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DETERMINATION OF COLOR PROPERTIES OF SOME SEEDS

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Abstract

The aim of this research to determine of color properties of seed related to help in safe passage for seed through cleaning and separation processes. Also investigate some seed properties can be used in design and development of multi-seed planting machine. Soya bean, wheat, corn, cotton faba bean and sunflowers were tested at department of agriculture engineering, faculty of agriculture, Tanta University, Egypt. Through 2022. The design of feed mechanism system required easy movement for seeds this is a critically moving during the filling of the feed disk, so must detriments of the small differences in the surface area and topography of the grains and determine some image analyses. There are clear differences between faba bean and soybean in Hue value was 0. 626. the intensity, and the browning index was 91.75 and 16.25 in faba bean while in soybean were 0. 565,85.33, and 21.79 respectively. While the differences between corn and wheat in Hue value was 0. 699.Also the intensity, and the browning index was 100.08, 17.30 in corn while in wheat were 0. 708. 97.94, and 13.38 respectively. Also, clear differences between cotton and sunflowers in Hue value was 0. 634. Also the intensity, and the Black & White band was 87.40, and 87.40 in cotton while in sunflowers were 0. 480, 96.75 and 96.75 respectively.

Key words: *soya bean, wheat, corn, cotton, faba bean, sunflowers, color properties*

INTRODUCTION

Faba bean is the most important food legume crop and the most important cool season food and feed legume crop grown in many countries around the world. The crop is adaptable to a wide range of soil types and environmental conditions. More than 4.1 million households reported growing the crop on nearly 0.5 million hectares of land, yielding over one million tonnes of grain [3].

Soybean, Glycine max (L.), is gaining popularity in Sub-Saharan Africa and other parts of the world because of its economic potential for poverty alleviation and nutrition improvement. Despite its classification as an oilseed, soybean has a significant protein content. To accommodate the increased demand for human consumption (e.g., soy milk) and industrial products, (e.g., oil). Soybean production in developing nations is hampered by a lack of access to and availability of high-quality seeds [6].

One of the most frequently farmed cereal crops, maize (*Zea Mays* L.), is widely utilised for food, forages, and industrial raw materials. Variety purity, as an important component in maize seed quality evaluation, has a significant impact on final yield and farmer economic benefits [9]. Wheat is the world's most mechanized crop in world, thus particles and mechanical components are constantly in contact during wheat seeding, harvesting, grading, storage, and other processes [13].

Cotton is the world's most widely produced fiber and oil crop. The epidermis of the seed coat creates cotton fibres, and the embryo produces oils and proteins [14].

Sunflower is an important oil seed and food crop, and it produce 10% of oil in the world. Because of its superior quality and high stability, sunflower oil is primarily used in food applications [7] [5].For a phenotyping method to be suitable for large-scale crop research, it must be non-destructive and effective. Advanced tools, such as light detection and range (LiDAR) or hyperspectral cameras, can provide detailed information, but they are usually expensive and difficult to use for people with non-engineering backgrounds. On the other hand, red, green and blue (RGB) cameras have long been used in agricultural research. They are inexpensive and easy to use, and modern models can capture images with high spatial accuracy, as it allows many complex image processing and analysis techniques to be able to extract and analyze different features from RGB images. A developed image analysis technology has also been used to determine the dimensions of the seeds using a flatbed scanner. for documentation through MATLAB program, which showed this technique a strong correlation between image analysis and experimental data for Egyptian maize and beans and the length and width of soybeans [2], [11].

There is predictability of end-season legume traits from the color and texture traits of seed images at the beginning of planting, where 140 color traits and 315 texture traits were derived based on the gray-level presence matrix from each image, and 5 techniques for fve regression classification. The best results were obtained by using the cube method as the regression method and using the random forest as the classification method. Yield (RMSE = 9.82, R2 = 0.68), maturity (RMSE = 3.70, R2 = 0.76) and seed size (RMSE = 1.63, R2 = 0.53) were identified as the possible early soybean traits. On the other hand, soybean, maize and wheat seeds scored the highest value for red (155.5, 144.9, 98), (156.4, 116, 41), (117, 89.2, 46.5) for red, green and blue, respectively [15], [8].

In the seeds of sunflower cultivars some traits such as color differed, illumination was chosen as a control factor. Four types of illumination were adopted for the studies: red (R = 255, G = 0, B = 0), green (R = 0, G = 255, B = 0), blue (R = 0, G = 0, B = 255) and white (R = 255, G = 255, B = 255). RGB metric values vary according to the equation used to define the metric,with some indicators having negative values, others positive, with sizes close to zero, and in some cases up to 2,348.3. The results showed that each channel had a maximum value that changes depending on the color of the seeds, for black. R = 182–189, G = 194–202, B = 211–218, and for white R = 112–118, G = 124–129, B = 133–139 [12], [1].

A digital image analysis (DIA) algorithm was developed to facilitate the classification of individual wheat grains using their compositional characteristics. Compositional features of individual nuclei are extracted from the different colors of the image to determine the color or gamut group that yields the highest classification accuracy in the grain. To reduce the computational time of the algorithm, the original grayscale values (250) were reduced to 32, 16, 8 or 4 grayscale values, the synthetic features extracted from each condition were used for classification and the results were compared. Compositional features extracted from green bars with a maximum gray level of 8 yielded the highest classification accuracy in grains. Using the best 15 features in the texture model, the classification accuracy for wheat was 85.2 and the classification accuracy for wheat was 87.0 [10]. The results show that stepwise regression models achieve quality predictions with coefficients of determination (R2) of 0.6949 for germination direction and 0.7148 for germination rate based on four distinct color parameters (R/(R + G + B), G/(R + G + B), (RG- B)/(R + G), and R/G), and the determination parameters passed the 0.01 test level [4]. The main objective of this research to determine of color properties of seed by image analyses. Also detriments of the small differences between (faba bean and soybean), (corn and wheat) and (cotton and sunflowers) by color indices.

MATERIALS AND METHODS

The experiment was carried out through 2022 at the Department of Agriculture Engineering, Faculty of Agriculture, Egypt, to verify the physical and optical properties of different seeds. These characteristics are used in the design and development of a metering device plate. Seeds dimensions were tested under a moisture level of 8 %. The current study was devoted to certain types of grains, which are Faba bean, Soybean, Corn, Wheat, Cotton, Sunflowers which were obtained from the Agricultural Research Centre. Samples were randomly selected and cleaned by hand as shown in

Measurements and determinations

- Optical properties

MATLAB software was used to measure the three additive primary colors of seeds, namely

(RGB). The 'R' value represents the red band, the 'G' value represents the green band, and the 'B' value represents the blue band. Also, Hue, the intensity was measured for all Varieties. Also, Black & White were used for cotton and sunflowers seeds, and a digital colorimeter was used to measure (L a b) for the browning index was calculated as:

-Hue band

$$H = \cos^{-1}\left\{\frac{\left(\frac{2R-G-B}{2}\right)}{((R-G)^2+(R-B)(G-B))^{0.5}}\right\} \text{.........(1)}$$

-Intensity, candela= lumen per Ste radian

$$I = \frac{1}{3}(R+G+B) \text{ ....(2)}$$

$$I2 = (R-B)/2 \text{.......... ....(3)}$$

-Black & White

$$B\&W = \{(R+G+B)/3\} \text{ .... (4)}$$

$$X1 = (3R+2G+1B)/6 \text{ ... .(5)}$$

$$X2 = (2R+1G+3B)/6 \text{ .... (6)}$$

$$X3 = (1R+3G+2B)/6 \text{ .... (7)}$$

-Browning Index

$$BI = \frac{100*(X-0.31)}{0.17} \text{..............................(8)}$$

$$X = \frac{a+1.75L}{5.645L+a-0.3012b} \text{.......................(9)}$$

where:
RGB Red, Green, Blue Bands
L=lightness of the colour, which range from 0 (dark) to 100 (white).
a =indicates green colour.
-b =indicates blue colour
+b =indicates yellow colour.

RESULTS AND DISCUSSIONS

The optical properties of various grains (Faba bean, soybean, corn, wheat, cotton, and sunflowers) were measured and statistically analyzed. The relationship between seeds optical properties and colour indices, Black & White, and browning index is depicted in figures (1 through 6).

Faba bean

The results showed, the different colours bands for faba bean seeds. The R color band ranged from 113 to 171, in B color band ranged from 23 to 86, and in G color band ranged from 75to 153 while Hue was 0.167 to0 .836, and the intensity ranged from74 to 138.6. Browning index ranged from 2.37 to 30.63 as shown in Fig. 1.

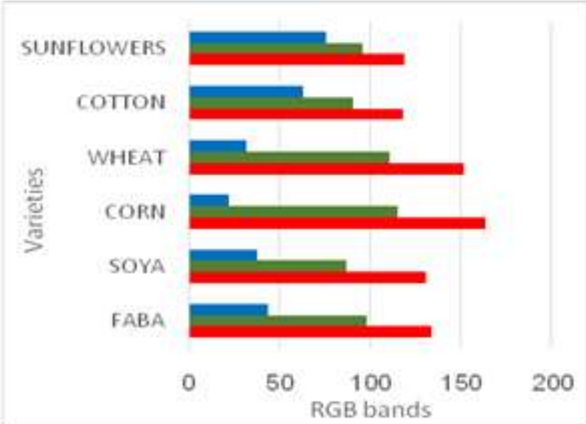

Fig. 1. The relationship between RGB bands and different varieties of seeds.
Source: Authors' determination.

Soyabean

The results showed, the different colors bands for soya bean seeds. The r color band ranged from 75 to 160, in b color band ranged from 18 to 65, and in g color band ranged from 55 to 111 while hue was 0.226 to 0.806, and the intensity ranged from 69 to 149.33. Browning index ranged from 4.48 to 60.28.as shown in Fig. 2.

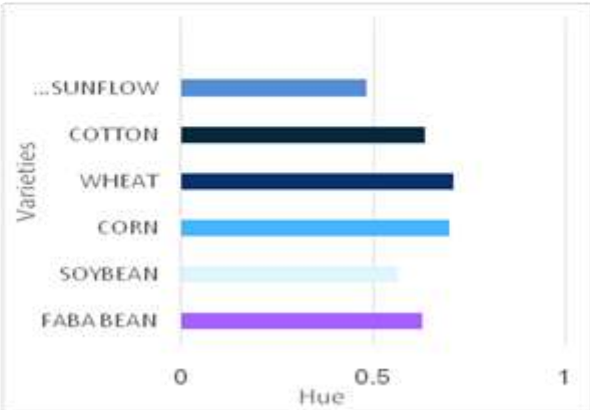

Fig. 2. The relationship between Hue and different varieties of seeds.
Source: Authors' determination.

Corn

The results showed, the different colors bands for corn seeds. The r color band ranged from 117 to 188, in b color band ranged from 4 to 121, and in g color band ranged from 78 to 158 while hue was 0.360 to 0.826,and the intensity ranged from 53.33 to 101.33.

Browning index ranged from 4.57 to 37.13.as shown in Fig. 3.

Fig. 3. The relationship between intensity and different varieties of seeds.
Source: Authors' determination.

Wheat

The results showed, the different colors bands for wheat seeds. The r color band ranged from 132 to 187, in b color band ranged from 12 to 83, and in g color band ranged from 85 to 150 while hue was 0.563 to 0.798, and the intensity ranged from 81.33 to 137.67. Browning index ranged from 3.17 to 31.91.as shown in Fig. 4.

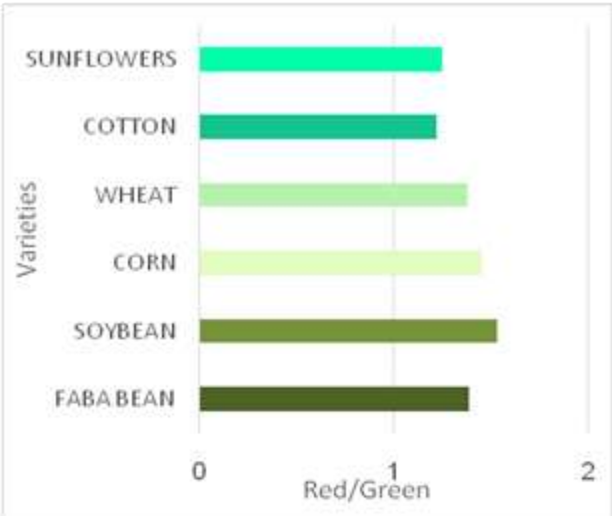

Fig. 4. The relationship between Red /Green band and different varieties of seeds.
Source: Authors' determination.

Cotton

The results showed, the different colors bands for cotton seeds. The R color band ranged from 82 to 103, in B color band ranged from 47 to 92, and in G color band ranged from 65 to 116 while Hue was 0.294 to 0.953,and the intensity ranged from 69.67 to 108.33. Black & White ranged from 69.67 to 108.33.as shown in Fig. 5.

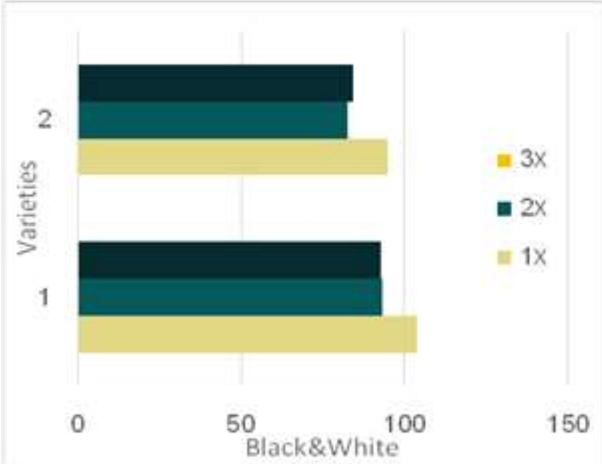

Fig. 5. The relationship between Black & White and cotton (1), sunflowers (2) seeds.
Source: Authors' determination.

Sunflower

The results showed, the different colors bands for sunflowers seeds. the Red color band ranged from 90 to 149, in B color band ranged from 55 to 97, and in G color band ranged from 75 to 134 while Hue was 0.146 to 0.847, and the intensity ranged from 76.67 to 126. Black & White ranged from 76.67 to 126.as shown in Fig. 6.

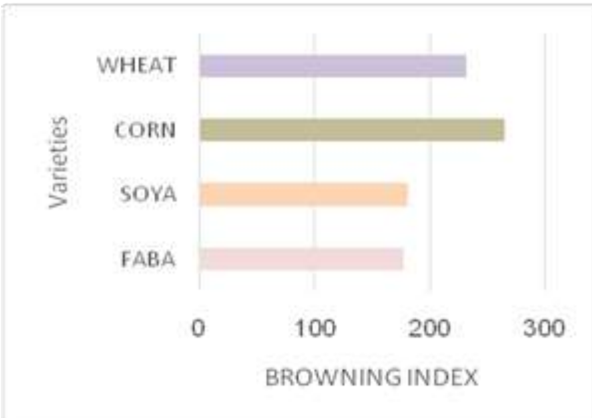

Fig 6. The relationship between Browning index and faba bean, soybean, corn, wheat seeds.
Source: Authors' determination

CONCLUSIONS

The results showed, the average of faba bean for the Red color band was 133.63, in Blue color band was 43.68, and in Green color band was 97,94 while Hue was 0. 626.Also the intensity, and the browning index was 91.75, 16.25 respectively.

The results showed, the average of soybean for the Red color band was 130.73, in Blue color band was 37,94, and in Green color band was 87.31 while Hue was 0. 565.Also the intensity, and the browning index was 85.33, 21.79 respectively.

The results showed, the average of corn for the Red color band was 163.21, in Blue color band was 22, and in Green color band was 115.05 while Hue was0. 699.Also the intensity, and the browning index was 100.08, 17.30 respectively.

The results showed, the average of wheat for the Red color band was 151.42, in Blue color band was 31.36 and in Green color band was 110.78 while Hue was0. 708.Also the intensity, and the browning index was 97.94, 13.38 respectively.

The results showed, the average of cotton for the Red color band was 118, in Blue color band was 62.94 and in Green color band was 90.42 while Hue was 0. 634.Also the intensity, and the Black & White band was 87.40, 87.40 respectively.

The results showed, the average of sunflowers for the Red color band was 118.97, in Blue color band was 75.63 and in Green color band was 95.68 while Hue was 0. 480.Also the intensity, and the Black & White band was 96.75, 96.75 respectively.

In terms of optical properties, certain crops have no databases so we can't possibly construct, design, or develop equipment for various activities on these crops in modern ways.

In order to achieve the greatest accuracy and the least time to extract the color characteristics, it is recommended to use an assistant programming program such as Matlab and others from the Digital Image Analysis (DIA) algorithm for analysis of every pixel in the image.

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THE VARIATION OF A WHEAT QUALITY INDEX IN RELATION TO MINERAL FERTILIZATION; CASE STUDY ON STARCH

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Abstract

The study evaluated the variation of starch content (ST) in wheat grains, under the influence of mineral fertilization. The experimental were organized and carried out in the period 2020 - 2021, within the SCDA Lovrin, Romania. The Ciprian wheat variety was cultivated by appropriate culture technology, in non-irrigated system, on a chernozem type soil. Three doses for nitrogen was applied (0, 60 and 120 kg ha^{-1}), two doses for phosphorus (0 and 60 kg ha^{-1}), and four doses for potassium (0, 40, 80 and 120 kg ha^{-1}). The starch content (ST, %) was determined by the non-destructive method (NIR), PERTEN INFRAMATIC 9200 device. Values of the starch content were recorded between 68.60–72.17±0.30% in the conditions of 2020 year, 69.15–72.73±0.26% in the conditions of 2021 year, respectively 68.94–72.42±0.28% as average values, over the study period. The data series distribution, average values over study period, was as a normal type, and safety vas confirmed by correlation coefficient (values between r=0.829 in the case of V15, and r=0.985 in the case of V10). ST variation, depending to N and PK (as a direct and interaction effect of fertilizers), was evaluated by regression analysis (R^2=0.880, p<0.001). Based on the values of the coefficients of the obtained equation, the optimal values for N and PK were calculated and the values x_{opt}=75.10 kg N ha^{-1} active substance (a.s.), and y_{opt}=120.00 kg PK ha^{-1} a.s. were obtained. The Cluster analysis used, facilitated the grouping of the tested variants, based on the Euclidean distances, in relation to the starch content values recorded in the wheat grains.

Key words: *cluster analysis, mineral fertilization, optimal doses, starch, wheat*

INTRODUCTION

Wheat is one of the world's main agricultural crops, providing basic resources for human and animal nutrition, as well as for various economic sectors [2, 19]. Wheat production is characterized based on numerous indices, in relation to which it has different directions of use [11, 15]. The quality indices of wheat production are primarily a genetic attribute of the cultivated biological material [25].
The quality level of wheat grains was studied as a result of the interaction [genotype x environment], environmental factors having a variable influence on the cultivated genotypes [5, 20]. The quality level of wheat production is at the same time the result of the interaction [plants x culture technology], through which farmers ensure optimal conditions for growth and development of the wheat crop, and compensate as much as possible the unfavourable effect (sometimes) of environmental factors [27].
Wheat quality indices have been studied by appropriate methods, from different perspectives, genetic, molecular, chemical, biochemical, physical, etc. in order to characterize different genotypes of wheat of importance for food, or fodder for animals, to evaluate the "genotype × environment" interaction, and to control quality indices through crop technologies [13]. Certain wheat quality indices have been studied in relation to different genotypes and growing conditions [6], and with climatic conditions [14]. Wheat quality traits and indices were also studied in order to identify key influencing factors [10]. Within the crop technologies, fertilization has a particularly important role in relation to quality indices of wheat production [28]. The role and importance of nutritional elements (macro- and micronutrient) were evaluated in different cultivated wheat genotypes, in relation to soil and climate conditions, with

plant physiological indices, quality indices and the destination of wheat production [3, 16].

The present study evaluated the variation of starch content in wheat grains in relation to mineral fertilization with NPK, and calculated the optimal doses, in relation to starch content.

MATERIALS AND METHODS

The study was carried out in 2020 - 2021 period, within the SCDA Lovrin, Romania. The wheat crop (Ciprian variety) was placed on a cambic chernozem soil type (medium fertility level), in a non-irrigated cropping system, and an adequate culture technology was ensured.

Mineral fertilizers were applie in three doses in the case of nitrogen (0, 60 and 120 kg a.s. ha^{-1}), in two fertilization levels in the case of phosphorus (0 and 60 kg a.s. ha^{-1}) and in four fertilization levels in the case of potassium (0, 40, 80 and 120 kg a.s. ha^{-1}). Fertilizers with phosphorus and potassium fertilizers were applied in the fall and incorporated with the basic soil work. Nitrogen fertilizers were applied in spring, in two rounds. The variation of the starch content in the wheat grains was evaluated, in relation to the applied mineral fertilization. Starch was determined by the non-destructive method (NIR), PERTEN INFRAMATIC 9200 device.

The analysis of the results was done by appropriate statistical methods, related to established statistical safety parameters (p, r, R^2, Coph.corr.), and the PAST [4] and Wolfram Alpha [23] software were used.

RESULTS AND DISCUSSIONS

Fertilization with mineral fertilizers, applied to the soil, in different doses of nitrogen (N), phosphorus (P), and potassium (K) influenced the nutrition of wheat plants, the Ciprian variety, and determined the variation of the starch content (ST) in the grains of wheat. Also, differences were recorded during the two experimental years, 2020 and 2021, at the same doses of fertilizers. Values of the starch content were recorded between 68.60–72.17±0.30% in the conditions of 2020 year, 69.15–72.73±0.26% in the conditions of 2021 year, respectively 68.94–72.42±0.28% in the case of the average values over the two experimental years. The values of the starch content (ST, %) for the two experimental years, and the average value, are presented in Table 1. The analysis by the Anova test (Alpha=0.001), confirmed the statistical reliability for experimental data, and the presence of the variance in the data set (Table 2).

Table 1. The values of the starch content of wheat, the Ciprian variety, during the study period

Trial	Fertilizers			Experimental period		
	N	P	K	2020	2021	Average values
V1	0	0	0	71.93	72.25	72.09
V2	0	0	40	71.78	72.73	72.25
V3	0	0	80	72.17	72.68	72.42
V4	0	0	120	71.93	71.85	71.89
V5	60	0	0	70.33	70.75	70.54
V6	60	0	40	70.30	71.03	70.66
V7	60	0	80	70.43	71.05	70.74
V8	60	0	120	70.35	70.35	70.35
V9	60	80	0	70.60	70.95	70.78
V10	60	80	40	70.60	71.08	70.84
V11	60	80	80	69.93	71.20	70.56
V12	60	80	120	70.48	71.13	70.80
V13	120	80	0	68.73	69.15	68.94
V14	120	80	40	68.60	69.43	69.01
V15	120	80	80	68.60	70.28	69.44
V16	120	80	120	68.63	69.88	69.25
SE				±0.30	±0.26	±0.28

Source: original data recorded from the experiment.

