,118.0	+49.05
West	3,681.8	5,044.6	5,345.1	6,933.2	+88.31

Source: Own calculation using Eurostat Database [14, 15].

The labor force engaged in this fundamental activity that supplies food to the other economic sectors is another aspect of agriculture as a branch of the economy to be examined, in addition to the agricultural area and the number of farms. One representative indicator of analysis particular to the agricultural economy is the Annual Working Unit (AWU). Overall, during the time frame of the analysis, this indicator has consistently decreased (Table 9). This trend was brought by the mechanization and automation of production processes, effective farm management, and, more recently, the digitalization of agriculture and the adoption of modern technologies.

The region that engages the most people in agricultural activity and generates the highest number of AWUs is North-East with a value of 258,790 AWUs in 2020 followed by South-Muntenia (189,600 AWUs). As an indicator of the agricultural economy with higher precision and accuracy, AWU per farm expresses how efficiently the labour force was

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used, having a value of 0.41 AWU/farm for Romania in 2020, the highest value at the regional level being attributed to the South-East region with 0.46 AWU/farm (Table 10).

Table 9. AWU evolution - thousands (2010-2020)

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	9,648.9	9,381.8	8,813.6	:	-
Romania	1,417.9	1,573.1	1,587.6	1,178.6	-16.87
North-West	213.9	218.1	217.2	176.9	-17.30
Center	158.1	157.5	156.2	136.4	-13.73
North-East	314.0	336.8	346.5	258.7	-17.59
South-East	179.1	196.9	203.7	149.9	-16.30
South-Muntenia	243.5	281.3	276.2	189.6	-22.15
Bucharest-Ilfov	13.1	12.2	12.7	7.1	-45.27
South-West Oltenia	193.7	252.7	271.9	168.4	-13.04
West	102.3	117.4	102.9	91.3	-10.72

Source: Own calculation using Eurostat Database [12]; : - missing data.

Table 10. AWU/farm (2010-2020) - ha

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	0.80	0.88	0.86	:	-
Romania	0.37	0.43	0.46	0.41	+11.11
North-West	0.40	0.44	0.45	0.40	-1.36
Center	0.40	0.44	0.47	0.43	+6.91
North-East	0.40	0.45	0.48	0.44	+9.90
South-East	0.39	0.45	0.50	0.46	+18.89
South-Muntenia	0.30	0.37	0.40	0.36	+19.44
Bucharest-Ilfov	0.39	0.48	0.61	0.42	+6.38
South-West Oltenia	0.34	0.45	0.50	0.36	+7.48
West	0.37	0.48	0.45	0.45	+20.59

Source: Own calculation using Eurostat Database; : - missing data [12, 14].

One factor that could influence the success of the agricultural industry as a whole is the degree of technical endowment highlighted by the Gross Fixed Capital Formation (GFCF). During the analysis period, both at the national and EU levels, the value of sector-specific buildings and agricultural machinery and equipment grew (Table 11). According to development regions, the Center Region witnessed the biggest gain in 2020 compared to 2020 (116.91%), while the West Region suffered the greatest decline (-29.17%).

Table 11. GFCF evolution (2010-2020) - mil. euros

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	47,807.3	51,253.7	48,690.8	56,009.2	+17.16
Romania	1,115.65	1,309.68	964.25	1,266.16	+13.49
North-West	207.22	219.81	160.98	151.57	-26.86
Center	152.48	163.08	131.67	330.74	+116.91
North-East	193.93	170.41	141.88	139.98	-27.82
South-East	138.54	250.58	144.05	122.36	-11.68
South-Muntenia	168.07	277.81	137.68	235.22	+39.95
Bucharest-Ilfov	40.16	9.62	92.99	47.67	+18.70
South-West Oltenia	112.11	114.87	67.65	165.56	+47.68
West	103.14	103.51	87.36	73.05	-29.17

Source: Own calculation using Eurostat Database [13].

For the two branches of agriculture (animal output and crop output) at the national level in 2020 the ratio was 1:3.8 while for the EU the same ratio was 1:2.5. Total agricultural output dynamics in 2020 related to 2010 show an increase in all regions of the country except the South-East Region. The maximum value characterizes the South-Muntenia Region with 2,748.49 million euro (Table 12).

Table 12. Agricultural output dynamics (2010-2020) - mil. euros

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	336,350.6	383,177.8	365,774.5	400,080.2	+18.95
Romania	14,092.3	16,260.6	14,036.0	15,341.3	+8.86
North-West	1,807.0	1,899.1	1,721.6	2,095.1	+15.94
Center	1,683.5	1,786.8	1,555.0	1,796.6	+6.72
North-East	2,298.4	2,650.5	2,143.6	2,436.5	+6.01
South-East	2,252.4	2,773.0	2,518.3	2,093.6	-7.05
South-Muntenia	2,575.7	3,295.5	2,768.4	2,748.4	+6.71
Bucharest-Ilfov	160.6	232.9	183.4	293.9	+82.96
South-West Oltenia	1,579.1	1,778.1	1,567.3	2,064.6	+30.74
West	1,735.2	1,844.4	1,578.1	1,812.2	+4.44

Source: Own calculation using Eurostat Database [13].

The animal husbandry sector (taken separately) displays a similar regional tendency; however, the North-East Region holds the highest share, with 734.64 million euros, while the Bucharest-Ilfov Region holds the lowest value, with 19.55 million euros (Table 13).

Table 13. Animal output dynamics (2010-2020) - mil. euros

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	131,726.1	156,076.2	145,358.2	158,498	+20.32
Romania	3,635.65	3,907.61	3,779.74	4,047.46	+11.33
North West	536.09	554.65	521.07	558.21	+4.13
Center	517.32	552.87	548.01	599.17	+15.82
North-East	640.55	682.22	679.08	734.64	+14.69
South-East	461.98	554.43	567.15	550.07	+19.07
South-Muntenia	651.12	672.38	643.99	639.99	-1.71
Bucharest-Ilfov	38.78	27.98	23.97	19.55	-49.59
South-West Oltenia	333.74	365.21	346.21	390.49	+17.00
West	456.09	497.86	450.25	555.33	+21.76

Source: Own calculation using Eurostat Database [13].

Finally, the most relevant indicator for comparison in terms of agricultural economics is agricultural output/farm, which in Romania, although increasing by 73.85% (from 2010 to 2020), is 6.2 times lower than the EU level as a whole (Table 14), mainly due to the high number of subsistence farms.

Table 14. Agricultural output/farm (2010-2020) - thousands euros

Region	2010	2013	2016	2020	%2020/2010
EU - 27 (from 2020)	27.90	35.98	35.61	44.12	+58.15
Romania	4.07	5.37	5.00	7.08	+73.85
North West	3.42	3.80	3.60	4.73	+38.29
Center	4.27	4.98	4.70	5.64	+32.24
North-East	2.91	3.51	2.98	4.11	+41.37
South-East	4.89	6.40	6.14	6.46	+32.04
South-Muntenia	3.22	4.37	3.99	5.27	+63.72
Bucharest-Ilfov	4.80	9.20	8.73	17.06	+255.62
South-West Oltenia	2.74	3.19	2.91	4.43	+61.59
West	6.34	7.47	6.96	8.94	+41.07

Source: Own calculation using Eurostat Database [13, 14].

The Bucharest-Ilfov Region, the most developed area in the country, is distinguished regionally in 2020 due to its lower number of farms, more effectively integrated use of

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capital injection and cutting-edge farming technologies. Apart from Bucharest-Ilfov Region (with an increase of 255.62%), the most significant increases belonged to South-Muntenia Region (with an increase of 63.72% in 2020 compared to 2010) and South-West Oltenia Region (+61.59%).

With 8.94 thousand euros, the West Region is the only region that still exceeds the national average of 7.08 thousand euros for this indicator (Fig. 6).

Fig. 6. Graphical comparison between regional/farm agricultural production value and the national average (2020) - thousands of euros

Source: Own design based on the data from Eurostat [13, 14].

CONCLUSIONS

Given the global climate change and technological advancements, analysis of the factors that contribute to efficient agriculture is crucial. Farm management and national agricultural policymakers must address these evolving challenges.

A top-to-bottom approach to developments (for the present work from the EU to national level and then by NUTS 2 Regions) can generate results that can be integrated into regional agricultural development policies.