Table 2. ANOVA test

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	148.223	15	9.88157	17.2972	1.33E-22	2.8035
Within Groups	63.9834	112	0.57128			
Total	212.207	127				

Source: original data recorded from the calculation.

The distribution of the data series (average values), is presented graphically in Figure 1, as normal probability plot, under conditions of statistical safety, assessed on the basis of the correlation values (r), with values that fell between r=0.829 in the case V15, to r=0.985 in the case of V10. The graphic representation of the average values for the starch content (ST) on the experimental variants is presented in Figure 2, in the form of a radial plot, with the highlighting of the peaks of values on the directions of the variants' representation.

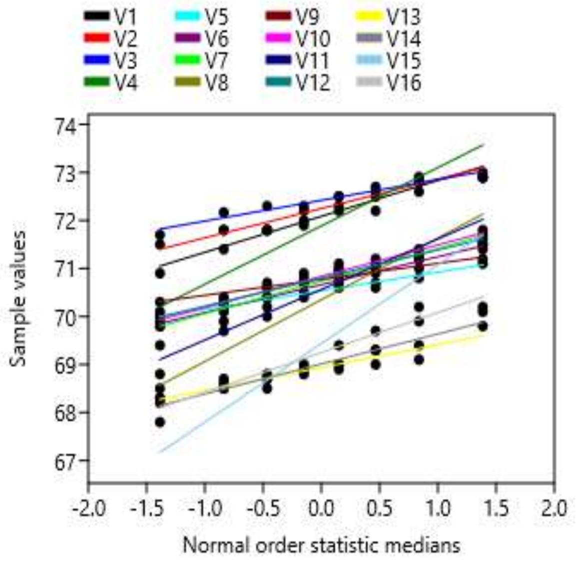

Fig. 1. The graphic distribution of the data series for starch content, as normal probability plot
Source: original graph based on experimental data.

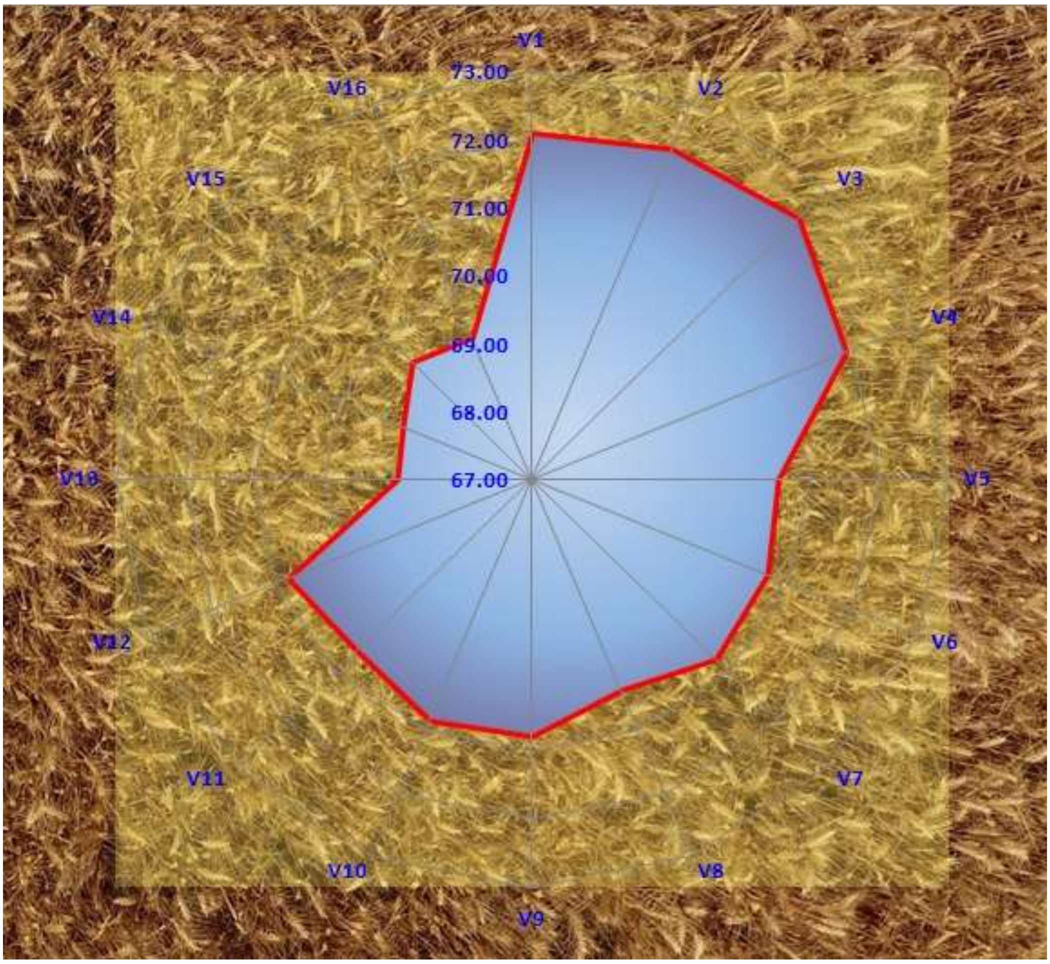

Fig. 2. The graphic representation of the starch content values in wheat, the Ciprian variety
Source: original graph based on experimental data.

The simple regression analysis facilitated the obtaining of equation (1), which described the variation of the starch content (ST) in the wheat grains, as direct relation with the applied fertilizers (NPK), under conditions of R^2=0.794, p<0.001.

$$ST = 0.630 \cdot N - 0.271 \cdot P + 0.468 \cdot K \quad (1)$$

where: ST – starch content (%);
N – nitrogen fertilizer;
P – phosphorus fertilizer;
K – potassium fertilizer

Equation (2) was also obtained through regression analysis, which described starch content variation, in relation to N and PK fertilizers (as a direct, and as interaction effect), under safety conditions (R^2=0.880, $p<0.001$). The graphic distribution regarding starch content variation in relation to applied fertilizers is presented in figure 3 in the form of 3D model, and in figure 4, in the form of isoquants. Based on the values of the coefficients of equation (2), the optimal values for N and PK were calculated and the values x_{opt}=75.10 kg ha^{-1} a.s. were found. N, and y_{opt}=120.00 kg ha^{-1} a.s. PK.

$$ST = ax^2 + by^2 + cx + dy + exy + f \quad (2)$$

where: ST – starch content (%);
x – nitrogen fertilizer (N, kg a.s. ha^{-1});
y – phosphorus and potassium fertilizer (PK, kg a.s. ha^{-1});
a, b, c, d, e, f – coefficients of the equation (2);
a= -0.00044939;
b= -0.00078700;
c= 0.92653190;
d= 0.72647611;
e= -0.00715836;
f= 0

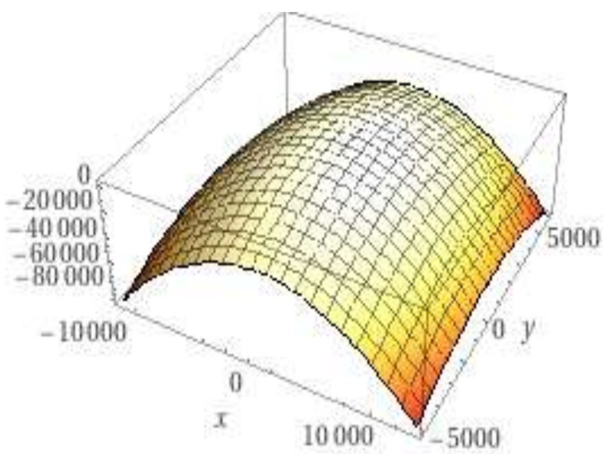

Fig. 3. 3D model of the variation of starch content (ST) in wheat depending on N (x-axis), and PK (y-axis)
Source: original graph.

The cluster analysis facilitated the obtaining of the dendrogram of of the variants association based on similarity, in relation to the values of starch content, depending on the applied mineral fertilization (Coph. corr.=0.842) (Figure 5).

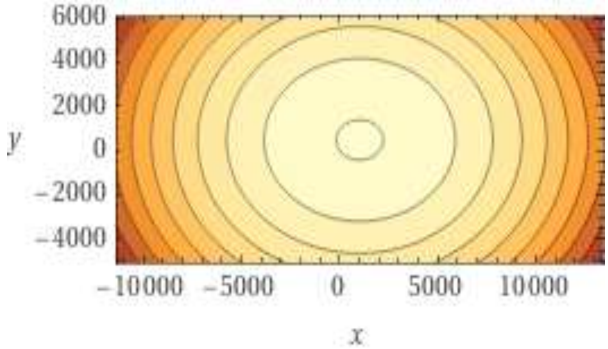

Fig. 4. Model in the form of isoquants, which represents starch content variation depending on N (x-axis), and PK (y-axis)
Source: original graph.

Two clusters resulted, each comprising several variants. The V1, V2, V3 and V4 variants within the C1 cluster were associated with the highest starch content. Variants V13, V14, V15 and V16 were associated within cluster C2, subcluster C2-1, with the lowest starch content.
The other variants were associated within cluster C2, subcluster C2-2, with intermediate values, regarding starch content. From the analysis of the dendrogram in figure 5, as well as the values of the SDI index (Table 3), the highest level of similarity was found between the V5 and V11 variants, respectively between the V9 and V12 variants, with the value SDI=0.02.
Based on the grouping of the variants, according to the similarity level for the starch content (expressed in Figure 5), and in relation to the average value for starch content (ST=70.66%), a graphic analysis was done additionally, in order to evaluate the position of each experimental variants in relation to the average starch content (Figure 6).
Starch is considered an important quality index for wheat grains, in relation to the use of wheat production for baking and pastry (bread, cookies, noodles, etc.).

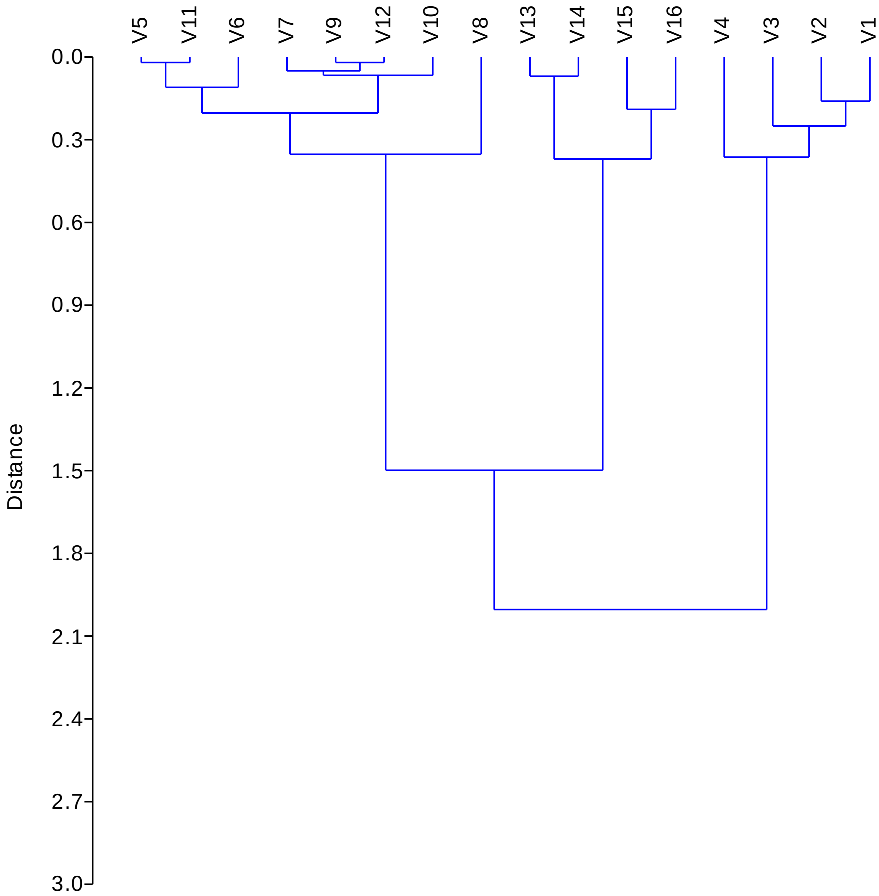

Fig. 5. Dendrogram of association of the variants according to the values of the starch content, the Ciprian wheat variety
Source: original dendrogram obtained on the basis of experimental data.

Table 3. SDI values for the variation of starch content in relation to mineral fertilization in wheat, the Ciprian variety

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16
V1		0.16	0.33	0.20	1.55	1.43	1.35	1.74	1.31	1.25	1.53	1.29	3.15	3.08	2.65	2.84
V2	0.16		0.17	0.36	1.71	1.59	1.51	1.90	1.47	1.41	1.69	1.45	3.31	3.24	2.81	3.00
V3	0.33	0.17		0.53	1.88	1.76	1.68	2.07	1.64	1.58	1.86	1.62	3.48	3.41	2.98	3.17
V4	0.20	0.36	0.53		1.35	1.23	1.15	1.54	1.11	1.05	1.33	1.09	2.95	2.88	2.45	2.64
V5	1.55	1.71	1.88	1.35		0.12	0.20	0.19	0.24	0.30	0.02	0.26	1.60	1.53	1.10	1.29
V6	1.43	1.59	1.76	1.23	0.12		0.08	0.31	0.12	0.18	0.10	0.14	1.72	1.65	1.22	1.41
V7	1.35	1.51	1.68	1.15	0.20	0.08		0.39	0.04	0.10	0.18	0.06	1.80	1.73	1.30	1.49
V8	1.74	1.90	2.07	1.54	0.19	0.31	0.39		0.43	0.49	0.21	0.45	1.41	1.34	0.91	1.10
V9	1.31	1.47	1.64	1.11	0.24	0.12	0.04	0.43		0.06	0.22	0.02	1.84	1.77	1.34	1.53
V10	1.25	1.41	1.58	1.05	0.30	0.18	0.10	0.49	0.06		0.28	0.04	1.90	1.83	1.40	1.59
V11	1.53	1.69	1.86	1.33	0.02	0.10	0.18	0.21	0.22	0.28		0.24	1.62	1.55	1.12	1.31
V12	1.29	1.45	1.62	1.09	0.26	0.14	0.06	0.45	0.02	0.04	0.24		1.86	1.79	1.36	1.55
V13	3.15	3.31	3.48	2.95	1.60	1.72	1.80	1.41	1.84	1.90	1.62	1.86		0.07	0.50	0.31
V14	3.08	3.24	3.41	2.88	1.53	1.65	1.73	1.34	1.77	1.83	1.55	1.79	0.07		0.43	0.24
V15	2.65	2.81	2.98	2.45	1.10	1.22	1.30	0.91	1.34	1.40	1.12	1.36	0.50	0.43		0.19
V16	2.84	3.00	3.17	2.64	1.29	1.41	1.49	1.10	1.53	1.59	1.31	1.55	0.31	0.24	0.19	

Source: original data obtained by calculation.

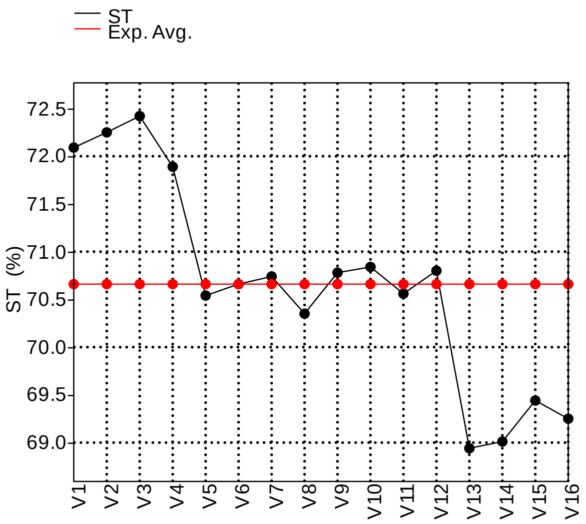

Fig. 6. The variants positioning based on starch content, in relation to average value (red line) on experiment
Source: original graph.

The synthesis and accumulation of starch, as well as the particularities related to the composition, structure, and transformations of starch have been studied in relation to genetic and environmental factors, and starch shows a greater sensitivity to thermal and water stress compared to other quality indices, such as be, for example, proteins [8].

Fertilization represents an important technological element for the variation of starch content in wheat. Xiong et al. (2014) [24] reported the variation in the distribution of starch granules in the grain endosperm, in relation to the level of nitrogen (0, and 240 kg ha^{-1} nitrogen), and the results suggested that high doses of nitrogen caused an increase in the number of small starch granules, and the decrease of large starch granules, variable but in different regions of the endosperm. Studying two different genotypes in relation to the water and nitrogen regime, Tong et al. (2021) [21] found the different response of the starch content in the two varieties, both in relation to water and nitrogen.

In relation to phosphorus, Zhang et al. (2018) [26] found changes in starch morphology, as well as in some genes expression, genes involved in wheat grains starch biosynthesis and degradation. The authors found and communicated that the 46 kg ha^{-1} phosphorus level, determined the increase in the genes expression associated to starch synthesis, the better accumulation of starch in wheat grains, and the starch granules formed at the respective phosphorus level released a much larger number of seeds reducing, compared to the starch formed at higher levels of phosphorus. The variation of the proportions of starch granules (surface area and volume) in grains of different wheat varieties, in relation to phosphorus fertilization, was also identified in other studies [9, 12].

In relation to potassium, some studies have confirmed the important role of potassium in improving photosynthesis, increasing stress tolerance of wheat plants, improving production, synthesis and translocation of starch in wheat grains, and ensuring optimal nutrition with potassium through fertilization is necessary [22].

Some studies evaluated the interaction of some microelements with basic macro-elements in wheat fertilization, in relation to plant nutrition status, productivity elements and wheat quality indices [1, 7].

The need to optimize wheat fertilization was also argued from the perspective of increasing the coefficient of utilization of nutritional elements, with a favourable impact on physical production, or on quality indices, as well as from considerations of the efficiency of the use of fertilizing resources, agricultural yields, and environmental protection [17, 18].

In relation to the present study conditions, the fertilizers optimal values, calculated according to the starch content values registered (x_{opt}=75.10 kg ha^{-1} a.s. N, and y_{opt}=120.00 kg ha^{-1} a.s. PK), can be taken into account, as guideline fertilization values for obtaining similar results for this quality index, of course in relation to the cultivated genotype, culture technology and environmental conditions.

CONCLUSIONS

Mineral fertilization tested in this study (doses and combinations), determined the differentiated accumulation of starch content in wheat grains, Ciprian cultivar, in relation to the three nutrients (NPK) administered.

A tendency to decrease the starch content, associated with the increase in the total level of fertilization, was found in the experimental and study conditions.

The values of the starch content showed different levels during the two experimental years, under the same fertilization conditions, which shows the influence of the vegetation conditions in achieving the respective starch quality indices.

In relation to the applied fertilization doses, and the recorded starch content values, the optimal doses were calculated at the level of x_{opt}=75.10 kg ha^{-1} a.s. for N, and y_{opt}=120.00 kg ha^{-1} a.s. for PK, values that can be taken into account for other studies or agricultural practice.

The cluster analysis facilitated to obtain the grouping of the experimental variants, based on the similarity of the starch content, and makes it possible to choose the fertilization system (levels, combinations) in relation to the quality indices estimated for wheat (starch in this case) as well as the budget allocated for fertilization in framework of agricultural technology.

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ASSESSMENT OF THE IMPACT OF MACROECONOMIC FACTORS ON UNEMPLOYMENT: LITHUANIAN CASE

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Abstract

This paper analyses the effect of inflation, gross domestic product (GDP) growth, and average salary on unemployment in Lithuania for the period from 2001 to 2021. First, the theoretical analysis is performed to review the links between inflation, GDP growth, average salary, and unemployment. Considering that the theoretical analysis reveals the effect of three macroeconomic factors, i.e., inflation, GDP growth, and average salary, on unemployment, the methodology of the research is described. It relies on the multiple regression model and its estimation using ordinary least squares (OLS). Econometric analysis reveals that only one out of three macroeconomic factors, i.e., GDP growth, has a statistically significant effect on unemployment and this effect is negative (based on the sign of the regression coefficient). In addition, to address the autocorrelation problem in the regression model, a lagged unemployment variable is included to the model, and it shows a statistically significant positive (based on the sign of the regression coefficient) effect on unemployment. The future study could only cover the agricultural sector since this sector is important for Lithuania and the macroeconomic indicators of this sector are unique compared to other economic activities or general indicators of Lithuania.

Key words: *average salary, gross domestic product growth, inflation, ordinary least squares, unemployment*

INTRODUCTION

Unemployment is probably one of the most important macroeconomic phenomena in every country. Scientists define this phenomenon in different ways. Some of them talk about different duration of unemployment, some of them describe different types of unemployment, etc. [24] defines unemployment as a phenomenon that brings social and economic losses and occurs in the labour market when the production factor, i.e., labour, is not fully used, which means the unemployment of economically active (not working but looking for work or ready to work) people. [6] stresses that unemployment occurs when the supply of labour exceeds the demand for labour.

The unemployment rate as an indicator is expressed as the ratio of the unemployed to the labour force and multiplied by 100% to obtain the percentage unit of measurement. It can be observed that when there is a difficult time or crisis in the economy, the unemployment rate in the countries increases, and when the economy grows in a country, unemployment decreases.

Unemployment phenomenon is important because it makes it possible to see how many people in the country are unemployed and how much government spending will have to be allocated in order to pay benefits to the unemployed. This factor can be important not only for the country but also for various companies that need employees. When a business or company expands into new markets, it is very important to analyse the economic situation in the region or country. And one of the factors that they may need to analyse is unemployment. According to that, the company can decide whether it will be difficult to find employees in a new market or whether it will have enough resources.

The focus of this paper is the analysis of the main macroeconomic factors affecting unemployment. These factors are inflation, GDP, and average salary as they are the most commonly used in the scientific literature analysing the effects on unemployment.

The relationship between inflation and unemployment is quite clearly reflected in the

Phillips curve which shows that as inflation increases, the unemployment in the country decreases and vice versa. However, there have been instances when both the country's inflation and unemployment rates have increased. Such a phenomenon is called "stagflation"[5]. [39 and 32] and other scientists also wrote about the relationship between inflation and unemployment.

The second factor that is quite often analysed by many scientists as affecting unemployment is economic growth. According to [4], economic growth can be measured by an increase in a total output of a country, i.e., gross national product, or real gross domestic product. The scientist explains that long-term economic growth has a positive effect on the national income and employment in the country. [11] and [22] also state that country‘s unemployment rate is greatly influenced by the pace of gross domestic product change. [43] who analyses the factors contributing to employment and unemployment, says that higher employment helps country's economy to grow faster. According to [28], economic growth is one of the most important macroeconomic goals as it raises tax revenues, improves the quality of individuals' lives, attracts public and private sector investment, and helps to create more new workplaces. [26] also explain that economic growth effectively contributes to the reduction of unemployment and poverty but cannot fully affect the unemployment rate on its own. [15] states that there is a negative relation between GDP and the unemployment rate in the short-term span of time. This negative correlation between GDP and unemployment rate is defined by Okun's law [26]. As [10] mention, Okun's law states that when GDP falls by 2-3%, the unemployment rate rises by 1%. However, [25] didn't find any statistically significant effect of GDP on unemployment.

One more economic factor which has an impact on unemployment is salary. In the salary literature, studies that analyse the minimum salary (e.g., [7]) or average salary (e.g., [11], [37]) can be found. According to neoclassical theory, higher labour productivity is strongly associated with higher salaries [30]. As [7] notice, when companies increase the minimum salary, unemployment rate increases as well. The scientists also mention about the thoughts of Fetullah Akin in 2017 who states that the impact of the minimum salary on the unemployment rate depends on the duration, thus with an increase of the minimum salary, the unemployment rate rises in the short-term. In the long-term, an increase of the minimum salary reduces unemployment rate, as the country's overall demand and production amount increase [7].

It is worth mentioning that [11] and [37] describe inverse dependence of the average salary and unemployment rate.

Scientists also analyse other factors affecting unemployment. For example: tax wedge on labour (e.g., [16], [9], etc.), labour market regulations (e.g., [8], [15], etc.), international trade (e.g., [18], [19], etc.), gross fixed capital formation (e.g., [27], etc.), trade union density (e.g., [3], [38], etc.), wage bargaining coordination (e.g., [36], [29], etc.) and other factors.

Taking all of this into account, the *problem* of the research can be defined as follows: how inflation, gross domestic product, and average salary affect unemployment? The *object* of the research is the impact of some macroeconomic factors on unemployment. The paper *aims* to analyse the effect of the main macroeconomic factors on unemployment in Lithuania.

Few research *methods* were used for this paper. Firstly, comparative analysis of literature was performed. Then the data for the research was collected and the statistical analysis was carried out. Finally, with collected data econometric analysis was conducted using ordinary least squares for time series data.

MATERIALS AND METHODS

The research is conducted using a multiple regression model for time series data. A general form of a multiple regression model is:

$$Y_t = b_0 + b_1X_{1t} + b_2X_{2t} + \ldots + u_t, \quad (1)$$

where:

Y refers to the dependent variable of the model;
X_1 and X_2 are independent variables of the model;
the coefficient b_0 represents the predicted value of Y when all Xs are equal to 0;
b_1 and b_2 coefficients denote the average predicted change in Y from a one unit increase in X_1 and X_2, respectively;
u_t is the error term; t denotes the time period [23].

In this study we analyse unemployment (*Unempl*) as the dependent variable (Y) of the regression model. Other macroeconomic factors that are included to the model, i.e., inflation (*Inflation*), GDP growth (*GDP*), and average salary (*ASalary*), are the independent variables (Xs) of the regression model. The regression model of this research can be presented as the following expression:

$$Unempl_t = b_0 + b_1 Inflation_t + b_2 GDP_t + b_3 ASalary_t + u_t \quad \text{....................(2)}$$

The measurement of the model variables is provided in Table 1.

Table 1. Variables of the model

Variable	Variable abbreviation	Indicator
Unemployment	*Unempl*	unemployment rate (% of total labour force)
Inflation	*Inflation*	inflation (annual %)
GDP growth	*GDP*	GDP growth (annual %)
Average salary	*ASalary*	average monthly salary (euros)

Source: Own determination.

Regression analysis of the model consists of few steps.

As the analysis of the relationship between the factors under consideration is described in the Introduction, here, there are mentioned only the steps that are related to the estimation and interpretation of the model.

First, collecting and analysing the data. Statistical analysis process allows to better understand the analysed data, to identify the trends, thus, it is an important step in the analysis.

Second, estimation of the regression model. At the beginning of this step, scatterplots analysis is used to check the spread of the data and to see how each observation interrelates. Scatterplots can show whether there is a linear or non-linear relationship between variables. Also, potential outliers' identification in the dataset is performed using standardized residual method. An observation is considered an outlier if the absolute magnitude of the standardized residual exceeds 3 standard deviations. In this study the ordinary least squares method is used for the estimation of the model. It is a common technique for the estimation of regression coefficients by minimizing the sum of squared residuals [17].

Third, verification of the model estimations and interpretation. The normality of residuals is tested by applying the Shapiro-Wilk test which rejects the hypothesis of normality when the p-value is less than or equal to 0.05. This test is used when the number of observations is less than 50 (the number of observations in this study is 21).

The problems of both multicollinearity and autocorrelation must be checked in the regression model. Bivariate correlation matrix is used to detect the problem of multicollinearity. If correlation coefficient among two independent variables of the model is higher than or equal to |0.8|, it indicates that variables are highly correlated and it causes the problem called multicollinearity. Durbin-Watson *d* test is used to detect the problem of autocorrelation. If the estimated value of *d* is closer to zero, there is evidence of positive autocorrelation, if it is closer to 4, there is evidence of negative autocorrelation, and the closer the value of *d* is to 2, the more evidence there is that there is no autocorrelation [20].

If the problem of autocorrelation is present in the regression model, a lagged dependent variable can be included to the regression model as an independent variable to solve this problem. Then the regression model can be expressed using the following equation:

$$Unempl_t = b_0 + b_1 Inflation_t + b_2 GDP_t + b_3 ASalary_t + b_4 Unempl_{t-1} + u_t, \quad \text{.................(3)}$$

where: $Unempl_{t-1}$ refers to a lagged (t-1) unemployment variable.
Durbin *h* statistic is used to check if the problem of autocorrelation is eliminated from the model, or it is still present in the model. This statistic is calculated using the following formula [20]:

$$h \approx \left(1 - \frac{d}{2}\right) \sqrt{\frac{n}{1 - n * \sigma^2}}, \quad \text{.................(4)}$$

where:
d refers to Durbin-Watson *d* statistic;
n is the sample size;
σ^2 denotes the variance of the estimator of the coefficient of lagged Y variable.
If the value of the Durbin *h* test is less than the critical value (in absolute terms; Student's t-test; 95% statistical significance), then there is no autocorrelation in the model; if the value is higher, there is autocorrelation [20].
The coefficient of determination is used to determine the goodness-of-fit of the model. This coefficient ranges from 0 to 1, and the closer it is to 1, the better the model. Also, the statistical significance of both the model (Fisher's F-test; $p<0.05$)) and the parameters / coefficients (using Student's t-test; $p<0.05$)) is evaluated.
Analysis covers the period 2001-2021 (an annual basis) in Lithuania. Data for the research were taken from The World Bank database and The Official Statistics Portal (hereinafter referred to as OSP) of Lithuania (Table 2). Data were analysed using SPSS statistical program.

Table 2. Data sources

Variable abbreviation	Data source
Unempl	The World Bank (2022a)[41]
GDP	The World Bank (2022b) [40]
Inflation	OSP (2022a) [33]
ASalary	OSP (2022b) [34]

Source: Own determination.

Based on the literature review and the research methodology, the following hypotheses were raised:
H1:Inflation negatively affects unemployment. The hypothesis is based on the research done by [5, 39, 32], etc.
H2: Economic growth has a negative effect on unemployment. This hypothesis is based on the previous research, such as [4, 11, 22, 43, 28, 26], etc.
H3: The average salary has a negative impact on unemployment. This is an expected outcome of the study, and it is based on the results of the research of other scientists (e.g., [11, 37, 30], etc.).

RESULTS AND DISCUSSIONS

Statistical data analysis

In this research Lithuanian unemployment, inflation, GDP growth, and average salary are analysed in 2001-2021. While analysing the collected data, first, main descriptive statistics are introduced. Mean, standard deviation (SD), minimum and maximum values of all four research variables are presented in Table 3. Table 4 represents Lithuanian data of unemployment, inflation, GDP growth, and average monthly salary in 2001-2021.

Table 3. Descriptive statistics

Variable abbreviation	Mean	SD	Min	Max
Unempl	10.12	3.93	4.25	17.81
Inflation	2.81	3.11	-1.30	10.60
GDP	4.06	5.15	-14.84	11.11
ASalary	686.94	362.13	284.50	1,579.40

Source: own calculations based on the data from The World Bank and OSP [33, 34, 35,40, 41].

The unemployment rate in Lithuania was not constant, increasing and decreasing trends can be observed in the analysed period. Since 2001 until 2007, unemployment in Lithuania was decreasing, this can be determined by various factors, such as creation of new businesses, the growth of economy, and as a result, new jobs were created, which led to the decreasing trend of unemployment.
Since 2007 until 2010, a sharp jump in the unemployment rate is noticeable, which was caused by the 2007-2008 global financial crisis.
Unemployment fell gradually between 2010 and 2019 in Lithuania.

Table 4. Lithuanian data, 2001-2021

Years	*Unempl*	*Inflation*	*GDP*	*ASalary*	Years	*Unempl*	*Inflation*	*GDP*	*ASalary*
2001	16.84	2.00	6.53	284.50	2012	13.36	2.80	3.84	615.10
2002	13.01	**-1.00**	6.75	293.60	2013	11.77	0.40	3.55	643.30
2003	12.87	**-1.30**	10.57	310.60	2014	10.70	-0.30	3.54	677.40
2004	10.68	2.90	6.57	332.90	2015	9.12	-0.10	2.02	714.10
2005	8.32	3.00	7.73	369.60	2016	7.86	1.70	2.52	774.00
2006	5.78	4.50	7.41	433.20	2017	7.07	3.90	4.28	840.00
2007	**4.25**	8.10	11.11	522.00	2018	6.15	1.90	3.99	***924.10***
2008	5.83	8.50	2.61	623.20	2019	6.26	2.70	4.57	***1,296.40***
2009	13.79	**1.30**	***-14.84***	***595.50***	2020	8.49	**0.20**	***-0.13***	1,428.60
2010	**17.81**	3.80	1.65	***575.80***	2021	7.11	**10.60**	5.00	1,579.40
2011	15.39	3.40	6.04	592.50					

Source: The World Bank and OSP [33, 34, 35,40, 41].

Each country's central bank aims to keep the country's price level stable. Typically, central banks set annual inflation target for the country and usually this target is around 2% in Eurozone countries [21]. As can be seen from Table 4, inflation in Lithuania during 2001-2021 period was quite varied, it both increased and decreased and was negative, which means that there was deflation. Since 2001 until 2003, annual inflation has been decreasing, and in 2002 and 2003 there was deflation, which means there was negative inflation, and the price level was falling or the value of money relative to goods was rising. Inflation increased from 2003 to 2008, but it fell dramatically in 2009. In 2020, inflation decreased, and the annual rate was very close to 0%; this could have been determined by the start of the global pandemic of the COVID-19 virus, and for the same reason, we see that in 2021, inflation increased significantly, and its rate was above 10%.

The biggest GDP drop was in 2009, when GDP fell very sharply, and economic growth turned negative (almost -15%). The main reason was global financial crisis that took place in 2007-2008 and which had a very strong impact on the economies of all countries, including Lithuania. Also, in 2020 economic growth again turned negative (about -0.13%), but it was not as high as in 2009. The reason of this fall was the global COVID-19 pandemic and the restrictions introduced by countries.

Average monthly salary grew for almost entire period of 2001-2021, except for 2009 and 2010, when, due to the global financial crisis in Lithuania, not only economic growth became negative, but also the average monthly salary decreased by about 28 euros. When comparing 2018 and 2019, we see a huge rise in the average monthly salary in Lithuania. During the year it increased by as much as 372 euros. The change in salaries was influenced by the changes in the tax system that came into force in 2019, i.e., the basic amount of the official salary was increased, the minimum monthly salary was also increased, the calculation of the tax-free amount of income changed [44].

Econometric analysis

At the beginning of an econometric analysis, scatterplot analysis is performed to check the spread of the data and to see how each observation interrelates. Scatterplots of the values of Y *vs* the corresponding values of X did not clearly show whether there is a linear or non-linear relationship between the variables under consideration.

The next step in econometric analysis is to check for outliers. They are described as abnormal observations that are far from other observations and that can have a negative impact on the study since they can change the coefficients of the regression model. In this paper, the standardized residual method to identify outliers is used. After analysing the outliers in the dataset using the standardized residual method, we can conclude that there are no outliers.

The Shapiro-Wilk normality test is used in this study to check the normality of the errors. After performing the Shapiro-Wilk normality test, the obtained p-value is equal to 0.07. Since the p-value is greater than 0.05, we conclude that the standard errors have a normal distribution. We also checked the mean and standard deviation values in the Shapiro-Wilk normality test. Based on the theory, the standard errors of a regression model have a normal distribution with a mean of 0 and a standard deviation of 1. In the case of our model, the mean is 0 and the standard deviation is about 0.92 which means that its value is very close to 1. Therefore, we came to the same conclusion that the standard errors have a normal distribution.

Next in our work, we checked for multicollinearity, i.e., whether the independent variables, in this case GDP, inflation, and average monthly salary, are not related to each other. To detect multicollinearity, we chose to calculate bivariate correlation coefficients. If the bivariate correlation coefficient is greater than |0.8|, then the multiple regression model will have a multicollinearity problem. Looking at the bivariate correlation coefficients in Table 5 and comparing them to |0.8|, we see that they are less than |0.8|, it means there are no highly correlated variables.

Also, since all p-values (Sig. (2-tailed)) of the correlation coefficients are greater than 0.05, the correlations between independent variables are statistically insignificant. We conclude that there is no multicollinearity problem in this multiple regression model.

Table 5. Bivariate correlation matrix

Variables	*Correlation*	*GDP*	*Inflation*	*ASalary*
GDP	Sig. (2-tailed)	1	0.47	0.31
	Correlation		0.17	-0.23
Inflation	Sig. (2-tailed)	0.47	1	0.21
	Correlation	0.17		0.29
ASalary	Sig. (2-tailed)	0.31	0.21	1
	Correlation	-0.23	0.29	

Source: own calculations based on the data from The World Bank and OSP [33, 34, 35,40, 41].

Since we have time series data, we further tested whether our model has autocorrelation problem. We used the Durbin-Watson *d* statistic to determine autocorrelation. After doing this test, we obtained d = 0.71. Since the estimated value of *d* is close to zero, there is evidence of positive autocorrelation in the model. We also tried to see graphically if there is an autocorrelation problem in the model. After including the lagged variable of the standardized residuals (ZRE(t-1); x axis), we drew the graph where the positive autocorrelation was visible since the points in the graph have an increasing trend from the left to the right (Figure 1).

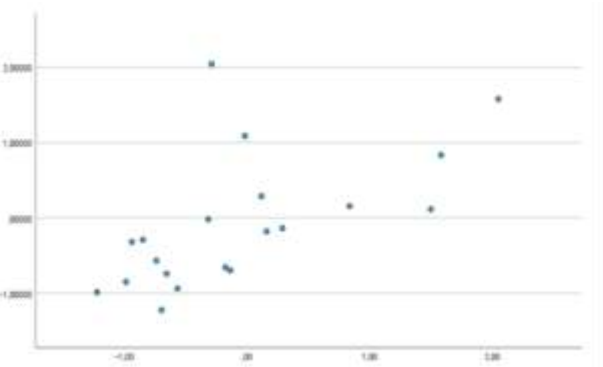

Fig. 1. Positive autocorrelation
Source: own calculations based on the data from The World Bank and OSP [33, 34, 35,40, 41].

In the next step, we removed autocorrelation by including a lagged dependent variable in the model. We created a new model with a lagged unemployment variable:

$$Unempl_t = b_0 + b_1 GDP_t + b_2 ASalary_t + b_3 Inflation_t + b_4 Unempl_{t-1} + u_t \quad ....(5)$$

Now, after running the Durbin-Watson test, we get d = 1.95. The standard deviation of the lagged dependent variable is equal to 0.12. We used Durbin's *h* statistic to check whether autocorrelation is still present in the model or it is eliminated:

$$h = (1 - (1.95/2))^* \sqrt{\frac{20}{1-20*0.12^2}} = 0.13 \quad ....(6)$$

The critical value of the Student’s t-test is equal to 2.09. Since 0.13<2.09, we make a conclusion that there is no autocorrelation in the model. Indeed, the graphical analysis of autocorrelation showed that the model no longer has this problem, as there is no visible relationship between the values (Figure 2).

Finally, the coefficients (three decimal digits since the coefficient of *ASalary* is small) of the regression model are presented in Table 6. Based on these coefficients, the equation of the regression model can be seen as the following:

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$Unempl_t = 3.141 - 0.396GDP_t - 0.001ASalary_t + 0.051Inflation_t + 0.841Unempl_{t-1}$.. (7)

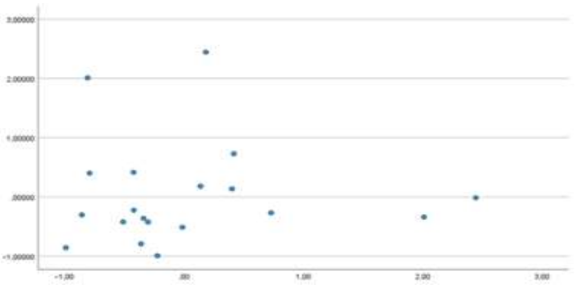

Fig. 2. No autocorrelation
Source: own calculations based on the data from The World Bank and OSP [33, 34, 35,40, 41].

Table 6. Coefficients of the regression model

Variables	Coefficients	p-value
Constant	3.141	0.106
GDP	-0.396	<0.001
ASalary	-0.001	0.505
Inflation	0.051	0.716
$Unempl_{t-1}$	0.841	<0.001

Source: own calculations.

The regression model is statistically significant (p-value of F-test is equal to 0.00). Only two variables in the regression model are statistically significant (p-value<0.05; Table 6). Interpretation of statistically significant coefficients: a one percentage point increase in GDP growth reduces unemployment rate by about 0.396 percentage point, holding other factors constant; a one percentage point increase in the previous year unemployment rate leads to, on average, a 0.841 percentage point increase in unemployment rate, holding other factors constant. Based on these results, we can state that only *H2* hypothesis is confirmed in this research.

The coefficient of determination which evaluates the fit of the model is equal to 0.85. It is close to 1, thus, it means that the model predicts very well. In other words, it means that the independent variables of the model explain 84.5% of the total variation in unemployment.

Agricultural indicators in Lithuania

Agriculture is one of the oldest businesses in Lithuania. From a historical perspective, Lithuania can be defined as an agricultural country and until now this sector is considered a priority sector of the country [2]. In terms of value added in Lithuania‘s agriculture, it increased in 2001-2021 period (Figure 3). Nevertheless, agriculture accounts only for about 3% in total Lithuania’s value added in the same period.

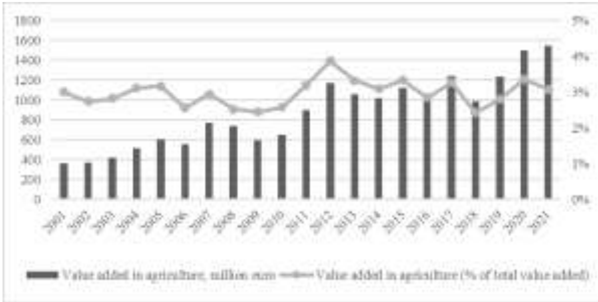

Fig. 3. Gross value added in Lithuania, 2001-2021
Source: own calculations based on the data from Eurostat [12].

According to [42], the importance of agriculture in the Lithuanian economy has been decreasing in the last decade. This was influenced by the decreasing number of rural residents - an average of 9,000 people leave the village and go to the cities every year. Analysing the migration data of the last fifty years, it can be noted that the rural population has halved.

In terms of Lithuanian labor force, a decrease in agricultural employment was observed in 2001-2020 (no available data for 2021) - compound average annual change rate of -5.9% (Figure 4). The share of agricultural employment in total employment sharply decreased in the same period - from 16% in 2001 to 5% in 2021.

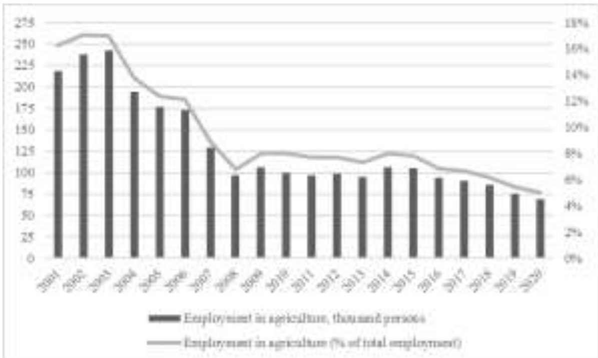

Fig. 4. Employment in Lithuania, 2001-2020
Source: own calculations based on the data from Eurostat [13].

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Agricultural income measured as index (2010=100) of the real income of factors in agriculture per annual work unit increased from 45.03 in 2001 to 189.06 in 2021. A rapid growth of agricultural income is observed in 2020 and 2021 (Figure 5).

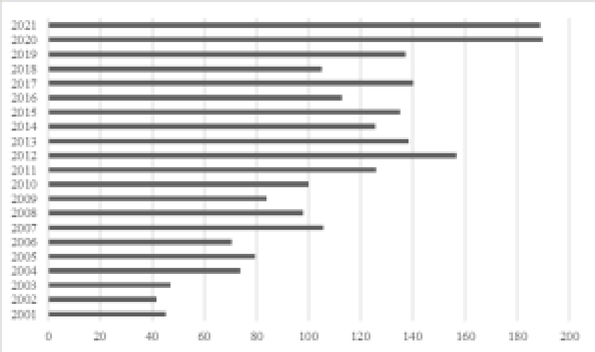

Fig. 5. Agricultural income in Lithuania (thousand euro), 2001-2021
Source: data from Eurostat [14].