The comparative analysis of the situation in the last year of analysis (2020) as well as the evolution of the indicators in the first year of analysis (2010) shows that Romania and the NUTS 2 region are experiencing significant positive changes in terms of agricultural performance and increasing the efficiency of inputs use in this sector.

The paper complements the national studies on the state and dynamics of agriculture with more detailed research with a regional approach without losing sight of developments at the country or EU level.

The main discrepancies between the regional or national situations of agriculture and the EU-wide average were reflected by the UAA/farm indicators (given that Romania has the highest number of farms in the EU, with an average of 4.42 ha/farm), but there were significant decreasing trends in the number of farms in each region, with the national average exceeding 25%. This decrease was accompanied, consequently, by an increase in economic size per farm in 2020 compared to 2010 of 63.7%.

The decrease in the number of AWUs and the increase in GFCF as effects of the increasing integration of new technologies and innovations in the fields have led to an increase in yield and the value of total production, with the lowest increase in the South-East region (+32.04), while in Romania the increase is 73.85 and in the EU-27 (from 2020) 58.15 %.

The study is focused on Romania's NUTS 2 regions, but it can be broadened to encompass all the EU's NUTS 2 regions. Future research initiatives should focus on regional comparisons across various Member States, as well as analogous worldwide evaluations.

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STUDIES ON THE EVOLUTION OF PROCESSING CAPACITIES OF MEAT PROCESSORS WHO HAVE ACCESSED GRANT FUNDS IN THE OLTENIA REGION, ROMANIA

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Abstract

In recent years, the meat processing sector in Romania has experienced rapid development, at the level of all existing regions. This was possible thanks to access to non-reimbursable European funds. It can be said that following the investments made, this sector has developed, resulting in a modern meat processing industry, where there is a permanent concern for food safety and quality. The present study was carried out to highlight the evolution of the production capacities of meat processors who accessed non-reimbursable funds in the South-West Oltenia Development Region. Investment value, processing capacity and the profit from the project set up by meat processing companies operatinng in teh region swere used to determine the investment efficiency in terms of specific invetment, investment pay back and coefficient of economic investment. In this region, between 2016 and 2020, 4 projects were financed, where the total increase in meat processing capacity, through the contribution of the National Rural Development Program, was 15,884 tons/year.

Key words: *meat, processing, funds, economic efficiency, modernization of processing capacity*

INTRODUCTION

Romania accessed European funds for agriculture and rural development in the period 2014-2020. During this funding period, Romania received more than 8.12 billion euros from the European Union budget, more precisely from the Agricultural Fund for Rural Development (FEADR), through the National Rural Development Program (PNDR) [19] [14]. Subsidies for investments in the field of meat processing increase the economic results of the supported companies and their competitiveness [5]. In order to develop a sustainable development strategy in the case of a meat processing enterprise, the following steps are followed: developing a methodology for economic evaluation of the company, processing and systematizing data, ensuring the collection, processing and transmission of information [7]. Investments in tangible and intangible assets made by meat processing enterprises in Romania are designed for the modernization and modernization of technological and manufacturing lines [15]. In order to improve the internal situation of a meat processing company, with regard to the economic and financial situation, it is recommended that each meat processing company has a review committee or audit representative within its staff [8] . The use of new technologies to achieve real improvement and increase productivity in a business can be effective in the long term only by correctly analyzing the current state of the company [10]. Following an analysis of companies in the meat processing industry, it turns out that these companies in this field perform much better than meat producers, respectively raw material producers. Both in the EU and Romania, livestock is declining, but meat production is increasing [9, 10]. In the context in which the pig market in the European Union is decreasing in terms of pig herds, and exports are increasing, in order to recover the pig market in Romania, both breeders and processors must comply with the strategy and measures imposed by authorities regarding pig breeding, transport and slaughter. Regarding unprocessed sheep meat, Romania has an efficient external trade, reflecting that it is a net exporting country [1, 2].

As the demand for automation increases, Romania and other countries in the European Union have adopted new technologies in the meat industry. However, due to the diversity of animals and anatomical peculiarities, meat processing requires advanced equipment to meet the challenges [17]. According to Smedescu, Romania has made significant progress, especially in large companies, highlighting the complexity of work dynamics in the meat processing industry in the European Union, influenced by market demand, technological advances and economic policies [16]. Likewise, Romania's progress in meat processing is notable, and the development of this sector in the European Union is marked by market demand and significant regional differences. Inefficiencies are related to managerial practices rather than local conditions [3], [13]. According to Lautenschlaeger, investments in meat processing are driven by the rigorous requirements and exacting standards of the industry, thus stimulating the adoption of advanced technologies and helping to improve processing efficiency [4]. Another approach is Popescu's, where he gives special importance to large cooperatives for the processing of meats that have a significant impact on the global food industry, demonstrating the ability to operate on an international scale. They comply with high quality and safety standards at all stages of processing. Through innovative practices, cooperatives offer products appreciated on international markets, contributing to increasing competitiveness and satisfying consumer demands [11].

MATERIALS AND METHODS

A first step in conducting this study was to conduct a bibliometric analysis of key word connections such as between meat processing, meat processing skills development and other associated terms.

The bibliometric analysis represents an alternative method for the statistical analysis of the public of different fields of study.

This instrument provides an organized and transparent process that broadly analyzes an area of research.

Carrying out the bibliometric analysis, with the help of a program, involves performing several phases such as: identifying the analyzed topic, selecting the database, exporting and entering the database into the software, and finally, analyzing the results. The present study was carried out to highlight the evolution of the production capacities of meat processors who accessed non-reimbursable funds in the South-West Oltenia Development Region.

In this region, in the period 2016 – 2021, 4 projects were financed (P1, P2 and P3Vl and P3Gj), which were accessed by 3 companies, which were noted as follows: SC MATRA SRL - P1, SC TELDOTRANS SRL - P2, SC AVICARVIL SRL - P3 (P3Vl, P3Gj). Following the request to the Regional Center for the Financing of Rural Investments (CRFIR) 4 South – West Craiova [13], but also to the beneficiaries of the projects, we obtained information on the processing capacities from the end of the implementation period of the projects, which were subsequently processed.

These data together with the investment value of the projects (data taken from the AFIR database), the initial processing capacity and the profit (data taken from the accounting balance of these companies) from the year in which the projects of these processors were submitted, were processed by evaluating investment efficiency.

Investment efficiency indicators:

1. *The specific investment (IS)* which is the ratio between the value of the investment (I) and the production - tons (P) and shows the size of the investment expenses for the creation of the processing capacity.

(a)for newly established processing capabilities:

$I_S = \frac{I}{P}$, ...(1)

(b) for the development of production capacity:

$I_S = \frac{I}{P_1 - P_0}$, ...(2)

2. *The investment payback period (D)* shows the length of time the investment (I) recovers from the profit (p).

$D=\frac{I}{p}$. ....(3)

3. *The coefficient of economic investment (E)* expresses the profit obtained for each euro invested and is the ratio between profit (p) and the value of the investment (I).

$E=\frac{p}{I}$. ....(4)

The situations regarding the herds of cattle, sheep and goats, pigs and poultry were processed and transformed into Livestock Unit) according to the conversion coefficient for each analyzed species as follows.

Table 1. Conversion coefficient from species into Livestick unit, LU

Species (Number of animals)	Livestock Unit conversion factor
Cattle	1.00
Swine	0.30
Sheep and Goats	0.15
Poultry	0.03

An analysis was made regarding the necessity of the investments made in the respective areas, taking into account the production of matter and the need for its processing.

RESULTS AND DISCUSSIONS

The subject "meat processing" is debated in over 1,000 papers written between 2002 and 2023, and they were included in the fields of Economy, Food Industry and Agriculture. With the help of the Web Of Science database, the document is exported in editable format with all specialist papers written on the subject of "meat processing" [14].

With the help of the VosWiewer program, maps are generated that contain the keywords mentioned at least 3 times, in a publication and countries that give special importance to the subject.

Fig.1 reflects the connection between ”meat processing” and other related terms.

Fig. 2 shows the relationship between ”meat processing” and other related terms by years.

Fig. 3 regards the keywords density in the field of meat processing.

Fig. 4 shows the connections between the authors of the countries that researched about "meat processing”.

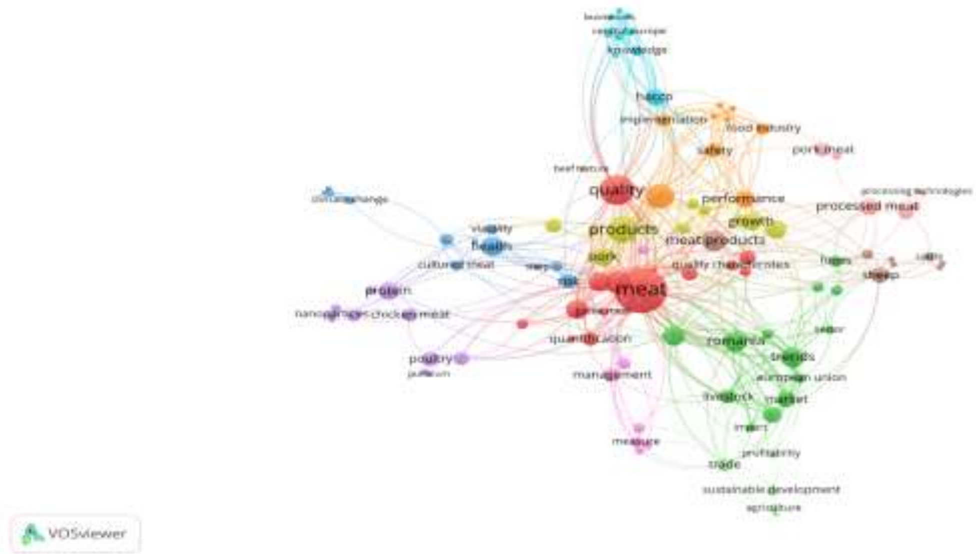

Fig. 1. The connection between ”meat processing” and other related terms
Source: Web of Science data processing with **VOSviewer software [20].**

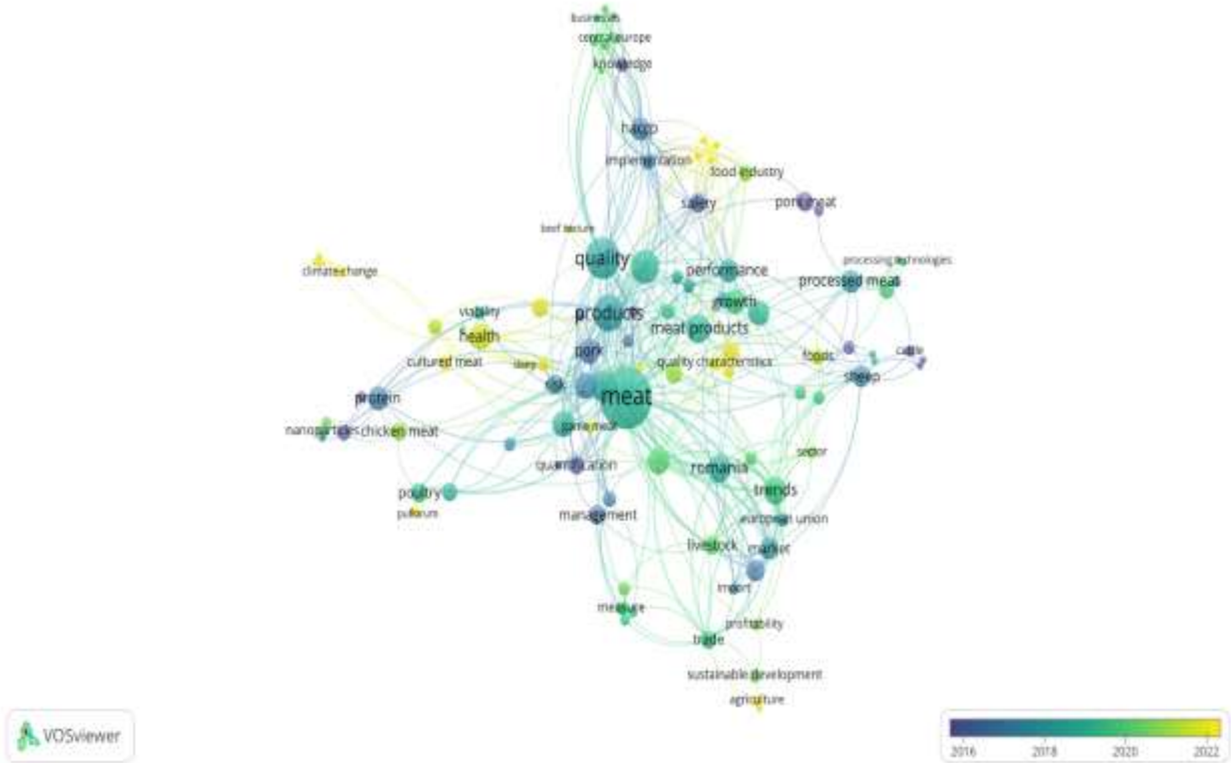

Fig. 2. The relationship between "meat processing" and other related terms by years
Source: Web of Science data processing with VOSviewer software [20].

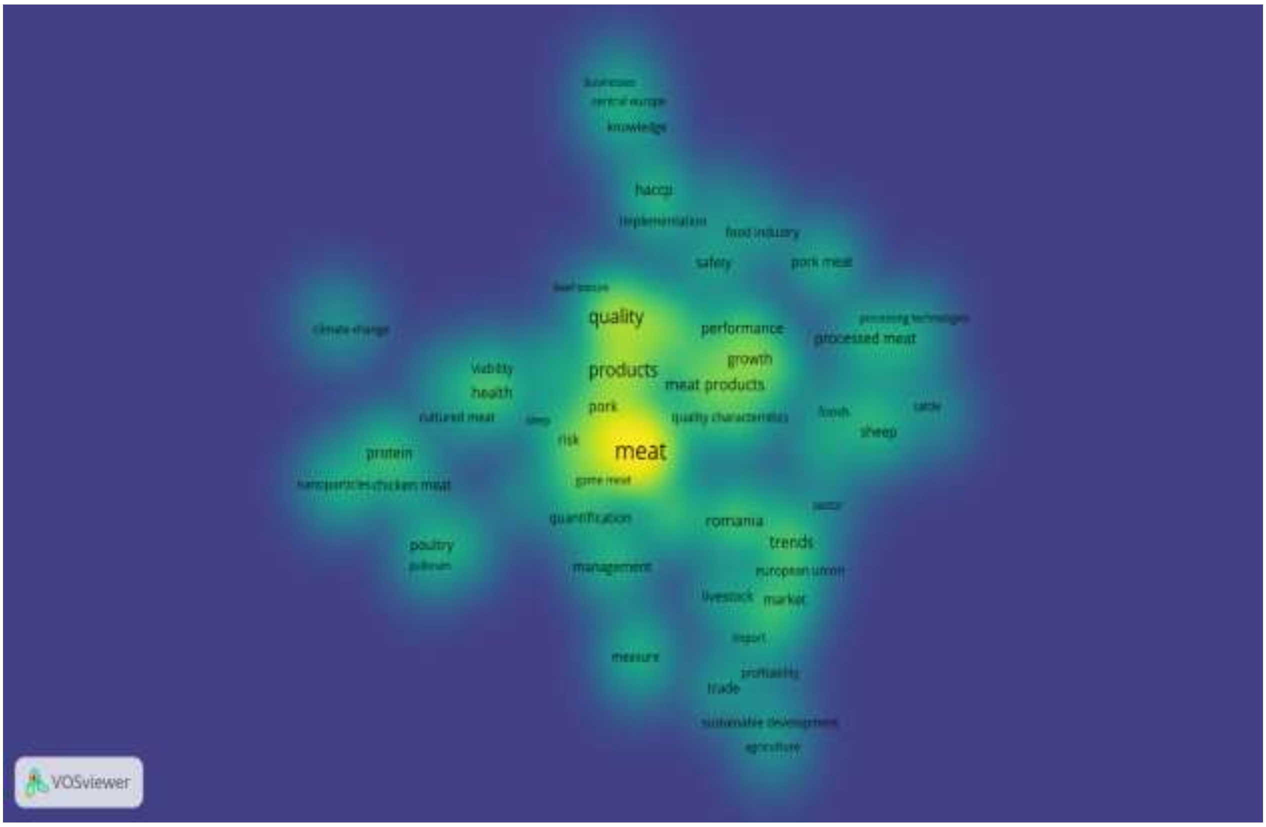

Fig. 3. Keyword density from the field of meat processing
Source: Web of Science data processing with VOSviewer software [20].