Employee compensation as percent of gross value added in 2001-2021 varies between activities in Lithuania (Figure 6). It is the highest in services during the analysed period.

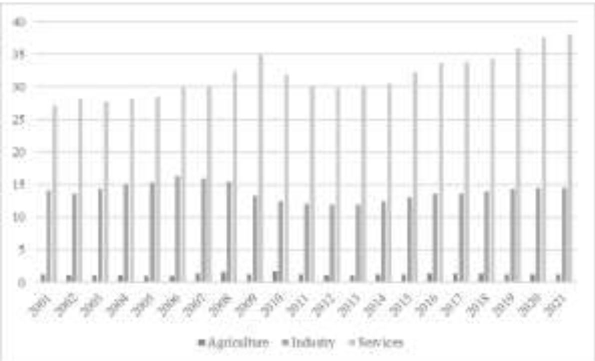

Fig. 6. Employee compensation in Lithuania (% of gross value added), 2001-2021
Source: data from OECD [31].

Inflation rate in agriculture can be reflected by the price indices of goods and services purchased for agricultural production purposes. Such goods and services include seeds, fuels, fertilizers, feeding stuffs, etc. Based on the data of [35], the highest price indices for agricultural production purposes in 2021 were for veterinary expenses (164.3 per cent), compound feeding stuffs for pigs (156.6 per cent), and herbicides (148.6 per cent) (2015=100), while the lowest price indices were for fungicides (65.1 per cent), other plant protection products (74.7 per cent), and PK fertilizers (76.3 per cent).

In conclusion, it can be said that the analysis of the indicators of the agricultural sector revealed that this sector has uniqueness, and this could be the incentive to conduct a study with the methodology applied in this work in the agricultural sector.

CONCLUSIONS

In this paper we analyse how unemployment is affected by such macroeconomic factors as inflation, GDP, and average salary since these factors are the most commonly used in the scientific literature. Based on the theory, each of the factors has a certain influence on the fluctuations of the unemployment rate. However, the empirical analysis revealed that not all factors have a statistically significant impact on unemployment.

The research covers the period from 2001 to 2021 in Lithuania. The methodology of the research relies on the multiple regression model; the method used for the analysis is ordinary least squares. Econometric analysis reveals that only one out of three macroeconomic factors, i.e., GDP growth, has a statistically significant effect on unemployment and this effect, based on the sign of the regression coefficient, is negative. It discloses that when GDP growth increases, unemployment decreases. The results prove the proposition of [1] who states that there is a negative relation between GDP and the unemployment rate. This negative correlation between gross domestic product and unemployment rate is defined by Okun's law [26].

To modify the regression model, a lagged unemployment variable is included, which shows a statistically significant positive (based on the sign of the regression coefficient) effect on unemployment, i.e., when a lagged (t-1) unemployment increases, unemployment (t period) also increases.

Based on the results of the research, hypothesis *H2* can be confirmed: economic growth negatively affects unemployment.

In the next research work the influence of various factors on unemployment in agriculture can be approached as analysis of agricultural indicators showed that this sector is important for Lithuania and it has various peculiarities.

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A WAY OF MITIGATION AND ADAPTATION TO CLIMATE CHANGE

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Abstract

Climate change is not only manifested by high temperatures, but means perverse, cascading effects that must be viewed in interaction. Climate change solutions can not only be cost-effective, but also improve the level and quality of life of the population while protecting the environment. In order to improve the situation, at the moment, the following actions are necessary: reducing emissions, adapting to the effects of climate change and financing the necessary adaptation measures. Photosynthesis, respiration, transpiration, stomatal conductance, assimilation, etc. can be used in the plant breeding process, with the aim of identifying plant genotypes with an increased potential for capturing CO_2 from the atmosphere, thus contributing to maintaining the global average temperature within the limits, which would not lead to the intensification of the greenhouse effect and the change of factors climatic. In order to carry out the study, grapevine genotypes of intraspecific origin from the V. vinifera L. and genotypes of interspecific origin (V. vinifera L. x M. rotundifolia Michx.) were used. The measurements were made in the period up to flowering, the formation (growth) of berries and in the period of mature berries (formed). Phytomonitoring was carried out with the help of the PTM-48A monitor, which is an automatic CO2 exchange monitoring system. Studies have shown that the interspecific grapevine genotypes are characterized by much better adaptive features than intraspecific genotypes in relation to climate change. The respective methodology can also be applied in the improvement process of different plant crops.

Key words: *climate change, genotypes, grapevine, photosynthesis, respiration, transpiration, stomatal conductance, assimilation*

INTRODUCTION

Climate change is an unprecedented challenge that human society has been facing, and the extent of its impact will largely depend on the level of awareness of the compromises that have to be reached and accepted globally. The real and alternative costs will increase with future climate change, affecting the health and economic well-being of the population. Therefore, the biggest challenge of society is to integrate sustainable strategies in the economic development. The development of society according to the principles of “green economy” provides for the restoration and maintenance of a sustainable, long-term balance between economic development and integrity of the natural environment, in forms understanded and accepted by society. The ability of living organisms to adapt to environmental conditions is a key factor in the evolutionary process. The adaptation of plants to climatic factors means nothing more than the modification of the physiological-biochemical and morphological-anatomical characteristics of the organism in the process of ontogenesis and the creation of other new criteria in the phylogenetic process. The adaptive potential of plants is their ability to survive, propagate and self-develop under the conditions of the ever-changing climate. Each organism has a certain ability to react to environmental factors, which is driven by the genetic code. Living organisms, during evolution, have developed certain capacities to react in response to climatic conditions. The coexistence of living organisms in a certain habitat is supported by heritability and genotypic changes. Due to genotypic changes, organisms adapt to environmental factors that are characteristic of a particular habitat. But due the development of new features, a normal existence of a newly formed genotype is possible under conditions where the initial variety could not develop normally. The process of photosynthesis of grapevine differs from that of other plants in the level, rate and degree of response to environmental and technological factors. All the green organs of a grapevine plant perform photosynthesis, but the main role in this process is performed by the leaf mesophyll. The dependence of photosynthesis on sunlight allows evaluating the efficiency of the use of light energy by the plant organism, this principle being established in the genetic code and represented by the mechanism of light energy use and the transformation of inorganic biogenic compounds into organic substances [8, 9]. Climate change doesn't just mean higher temperatures, it means perverse, cascading effects that must be viewed in interaction. Climate change solutions can not only be cost-effective, but also improve the level and quality of life of the population while protecting the environment. There are three general categories of actions: reducing emissions, adapting to the effects of climate change and financing the necessary adaptation measures [8].

MATERIALS AND METHODS

In order to carry out the respective study, grapevine genotypes of intraspecific origin from the *Vitis vinifera* L. group were used, such as: Muscat de Alexandria, Coarna Neagră, Sauvignon, Cabernet-Sauvignon etc.
Genotypes of interspecific origin (*Vitis vinifera* L. x *Muscadinia rotundifolia* Michx.), such as: Ametist, Alexandrina, Augustina, Nistreana, Malena, Sarmis, etc. [2]. The measurements were made in the pre-flowering stage of grapevine, In the fruit development stage, In the fruit maturation stage. Phytomonitoring was carried out with the help of the PTM-48A monitor, which is an automatic CO_2 exchange monitoring system. The system is equipped with four chambers for fixing on the leaf, which work sequentially, when one of the chambers is closed the others are open. The working mechanism of this system consists in the analysis of the gas exchange based on the concentration of CO_2 at the exit of the measuring chamber of the leaf in relation to the concentration of CO_2 in the environment at the time of measurement.
The statistical processing of the data was carried out by applying the Statistica 10 computer software (Stat sof INC, USA) and Microsoft Excel 2010 [5, 10, 1].

RESULTS AND DISCUSSIONS

The photosynthesis irradiance curve makes it possible to understand the eco-physiological characteristics of a species, and in turn, these indices give us the opportunity to compare different plant genotypes in more or less similar conditions, thus determining the productive capacity and resistance to environmental factors [3, 4, 6,11,7].
Analysing light intensity and photosynthetic activity *in the pre-flowering stage of grapevine* in intraspecific genotypes (Sauvignon, Muscat de Alexandria etc.) it was found that at a light intensity of 1,000-1,500 **μmol**/m^2*s, the photosynthetic activity was on average 7-9 μmol (CO_2)/m^2*s, and starting from the sunlight intensity of 1,500 μmol/m^2*s, the intensity of photosynthetic activity was declining. In the interspecific grapevine genotypes (Ametist, Augustina, Alexandrina, Regent, Viorica etc.), at a light intensity of 1,000-1,500 μmol/m^2*s, the photosynthetic intensity was on average 10-12 μmol (CO_2)/m^2*s, these indices of photosynthesis were maintained at an intensity of sunlight of 2,000-2,500 μmol/m^2*s.
In the fruit development stage, intraspecific genotypes (Sauvignon, Muscat de Alexandria etc.), at a light intensity of 1,000-1,500 μmol/m^2*s, demonstrated a photosynthetic activity of 8-10 μmol (CO_2)/m^2*s, these indices were also maintained at the light intensity of 2,000 μmol/m^2*s, then the intensity of photosynthesis decreased. Interspecific genotypes (Ametist, Augustina, Alexandrina, Regent, Viorica etc.) at a light intensity of 1,000-1,500 μmol/m^2*s, demonstrated a photosynthetic activity of 8-11 μmol (CO_2)/m^2*s, these indices were maintained at a light intensity of 2,000 μmol/m^2*s, and at a light intensity of 2,500

µmol/m^2*s there was a decrease in the photosynthetic activity.

In the fruit maturation stage, intraspecific genotypes (Sauvignon, Muscat de Alexandria etc.), at a light intensity of 1,000-1,500 µmol/m^2*s, demonstrated an average photosynthetic activity of 3-6 µmol (CO_2)/m^2*s, these indices were maintained up to a light intensity of 1,700 µmol/m^2*s, then they were decreasing. Interspecific genotypes (Ametist, Augustina, Alexandrina, Regent, Viorica etc.), at a light intensity of 1,000-1,500 µmol/m^2*s, demonstrated an average photosynthetic activity of 8-9 µmol (CO_2)/m^2*s, these indices of photosynthesis were maintained up to a light intensity of 2000 µmol (CO_2)/m^2*s, and at a higher light intensity the photosynthetic activity was characterized by a slight decrease.

The analysis of the transpiration rates depending on temperature fluctuations, *in the pre-flowering stage*, in the intraspecific genotypes of grapevine (Sauvignon, Muscat de Alexandria etc.) demonstrated that at a temperature of 15 °C, the transpiration rate was 4.5-6.0 mg/m^2*s, and at a temperature of 30 °C the transpiration rate was 25-30 mg/m^2*s. In interspecific genotypes (Ametist, Augustina, Alexandrina, Regent etc.), at the temperature of 15 °C, the transpiration rate was 3.75-5.25 mg/m^2*s, and at 30 °C, it was 23-26.5 mg/m^2*s.

In the fruit development stage, the intraspecific genotypes of grapevine (Sauvignon, Muscat de Alexandria etc.), at the temperature of 20 °C, had a transpiration rate of 4-5 mg/m^2*s, and at 35 °C, it was 50-55 mg/m^2*s. The intraspecific genotypes (Ametist, Augustina, Alexandrina, Regent etc.) at the temperature of 20 °C had a transpiration rate of 5.75-7.75 mg/m^2*s, and at 35 °C, it was 42.5-45 mg/m^2*s.

In the fruit maturation stage, the intraspecific genotypes (Sauvignon, Muscat de Alexandria etc.) at the temperature of 20 °C had a transpiration rate of 8-10 mg/m^2*s, and at 30 °C – 38-45 mg/m^2*s. The interspecific genotypes (Ametist, Augustina, Alexandrina, Regent etc.) at the air temperature of 20 °C had a transpiration rate of 7.75-9.75 mg/m^2*s, and at 35 °C – 35-40 mg/m^2*s.

The analysis of the relationship between stomatal conductance and light intensity has shown that *in the pre-flowering stage*, in the intraspecific genotypes of grapevine: Muscat de Alexandria, Coarnă Neagră etc. at a sunlight intensity of 1000 µmol/m^2*s, stomatal conductance was on average 0.2-0.4 mm/s, as the sunlight intensity increases to 2,000 µmol/m^2*s, stomatal conductance decreased to 0.1-0.2 mm/s. In the interspecific genotypes: Ametist, Alexandrina, Augustina etc., at a sunlight intensity of 1,000-1,500 µmol/m^2*s, stomatal conductance was 1.5-2.0 mm/s, and at an intensity of 2,000 µmol/m^2*s, stomatal conductance was 0.7-1.2 mm/s.

In the fruit development stage, in the intraspecific genotypes of grapevine: Muscat de Alexandria, Coarnă Neagră etc., at a light intensity of 1,000 µmol/m^2*s, stomatal conductance was 0.5-0.8 mm/s, and at the light intensity of 2,000 µmol/m^2*s, it was 0.4-0.6 mm/s. In the interspecific grapevine genotypes Ametist, Alexandrina, Augustina etc., at a light intensity of 1,000 µmol/m^2*s, stomatal conductance was 1.5-2.2 mm/s, and at the light intensity of 2,000 µmol/m^2*s, it was 2.5-3.5 mm/s.

In the fruit maturation stage, in the intraspecific genotypes: Muscat de Alexandria, Coarnă Neagră etc. at a sunlight intensity of 1,000 µmol/m^2*s, stomatal conductance was on average 0.8-1.2 mm/s, and at the light intensity of 2,000 µmol/m^2*s – 0.2-0.5 mm/s. In the interspecific grapevine genotypes: Augustina, Alexandrina, Ametist etc., at a light intensity of 1000 µmol/m^2*s, stomatal conductance was 2.5-3.5 mm/s, and at 2000 µmol/m^2*s, stomatal conductance was 1.5-2.5 mm/s. While studying photosynthesis and assimilation in relation to respiration in intraspecific grapevine genotypes, such as: Muscat de Alexandria, Sauvignon, Coarna Neagră etc., it was found that at the intensity of photosynthetic activity of 8-10 µmol (CO_2)/m^2*s, real assimilation was 8-9 µmol (CO_2)/m^2*s, and the activity of the respiration process was in the range of 1.0-1.4 µmol (CO_2)/m^2*s. In interspecific genotypes, such as: Algumax, Ametist, Nistreana, Augustina etc., at an intensity of the photosynthesis of 12-15 µmol (CO_2)/m^2*s, the real assimilation was 12-14 μmol (CO_2)/m^2*s, and the intensity of the respiration process was 0.8-2.0 μmol (CO_2)/m^2*s. Studies have shown that the interspecific grapevine genotypes are characterized by much better adaptive features than intraspecific genotypes in relation to climate change. The adaptability of organisms is a key issue in the process of evolution. The adaptation of plants to climatic factors is nothing more than the modification of the physiological-biochemical and morphological-anatomical characters of the organism in the process of ontogenesis and the creation of new capacities in the phylogenetic process. The adaptation potential of plants represents their ability to survive, multiply and self-develop in the continuous change of climatic factors [2, 11, 7].

CONCLUSIONS

Taking into account the effectiveness of physiological processes, such as: photosynthesis, respiration, transpiration, stomatal conductance, assimilation etc., in the process of plant breeding, it is possible to identify plant genotypes with an increased potential for capturing carbon dioxide from the atmosphere, thus helping to maintain the global average temperature within limits that would not lead to an intensification of the greenhouse effect and climate change.

This method can also be applied in the process of breeding different plant crops. In this case, it is necessary to apply techniques and methods of plant breeding to create plant genotypes that will be used to expand the forest areas, to stop desertification processes, to create protective forest belts, for the sustainable use of agricultural and other types of land etc., and which will be characterized by a high efficiency of the photosynthesis process under the new climatic conditions.

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METHODS FOR THE BIOCONVERSION OF MINERAL FERTILIZERS INTO GREEN FODDER ON A PEAT BOG

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Abstract

The article presents the results of the fifth year of research in a two-factor field experiments, all variants were compared with absolute control without overseeding and fertilizer application. The agroeconomic and agro-energy efficiency of the use of the studied agricultural practices has been determined. An analysis of the agroeconomic and energy assessment showed that the combination of the use of direct sowing and fertilizers over five years of observation and research (from 2017 to 2021) was effective and contributed to a reduction in the cost of 100 feed unit ha-1 by an average of 41-46%; obtaining the greatest profit – 376-826 $ ha-1. The highest payback of a feed unit of 1 kg of NPK was also noted in variants with a cultivated phytocenosis, this indicator increased by 1.2-1.6 times compared to the natural phytocenosis. It was found that the use of overseeding against the background of NPK increased the energy efficiency from 1.6-2.0 to 2.9-3.4. Therefore, taking into account the recoupment of energy costs, we can conclude that N60P90K120 and both doses of NPK in a cultivated phytocenosis can be considered energetically optimal doses of fertilizers in a natural phytocenosis.

Key words: *small-contour developed peat, mineral fertilizer, perennial grasses, sowing without damaging the sod, net income, profitability, agro-energy coefficient*

INTRODUCTION

When solving environmental issues of using and protecting depleted peatlands, the issue of creating cultivated long-term hayfields on peat soils is topical. Perennial grasses are adapted to the conditions of depleted peatlands: they utilize the energy of the sun, atmospheric precipitation, use soil nitrogen more fully, are characterized by longevity and a long growing season, during which they are alienated several times, which determines the characteristics of their mineral nutrition and the need for fertilizers [4, 7, 10, 11].

The use of indicators of agronomic, economic and energy efficiency makes it possible to identify the most profitable options for the use of fertilizer in combination with overseeding and without it, which can be used in agricultural production when growing herbs on a peat bog.

The purpose of the research is to develop effective low-cost agro-biotechnological methods for using the developed small-scale peatland in agricultural production in terms of cost and energy.

MATERIALS AND METHODS

The studies were carried out from 2017 to 2021 in the Vladimir region at the Baigush peat deposit, the type of peat is transitional (A -15.4%, R - 45%). The soil is bog-podzolic (Gleyic (Histic) Albeluvisols) with the following agrochemical indicators: humus content - 1.86 - 2.0%, pHKCl - 6.1-6.4; the content of mobile phosphorus is 56-75 mg/kg of soil, exchangeable potassium is 46.5-58.2 mg/kg, the thickness of the arable layer is 27-39 cm.

On a small part of one of the five peat maps, which was more cultivated and less than the others was in a flooded state, in 2017 a field experiment was laid to determine the effectiveness of using a direct sowing of a mixture of seeds of red clover and timothy meadow in undisturbed sod, and applying various doses mineral fertilizers on the productivity of meadow phytocenosis and soil fertility [1].

The studies were carried out according to the following experience scheme:

1. NF - natural phytocenosis without oversowing clover-timothy mixture - absolute control
2. CF - cultural phytocenosis with overseeding of clover-timothy mixture
3. NF + N60 P60 K90
4. CF + N60 P60 K90
5. NF + N60 P90 K120
6. CF +N60 P90 K120

The plot area is 62.5 m^2 (12.5 × 5 m), 4-fold repetition, the total area under the experiment is 0.15 ha.

Phosphorus, potash and some nitrogen fertilizers were applied during the spring regrowth of grasses. The rest of the nitrogen fertilizers were applied after grass mowing. Research work was based on the methodology for conducting experiments on hayfields and pastures [9]. Soil and plant samples were analyzed in the laboratory using the following methods: pHkcl - according to the TsINAO method (GOST 26483-85); hydrolytic acidity - according to the Kappen method in the modification of TsINAO (GOST 26212-91); the sum of absorbed bases - according to the Kappen method (GOST 27821-88); mobile compounds of phosphorus and potassium - according to the Kirsanov method in the modification of TsINAO (GOST R 54650-2011). The nitrifying capacity of the soil was determined by the Kravkov method, the cellulolytic activity was determined by the application method, and the density and density of the solid phase of the soil was determined by the gravimetric method. Analysis of plant samples was carried out in the laboratory by the following methods: nitrogen content according to GOST R 51417-99 with further conversion into crude protein (coefficient 6.25), phosphorus - according to GOST 26657-97, potassium - according to GOST 30504-97; dry matter content - according to GOST 31640-2012 [12].

Accounting for the yield of grasses was carried out at the onset of the beginning of the phase of flowering of leguminous plants and earing of cereals. Determination of the quality of perennial grasses was carried out using generally established methods [2, 13], calculations of the economic and energy efficiency of agricultural practices were performed using methods for determining the agronomic and economic efficiency of fertilizers in the forage production system [5, 6, 8]. The main indicators of the agronomic efficiency of the studied methods are the yield increase [3]. When calculating the economic and energy efficiency, the costs of seeds, fertilizers, sowing, harvesting and product refinement were taken into account. Energy performance indicators include specific energy consumption of energy per unit of crop and energy return (agro-energy coefficient). Marketable yield was estimated in $ kg-1 in current year prices. For an objective assessment of the studied agricultural practices, they were compared with the basic technology used in areas with thin peat-bog soils, including the following operations: cutting shrubs and small forests with a brush cutter, non-moldboard plowing and harrowing; disking in several tracks; layout; fertilizer application; rolling; sowing; mowing. Doses of fertilizer application, data on the productivity of grasses for the basic technology are taken as in the option "cultivated phytocenosis + N60P90K120".

RESULTS AND DISCUSSIONS

The influence of the studied agricultural practices on the agrochemical characteristics of the soil are presented in table 1. The content of phosphorus and potassium available to plants in the variants with the use of mineral fertilizers increased on average 2-3 times compared to the variants without fertilizers. The increase over five years of research in variants without fertilizers was ~5 mg/kg of mobile phosphorus and ~10 mg/kg of exchangeable potassium. At the same time, in the fertilized variants, the increase relative to the initial content of available phosphorus and potassium was 50-74 mg/kg and 87-118 mg/kg, respectively. The application of the studied methods did not have a negative impact on the pH values in the root layer of the soil of the field experimental plot.

Table 1. Agrochemical characteristics of the soil of the experimental plot (0-20 cm)

Options	pH		Mobile Phosphorus content, mg kg^{-1}		Exchangeable Potassium content, mg kg^{-1}	
	1*	2*	1*	2*	1*	2*
NF- natural phytocenosis	6.2	6.15	51.7	55.5	40.8	50.4
CF- cultural phytocenosis	6.05	6.35	48.4	52.1	32.1	56.8
NF+N60P60K90	6.2	6.64	51.7	102	40.8	146
CF+ N60P60K90	6.05	6.06	48.4	126	32.1	150
NF+ N60P90K120	6.2	6.29	51.7	110	40.8	128
CF+ N60P90K120	6.05	6.14	48.4	102	32.1	123

Note: 1* - before laying the experience, 2* - at the end of the fifth year of research
Source: Own calculation.