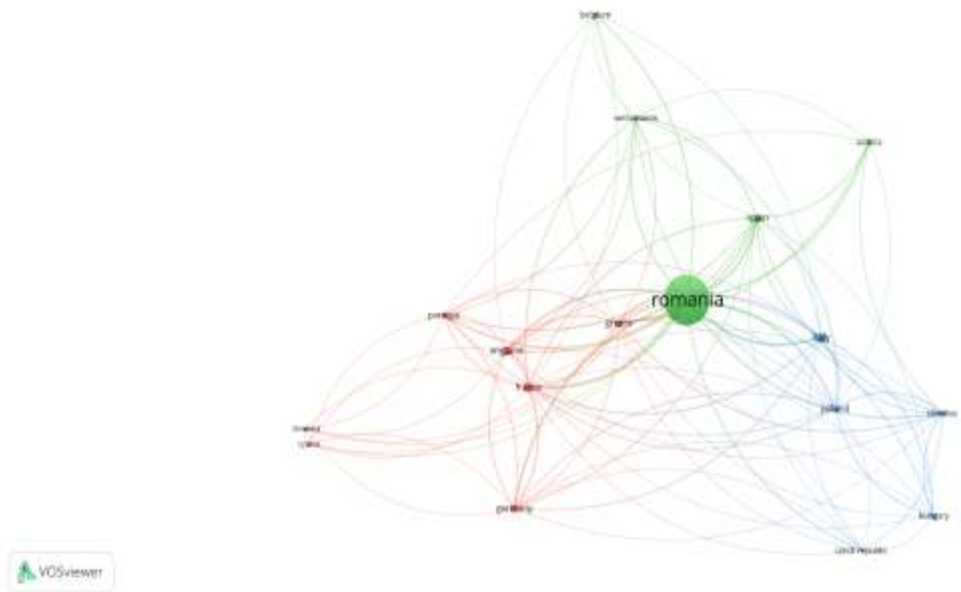

Fig. 4. The connections between the authors of the countries that researched about "meat processing"
Source: Web of Science data processing with VOSviewer software [20].

The size and color features provided by the VOSViewer software help identify groups. Thus they identified several clusters, as follows (Figure 1):
-*The red cluster,* highlighted by the term "meat", shows us in words the main ideas about meat such as "quality", "meat products", "quantification";
-*The green box*, highlighted by "Romania" and "European Union", shows us the main key ideas, such as: "sustainable development", "agriculture", "trade", "livestock", "market", "import", "foods";
-*The brown box*, represented by the term "processed meat", shows us the links between "processing technologies", "sheep", "cattle", "pork meat", "meat products".
-*The orange circle*, which we can call "food industry", includes the keywords "implantation", "performance", "safety";
-*The blue circle*, which we can call "HACCP", includes links between the terms "central Europe", "businesses", "knowledge", "climate change".
As for the keywords used in scientific works by year, Figure 2 shows the interest in certain topics, in the interval 2016 – 2022, i.e. over a period of 6 years. So, between 2016 and 2018, the researchers were concerned with meat, processed meat, meat products, quality, management, implementation, HACCP, Romania. In the following years, 2018 – 2020, the research focused on food industry, processing technologies, businesses, Central Europe, measure, growth, livestock. In the last interval, 2020 – 2022, the attention was on the terms climate change, quality characteristics, foods, health, cultured meat, agriculture (Figure 2).
Figure 3 suggests the density of the keyword, based on the concentration of the central node from which they originate, namely, the color of the node is influenced by the number of nearby elements. So, in our case, the density of the created map is about the keyword "meat", the research focusing on quality, processed meat, meat products, sustainable development, management.
The link between countries is important to highlight the countries of interest in this study. The intensity of the nodes on the map represent the partnerships between institutions, and the colors show us the multitude of research directions. The countries that show particular importance to the analyzed topic are a good part of the European Union countries (Spain, Holland, Poland, Italy, Greece, France, Hungary), also England, and Romania is the strongest node (Figure 4).
Table 1 shows that the value of the 4 projects is 14,071,539 euros, where the non-refundable value of the investments is 5,893,046 euros.

Table 2. The value of investments and the situation of the production capacities of the processors at the end of the implementation of the projects

Project	Investment value (euro)	The non-refundable value of the investment (euro)	Rate of public support (%)	Initial capacity (tons/year)	Final Capacity* (tons/year)	Final Capacity* (tons/year)
P_1 (2017)	986,126	493,063	50	0	1,200	1,200
P_2 (2018)	1,658,183	829,091	50	1,148	1,148	0
P_3 Vl (2016)	5,731,230	2,292,492	40	0	774	774
P_3 Gj (2019)	5,696,000	2,278,400	40	18,250	32,120	13,870
Total	**14,071,539**	**5,893,046**	-	**19,398**	**35,242**	**15,844**

Source: Own calculation based on data Regional Center for the Financing of Rural Investments 4 SV Craiova [12].

Table 2 shows that the value of the 4 projects is 14,071,539 euros, where the non-refundable value of the investments is 5,893,046 euros. The initial total processing capacity is 19,250 tons/year and the final total processing capacity is 35,242 tons/year, resulting in an increase in processing capacity of 15,844 tons/year. Although the potential of this region is much greater, out of the 5 counties, only 3 counties managed to access non-reimbursable funds, these being Olt, Vâlcea and Gorj, and the counties in Dolj and Mehedinți had no funded projects.

The total increase in meat processing capacity in this region, through the contribution of the National Rural Development Program, is 15,884 tons/year. The P1 project, financed in 2017, establishes a new processing capacity with a total investment of 986,126 euros, half of which—493,063 euros—is provided as non-reimbursable support (50%). The project aims for a final processing capacity of 1,200 tons per year (Table 1). The P2 project, funded in 2018, focuses on modernizing an existing processing facility with an investment of 1,658,183 euros, of which 829,091 euros (50%) is covered by non-reimbursable support. This upgrade does not increase the processing capacity, which remains at 1,148 tons of processed meat per year (Table 2).

The P3 Vl project, financed in 2016 in Vâlcea County, establishes a new processing capacity with an investment of 5,731,230 euros, including 2,292,492 euros in non-refundable support, covering 40% of the total. The target processing capacity for this project is 774 tons per year. The P3 Gj project, financed in 2019 in Gorj County, focuses on expanding poultry slaughter capacity with an investment of 5,696,000 euros, of which 2,278,000 euros (40%) is non-refundable support. The initial slaughter capacity is 18,250 tons per year, with the project aiming to reach a final capacity of 32,120 tons per year, reflecting an increase of 13,870 tons annually (Table 2). Table 3 presents the indicators for investment efficiency.

Table 3. Investment efficiency indicators

Project	Specific investment (euro/tonne)		Recovery time (years)	Economic efficiency
	Newly established processing capacity	Development / Modernization of processing capacity		
P_1	821.77	-	4.24	0.24
P_2	-	1,444.41	7.32	0.14
P_3 Vl	7,404.69	-	5.61	0.18
P_3 Gj	-	410.67	7.18	0.14

Source: Own calculation based on data Regional Center for the Financing of Rural Investments 4 SV Craiova [12].

The specific investment P1 is 821.77 euros, for a newly established meat processing capacity, the investment recovery period is approximately 4 years, and the economic efficiency is 0.24. In the case of P2, the specific investment for the modernization of the meat processing capacity is 1,444.41 euros for each processed ton, the investment recovery period is approximately 7 years, and the economic efficiency is 0.14, which shows that it has approximately the same indicators as in the case of P3 Gj. The specific investment for the establishment of a poultry meat processing capacity, at P3 Vl is 7,404.69 euros for each ton of processed meat, the investment recovery period is approximately 5 and a half years. The economic efficiency is 0.18, from which it follows that for each euro

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invested the profit is 0.18 euro. In 2019, P3 Gj develops its poultry meat slaughtering capacity, the specific investment is worth 410.67 euros for each ton of slaughtered meat, the investment recovery period is approximately 7 years. The economic efficiency is 0.14, from which it follows that for each euro invested the profit is 0.14 euro (Table 3).

The type of investment is a very important factor in the performance differences of investments between projects, projects to establish new capacities, as in the case of P1 and P3VL projects, require much higher initial costs, because they involve the construction of new factories, compared to modernizations as in the case of the P2 project, or in the case of the expansion of already existing capacities as in the case of the P3GJ project. Consequently, the specific investment SI is much higher in the case of projects that establish new capacities, as in our case with the P3VL project, which has a much higher SI than the other projects, with a value of 7,403.66 euros/ton. The differences in the quality and complexity of the equipment purchased for modernization or establishment can vary significantly between projects. In the case of P3VL with a specific investment of 7,403.66 euros/ton, it reflects a much more advanced technology and high infrastructure costs, compared to P3GJ with a specific investment of 410.77 euros/ton, where the expansion of the slaughterhouse can be achieved with relatively less equipment expensive. Own contribution and non-reimbursable support varies between projects, P3Vl and P3Gj projects have a 40% support, while P1 and P2 benefit from a 50% support, these differences directly influence the financial pressure on each company and affect the way they have managed investments. Managerial skills and experience in implementing similar projects can influence the efficiency of the investment. A company with more experience in grant management and meat processing can optimize costs and reduce implementation risks, which could explain differences in performance between projects (Table 2 and Table 3).

Table 4. Herds of cattle, pigs, sheep and goats, birds in 2019, in the South - West Oltenia Region

Animal category	Dolj County		Gorj County		Mehedinți County		Olt County		Vâlcea County		South - West Oltenia Region	
	Number of Animals	Livestock Unit	Number of Animals	Livestock Unit	Number of Animals	Livestock Unit	Number of Animals	Livestock Unit	Number of Animals	Livestock Unit	Number of Animals	Livestock Unit
Cattle	30,339	30,339	32,732	32,732	29,142	29,142	31,985	31,985	41,091	41,091	165,289	165,289
Swine	127,301	38,190	81,971	24,591	69,880	20,964	150,106	45,032	69,823	20,947	499,081	149,724
Sheep and goats	314,858	47,229	144,498	21,675	182,936	27,440	215,467	32,320	137,555	20,633	995,314	149,297
Poultry	2,042,159	61,265	1,092,285	32,769	878,243	26,347	1,703,521	51,106	2,133,934	64,018	7,850,142	235,504
Total Livestock Unit	-	**177,023**	-	**111,767**	-	**103,894**	-	**160,442**	-	**146,689**	-	**699,815**

Source: Own calculation based on data www.statistice.insse.ro [16].

Table 5. Livestock Unit, Number of funded projects, Number of Business Consulting and Management companies*

County	Livestock Unit	Number of funded projects	Number of Business Consulting and Management companies*
Dolj	177,023	0	344
Gorj	111,767	1	90
Mehedinți	103,894	0	60
Olt	160,442	2	107
Vâlcea	146,689	1	130
South - West Oltenia Region	**699,815**	**4**	**731**

Source: Own calculation based on data www.topfirme.com [18].

Location and local infrastructure total costs, such as raw material transport costs, access to utilities (energy, water), labor availability and proximity to markets vary. As shown in Table 5, the raw material production in the 5 counties was: in Dolj county 177,023 livestock unit were produced, in Gorj county 111,767 livestock unit were produced, in Mehedinti county 103,894 livestock unit were produced, in Olt county there were produced

160,444 livestock unit, and in Valcea county 146,689 livestock unit were produced. Raw material production, expressed in Livestock Units, reflects the agricultural and zootechnical potential of each county, which is essential for the development of the meat processing sector. In counties where raw material production is higher, meat industry companies are more motivated to access funds to develop or modernize their processing capacities. This may partly explain why certain counties have been more active in accessing funds.

Dolj county had the highest production of raw material (177,023 livestock unit), which indicates a high potential for the livestock sector and implicitly for meat processing. However, the fact that Dolj has not accessed funds may be an indication that there are other inhibiting factors such as consultancy or infrastructure. Dolj County has the largest number of consulting firms (344), which suggests a high capacity to access funds, the absence of access may indicate an inefficient distribution of consulting resources, or other obstacles have prevented local firms from submitting viable projects (Table 4 and Table 5).

Olt County (160,444 livestock unit) and Vâlcea (146,689 livestock unit) have accessed funds, and their high raw material production is a factor that has supported the development of processing capacities. These counties have greater potential for farmers and processors to work together effectively. The counties of Olt (107 firms) and Vâlcea (130 firms) accessed funds, which suggests that a sufficient number of consulting firms active in these counties contributed to the success of accessing funds. These companies provided support for the preparation and management of financing projects (Table 4 and Table 5).

Gorj (111,767 livestock unit) and Mehedinți (103,894 livestock unit) have lower production, which could limit the motivation for massive investment in processing. However, Gorj has accessed funds to expand its slaughtering capacity, suggesting that a certain production threshold is required to justify such investment. Gorj County (90 firms) accessed funds, even if the number of consulting firms is relatively small compared to other counties. This indicates that while the number of consulting firms may be an important factor, it is not necessarily decisive whether the existing ones are well trained and efficient. Mehedinți County (60 firms) did not access funds, and the small number of consulting firms may be one of the main reasons. The lack of a sufficient number of consultants can limit the ability of local companies to prepare competitive projects for accessing funds (Table 4 and Table 5).

CONCLUSIONS

The P1 project, launched in 2017, establishes a new processing capacity with a total investment of 986,126 euros, including 493,063 euros in non-refundable support, covering 50% of the cost. The target processing capacity for this project is 1,200 tons per year.

Project P2, funded in 2018, focuses on modernizing the processing capacity, with an investment of 1,658,183 euros, half of which—829,091 euros—comes from non-refundable support. This modernization does not increase the processing capacity, which remains at 1,148 tons of processed meat per year.

The P3 Vl project, initiated in 2016, establishes a new processing capacity with an investment of 5,731,230 euros, including 2,292,492 euros (40%) in non-reimbursable support. The intended processing capacity for this project is 774 tons per year.

The P3 Gj project, funded in 2019, aims to expand slaughter capacity with an investment of 5,696,000 euros, 40% of which—2,278,000 euros—is covered by non-refundable support. The initial slaughter capacity was 18,250 tons per year, and the project aims to reach 32,120 tons per year, marking an increase of 13,870 tons annually.

Raw material production has a direct influence on the development potential of the meat processing sector in each county. Counties with a higher production (such as Olt and Vâlcea) are more likely to justify significant investments and, implicitly, to access non-reimbursable funds. In order to boost access to funds in unsuccessful counties (such as Dolj and Mehedinți), it is necessary to improve the collaboration between the agricultural sector, the business environment and consultants, as well as to support the development of a larger number of local consulting firms.

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ANALYSIS OF FARMERS' HEMP GROWING TENDENCIES AND EXPECTATIONS: THE CASE OF TÜRKİYE

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Abstract

The purpose of this study is to analyze the factors affecting the tendency of farmers to grow hemp in Rize province of Türkiye. The data was collected by face-to-face survey method from 90 farmers with proportional sampling. A five-point Likert scale was used to evaluate farmers' knowledge levels, opinions and attitudes regarding hemp growing, and their tendencies and expectations towards hemp growing. Best-Worst analysis was performed to determine the most important support practices that farmers expect from the government to grow hemp. The Fuzzy Paired Comparison method was used to determine which criteria farmers will attach importance to when growing hemp. According to the study results, 46.7% of the farmers have grown hemp before. However, it has been determined that farmers need more information about hemp growing. 48.9% of farmers are willing to grow hemp individually and 35.6% under contract. Farmers do not find the current supports sufficient and think that they should be diversified. For example, land use, seed supply and grant support are among their expectations. 36.6% of farmers think that hemp growing is profitable. 56.6% of farmers argue that hemp growing will not be more profitable than other products such as tea and hazelnuts. 56.7% of farmers stated that they would turn to hemp growing if government support was increased. The most important criteria that farmers will consider for growing hemp are climate conditions, soil structure and yield, respectively. For hemp growing to develop in this region, farmers' expectations regarding supports and market alternatives must be met.