Thus, it can be concluded that the use of mineral fertilizers contributed to the accumulation of reserves of mobile phosphorus and potassium compounds in the arable soil layer, which reduced the risk of soil degradation in the developed peat bog. The application of the studied agricultural practices had an impact on the yield of green mass of the herbage. For four years of economic use of grasses, their yield of grasses against the background of mineral fertilizers in combination with oversowing significantly exceeded the control variant, as well as the variant with oversowing without fertilizers (Table 2).

Table 2. Productivity of green mass of perennial grasses for four years of economic use, t ha-1

Options	Years of use				Average	Collection on average for four years	
	2018	2019	2020	2021		f.u.*	d.p.*
Natural phytocenosis							
Without fertilizer (control)	0.34	0.65	7.8	2.4	2.8	0.56	0.18
N60H60K90	0.86	2.53	16.4	7.4	6.8	1.36	0.28
N60P90K120	1.0	3.85	21.9	8.0	8.7	1.73	0.36
Cultural phytocenosis							
Without fertilizer	1.92	2.3	14.2	4.5	5.7	1.14	0.24
N60H60K90	2.46	5.01	27.6	13.5	12.1	2.43	0.51
N60P90K120	2.34	6.12	28.6	15.0	12.9	2.58	0.55
$LSD*_{0.5}$	0.4	1.3	2.7	3.0			
$LSD_{0.5}$ factor A	0.1	0.8	1.9	2.2.			
$LSD_{0.5}$ factor B	0.3	0.9	1.6	1.8			

*Note: f.u. – feed unit; d.p. – digestible protein; LSD - least significant difference; factor A – overseeding; factor B - fertilizer application
Source: Own calculation.

The highest productivity of grasses was noted with the combined use of agricultural practices and, on average, exceeded the control by 4.3-4.8 times, the use of only overseeding allowed to increase the productivity of grasses by 2 times, and the use of only fertilizers without overseeding - on average 2.8-3 times. The use of overseeding and the annual application of mineral fertilizers had a positive effect on the nutritional value of grasses: the content of feed units and digestible protein in grass yields per 1 ha. A similar trend in the influence of agricultural practices in the cultivation of clover-timothy mixture was also noted when calculating the content digestible protein in the resulting green fodder. An assessment of the agroeconomic efficiency of the studied agricultural practices over a five-year period is presented in Table 3. The combination of fertilizers with overseeding provided the highest net income (376-826 $ ha-1) and profitability (72.2-85.5%), the indicator the payback of a feed unit of 1 kg of NPK increased by 1.2-1.6 times compared with the options with natural phytocenosis.

Table 3. Agro-economic efficiency of using direct sowing and application of fertilizers on an exhausted peatland when growing perennial grasses (five years in total)

Options	Collections feed units, T ha^{-1}	Conditionally net income, \$ ha^{-1}	Profitability, %	Payback, f.u./1 kg NPK
Natural phytocenosis				
Without fertilizer (control)	2.23	-	-	-
N60H60K90	5.44	77.8	8.4	3.1
N60P90K120	6.94	210	19.8	3.5
Cultural phytocenosis				
Without fertilizer	4.58	376	79.8	-
N60H60K90	9.71	826	85.5	4.9(7.1)*
N60P90K120	10.4	803	72.2	4.3(6)*
Basic technology				
N60P90K120	10.4	561	41.4	3.1

Note: * to control.
Source: Own calculation.

The energy assessment of the studied agrobiotechnologies was carried out taking into account four main indicators: the collection of metabolizable energy from 1 ha, their payback from the collection of metabolizable energy - the agro-energy coefficient (energy return) and the unit costs per 1 Giga Joule (GJ) produced. Such an analysis makes it possible to justify multivariate proposals, taking into account the need to increase feed production and the possibility of applying various costs for this (Table 4).

Table 4. Agro-energy efficiency of the use of agricultural practices in the cultivation of perennial grasses

Options	Output from 1 ha		Total energy costs		Energy return, units
	DM, t	EE, GJ	Per 1 ha GJ	Per 1 kg DM, MJ	
Natural phytocenosis					
Without fertilizer (control)	4.0	47.1	11.6	2.9	4.0
N60H60K90	7.9	61.1	38.6	4.9	1.6
N60P90K120	10.8	83.5	41.0	3.8	2.0
Cultural phytocenosis					
Without fertilizer	10.0	69.4	12.5	1.2	5.5
N60H60K90	13.9	115	36.3	2.8	2.9
N60P90K120	16.9	144	41.8	2.6	3.4
Basic technology					
N60P90K120	16.9	144	91.8	5.4	1.6

*Note: DM- dry matter; EE - exchange energy
Source: Own calculation.

The lowest costs of total energy per 1 ha were obtained in the variants without the use of mineral fertilizers and they amounted to 11.6-12.5 GJ, per 1 kg of dry matter - 1.2-2.9 MJ, and the highest agro-energy coefficient was noted, which amounted to 4.0-5.5 units. But this does not mean that options without fertilizers are promising, because. nutrient reserves in the soil of these options are not replenished and there is a risk of degradation of soil fertility. It has been established that N60P90K120 and both doses of NPK in a cultivated phytocenosis can be considered energetically optimal doses of fertilizers in a natural phytocenosis, the energy return in these options was 2.0-3.4 units.

CONCLUSIONS

Profit and the greatest payback of 1 feed unit in the experiment depended on the use of fertilizers and the use of overseeding of grass seeds. An analysis of the agro-economic and energy assessment showed that the combination of the use of methods for five years of research was effective and contributed to a reduction in the cost of 100 f.u. ha-1 by an average of 41-46%; getting the most profit.

Thus, the collection of fodder units per 1 ha with the use of only oversowing increased 2 times, and with a combination of fertilizers with oversowing, compared with options without oversowing, 1.5-1.8 times, while compared with the control - 4.4 times. -4.7 times. The highest payback of a feed unit of 1 kg of NPK was also noted in variants with a cultivated phytocenosis, this indicator increased by 1.2-1.6 times compared to the natural phytocenosis. It was found that the use of overseeding against the background of NPK increased the energy efficiency from 1.6-2.0 to 2.9-3.4.

Therefore, taking into account the payback of energy costs and the impact of methods on soil fertility, we can conclude that N60P90K120 and both doses of NPK in a cultivated phytocenosis can be considered energetically optimal doses of fertilizers in a natural phytocenosis.

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COMPARATIVE ANALYSIS OF THE ECONOMIC PERFORMANCE OF SHIKA BROWN, ISA BROWN AND HARCO BLACK LAYERS: AN EXPERIMENTAL APPROACH

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Abstract

The Shika brown layer is a Nigeria indigenous hybrid bred to solve the problem of adaptability to the local weather condition of the exotic layer strains (Isa brown and Harco black). Data were collected from the experiment conducted using 117 point of lays obtained from the three genotypes. Costs incurred on inputs such as feeds and drugs along with income generated from eggs produced including the returns from the sale of spent layers were considered for comparative economic analyses. Analysis of variance (ANOVA), profitability and productivity analyses were employed in data analysis. The ANOVA showed significant differences (p<0.05) in the average body weight and egg production of Shika brown, Isa brown and Harco black. Shika brown had the highest gross margin and a profitability index of 0.38 compared to Isa brown and Harco black. The results showed that the three layer strains are all good converters of feed to eggs, though Isa brown seems to be more productive. Shika brown had the lowest mortality of 10.3 % compared to that of Isa brown and Harco black of 23 % and 26 % respectively, thus, showed hardy and less susceptibility distinctiveness to diseases. The need to give increased preference to Shika brown chicken based on its adaptability and profitability indices is recommended.

***Key words**: shika brown, adaptability, economic analysis, egg production, layer strains*

INTRODUCTION

Poultry production is important to the biological needs, economic and social development of the people in any nation [16]. The Nigerian poultry industry has been rapidly expanding in recent years and is therefore one of the most commercialized subsectors of Nigerian agriculture [1, 22]. Poultry is strategic in addressing the animal protein intake of man because of its high fecundity, growth rate, short gestation period and unparalleled competence in nutrient transformation to high quality animal protein [7]. The demand for poultry egg in Nigeria has risen from 500,000 metric tonnes in 1980 [10] to about 1, 500,000 metric tonnes in 2012 [8]. Commercial layer strains produce eggs for food and processing industries. As a commercial enterprise, the success depends largely on the total number and weight of eggs produced. Despite the strategic role of poultry in addressing animal protein intake shortage in human, there is strong evidence that there are genetic differences in growth rate between strains of chickens [5]. Empirically, there are climatic factors militating against the survival of the poultry industry [4, 13, 20, 15]. The commercial layer strains reared in Nigeria are majorly exotic breed [18]. There are unfavourable tropical weather conditions which impact negatively on the productivity of all domestic animals including poultry and also the problem of adaptability to the local weather conditions with these imported strains, scarcity of feed ingredients and high costs of other poultry equipment [9]. Harco black and Isa brown are among the most popular exotic laying chickens in Nigeria. The climatic variation which affects the productivity of the exotic breeds leads to the innovation of an indigenous breed (Shika brown) with high resistance to adverse climatic conditions. However, due to climatic

variations, these exotic breeds of layers in the country are susceptible to local diseases and heat stress thereby inhibiting them from expressing their full genetic potentials which consequently result to low productivity [17].
Studies have been conducted on these strains [2, 3, 14] with none on the comparative analysis of the economic performance of the strains managed under the same housing and environmental condition to examine that which is most profitable as an outcome of egg production and as culled birds. This economic question was addressed through the application of experimental method, thus, the research gap filled by the study.

MATERIALS AND METHODS

The birds used for the study were reared at Ilorin, Kwara state, North Central, Nigeria, using private poultry facilities. Ilorin has a co-ordinate of 8°30' 0" North, 4°33' 0" East. It lies on an altitude of 305m, 1001' above sea level; with annual rainfall, relative humidity and day temperature of 600-1,200 mm, 65-80 % and 33-37^{0}C respectively. Hens were reared on battery cage system and intensively housed in separate pens. The average feed consumption rate for both Shika brown and Harco black was 1.4 kg/day while that of the Isa brown layers was 1.2 kg/day. Water was given to the layers *ad libitum* fortified with vitamins and micronutrients. They were dewormed at three months interval. Antibiotics and vaccines against Newcastle diseases were administered on regular basis. Daily recordings of egg production were taken on breed basis and this continued until the birds were one year in lay. The study was carried out between March 2015 and March 2016. Data on 117 Shika brown, Isa brown and Harco black commercial layer strains were collected for the study. This included cost of inputs such as feeds, drugs, veterinary services, and sales from eggs produced. These costs and revenue generated were computed separately for the three strains in order to compare the efficiency and net returns.

Analytical Technique

Budgetary Technique

The profitability of layer production was examined using the budget analysis as adopted by [6]. It is expressed as:

Gross Margin = Total Revenue –Total Variable Cost .... (1)

where:
Total Revenue is the total value of crates of eggs laid (₦);
Total Variable Costs are costs on feeds, veterinary services and drugs (₦)

Net Profit = Total Revenue –Total Cost .... (2)

Total Cost = Total Fixed Cost + Total Variable Cost .... (3)

where:
Total fixed costs are the deprecation value on cage.

Productivity Ratio

Productivity of layer production was examined through the average productivity of the inputs used in production. Two indicators were used to assess feed and drugs and veterinary services productivities. These productivities are estimated as;
Feed productivity: the ratio of egg produced per feed consumed. It is expressed as:

Quantity of egg produced / Quantity of feed consumed .... (4)

Drugs and veterinary services productivity: the ratio of egg produced per drugs and veterinary services provided. It is expressed as:

Quantity of egg produced/Costs on drugs and veterinary services .... (5)

RESULTS AND DISCUSSIONS

Body weights of Shika brown, Isa brown and Harco black hen

The result of the body weight of the three breeds (Shika brown, Isa brown and Harco black) at the pullet stage is presented in Table

1. A statistical difference (p<0.05) in the body weight of Shika brown, Isa brown and Harco black was observed at week 19 and week 21. The results showed that Harco black was significantly higher (p<0.05) in body weight than both Shika brown and Isa brown at 19 and 21 weeks of age.

Table 1. Body weights of Shika brown, Isa brown and Harco black pullets (17–21 weeks old)

Weeks	**Breeds (N=39 Replicates)**	**Mean**	**SEM**	**F**	**Sig**
WEEK 17	SHIKA BROWN	1.425	0.0174	1.116	0.331
	ISA BROWN	1.391	0.0161		
	HARCO BLACK	1.414	0.016		
WEEK 18	SHIKA BROWN	1.475	0.020	1.510	0.225
	ISA BROWN	1.520	0.021		
	HARCO BLACK	1.478	0.019		
WEEK 19	SHIKA BROWN	1.593	0.022	16.852	0.000
	ISA BROWN	1.592	0.023		
	HARCO BLACK	1.764	0.028		
WEEK 20	SHIKA BROWN	1.762	0.025	0.788	0.457
	ISA BROWN	1.730	0.022		
	HARCO BLACK	1.773	0.027		
WEEK 21	SHIKA BROWN	1.781	0.025	3.497	0.034
	ISA BROWN	1.810	0.022		
	HARCO BLACK	1.866	0.023		

Source: Data Analysis, 2017.

Egg weights of the Shika brown, Isa brown and Harco black hens

The mean weekly egg weights of the Shika brown, Isa brown and Harco black hens result is presented in Table 2.

Table 2(a). Mean weekly egg weights of Shika brown, Isa brown and Harco black hens

WEEK	MEANS			F	Sig.
	SHIKA BROWN	ISA BROWN	HARCO BLACK		
1	14.833 ^{a}	5.8733 ^{a}	15.280 ^{a}	2.170	0.127
2	31.466 ^{a}	29.413 ^{a}	7.426 ^{b}	105.600	0.000
3	33.080 ^{c}	31.913 ^{c}	24.366 ^{b}	5.041	0.011
4	32.773 ^{a}	33.293 ^{a}	40.426 ^{b}	4.771	0.014
5	37.623 ^{a}	34.553 ^{b}	46.300 ^{c}	44.364	0.000
6	38.060 ^{a}	37.333 ^{a}	48.193 ^{c}	12.622	0.000
7	38.633 ^{b}	38.120 ^{b}	54.153 ^{a}	51.527	0.000
8	40.313 ^{a}	38.807 ^{a}	51.046 ^{b}	7.097	0.002
9	44.253 ^{c}	41.980 ^{c}	52.406 ^{a}	10.178	0.000
10	47.940 ^{b}	45.286 ^{b}	56.560 ^{c}	21.971	0.000
11	51.160 ^{a}	49.453 ^{a}	57.573 ^{b}	10.564	0.000
12	54.093 ^{c}	54.440 ^{c}	50.820 ^{c}	1.100	0.342
13	58.073 ^{b}	55.880 ^{b}	56.373 ^{b}	0.961	0.391
14	60.800 ^{a}	57.120 ^{a}	57.206 ^{a}	2.817	0.071
15	63.300 ^{b}	58.380 ^{c}	57.706 ^{c}	9.278	0.000
16	66.633 ^{a}	60.300 ^{b}	56.380 ^{b}	28.659	0.001
17	65.000 ^{a}	49.913 ^{b}	58.193 ^{c}	4.932	0.000
18	66.046 ^{b}	57.953 ^{bc}	55.233 ^{c}	1.318	0.012
19	59.540 ^{c}	56.326 ^{c}	57.513 ^{c}	0.970	0.279
20	57.080	59.233 ^{b}	58.226 ^{b}	1.073	0.388

^{a,b,c} is the significance differences as gotten from ANOVA test of significance
Source: Data Analysis, 2017.

The result therefore, shows that there exist a significant difference among the breeds in most of the weeks and where significant differences were observed, treatment means were subjected to Duncan's Post Hoc Test and considered significance at P<0.05. The results showed that Harco black eggs weighed most and there were significance differences (P<0.05) at week 19 and 21 which is followed by Shika brown then Isa brown layers. Hence, the weight of the egg influences the egg price since there is a direct relationship between the size of egg and the price of egg sold.

Table 2(b). Mean weekly egg weights of Shika brown, Isa brown and Harco black hens

WEEK	MEANS			F	Sig.
	SHIKA BROWN	ISA BROWN	HARCO BLACK		
21	60.446 [a]	58.906 [a]	61.153 [a]	0.910	0.351
22	61.266 [c]	59.673 [c]	60.666 [c]	1.042	0.410
23	57.233 [a]	60.873 [a]	59.893 [a]	1.769	0.362
24	58.080 [b]	60.980 [b]	58.493 [b]	17.038	0.183
25	65.020 [c]	59.773 [a]	61.380 [a]	28.659	0.000
26	62.573 [a]	57.113 [b]	60.666 [a]	9.302	0.000
27	67.046 [c]	60.413 [ac]	52.006 [a]	5.088	0.011
28	57.453 [a]	55.466 [a]	63.693 [b]	7.056	0.002
29	57.453 [b]	45.986 [a]	55.186 [b]	2.872	0.068
30	57.500 [b]	47.846 [c]	60.606 [b]	11.376	0.000
31	58.873 [b]	51.526 [c]	57.360[bc]	4.024	0.025
32	58.426 [a]	55.086 [a]	56.260 [a]	1.002	0.376
33	57.313 [c]	48.520 [b]	56.586 [c]	3.435	0.042
34	59.746 [b]	51.626 [a]	60.626 [a]	7.825	0.001
35	59.240 [b]	56.993[ab]	60.273 [b]	3.787	0.031
36	57.140 [a]	57.806 [a]	59.886 [a]	1.228	0.303
37	56.980 [c]	56.360 [c]	59.186 [c]	1.913	0.160
38	55.926 [b]	57.093[ab]	59.746 [a]	5.629	0.007
39	54.693 [b]	57.126 [b]	60.200 [b]	16.864	0.000
40	57.200 [c]	56.886 [c]	57.886 [c]	0.212	0.810

[a,b,c] is the significance differences as gotten from ANOVA test of significance
Source: Data Analysis, 2017.

Table 2(c). Mean weekly egg weights of Shika brown, Isa brown and Harco black hens

WEEK	MEANS			F	Sig.
	SHIKA BROWN	ISA BROWN	HARCO BLACK		
41	56.533 [a]	54.286 [a]	57.3600 [a]	1.058	0.356
42	55.686 [c]	54.320 [c]	56.260 [c]	0.02	0.741
43	55.986 [b]	56.026 [b]	56.586 [b]	0.060	0.942
44	58.266 [c]	58.000 [c]	60.626 [c]	2.225	0.121
45	57.620 [c]	57.566 [c]	60.273 [c]	3.134	0.054
46	57.720 [a]	56.340 [a]	59.886 [a]	2.897	0.066
47	57.306 [a]	56.620 [a]	59.186 [a]	1.897	0.163
48	58.073 [b]	57.140 [b]	59.746 [b]	2.309	0.112
49	56.793 [a]	56.900 [b]	60.200 [c]	10.064	0.000
50	56.700 [b]	56.433 [b]	57.886 [b]	0.436	0.650
51	56.846 [c]	57.280 [b]	60.200 [a]	8.638	0.001
52	56.813 [a]	57.093 [a]	57.886 [a]	0.202	0.818

[a,b,c] is the significance differences as gotten from ANOVA test of significance
Source: Data Analysis, 2017.

Egg production in laying hens

From the results in Table 3, there is a significant difference between the rate of egg production of Shika brown, Isa brown and Harco black layers {F (2, 465= 18.375, p= 0.000}. Table 3 and Fig. 1 clearly demonstrates that Isa brown layer strain records higher egg production than the Shika brown and Harco black layer strains for almost all weeks. The mean weekly egg production for the Isa brown layer is 175.3 while it is 163.3 and 145.7 for the Shika brown and Harco black layer strains respectively. The findings of this study correspond with the results of [19, 11, 12]. They all observed that there exists a significant difference in the laying pattern of various breeds of commercial layers.

Table 3. Effect of breed on 52-week egg production in laying hens

SOURCE	Sum of Squares	Df	Mean Square	F	Sig
BETWEEN BREEDS	5924.543	2	2962.271	18.375	0.000
WITHIN BREEDS	74963.122	465	161.211		
TOTAL	80887.665	467			

Source: Data Analysis, 2017.

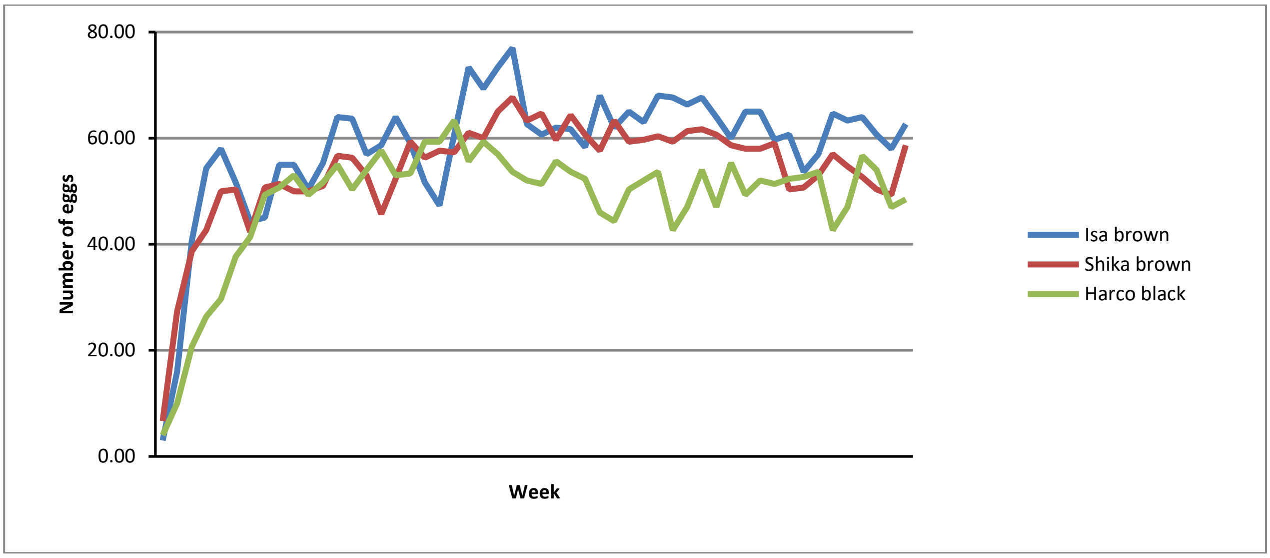

Fig. 1. Trend in the egg production of Shika brown, Isa brown and Harco black layers
Source: Data Analysis, 2017.