Key words: *hemp growing, hemp economics, agricultural product pattern, farmer preferences*

INTRODUCTION

Hemp is a multi-dimensional agricultural product that can be evaluated within the scope of oil plants, both medicinal-aromatic plants and fiber plants, as it is a plant from which fiber is obtained with its stem and oil is obtained from its seeds. Studies on hemp indicate that it has 2,500 uses, and some sources say it has up to 5,000 uses. The economic value of both fiber and seed of hemp has paved the way for the plant to be used in various products [21]. The use of hemp has spread to many areas such as textile and paper industries, plastic industry, furniture industry, feed production, essential oil production, pharmacy and cosmetics. Additionally, biodiesel can be produced from hemp[43, 5, 34].

According to FAO's 2022 data, 354,560 tons of hemp fiber (raw and semi-processed) were produced in 253,484 hectares of land in the world, and 42,267 tons of hemp seeds were produced in 43,622 hectares of land [15]. The countries that produce the most hemp seeds are France, China, Russia and Chile, the countries that produce the most hemp fiber are North Korea, Netherlands, China, Italy and Chile. 32 countries in the world allow farmers to grow industrial hemp. However, in recent years, this number has increased to over 40 [7].

Many studies have been conducted on the economic aspects of hemp production in different countries of the world [41, 40, 25, 28, 12, 10, 20, 30, 29, 45, 6, 49, 22, 23]. In these studies, the cost and profitability levels of industrial production were mostly examined.

While hemp growing was carried out freely in Türkiye until 1933, for the first time in 1933, within the scope of the Law No. 2313 on the Control of Narcotic Drugs, it was stipulated that hemp growing could only be carried out in a controlled manner for fiber, seed, stem and similar purposes. Amendments were made to the relevant law first in 1979 and then

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in 1990. In accordance with the regulation numbered 20672 prepared in 1990, it was determined that hemp growing could be carried out in a controlled manner in 20 provinces. Finally, with the Regulation on Hemp Growing and Control in 2016, controlled hemp growing was brought back to the agenda in 19 provinces. These provinces are Amasya, Antalya, Bartin, Burdur, Corum, Izmir, Karabük, Kastamonu, Kayseri, Kütahya, Malatya, Ordu, Rize, Samsun, Sinop, Tokat, Usak, Yozgat and Zonguldak [43, 1].

According to TURKSTAT data, while 31 tons of fiber hemp were produced in an area of 36.5 hectares in Türkiye in 2022, 359 tons of fiber hemp were produced in an area of 211.7 hectares in 2023. While 159 tons of hemp seeds were produced in an area of 196.3 hectares in 2022, 327 tons of hemp seeds were produced in an area of 392.3 hectares in 2023 [46].Tasköprü district of Kastamonu province has been the most important center in Türkiye for hemp growing, especially for its fiber, until recent years. For seeds, Ödemis and Tire districts of Izmir province and Burdur province are the leading ones. In Gümüshaciköy district of Amasya province, the best quality hemp seeds in the world were produced. However, today hemp production is mostly carried out in the Vezirköprü district of Samsun province [5].

Many studies have been conducted on the growing characteristics and usage areas of hemp in Türkiye [1, 26, 16, 5, 52, 27, 39, 11, 13, 18, 32]. It is seen that some studies have been done on the economics of hemp growing in recent years [4, 54, 7, 47, 50, 9, 48, 44, 51]. However, hemp production needs to be expanded to meet the demand for use in different sectors and to create export opportunities. For this purpose, farmer tendencies and expectations need to be revealed through research. The data obtained in this way can be the basis for preparing appropriate policies.

One of the provinces in Türkiye where farmers are allowed to produce hemp is Rize province. Economic activities are limited in this region. Farmers mostly produce tea. In addition, hazelnuts and kiwi are also produced. However, especially the tea plantations in the region are quite old and will need to be dismantled soon. Farmers are turning to alternatives where they can earn higher income. Therefore, investigating the possibilities and conditions of popularizing hemp growing in this region can provide important contributions in terms of scientific and policy implementation.

The purpose of this study is to analyze the factors affecting the tendency of farmers to grow hemp in Rize province of Türkiye. Based on this, the aim is to evaluate the conditions and opportunities for hemp growing in the region.

MATERIALS AND METHODS

The data that constitutes the main material of the study was obtained by face-to-face survey method from the farmers in Findikli district of Rize province, Türkiye. In addition, data published by different institutions and the results of previous studies on the subject were also used.

It was decided to conduct the study in Rize province because it has a significant potential in terms of hemp production. According to the information received from the Rize Provincial Directorate of the Ministry of Agriculture and Forestry, it was determined that the district with the highest willingness to grow hemp in recent years was Findikli and the farmers in this district were included in the scope of the study (Figure 1).

Fig. 1. Rize province and its districts
Source: [3].

There are a total of 23 villages and 8 neighbourhoods in Findikli district. According to the information received from Findikli

District Directorate of the Ministry of Agriculture and Forestry and because they are more suitable for hemp growing, Arslandere, Sümer, Hara and Avcilar villages and Yenimahalle and Ilica neighbourhoods were included in the scope of the research. The total number of farmers registered with Farmer Registration System in these six settlements was determined as 590 and these farmers constitute the main population of the study. It was decided to include a portion of the total number of farmers within the scope of the research through proportional sampling, and the following formula was used for this purpose [31]. It is seen that this formula is used in many studies [17, 14, 19].

$$n = \frac{Np(1-p)}{(N-1)\sigma^2{}_{px} + p(1-p)} \qquad (1)$$

In the formula:
n = Sample size
N = Total number of farmers
p = Proportion of farmers willing to produce hemp (0.5 was taken for maximum sample size)
σ^2px = Variance.

In the study, calculations were made based on a 90% confidence interval and an 8% margin of error, and the sample size was determined as 90. In determining the number of farmers to be interviewed in each settlement, the shares of the settlements in the total number of farmers were taken as basis. The farmers to be interviewed in the settlements were determined using the random numbers table. Study surveys were conducted in March 2021.The study was found ethically appropriate with the decision of Ege University Scientific Research and Publication Ethics Committee numbered E.2204/2021.

In the analysis of data, farmers are divided into 3 groups according to land size. Farmers with less than 1.5 hectares of land (33 farmers) formed the first group, farmers with 1.5-3.0 hectares of land (27 farmers) formed the second group, and farmers with more than 3.0 hectares of land (30 farmers) formed the third group.

The socio-economic characteristics of the farmers were determined. For this purpose, the ages, education periods, household size, land and parcel size, family labour potential, capital level and organizational status of the farmers were examined. Then, the farmers' knowledge levels, opinions and attitudes about hemp growing, tendencies and expectations for hemp growing were evaluated. At this stage, a five-point Likert scale was used [8].

In the study, Best-Worst analysis was performed to determine the most important support practices that farmers expect from the government to grow hemp. Farmers were asked to comment on 11support applications. Best-Worst Analysis is based on the logic of comparing each criterion according to the best (most important) and worst (least important) criteria, rather than comparing each criterion with others one by one. The application stages of the method are as follows [36, 37]:

Step 1: The decision matrix is created.
Step 2: The most important and least important (least important) criteria are determined.
Step 3: An evaluation between 1 and 9 is made by comparing each criterion with the most important criterion.
Step 4: Similar to the previous step, the least important criterion is determined and compared with other criteria.
Step 5: Optimal weights are calculated.

In the study, the Fuzzy Paired Comparison method was used to determine which criteria farmers will attach importance to when growing hemp. Farmers were presented with six criteria to determine their decision preferences. The steps of the method can be summarized as follows [38, 42, 35].

First, pairwise comparisons are presented to indicate individual preferences. For example, the degree of preference of objectives K and H, G_{KH}, is measured according to the distance between them. The change in the value was between 0 and 1 for each element. The total distance is equal to the following.

If G_{KH}=0.5 then K≈H; If G_{KH}>0.5 then K>H; If G_{KH}<0.5 then K<H

The number of pairwise comparisons of the objectives (C) is determined as C= [(Z.(Z-1))/2].
In the formula, Z represents the number of preferred objectives.
In the study, 15 comparisons were presented to each farmer according to six different criteria. Effective factors are listed from largest to smallest according to their weight [17]. Gcr preference was obtained in each pairwise comparison. The measurement of the degree of preference of r over c can be expressed as gcr=1-grc. Then, a fuzzy preference matrix was created. The following expression was used for this.

$$\text{Gcr} = \begin{cases} 0 \quad if c = r \ \forall c, r = 1, \ldots . n \\ g_{cr} if c \neq r \ \forall c, r = 1, \ldots . . n \end{cases} \qquad (2)$$

In the study, a 6x6 fuzzy preference matrix was created as follows (G):

$$G = \begin{bmatrix} g_{11} g_{12} g_{13} g_{14} g_{15} g_{16} \\ g_{21} g_{22} g_{23} g_{24} g_{25} g_{26} \\ g_{31} g_{32} g_{33} g_{34} g_{35} g_{36} \\ g_{41} g_{42} g_{43} g_{44} g_{45} g_{46} \\ g_{51} g_{52} g_{53} g_{54} g_{55} g_{56} \\ g_{61} g_{62} g_{63} g_{64} g_{65} g_{66} \end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

The preferred intensity (μj) of each objective separately was obtained using the following equation. The μj value varies between 0 and 1.

$$\mu j \ = 1 - (\textstyle\sum_{c=1}^{n} G_{cr}^{2} \, / (n-1))^{1/2} \ldots\ldots\ldots\ldots(4)$$

Whether the purpose of comparison is equally important was determined by the Friedman Test. Additionally, Kendall's coefficient of fit was used for the lines.

RESULTS AND DISCUSSIONS

In the socio-economic characteristics of the farmers are presented in Table 1.
7.8% of farmers are women and 92.2% are men. The ages of the farmers range from 35 to 73, with the average being 53.65.
Education periods vary between 5-15 years, with an average of 10.13 years.

Table 1. Socio-economic characteristics of farmers

Characteristics	Farm groups			
	Group 1 (<1.5 ha)	Group 2 (1.5-3.0 ha)	Group 3 (>3.1 ha)	General
Age of farmer	49.13	56.74	55.24	53.65
Education period of farmer (year)	9.87	10.15	10.36	10.13
Household size	3.73	3.46	4.31	3.83
Family labour potential (MLU)	2.54	2.02	2.67	2.41
Land size (ha)	0.72	2.19	4.21	2.44
Average parcel size (ha)	0.19	0.30	0.34	0.32
Equity rate (%)	94.1	95.5	97.5	95.8
Cooperative partnership rate (%)	48.5	40.7	53.3	47.8

Source: Results of this study.

The total population in the farms examined is 345 people and the average household size is calculated as 3.83 people. Women constitute 43.3% of the total population in farms. The rate of the population aged 15-49 in the total population is 37.6%.
While calculating the family labour potential, the population was first converted into male labour unit (MLU) and then into male labour day (MLD) with the approach that they can work 300 days a year [24]. The average family labour potential in farms was determined as 2.41 MLU.
The land size in farms varies between 0.5-6.0hectares. The average land size and average number of parcels were determined as2.44hectares and 7.70, respectively. The average parcel size was calculated as 0.32 decares. Farmers generally cultivate their own land.
Land assets constitute 98.0% of the total active capital in farms. It is seen that building assets have a significant share (54.9%), followed by soil assets (38.7%) and plant assets (4.0%). However, it was determined that 95.8% of the liabilities consisted of equity capital.47.8% of the farmers are partners in any agricultural cooperative.
It was determined that farmers produce tea on 79.7% of the average farm land. Other grown products are hazelnuts and kiwi. It has been determined that cow milk, eggs and honey are also produced in the farms, albeit to a limited

extent. 80.5% of the average total gross production value in the farms was provided by tea (Table 2).

Table 2. Gross production values obtained by farmers according to products (US$)

Products	Farm groups				
	Group 1 (<1.5 ha)	Group 2 (1.5-3.0 ha)	Group 3 (>3.1 ha)	General	%
Tea	155,840.46	270,940.17	491,025.64	328,915.81	80.5
Hazelnut	21,730.77	1,887.46	31,686.61	18,691.45	4.6
Kiwi	3,988.60	2,136.75	14,957.26	7,676.64	1.9
Animal products	32,805.41	47,272.65	71,457.57	53,272.36	13.0
Total	214,365.24	322,237.03	609,127.08	408,556.26	100.0

Source: Results of this study.

In order to determine the farmers' level of knowledge about hemp growing, they were asked to what level they agreed with some statements (Table 3). According to the results, farmers know the hemp and know where it is used. Although 74.5% of farmers know the problems, they will encounter in hemp growing, they also think that they do not have knowledge of pesticide and fertilizer applications, tools and equipment used and marketing.46.7% of the farmers have growing hemp before.44.5% of farmers know the planting and harvest periods for hemp growing.

Table 3. Knowledge levels of farmers regarding hemp growing*

Knowledges	**Farm groups**			
	Group 1 (<1.5 ha)	Group 2 (1.5-3.0 ha)	Group 3 (>3.1 ha)	General
I've heard of the hemp before	5.00	4.96	5.00	4.99
I know the purposes for which the hemp is used.	4.88	4.74	4.83	4.82
I have grown hemp before	3.25	2.22	2.70	2.75
I know the planting and harvest periods of the hemp	3.24	3,00	3.23	3.17
I know where to market the hemp	2.03	1.93	2.23	2.07
I know the tools and equipment used in hemp growing	2.76	2.41	2.90	2.70
I know the pesticides and fertilizers used in hemp growing	2.42	2.26	2.73	2.48
I know the problems that can be encountered in hemp growing	4.55	3.59	4.40	4.21

*1: Strongly disagree, 2: Disagree, 3: Undecided, 4: Agree, 5: Strongly agree
Source: Results of this study.

The most important information sources of farmers about hemp growing are their own experiences (66.7%), recommendations of other farmers (13.3%), internet (10.0%), pesticide and fertilizer dealers (3.3%), technical staff of the Ministry of Agriculture and Forestry (2.2%) and other sources of information (4.5%).

To determine their opinions and attitudes about hemp growing, farmers were asked to what level they agreed with some statements (Table 4).

While 48.9% of farmers want to grow hemp individually, 35.6% of farmers prefer contract production.

53.3% of farmers do not approve of growing due to intense inspections.

36.6% of farmers think that hemp growing is profitable.

56.6% of farmers argue that hemp growing will not be more profitable than other products such as tea and hazelnuts.

56.7% of farmers stated that they would turn to hemp growing if government support was increased.

Table 4. Opinions and attitudes of farmers towards hemp growing*

Opinions and attitudes	Farm groups			
	Group 1 (<1.5 ha)	Group 2 (1.5-3.0 ha)	Group 3 (>3.1 ha)	General
I prefer to grow hemp for fiber purposes	3.36	3.52	3.13	3.33
I prefer to grow hemp for seed purposes	3.30	3.22	2.67	3.07
I think growing hemp for fiber purposes is more profitable	3.03	2.96	2.73	2.91
I think growing hemp for seed purposes is more profitable	3.06	2.59	2.73	2.81
I prefer to grow hemp individually	3.75	2.81	3.33	3.33
I prefer to grow hemp on a contract basis	3.48	2.96	3.73	3.41
I do not favor hemp growing due to intense controls.	2.12	1.96	1.86	1.99
I am hesitant to focus on the production of a new product	4.55	3.59	4.40	4.21
I have prejudices towards growing hemp	1.82	2.19	1.73	1.90
I think hemp growing is profitable	3.53	3.22	2.87	3.21
I think the production of other products is more profitable (tea, hazelnuts, etc.)	2.42	2.52	1.97	2.30
If government support is increased, I may decide to grow hemp.	3.42	3.92	2.73	3.34

*1: Strongly disagree, 2: Disagree, 3: Undecided, 4: Agree, 5: Strongly agree
Source: Results of this study.

In a study conducted in Vezirköprü district of Samsun province, Türkiye the net profit that could be obtained from fiber hemp production was determined as 3,812 US$/ha, and the net profit that could be obtained by producing seeds and fiber together was 4,333 US$/ha [4].In another study conducted in the same region, the net profit that could be obtained from seed hemp production was determined as 2,032 USUS$/ha, the net profit that could be obtained from fiber hemp production was 5,721 US$/ha, and the net profit that could be obtained by producing seeds and fiber together was determined as 8,233 US$/ha [47]. In another study, it was determined that the production of seeds and fiber together gave more profitable results [9]. These results show the economic feasibility of hemp production.