Productivity analysis of Shika brown, Isa brown and Harco black layers

The estimate of productivity for the three different layer strains is presented in Table 4. The partial productivities revealed higher productivities for Isa brown layers as compared with the Shika brown and Harco black layers. Isa brown layer had a productivity difference of 1.38 and 1.78 than Shika brown and Harco black respectively in their feed to egg conversion ratio. Nevertheless, it can be said that the three breeds are good converters of feeds to eggs because Harco black and Shika brown produce bigger eggs while Isa brown had the highest number of eggs laid.

Table 4. Estimated Productivities for Shika brown, Isa brown and Harco black layers

Productivity	Shika brown	Isa brown	Harco black
Veterinary services and drugs (number of eggs/₦)	1.16	1.25	1.03
Feed (number of eggs/total quantity of feed in kg)	6.17	7.55	5.77

Source: Data Analysis, 2017.

Profitability analysis of Shika brown, Isa brown and Harco black layers

The result of the costs and returns of the different layer strains is presented in Table 5. It showed that Shika brown has the highest gross margin of ₦56,542.52 followed by Isa brown with ₦52,788.79. The variation observed despite Isa brown producing the higher numbers of egg stem down to Shika brown producing bigger eggs and egg size influences the price. Harco black had the least gross margin (₦48,177.25). Expectedly, considering the gross margin value, the profitability index shows that the Shika brown layer is the most profitable of the different strains of layers. This is in tandem with the findings of [21] who reported a significant (p<0.01) effect of breed on the gross margin of black and brown commercial layer strains.

Table 5. Cost and Returns for Shika brown, Isa brown and Harco black layers (₦) at 52 weeks

ITEMS	SHIKA BROWN	ISA BROWN	HARCO BLACK
Total Revenue	186,515.34	180,173.01	₦178,150
Less variable cost			
Cost of feed	122,684.32	120,095.72	122,684.32
Cost of drugs and veterinary services	7,288.5	7,288.5	7,288.5
Gross margin	56,542.52	52,788.79	48,177.18
Less fixed cost			
Cost of layers	6,240	5,850	5,850
Depreciation value of cage	12,000	12,000	12,000
Net Returns	38,302.52	34,938.79	30,327.18
Profitability index	0.38	0.36	0.33

Source: Data Analysis, 2017

Mortality Rate in Percentage; 0.10, 0.23, 0.26 for Shika brown, Isa brown and Harco black respectively.

Harco black recorded highest percentage of mortality rate of 26% which occurred mostly during the dry season due to their inability to withstand the harsh weather condition. Isa brown had mortality rate of 23% while Shika brown recorded the least percentage mortality of 10.3% because they could adapt to the change in weather condition.

CONCLUSIONS

In all, the analysis revealed that Shika brown layers are more profitable but all the breeds are good converters of feed to eggs. The results on mortality showed that Shika brown has more resistance to weather and diseases and also that Isa brown has the lowest production cost. The result on profitability analysis showed that Shika brown layers are the most profitable breed while egg production showed that Isa brown has the highest number of eggs compared with Shika brown and Harco black. Shika brown recorded the highest net profit compared with Isa brown and Harco black. From the results of the study, profitability and survivability was highest in the Shika brown than in the other two strains. The study therefore recommended the need to give increased preference to Shika brown chicken based on its adaptability and profitability indices. This could be achieved by educating the farmers on the different kinds of layer. More so, stakeholders and policy makers should lend a hand in making Shika brown available in all parts of the country.

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ELEMENTS OF PRODUCTIVITY AND PRODUCTION QUALITY IN PEPPERS IN RELATION TO THE VARIETY AND APPLIED FERTILIZATION

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Abstract

The variation of some parameters of flowering, fruiting, and pepper production, in relation to the fertilization system, was evaluated. The study took place in the area of Cuied Locality, Arad County, Romania. The experiment was in a protected system, modular solar, the summer-autumn crop cycle, year 2020, with a specific technology. Two long pepper varieties of the Kapia type were cultivated (Dumbo 34 - D 34; Elephant's Ear - EE). Three products were used for fertilization, BioHumusSol (BHS), Cropmax (CroM) and Bionat (BioN), together with a control variant (C). The number of pollinated and fertilized flowers per plant (pff) varied between 5.00±0.35 (EE C) and 8.60±0.41 (D34 CroM), and the number of fruits per plant (FruNP) varied between 5.00±0.32 (EE C) and 8.00±0.49 (D34 CroM). The average fruit weight (FaW) varied between 83±13.30 g (D34 C) and 274±22.7 g (EE CroM). The average fruit production per plant (ApP) varied between 0.580±0.13 kg plant^{-1} (D34 C) and 1.920±0.20 g plant^{-1} (EE CroM). Quality I production (YQ1, %) varied between 10.20% (S34 C) and 76.00% (EE CroM), and quality II production (YQ2, %) varied between 24.00% (EE CroM) and 89.80% (D34 C). According to PCA, PC1 explained 68.383% of variance, and PC2 explained 28.917% of variance in relation to flowering and fruiting parameters; PC1 explained 65.489% of variance, and PC2 explained 34.28% of variance in relation to productivity and production parameters, respectively PC1 explained 61.09% of variance, and PC2 explained 38.91% of variance in relation to production quality. The regression analysis facilitated to describe the variation of production by quality classes (YQ1) in relation to productivity parameters.

Key words: *fertilizers, modeling, PCA, peppers, production quality*

INTRODUCTION

Within the vegetable plants, pepper (*Capsicum* spp. L.) is of particular interest due to the great diversity of genotypes, with high ecological plasticity, which makes it possible to cultivate it in different areas around the globe, in different culture conditions (open field, protected areas, pots, etc.) [10].

Pepper (*Capsicum* spp. L.) is one of the oldest plants cultivated by humans, and it originates in the tropical and subtropical areas of Central and South America [27, 41]. There are mentioned approx. 43 species within the genus Capsicum, and a diverse group of types (sweet peppers, hot peppers, etc.), used in food since ancient times, and today they show high importance from a commercial and food perspective, but also phytopharmaceutical or other purposes, etc. [5, 15, 22, 26].

Pepper has been studied from a food resource perspective [14, 25], or different active principles with use in pharmacy and medicine, but also as an ornamental plant or other uses [7, 35, 38].

From the perspective of pepper cultivation for food purposes, the relationships of plants have been studied with climatic conditions, especially with temperatures [1, 16, 23], with the soil, and soil-related factors [4, 18, 24], with fertilizer resources [17, 20, 40], with water regime [13, 31], with different biotic and abiotic stress factors [2, 3, 26]. For the quick and non-destructive evaluation of some symptoms at leaf level, regarding pathogens, imaging analysis is an accessible and easy-to-use method [8, 12].

Pepper has high ecological and technological plasticity and has been studied both under classic culture conditions, on soil, as well as

on substrates and artificial growth media, in hydroponic systems, for which growth system appropriate technologies are developed [34].
Different quality indices have been studied in relation to the growing conditions and the destination of pepper production [9, 19].
The present study analyzed the variation of indices and parameters of flowering, fruiting, productivity, production and quality in two long pepper varieties of the Kapia type, in relation to the fertilization system applied.

MATERIALS AND METHODS

The study evaluated fruit quality variation in pepper (*Capsicum annuum* L.). The study took place in the area of Cuied Locality, Arad County, Romania.
The experiment was organized in protected conditions, modular solar system, the summer -autumn crop cycle year 2020. An appropriate technology was provided for the long pepper culture, in a protected space conditions.
Two long pepper varieties of the Kapia type were studied, respectively Dumbo 34 (D 34) and Elephant's Ear (EE). Three products were used for fertilization, BioHumusSol (BHS), Cropmax (CroM) and Bionat (BioN), along with a control variant (C). The experiment was organized in three repetitions. Eight experimental variants resulted from the combination of the varieties and the fertilizers used (Table 1).

Table 1. Experimental variants of long pepper, Kapia type

Experimental variants		
Treatment	Cultivar	Variant Code
Control	Elephant's Ear	EE C
	Dumbo 34	D34 C
BioHumusSol	Elephant's Ear	EE BHS
	Dumbo 34	D34 BHS
Cropmax	Elephant's Ear	EE CroM
	Dumbo 34	D34 CroM
Bionat	Elephant's Ear	EE BioN
	Dumbo 34	D34 BioN

Source: Original data.

Parameters were analyzed: Flowering and fruiting parameters – Ffp (flowers number on the plant – FloNP; pollinated and fertilized flowers – pff; aborted flowers – af; fruits number on plant - FruNP), and Productivity, production and quality parameters – Ppqp (Fruit average weight – FaW; Average production on plant – ApP; production per surface unit – Y; production by quality classes I and II – YQ1, YQ2). For the comparative analysis of the results, average values per variety (Average by variety) and per experiment (Experiment average) were calculated.
The fruits were harvested at maturity for consumption and use (Photo 1), from the beginning of September to the end of October - beginning of November.

Photo 1. Kapia long pepper from the experiment, at the time of harvest
Source: Original image.

The experimental data regarding the parameters proposed in the study were recorded and processed appropriately, under a mathematical and statistical aspect.
In order to quantify the differentiated response of the pepper varieties studied, in relation to fertilization, based on the determined parameters; PCA analysis, Cluster analysis and Regression analysis were performed.
The ANOVA test was used to evaluate the reliability of the data and the presence of variance in the data set. Adequate statistical safety parameters were considered for the safety of the results of the analysis made [11].

RESULTS AND DISCUSSIONS

The two pepper varieties, Elephant's Ear (EE) and Dumbo 34 (D 34), responded differently to the applied fertilization, and the values of the flowering parameters, of the fruiting parameters and of the recorded production, by quality classes (Q1, Q2), are presented in Tables 1 and 2.

Table 1. Flowering and fruiting parameters in peppers under the influence of experimental variants

Experimental variants			FloNP			FruNP
Treatment	Cultivar	Variant Code	TFN	pff	af	
Control	Elephant's Ear	EE C	9.50±0.19	5.00±0.35	4.50±0.49	5.00±0.32
	Dumbo 34	D34 C	10.50±0.31	8.30±0.41	2.20±0.19	7.00±0.49
BioHumusSol	Elephant's Ear	EE BHS	9.00±0.19	6.80±0.35	2.20±0.49	6.00±0.32
	Dumbo 34	D34 BHS	9.20±0.31	7.00±0.41	2.20±0.19	7.00±0.49
Cropmax	Elephant's Ear	EE CroM	9.00±0.19	7.00±0.35	2.00±0.49	7.00±0.32
	Dumbo 34	D34 CroM	9.40±0.31	8.60±0.41	1.20±0.19	8.00±0.49
Bionat	Elephant's Ear	EE BioN	10.00±0.19	6.00±0.35	4.00±0.49	6.00±0.32
	Dumbo 34	D34 BioN	8.60±0.31	6.40±0.41	2.20±0.19	6.00±0.49
Average by variety	Elephant's Ear		9.38±0.19	6.20±0.35	3.18±0.49	6.00±0.32
	Dumbo 34		9.43±0.31	7.58±0.41	1.95±0.19	7.00±0.49
Experiment average			9.40±0.15	6.89±0.31	2.56±0.29	6.50±0.31

Sources: Original data from the experiment.

Table 2. Productivity, production and quality parameters in peppers under the influence of experimental variants

Experimental variants			FaW	ApP	Y	YQ1		YQ2	
Treatment	Cultivar	Variant Code	g piece^{-1}	kg plant^{-1}	kg ha^{-1}	kg ha^{-1}	%	kg ha^{-1}	%
Control	Elephant's Ear	EE C	141±22.7	0.705±0.20	31725	4631	14.60	27094	85.40
	Dumbo 34	D34 C	83±13.30	0.580±0.13	26100	2662	10.20	23438	89.80
BioHumusSol	Elephant's Ear	EE BHS	181±22.7	1.140±0.20	51300	26317	51.30	24983	48.70
	Dumbo 34	D34 BHS	125±13.30	0.880±0.13	39600	25186	63.60	14414	36.40
Cropmax	Elephant's Ear	EE CroM	274±22.7	1.920±0.20	86400	65664	76.00	20736	24.00
	Dumbo 34	D34 CroM	157±13.30	1.405±0.13	63225	36544	57.80	26681	42.20
Bionat	Elephant's Ear	EE BioN	227±22.7	1.360±0.20	61200	39352	64.30	21848	35.70
	Dumbo 34	D34 BioN	154±13.30	0.925±0.13	41625	22436	53.90	19189	46.10
Average by variery	Elephant's Ear		205.75±22.7	1.280±0.20	57656.25	33991	51.55	23665.25	48.45
	Dumbo 34		129.75±13.30	0.948±0.13	42637.5	21707	46.38	20930.5	53.62
Experiment average			167.75±17.60	1.114±0.12	50146.88	27849	48.96	22297.88	51.04

Sources: Original data from the experiment.

The total number of flowers per plant (TFN) varied between 8.60±0.31 (D34 BioN) and 10.50±0.31 (D34 C). The number of pollinated and fertilized flowers per plant (pff) varied between 5.00±0.35 (EE C) and 8.60±0.41 (D34 CroM). The number of aborted flowers per plant (af) varied between 1.20±0.19 (D34 CroM) and 4.50±0.49 (EE C). The number of fruits per plant (FruNP) varied between 5.00±0.32 (EE C) and 8.00±0.49 (D34 CroM).
In the case of productivity and production elements, the average fruit weight (FaW) varied between 83±13.30 g (D34 C) and 274±22.7 g (EE CroM). The average fruit production per plant (ApP) varied between 0.580±0.13 kg plant^{-1} (D34 C) and 1.920±0.20 g plant^{-1} (EE CroM). Quality I production (YQ1, %) varied between 10.20% (S34 C) and 76.00% (EE CroM), and quality II production (YQ2, %) varied between 24.00% (EE CroM) and 89.80% (D34 C).
The ANOVA test confirmed the reliability of the experimental data and the presence of variance in the data set, on the two evaluated parameter categories, Flowering and fruiting parameters (Ffp), Productivity, production and quality parameters (Ppqp), Table 3 (Alpha=0.001).

Table 3. ANOVA test

Source of Variation	SS	df	MS	F	P-value	F crit
	Flowering and fruiting parameters (Ffp)					
Between Groups	264.1186	3	88.03953	106.7126	3.97E-19	6.59454
Within Groups	33.00063	40	0.825016			
Total	297.1192	43				
	Productivity, production and quality parameters (Ppqp)					
Between Groups	2.58E+10	6	4.3E+09	51.15377	1.15E-23	4.27529
Within Groups	5.88E+09	70	83965601			
Total	3.16E+10	76				

Source: Original data.

In order to find out the distribution and association of variants (variety and fertilization) with determined parameters, PCA analysis was used.

In relation to flowering and fruiting parameters (Ffp), the PCA analysis led to the diagram in Figure 1, in which the association of some variants with studied parameters was observed (eg D34 C variant with the FloNP parameter, D34 CroM variant with pff and FruNP parameters; the variants EE BioN and EE C with the af parameter - in the case of the two variants, the highest number of aborted flowers was recorded). PC1 explained 68.383% of variance, and PC2 explained 28.917% of variance.

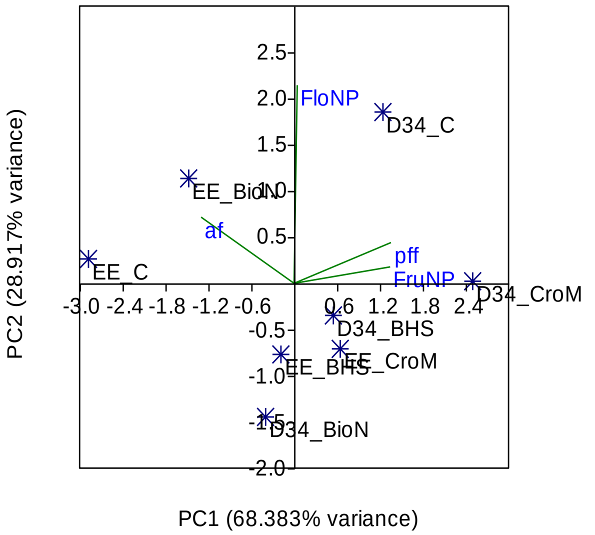

Fig. 1. PCA diagram in relation to flowering and fruiting parameters (Ffp)
Source: Original figure

The cluster analysis in relation to flowering and fruiting parameters (Ffp) led to the dendrogram in Figure 2, in which the variants were grouped on the basis of similarity in relation to the determination of the values of the considered parameters, under conditions of statistical safety (Coph.corr.= 0.810).

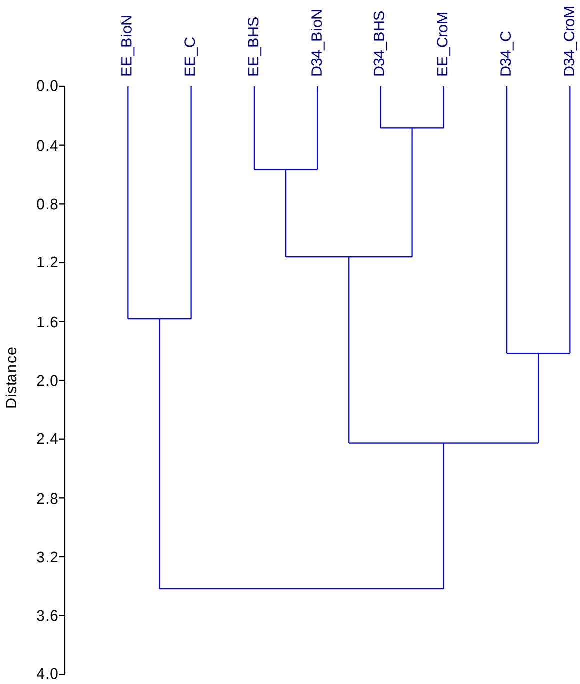

Fig. 2. Dendrogram generated by cluster analysis in relation to flowering and fruiting parameters (Ffp)
Source: Original figure.

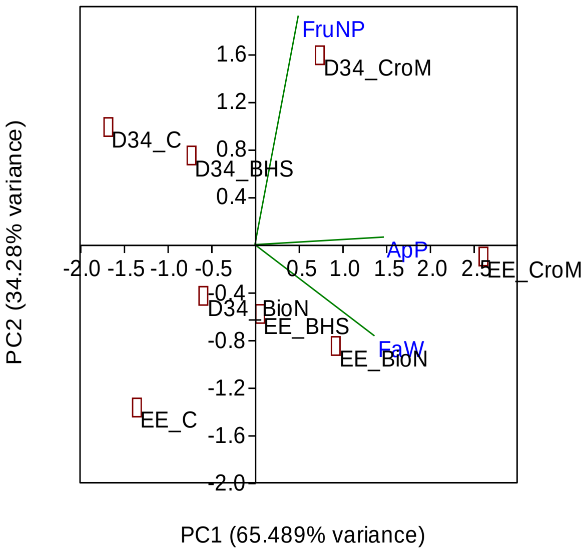

Fig. 3. PCA diagram in relation to productivity, production per plant parameters
Source: Original figure.

The formation of two distinct clusters was found. A C1 cluster that includes the variants EE C and EE BioN, with a high number of aborted flowers (af). Cluster C2 included the other variants, grouped into two sub-clusters.

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The highest level of similarity was recorded between the D34 BHS and EE CroM variants (SDI=0.2828).

According to PCA, in relation to productivity and production per plant parameters, the diagram in Figure 3 was generated, in which PC1 explained 65.489% of variance, and PC2 explained 34.28% of variance.

The resulting diagram showed the association of the D34 CroM variant with the FruNP parameter, the association of the EE CroM variant with the ApP parameter, and the association of the EE BioN variant with the FaW parameter. It was also found the independent positioning of some variants in relation to the considered parameters (eg. variant D34 C, variant D34 BHS).

The cluster analysis, in relation to productivity and production per plant parameters, led to the dendrogram in Figure 4, under statistical safety conditions (Coph.corr. =0.817).

Within a cluster (C1) the variants EE CroM and EE BioN were associated with high values for the FaW parameter (average fruit weight, g). The highest level of similarity was recorded between the variants D34 CroM and D34 BioN (SDI=3.6374).

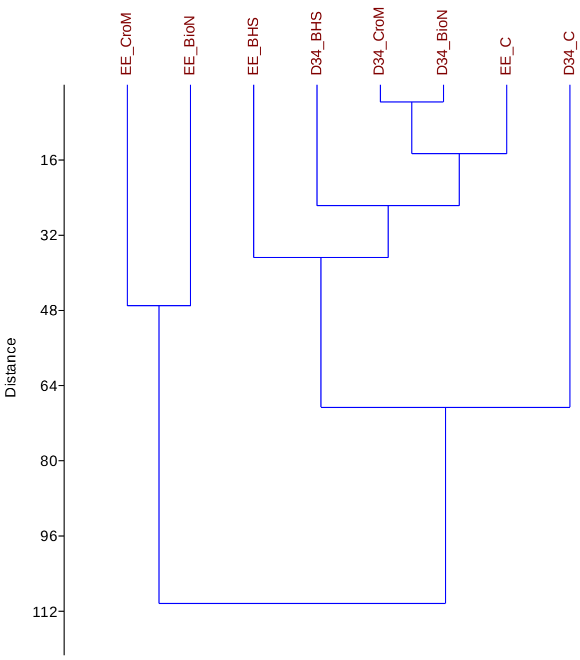

Fig. 4. Dendrogram generated by Cluster analysis in relation to productivity and production per plant parameters
Source: Original figure.

In relation to production quality (Q1 and Q2, physical values), the PCA analysis generated the diagram in Figure 5, in which PC1 explained 61.09% of variance, and PC2 explained 38.91% of variance. In the resulting diagram, the distinctive association with the Q1 quality (as biplot) of the EE CroM variant was found. The EE BHS variants of the D34 CroM were associated with the Q2 quality (as biplot).