Farmers in the research region produce more tea. In recent years, due to problems in tea production and the fact that most tea plantations are close to reaching the end of their economic life, farmers are turning to alternatives. As a matter of fact, in a study conducted in Rize province, it was determined that farmers gained losses from tea [53]. In another study conducted in Rize province, 56% of the farmers stated that they encountered problems in marketing fresh tea [33]. Considering the soil structure and climate conditions in Rize province, conditions and opportunities for hemp are important.

The Ministry of Agriculture and Forestry provides field-based input (fertilizer and diesel), premium (difference payment), organic and good agricultural practices support to farmers engaged in crop production in Türkiye. In addition, low-interest loan supports are also available. Farmers who will grow hemp can also benefit from area-based input supports. However, there is no premium or direct income support for hemp. Studies on the appropriate support model for hemp are continuing in the Ministry of Agriculture and Forestry. At this stage, the opinions and expectations of the farmers are also important. The farmers within the scope of the study do not find the current support for hemp sufficient. They also think that the types of supports should be increased. Farmers believe that input prices have increased recently, and that work should be done in this direction (Table 5). As a matter of fact, in a study conducted in Vezirköprü district of Samsun province, farmers stated that the most important problem in hemp growing is the increases in input prices [52].

Table 5. Opinions of farmers regarding government supports in hemp growing*

Opinions	Farm groups			
	Group 1 (<1.5 ha)	Group 2 (1.5-3.0 ha)	Group 3 (>3.1 ha)	General
Hemp growing supports in Türkiye is enough	1.45	1.63	1.67	1.58
Input prices should be reduced instead of cash payments	4.15	3.74	3.87	3.93
The types of supports applied are sufficient	1.55	1.74	1.70	1.66
Farmers use the supports they receive for their intended purpose	1.15	1.70	1.63	1.48
Supports do not affect my production decisions	2.03	1.77	2.60	2.15

*1: Strongly disagree, 2: Disagree, 3: Undecided, 4: Agree, 5: Strongly agree
Source: Results of this study.

In the study, Best-Worst analysis was performed to determine the government support practices that farmers consider important and unimportant. According to the results of the best-worst analysis, the most important support practices that farmers expect from the government for hemp growing are providing suitable land, supplying seeds and meeting needs through grants. Farmers do not consider tool-equipment support and credit provision of government important for hemp growing (Table 6). In the study, Fuzzy Paired Comparison analysis was performed to determine the criteria that farmers will give importance to when growing hemp.

Table 6. Results of Best-Worst analysis

Support applications	Best frequency (B)	Worst frequency (W)	Mean (B-W)
Premium	0	3	-0.0333
Grant	16	5	0.1222
Credit	0	17	-0.1889
Diesel fuel	1	1	0.0000
Fertilizer	4	1	0.0333
Seed	20	2	0.2000
Land	34	11	0.2555
Organization	6	8	-0.0222
Direct income	8	2	0.0667
Tools-equipment	0	40	-0.4444
Control	1	0	0.0111

Source: Results of this study.

Table 7. Results of Fuzzy Paired Comparison analysis

Criteria	Minimum	Maximum	Mean	Standard deviation	Order of importance
Climate conditions	0.100	0.900	0.587	0.173	1
Soil structure	0.119	0.900	0.579	0.183	2
Yield	0.100	0.874	0.549	0.158	3
Production cost	0.100	0.900	0.324	0.162	4
Government supports	0.100	0.900	0.304	0.180	5
Price	0.100	0.900	0.262	0.163	6
Friedman test is significant at p<0.01. Kendall's W: 0.362					

Source: Results of this study.

Farmers were presented with six criteria to determine their decision preferences. These criteria: climate conditions, soil structure, yield, production cost, government supports and price. In the study, 15 comparisons of six different criteria were presented to each farmer. Results were evaluated using the Friedman Test and Kendall's coefficient of concordance. According to the analysis results, the most important criterion that farmers consider for growing hemp was determined to be climate conditions. This is followed by soil structure, yield, production costs, government supports and price, respectively. The Friedman test shows that there is a statistical difference between preferences. In this study, Kendall's W value was determined as 0.362. Accordingly, when determining the weights of important criteria, the harmony between farmers is at a poor level (Table 7).

CONCLUSIONS

In this study conducted in the Findikli district of Rize province, the trends and expectations of farmers regarding hemp production were analyzed. According to the study results, 46.7% of the farmers have grown hemp before. However, it has been determined that farmers need more information about hemp growing. 48.9% of farmers are willing to grow hemp individually and 35.6% under contract. Farmers do not find the current supports sufficient and think that they should be diversified. For example, land use, seed supply and grant support are among their expectations. 36.6% of farmers think that hemp growing is profitable. 56.6% of farmers argue that hemp growing will not be more profitable than other products such as tea and hazelnuts. 56.7% of farmers stated that they would turn to hemp growing if government support was increased. The most important criteria that farmers will consider for growing hemp are climate conditions, soil structure and yield, respectively.

The Black Sea Region and Rize, one of the provinces in this region, is a region where hemp production can be achieved at low cost due to the soil type and rainfall amount. For hemp growing to develop in this region, the expectations of the farmers must be met. From this perspective, the development of local varieties, the solution of the marketing problem, the increase of extension efforts and the development of appropriate support tools are among the most important expectations.

In recent years, hemp breeding and variety development efforts in Türkiye have yielded important results. Samsun Ondokuz Mayis University started its activities and in cooperation with the Black Sea Agricultural Research Institute, Narlisaray hemp variety with low Tetrahydrocannabinol (THC) rate and high fiber and stem yield was developed. The Ministry of Agriculture and Forestry has assigned the General Directorate of Agricultural Enterprises (GDAE) to propagate the Narlisaray variety. To prevent the genetic structure of the Narlisaray variety from being damaged, GDAE carried out seed production in 4 hectares of land in the Gökhöyük farm in 2019, through contract production, and in 12.7 hectares of land in the Narlisaray village of Vezirköprü district. The Ministry of Agriculture and Forestry currently produces and distributes seeds for farmers. The Ministry is currently working on developing an appropriate support model for hemp. On the other hand, efforts are being made to encourage the private sector to demand and process products in this field. On January 11, 2019, the "Report and Action Plan on Industrial Hemp Growing in Türkiye" was prepared with the participation of the Ministry of Agriculture and Forestry, the Ministry of Industry and Technology, the Ministry of Health, Turkish Scientific and Technological Research Council and Samsun Ondokuz Mayis University [2].

Most of the hemp fiber needed in Türkiye is met by imports. It is predicted that hemp fiber imports will decrease in the coming years in parallel with the increase in hemp growing areas in Türkiye. Hemp yield in Türkiye is low compared to other countries. Reducing production and operating costs and increasing efficiency depends on the development of agricultural techniques and mechanization. To solve these problems in Türkiye, the project "Improving Agricultural Techniques and Mechanization in Plants from whose Stems Fiber is Obtained, Reducing Production and Operating Costs" was developed in partnership with the public and private sectors, with the support of the General Directorate of Agricultural Research.

The hemp market in Türkiye is developing. Hemp seeds can enter the oil sector, functional and health food sector and nutraceutical sectors. There is a growing market for hemp oil in cosmetics and body care products. It has high potential for the pet and veterinary markets. For hemp fiber; textile, composites, construction materials, animal bedding, pulp and paper products sectors are important markets. In hemp growing, marketing the fiber by separating it by machine or traditional method makes it less profitable than marketing it without separating the fiber from the stem. However, mechanized agriculture is recommended especially when it is desired to obtain fiber [4].

Some measures need to be taken to increase hemp production in Türkiye. First, farmers should be informed about hemp production and be made aware of the importance of its production. Regions and farmers with knowledge about hemp production should be designated as pilot regions and production should be encouraged. Varieties with low THC content should be developed to facilitate controlled growing and control. Varieties suitable for country and regional adaptations should be developed and registered, local and national hemp varieties should be used. State-controlled seed production should be increased, and farmers should be prevented from purchasing seeds at high prices. Production costs should be reduced and productivity per hectare should be increased by improving mechanization in production. Cooperation between industrialists and farmers should be ensured and the contract farming model should be encouraged to meet the annual need for industrial hemp raw materials. The hemp processing industry should be developed and encouraged. In conclusion, if these measures are taken, Türkiye will be able to benefit significantly from hemp and at the same time, the competitiveness of Turkish hemp in the foreign market will be increased.

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