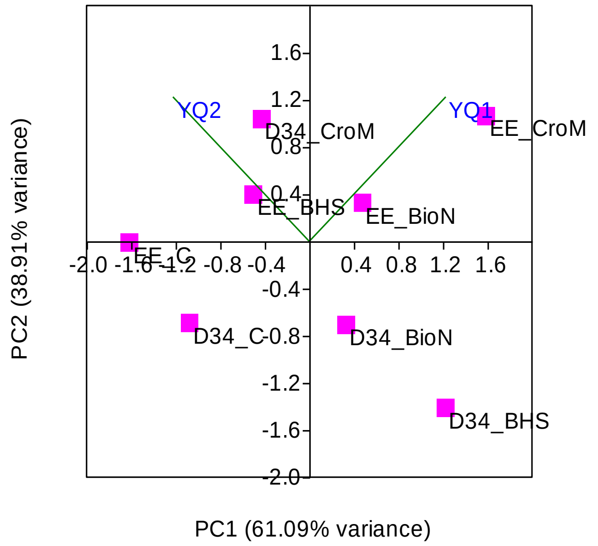

Fig. 5. PCA diagram in relation to the quality of pepper production, given by the experimental variants
Source: Original figure.

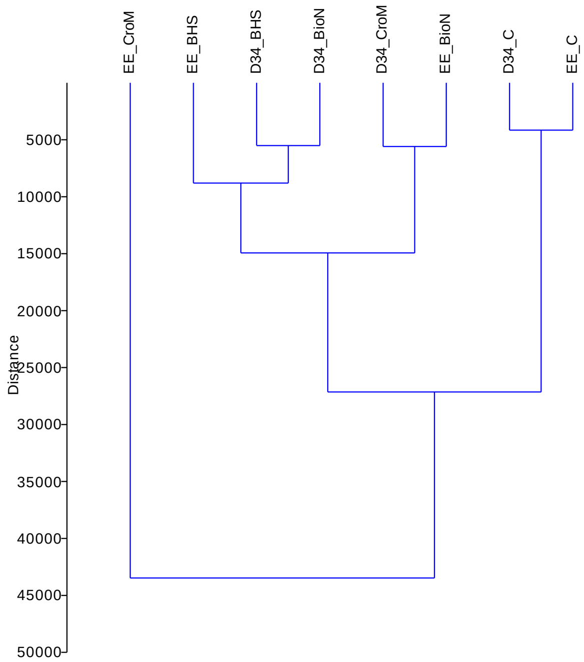

Fig. 6. Dendrogram generated by Cluster analysis in relation to the quality of pepper production (YQ1, YQ2, physical values)
Source: Original figure.

The clus The other experimental variants presented a lower affinity, or were positioned independently compared to the two parametric quality ones (Q1 and Q2, as biplot).

The cluster analysis of the data in relation to the production quality (YQ1 and YQ2, physical values) led to the dendrogram in Figure 6 (Coph. corr.=0.862). The independent positioning of the EE CroM variant with a high value for the physical production of pepper was found, and the other variants were associated within a separate cluster, with several sub-clusters.

ter analysis in relation to the quality of YQ1 pepper production (percentage values) led to the dendrogram in Figure 7 (Coph. corr. = 0.955). The positioning of the variants was found in relation to the degree of similarity for the generation of YQ1 quality fruit (% of total fruit production). Within a C1 cluster, the D34 C and EE C variants were positioned with a low percentage level in the formation of Q1 quality fruits.

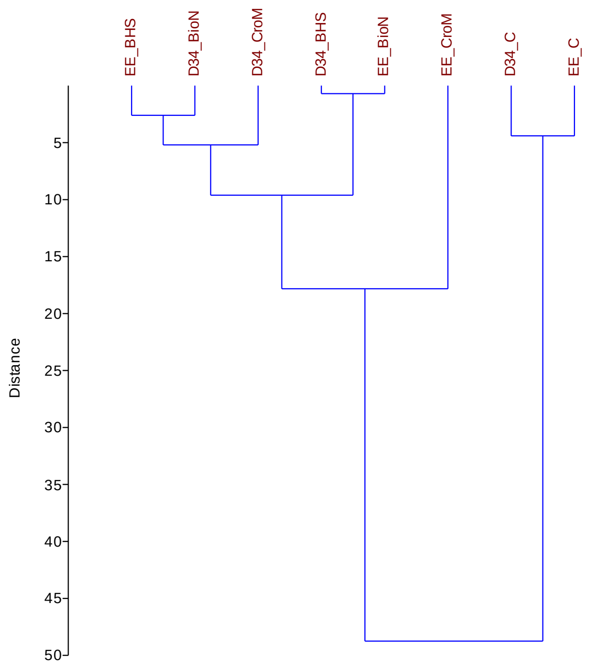

Fig. 7. Dendrogram generated by Cluster analysis in relation to the quality of pepper production (YQ1, percentage values)
Source: Original figure.

The other variants were positioned in a C2 cluster, in several sub-clusters. Meanwhile, the EE CroM variant with the highest percentage of YQ1 quality fruits from the total production (76%) was positioned in the C2 cluster, and the other variants were positioned according to the degree of similarity. The highest level of similarity was recorded between the D34 BHS and EE BioN variants (SDI=0.7).

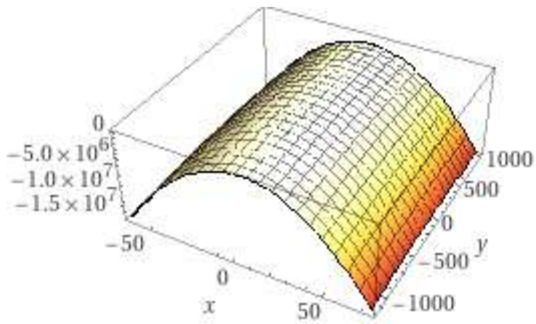

Fig. 8. 3D representation of the variation of pepper production, quality I (YQ1), in relation to FruNP (x-axis) and FaW (y-axis) parameters
Source: Original figure.

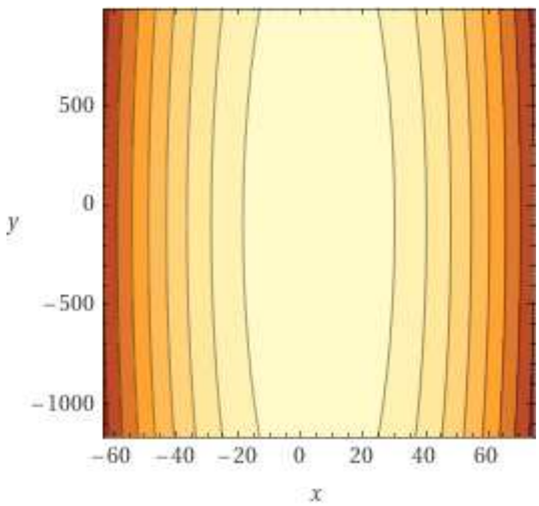

Fig. 9. Representation in the form of isoquants of the variation of pepper production, quality I (YQ1), in relation to FruNP (x-axis) and FaW (y-axis) parameters
Source: Original figure.

Through the regression analysis, it was analyzed how determined parameters and productivity elements contributed to the formation of pepper production (quality I, YQ1 was considered in the analysis).

The variation of pepper production, YQ1, in relation to FruNP and FaW was described by equation (1), under conditions of R^2=0.991, p=0.0215, Ftest=45.6614. The graphic distribution in 3D form and in the form of isoquants of YQ1 production in relation to FruNP (x-axis) and FaW (y-axis) is presented in Figure 8 and 9.

$$YQ1 = ax^2 + by^2 + cx + dy + exy + f \quad (1)$$

where: YQ1 – pepper production, quality I (YQ1);
x – fruits number on the plant (FruNP);
y – fruit average weight (FaW);
a, b, c, d, e, f – coefficients of the equation (2);
a= -3342.78077776;
b= -0.66500979;
c= 38387.90471968;
d= -119.63518237;
e= 97.11309785;
f= -142767.44321

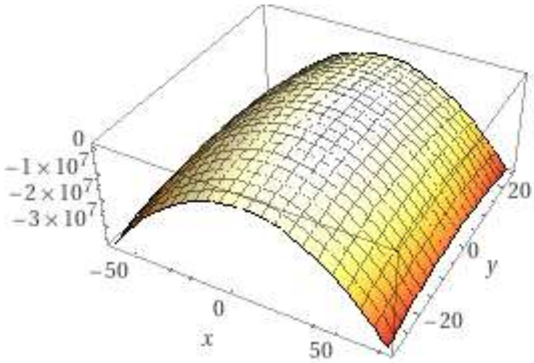

Fig. 10. 3D representation of the variation of pepper production, quality I (YQ1), in relation to FruNP (x-axis) and ApP (y-axis) parameters
Source: Original figure.

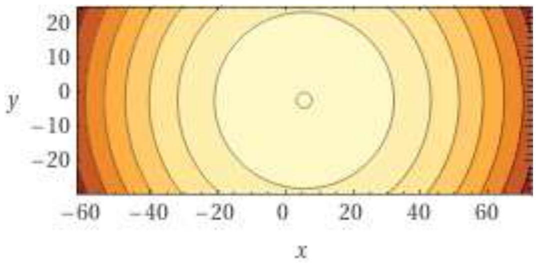

Fig. 11. Representation in the form of isoquants of the variation of pepper production, quality I (YQ1), in relation to FruNP (x-axis) and ApP (y-axis) parameters
Source: Original figure.

The variation of pepper production, YQ1, in relation to FruNP and ApP was described by equation (2), under conditions of R^2=0.983, p=0.0421, F test = 23.0799. The graphic distribution in 3D form and in the form of isoquants of YQ1 production in relation to FruNP (x-axis) and ApP (y-axis) is presented in Figure 10 and 11.

$$YQ1 = ax^2 + by^2 + cx + dy + exy + f \quad (2)$$

where: YQ1 – pepper production, quality I (YQ1);
x – fruits number on the plant (FruNP);
y – average production on plant (ApP)
a, b, c, d, e, f – coefficients of the equation (2);
a= -7171.59275;
b= -7491.81907;
c= 80016.74802;
d= -34453.02839;
e= 14079.11056;
f= -238720.24343

Fertilizers represent important inputs for plant production, and the properties of fertilizers make the effect of fertilization on plant production (quantitative and qualitative) to be different [30, 39].

At the same time, crop plants, and especially vegetables, due to the great diversity of cultivated species and genotypes, the different growth systems and technologies, as well as in relation to the vegetation stages, have different requirements for nutrients, in direct relation to the quantity and production quality [6, 21, 28, 30, 32].

Therefore, studies and experiments with fertilizers are always up-to-date in order to find the balance between genotype (through its specificity), fertilization (an important component of culture technology), the level and quality of production (the product of the agricultural technological process), but also the impact on the environment [6, 21, 29, 32].

The quality of pepper production in relation to the fertilization system (different fertilizers, nutrients, application techniques) was communicated in some studies. Lu et al. (2021) [20] reported in their study the significant improvement of the yield, but the reduction of the nutritional quality of pepper fruits by magnesium fertilization.

The share of pepper production by quality classes in relation to fertilization (vermicompost, solarized manure, and inorganic NPK) was reported by Valenzuela-Garcia et al., 2019 [36], and the authors reported a share of 60% in Second-Class Quality , and 25% in First-Class Quality.

The efficiency of the use of nutrients (especially N) was also studied in pepper culture, in relation to different fertilizing resources, genotypes, conditions and culture technologies. Silva et al. (2020) [33] reported a decrease in NUE (nitrogen use efficiency) and an increase in the concentration of nitrates in the substrate with an increase in the rate of

N from fertilizers under the study conditions (N rates: 0, 1.5, 3.0, 4.5, 6.0 and 7.5 g plant^{-1}). The efficiency of N use (four doses) in relation to the watering regime (four levels of irrigation) was studied in greenhouse conditions, and the authors reported the decrease of partial factor productivity of nitrogen (PFPN) in relation to the increase of nitrogen application rate, as well as the initial increase followed by the decrease when it was also associated with the watering regime [37].

The results communicated through the present study fall within the interest for the optimization of pepper culture technology through fertilization in relation to the cultivated genotypes, in order to obtain productions in higher classes of quality and economic efficiency.

CONCLUSIONS

The two long pepper varieties, of the Kapia type (Elephant's Ear and Dumbo 34), utilized the applied fertilizer resources differently.

This was quantified by Flowering and fruiting parameters (Ffp), respectively by Productivity, production and quality parameters (Ppqp).

PCA analysis and cluster analysis (CA) facilitated the distribution, association and grouping of the variants given by the 'genotype x fertilizer' combination in relation to the response quantified by the values of each analyzed parameter. Thus, within the PCA, PC1 explained 68.383% of variance, and PC2 explained 28.917% of variance in relation to flowering and fruiting parameters; PC1 explained 65.489% of variance, and PC2 explained 34.28% of variance in relation to productivity and production parameters, respectively PC1 explained 61.09% of variance, and PC2 explained 38.91% of variance in relation to quality parameters. Within the CA, the variants were grouped into clusters based on similarity in the generation of the values of the analyzed parameters, under conditions of statistical safety.

The regression analysis facilitated the obtaining of models in the form of equations, as well as graphic models (3D and in the form of isoquants) that described the variation of the production of quality I (YQ1) in relation to the productivity parameter at the plant level.

The obtained results are of scientific interest but also for horticultural practice, as they facilitate the highlighting of the 'variety × fertilizer' combinations that have led to significant results, under conditions of statistical certainty.

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EVOLUTION OF ECONOMIC AND SOCIAL INDICATORS OF RURAL AREAS IN ROMANIA

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Abstract

In recent decades. rural areas have been facing numerous problems. such as an ageing population. lack of jobs, migration of young people, poor infrastructure which negatively affect the quality of life of rural inhabitants. The aim of the study is to observe the economic and social evolution of the Romanian countryside over the last 10 years, taking into account the disruptive phenomena that have occurred during this period. The study is based on a quantitative and qualitative analysis of data provided by the National Institute of Statistics. In both urban and rural areas, the population tends to decline. In the case of the urban population. there was a 4.09% decrease over the period analyse, from 10.9 million to 10.46 million inhabitants. In contrast, the rural population decreased by 4.57% during the period, from 9.3 million to 8.87 million. Among the main reasons for this decrease, we can mention the high mortality rate (high degree of ageing). but also the migration of the population to Western European countries. a phenomenon that was accentuated with Romania's accession to the European Union in 2007.

Key words: rural areas, demography, income, Romania

INTRODUCTION

The rural area as a whole represents the place where activities predominantly related to agriculture and animal husbandry are carried out and where the inhabitants of rural areas carry out various craft activities depending on the specific area in which they are located [1].
For Romania, rural areas are of particular importance in part because a significant percentage of the country's population lives in villages. but also because rural areas are the place where ancient traditions and customs are preserved, which gives a clear picture of the identity of the Romanian people [9, 12].
Our great Romanian poet, Lucian Blaga, said that "eternity was born in the village". This verse can be explained by the fact that the village is the Romanian countryside; is the place where man connects best with nature, with the specific flora and fauna of our country [4].
The connection between the urban environment and the countryside is still preserved in Romania, unlike in other European countries, where rural spaces of great significance have been lost due to the expansion of urban areas, but also because most of the inhabitants of cities have lost touch with the countryside [3, 11].
In Romania, things are a little different, in that many city dwellers still have relatives 'in the country', still know the charm of the village and how the food they put on the table is produced.
In this context, the countryside is extremely important because without the work of people in the countryside, without preserving traditions and customs, our identity as a people would be lost [6].
The performance of the countryside remains linked to agricultural activity, which is the main preoccupation of the rural population. The performance of the agricultural sector since Romania's accession to the European Union (2007) has also been reflected in the development of the Romanian countryside. European funding programmes have contributed to the development of rural businesses and, in some cases, have allowed

the rescue of specific crafts that without European funding would have become a memory [2, 7].

The Romanian countryside has undergone many transformations, which can largely be linked to Romania's history. The rural area still needs support and European and national funding is extremely important to solve most of the problems faced by the rural environment [5, 10].

The aim of the study is to observe the economic and social evolution of the Romanian countryside over the last 10 years, taking into account the disruptive phenomena that have occurred during this period.

MATERIALS AND METHODS

The data used come from the National Institute of Statistics, accessed on 26.07.2022, and were analyzed quantitatively and qualitatively. They have been plotted to illustrate trends in the evolution of selected indicators, facilitating their understanding. At the same time, the main statistical indicators such as minimum, maximum, arithmetic mean. The annual rate, standard deviation, and coefficient of variation were analyzed. The coefficient of variation is the ratio of the standard deviation to the mean when the mean is different from 0 and is expressed as a percentage.

$$C.V. = \frac{\sigma}{\bar{x}} 100 \qquad (1)$$

The standard deviation is expressed using the same unit of measurement as the values in the series under consideration and is a very precise indicator of the spread of the series.

$$\sigma = \sqrt{D} \text{ sau } \sigma = \sqrt{\frac{(x_1 - \overline{X})^2 + (x_2 - \overline{X})^2 + ... + (x_n - \overline{X})^2}{n-1}} \qquad (2)$$

The student test is a decision method that helps us to validate or invalidate a statistical hypothesis with a certain degree of certainty. The statistical test consists of obtaining an inference based on a selection of the population by testing a certain hypothesis. Often this hypothesis is a statement about the value of the unknown population density parameter, for example, the population mean or dispersion.

RESULTS AND DISCUSSIONS

Economic factors

In Romania, agriculture specific activities such as: plant cultivation, animal husbandry, fish farming, beekeeping which are important sub-branches of agriculture significantly contributing to Gross Domestic Product (Figure 1).

An analysis of the share of agriculture, forestry and fisheries in GDP over the period 2011-2020 shows that there has been a downward trend throughout the period. In 2020, the agricultural sector contributed by 4.4% to GDP formation, while in 2011 the share of agriculture in the formation of GDP was 6.8%. It can be seen that, since 2015, the share of the agricultural sector in the formation of GDP has been below 5% until 2020 (Figure 1).

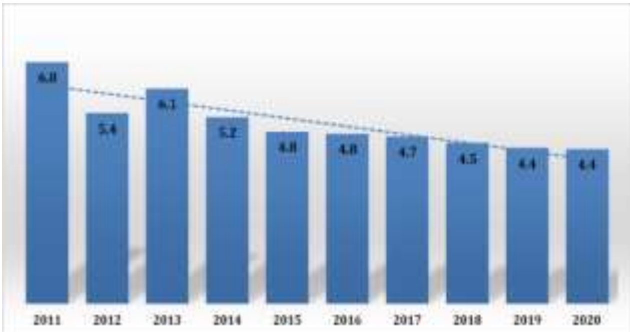

Fig. 1. Share of agriculture, forestry and fisheries in GDP, 2011-2020 (%)
Source: NIS, 2022 [8].

At the national level, the income of inhabitants showed an increasing trend, so that if in 2011, the average income per person was 839.5 lei, in 2019 it was 1,852.7 lei/person, representing an increase of more than 120%.

It should be noted that in 2018 social contributions were transferred from the employer to the employee. Practically, the significant increase in 2018 compared to 2017 was artificial. Net salary was not influenced too much (Figure 2).

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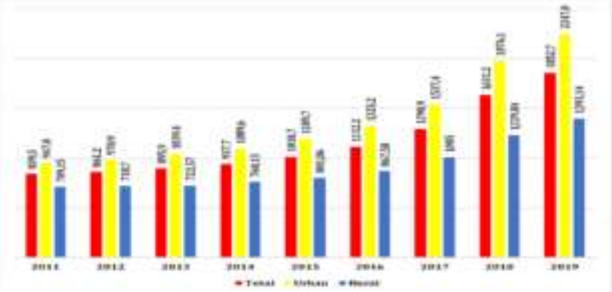

Fig. 2. Comparative analysis of the average monthly income, 2011-2019 (RON/person)
Source: NIS, 2022 [8].

In Figure 3 the evolution of the average monthly income of the employees in the period 2011-2019 has been represented, showing a general upward trend in urban areas. The average income in 2019 compared to the reference year increased by 148.6%, while the average income in rural areas was 133.3%. Thus, indicating the income gap between the two residence environments.

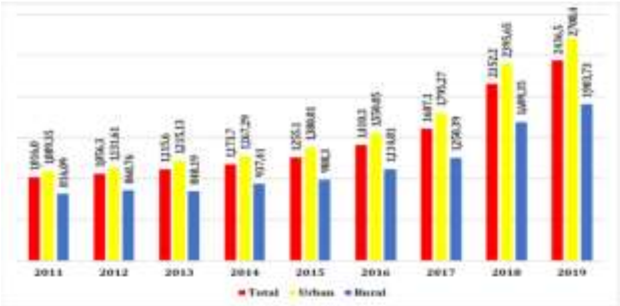

Fig. 3. Comparative analysis of the average monthly income of employees in the period 2011-2019 (RON / person)
Source: NIS, 2022 [8].

These differences in income between the two residence environments can be attributed to existing jobs in urban areas compared to rural areas, which are predominantly concentrated towards low-paid activities. At the national level, the average income of employees increased by 140%. from 1,016 lei/person to 2,436.5 lei/person (Figure 3).
Taking into account the fact that in rural areas, the share of elderly people is significant, the evolution of their average monthly income was analyzed. Therefore, in rural areas, an increase of 66.7% was observed from 766.4 lei/person (2011) to 1,277.7 lei/person (2019), while in urban areas, the average income of pensioners increased by 84%. from 844 lei/person (2011) to 1,626.7 lei/person (2019).
A significant difference was observed between the average income of pensioners between the two residence environments, explained by the fact that older people in rural areas worked in low-paid areas, such as agriculture (working in CAPs). Therefore, social contributions were much lower than for urban residents (Figure 4).

Fig. 4. Comparative analysis of the average monthly income of pensioners between 2011 and 2019 (lei/person)
Source: NIS, 2022 [8].

Social Factors

Over the last 10 years, Romania's population has decreased significantly by 4.31%, so that while in 2011 Romania had 20.2 million inhabitants (residents), in 2020 it reached 19.33 million inhabitants (Figure 5).
Both in urban and rural areas registered a decrease of the population, so that in the case of the urban area the population declined by 4.09% in the analysed period, from 10.9 million inhabitants to 10.46 million inhabitants.
One of the main reasons for this decrease may be the high mortality rate (high degree of ageing), but also the migration of the population to Western European countries, once this was facilitated by Romania's accession to the European Union.
In the case of the rural population, there was a decrease of 4.57% in the period under review, from 9.3 million to 8.87 million inhabitants, caused by migration of the population to urban centers (Figure 5).

Analysing the averages of urban and rural population for the period 2011-2020 using the Student Test method

We find that the two variables are statistically dependent. with a critical T distribution value of 22.7 (highly significant. probability 0.001***) (Table 1).

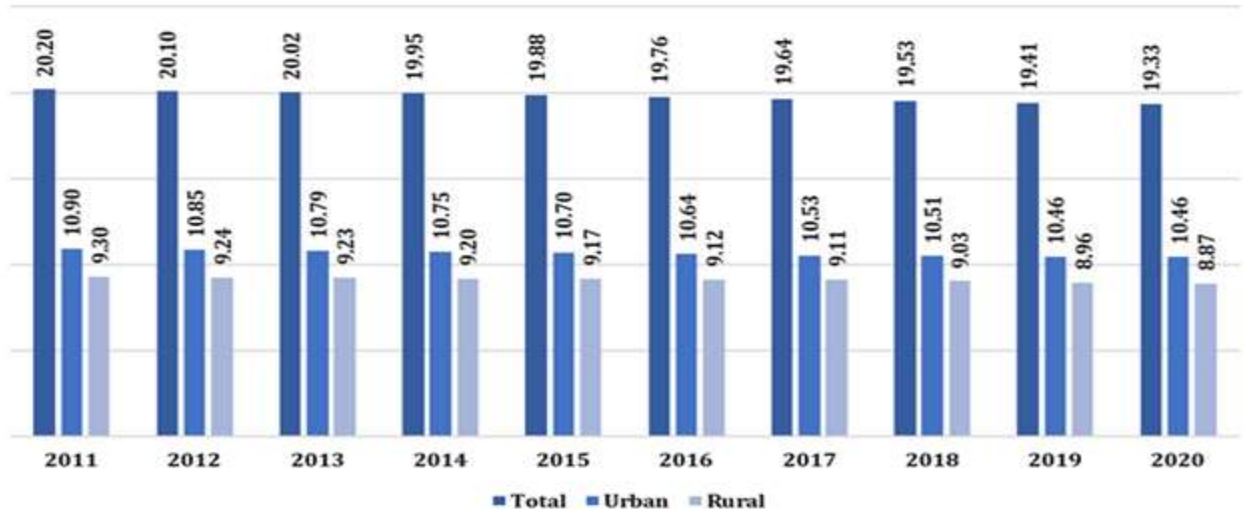

Fig. 5. Evolution of Romania's population by residence 2011-2020 (million inhabitants)
Source: own processing based on WoS data.

Regarding the evolution of the rural population. It can be seen that all the development regions recorded population decreases, with the exception of the Bucharest-Ilfov Region and the Western Region. In the case of the Bucharest-Ilfov region.

Table 1. Comparison of urban and rural population averages between 2011 and 2020 using Student Test method

Residential environments	N1	N2	M1	M2	GL	S1^2	S2^2	tcalc
Urban-rural	10	10	10.66	9.12	18	0.03	0.02	-22.7
The critical values of the distribution of T	Probab. 0.05		2.1	*	semnificant			
	Probab. 0.01		2.9	**	semnificant distinctive			
	Probab. 0.001		3.9	***	very semnificant			

Source: Own calculation.

There was an increase of the number of inhabitants by 19.44% during the period under analysis, which was determined by the migration of the population from the urban area to the localities in the vicinity of Bucharest (Table 2).

Table 2. Analysis of the main statistical indicators on the rural population 2012-2020

Regions	Min	Max	Average	Annual rate	Standard deviation	Coeff. of variation
	millions of people	millions of people	millions of people	%	millions of people	%
TOTAL	8.87	9.24	9.10	-0.51	0.127	1.40
NORTHWEST	1.20	1.23	1.22	-0.26	0.008	0.68
CENTER	0.99	1.00	0.99	-0.06	0.003	0.31
NORTH-EAST	1.84	1.92	1.89	-0.54	0.028	1.50
SOUTH-EAST	1.11	1.18	1.15	-0.77	0.024	2.10
SOUTH MUNTENIA	1.75	1.89	1.83	-0.97	0.049	2.68
BUCUREȘTI - ILFOV	0.22	0.27	0.25	2.24	0.016	6.36
SOUTH-WEST OLTENIA	1.02	1.11	1.07	-1.07	0.032	3.01
WEST	0.69	0.70	0.70	0.05	0.002	0.35

Source: NIS, 2022 [8].

Analysing the evolution of the population in Romania in the period 2011-2020, the population between 40 and 44 years (1.5 million inhabitants) was found to be concentrated in the age bracket, but their number decreased by 12% during the period analysed. It is worth noting the increase in the population aged 65-69 years (1.2 million inhabitants) of 34.7% over the period analysed, as well as the population over 85 years (403 thousand inhabitants) with an increase of 54.6% indicating an increase in life expectancy that can be attributed to the increase in the standard of living.

It should be noted that an increase in the number of inhabitants over 65 may have a negative effect.

Impact on the national budget if this number is not supported by an increase in the number of inhabitants in the active population.

CONCLUSIONS

In both urban and rural areas, the population tends to decline. The urban population decreased by 4.09% during the period under review, from 10.9 million to 10.46 million. In contrast,

rural population decreased by 4.57% during the period, from 9.3 million to 8.87 million. Among the main reasons for this decrease, we can mention the high mortality rate (high degree of ageing), but also the migration of the population to Western European countries, a phenomenon that was accentuated with Romania's accession to the European Union in 2007.

Regarding the evolution of the rural population, it is noted that all the development regions are experiencing population decreases, with the exception of the Bucharest-Ilfov Region and the Western Region. In the case of the Bucharest-Ilfov region, the number of inhabitants increased by 19.44% during the period under review, due to the migration of the population from the urban area to the localities in the vicinity of Bucharest. In 2020, Iasi County had the highest share of rural inhabitants, 4.7% of the total rural population. with 420.3 thousand inhabitants. Suceava and Prahova counties also had a share of 4.2% and 4.1% respectively of the total rural population, with a population of 368.8 thousand inhabitants and 348.5 thousand inhabitants.

In the urban environment, the population aged between 40 and 44 years old has the highest number of inhabitants. In contrast to the urban environment, in the rural environment, there have been significant decreases, such as the young population, aged 0 to 4 years, and those aged 5 to 9 years, of 12.1% and 17.6% respectively. Both urban and rural areas show significant increases in income. Thus, the average monthly income in urban areas increased by 137.3%. from 947 lei/person to 2,247 lei/person, while in rural areas there was an increase of 96.5%, from 709.15 lei/person to 1,393.14 lei/person. The difference in income between the two residence environments is significant. the average wage income recorded in rural areas is 38% lower than in urban areas.

Comparing the average monthly incomes of farmers in the two regions in 2019 shows a significant difference. The average monthly income in the South-Muntenia region was 995.3 lei/person. while in the West region it was 1,366.9 lei/person, representing a difference of 27.2%. This difference can be attributed to the labour force working in the sector, correlated with the positioning of the western region, as they are more likely to migrate to countries close to the border because of higher wages (Hungary. Austria). It should be noted that the highest average monthly wage was recorded in the central region, which can be attributed to the shortage of labour in the region and the difficulty of manual work specific to the predominant crops in this area (potatoes).

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GENETIC TRANSFORMATION IN AGRICULTURE: THE REAL CHANCE FOR ENSURING WORLDWIDE SUSTAINABLE FOOD SECURITY

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Abstract

Obtaining genetically modified (GM) organisms, with superior biological and productive performances, represents the priority objective of modern applied genetics research, oriented towards the development of effective procedures for increasing genetic variability, according to the requirements of breeding programs of economically interesting species. GM crops can contribute essentially to the millennium development goal, that of reducing poverty and increasing food security, by optimizing agricultural productivity. GM plants have improved traits that include herbicide tolerance, disease and pest resistance, drought tolerance, health or nutritional benefits, a longer shelf life, or a more efficient industrial use. Also, the GM crops contribute to sustainable environmental protection by reduction of the pesticides application amount and reduction of CO2 emissions. In this context, the aim of the present paper is the worldwide brief radiography of transgenesis, in terms of surfaces, the main producing countries, but also of the main GM crops and their market. The research method consisted in selecting of several scientific results from the WOS, Clarivate Analytics, Scopus and Springer databases. Also, were accessed several statistical data of the ISAAA, USDA, Research and Market, MADR, etc. The main producing countries of GM crops are USA, Brazil, Argentina, Canada, India, Paraguay and China. The largest GM areas are occupied by soybean, maize, cotton, canola and alfalfa. The global agricultural biotechnology market for transgenic crops is expected to reach 12.07 billion USD in 2026, growing by 18.2% compared with 2021. Genetic transformation and GM agricultural crops represent an effective strategy and real chance to counteract climate change and food insecurity, and recently developed genetic engineering techniques will play an important role in the future.

Key words: *GM crops, biotechnology, food security, sustainability, environment*

INTRODUCTION

Genetics is the key to deciphering the quintessence of life on Earth and genetic discoveries will certainly solve the most spectacular problems that this science raises. The most important result of biological evolution is genetic engineering, which creates unlimited possibilities of direct intervention on genetic material, with economic and social implications among the most promising.

Genetic engineering, known as recombinant DNA techniques or genetic modification/transformation, refers to changing of the genetic makeup of an organism using transgenesis. GM organisms are modified through the application of transgenesis or DNA recombination technology, the transgene being incorporated into the host genome or a host gene having its expression modified [15]. The terms genetically modified organism, transgenic organism and genetically configured organism are similar.

Genetic transformation techniques aim to substantially increase the food production for a continuously growing human population. In this context, modern biotechnology is a high-tech version of conventional breeding, able to achieve innovative products (plants and animals with superior productive qualities), within record time, unimaginable in practices of the conventional agriculture [9, 10].

The climate changes directly influence crops yield and indirectly might result in increase invasion of weeds, pests and pathogens [18, 22]. Current conditions require essential changes to be made in classical plant breeding technologies, and one of the ways is genetic modification. Transgenesis ensures the creation of new plants with targeted performance – increased productivity and quality, disease resistance and tolerance to adverse climatic factors [4, 5].

The importance of GM plants is extremelly important given that a still essential problem is the consequences caused by fungal and viral diseases in agricultural crops [6, 7, 8]. The resistance of agricultural plants to various diseases is, in most cases, a polyfactorial genetic trait. Transgenic plants until recently interested only agriculture and the food industry, but at the beginning of the new millennium, the trend of their use in many other fields is already obviously: the wood and paper industry, textile, pharmaceutical, etc. It is anticipated that the maximum potential value added to transgenic crop plants resides in the modifications of the finished products, such as, for example: increasing the content of starch, proteins, oils and sugars; modification of the baking properties of cereals; increasing the content of β-carotene; increasing the shelf life of fruits or vegetables, etc.

Globally, there are two attitudes towards the use of new cropping systems based on transgenic plants: (i) increasing the number of transgenic species and extending the areas allocated to them and (ii) limiting or even banning their cultivation [25, 26]. In Europe, where genetic transformation faces the strongest public resistance, many politicians, experts and agricultural leaders have nevertheless started to support it.

Food security is political at the state and global level, involving the intervention of most domains that ensure the development of a population's well-being. In this regard, the World Declaration on Nutrition states that "*every Government is responsible above all for the protection and promotion of food security and the good nutritional status of its population and in particular for the protection of vulnerable groups of the population and must be a key objective of human development; it must be in the center of socio-economic development plans and strategies*" [24].

Considering the immense potential of agricultural genetic transformation in ensuring food security, considerable financial efforts are being made worldwide for the development of this field, for the training and improvement of specialists and the creation of innovative techniques.

FAO is concretely involved both in the development programs of genetic bioengineering and biotechnologies, as well as in the processes of transferring their results to underdeveloped or developing countries, which do not have the possibility, by their own means, to achieve the biotechnological revolution. In this way, the respective countries will be able to improve their food security situation and, at the same time, align with current trends in environmental protection and biodiversity conservation.

MATERIALS AND METHODS

For a truly revolution in plants genetic transformation field, the main objective is the combination of modern molecular tools, sustainable screening technologies and economic evaluation.

The main objective of this paper was to review the importance of GM crops for the sustainable food security and environmental protection at the global level; the presentation of the areas and the most important producing countries of GM crops, the main cultivated GM species as well as some aspects of the GM agricultural crops market.

The research method consisted in selecting of several scientific results from the WOS, Clarivate Analytics, Scopus and Springer databases. Also, were accessed several statistical data of the ISAAA, USDA, Research and Market, and MADR.

RESULTS AND DISCUSSIONS

Transgenesis given a new tool to improve food security and reduce poverty. In recent years, new genetics modification techniques have been developed, such as TALENs, zinc finger nuclease and CRISPR/Cas9, also called gene editing, site-directed mutagenesis or novel breeding techniques. TALEN technology can be useful in this regard for precisely introducing genes of interest into plants and understanding how plant genes are regulated, how they respond to foreign molecules and how they repair their DNA [17, 23].

Millions of farmers around the world continue to choose transgenic crops due to the socio-economic and environmental benefits, as well as the important role they play in addressing food security.

Advances in plant biotechnology and agriculture depend on the efficient combination and application of various scientific inputs: phytovitroculture, cell biology, biochemistry, informatics, etc., and these advances can generate new solutions for food security [3]. The combination of new molecular tools, screening technologies and economic evaluation thus becomes the main objective of the revolution in the field of plants genetic transformation [16].

Genome editing is an extremely complex process, with a rather long history, which intervenes on the genetic code of an organism, with the help of editing or transformation at the level of genes and DNA. The modern genetic editing techniques like Zinc finger nucleases (ZFNs), Transcription Activator-Like Effector-based Nucleases (TALENs), CRISPR-Cas [14] or next generation sequencing (NGS) system [19] have a huge potential in the future for solving many issues related to plant resistance to diseases and pests and implicitly increasing food security worldwide. It is forecast that the genetic editing of pathogen targets in host will help the global Gene Editing market to reach USD 5441.3 million in 2028 [14].

Worldwide surfaces and the main transgenic crops

More than 25 years have passed since the approval of the cultivation of the first transgenic plants (1996). Since then, the areas allocated to genetically modified plants (soybean, maize, cotton, canola, etc.) tolerant to herbicides and/or resistant to attacks of some pests have increased continuously, exceeding 190 million hectares in 2020 (Figure 1) [12].

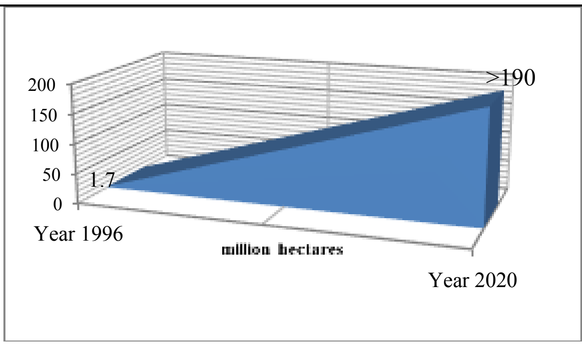

Fig. 1. Global area of biotech crops (million hectares) (1996-2020)
Source: Own design based on [12].

Transgenic plants fully contribute to ensuring food security by increasing productivity, conservation of biodiversity, reduction of gas emissions and the impact of pesticides on the environment, etc. Globally, the main producing countries of GM crops are USA, Brazil, Argentina, Canada and India (Figure 2). In 2018, Canada overtook India (6.3% of global biotech crops) [12].

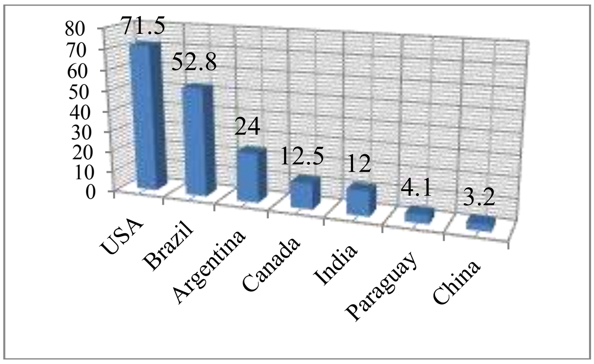

Fig. 2. The main producing countries of GM crops (million hectares)
Source: Own design based on [12].

In terms of the share of the main genetically modified crops, ISAAA Report (2021) shows that approximately 20 million farmers from 67 countries have cultivated approx. 191 million hectares of genetically modified (GM) plants, the largest areas being occupied by the following crops (Figure 3): GM soybean – 96 million hectares (50% of the global area); GM maize – 59 million hectares (30%); GM cotton – 25 million hectares (13%); rapeseed (canola) – 11 million hectares (5%) and alfalfa – 2 million hectares (2%). The leader in the field is USA; over two-thirds of food produced in USA contains at least one ingredient derived from a genetically modified plant [12]. In fact, USA grows transgenic plants on 73.1 million hectares (equivalent to 40% of the area allocated to transgenic plants globally) and having an average adoption rate of new technologies of 93% for maize, 94% for soybeans and 96% for cotton.

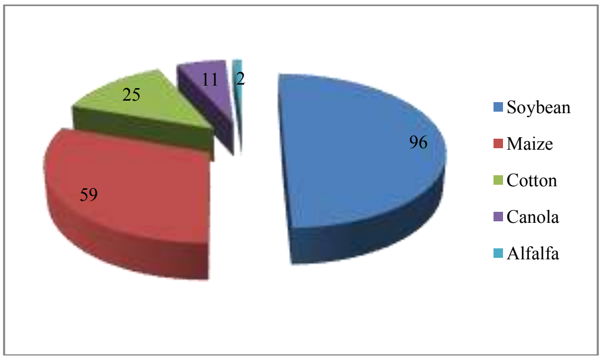

Fig. 3. The areas occupied by the main transgenic crops worldwide (million hectares)
Source: Own design based on [12].

GM soybean represents 50% of all biotechnological crops in the world. Over 96 million hectares, representing 78% of the total 124 million hectares dedicated to this crop, are cultivated with transgenic soybean. The largest growers of GM soybean are the USA (32 million hectares), Brazil (31 million hectares), Argentina (19 million hectares), Paraguay (3 million hectares), Canada (2 million hectares), Uruguay (1 million hectares), Bolivia (1 million hectares) (Figure 4) and, on smaller areas, South Africa and Chile.

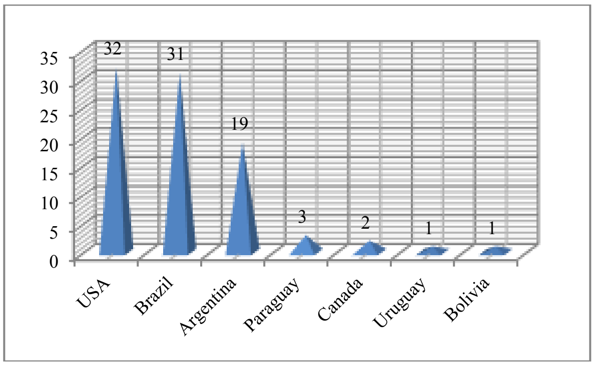

Fig. 4. The largest growers of GM soybean (million hectares)
Source: Own design based on [12].

The amount collected by GM soybean growers is over US$5 billion from each year.

GM maize production is concentrated in the USA, Brazil, Argentina, Canada, Paraguay and South Africa, but also other countries, their number being 14. The areas cultivated with GM maize worldwide are over 59 million hectares [12].

As for the areas cultivated with canola (GM rapeseed), they increased, worldwide, from 8.5 million hectares in 2016 to 10.5 million hectares in 2020. The increase was due to the global demand for edible oil. The big growers are the USA, Canada and Australia and Chile, which annually collect approx. $0.7 billion for canola production. It can be appreciated that areas sown to canola could increase significantly in the coming period, in response to the demand for vegetable oil and biodiesel [12]. Of the global total of 35 million hectares cultivated with rapeseed, 29%, i.e. 10.1 million hectares are cultivated with canola genetically modified hybrids.

Total intended area to GM sugar beet crops is about 480,000 hectares and is grown only in USA and Canada.

Other transgenic crops grown worldwide are:
- DroughtGard™ maize, drought tolerant (275,000 hectares in USA);
- Sweet corn (1000 hectares in USA);
- Papaya (8550 hectares in China and 1000 hectares in USA);
- Innate™ potato (2500 ha in USA). This GM potato can be stored for a longer time, does not brown after peeling and, prepared at high temperatures, has a low content of acrylamide, a potentially carcinogenic substance;
- Arctic GM apples oxidation-resistant (USA)
- Bt eggplant (700 hectares in Bangladesh), etc.

Three types of GM soybeans were authorized by the European Commission in 2020 for food use and fodder production, namely soybeans *MON 87708* (Genuity Roundup Ready *2Xtend*), *MON 89788* (Genuity Roundup Ready *2Yield*), respectively *A5547-127* (Liberty Link) [2]. The three GM soybean varieties went through a complex authorization procedure, which included a comprehensive favorable assessment by the European Food Safety Authority (EFSA). Even if it seems like good news for many Romanian farmers, who depend on imports of groats (mostly from transgenic soybeans), the authorization decision does not cover the cultivation process. European officials say that all member countries of the community block (EU27) had the right to express their point of view in the Permanent Committee and, subsequently, the Appeal Commission [2].

Future transgenic agricultural crops include beta-carotene-enriched golden rice tested in the Philippines and Bangladesh; Fusarium-resistant bananas and disease-resistant and drought-tolerant biotech wheat tested in Australia; high yielding and high biomass wheat in the United Kingdom; Uganda's *Desiree* and *Victoria* blight-resistant potato varieties; *Maris Piper* potato variety, resistant to nematodes and lower acrylamide content in EU; insect resistant chickpea and biotech mustard as a source of oil in India; drought-tolerant sugar beet in India and Indonesia; omega-3 enriched camelina in EU, etc. [11].

Starting with 2016, for the first time since Romania's accession to the European Union, the area cultivated with genetically modified plants locally reached zero [13]. The only genetically modified plant allowed by the European Commission, the *MON810* maize resistant to lepidopteran insects (produced by the American company Monsanto), was introduced into crops less and less until 2015, when it was still present on only 2.5 hectares at the Secuieni Agricultural Development Research Station, in Neamţ County [13].

According to Ministry of Agriculture data, in 2007, Romanian farmers they cultivated 332.5 hectares with GM maize, after which the areas suddenly increased to over 6,100 hectares in 2008, when 58 growers introduced it into cultivation. 2008 was, however, the only "boom" year for GM maize MON 810 in Romania because, subsequently, the areas significantly decreased year by year [13].

In 2015, in Romania began the field testing of GM plums, resistant to the plum virus (Bistrita Pomiculture Research and Development Station obtained the approval of the European Commission as early as 2011). The area cultivated with GM plums was 1200m^2 in 2015. However, the Research Companies in the field were no longer interested in doing tests on the EU territory, considering that the authorizations cost a lot and the prospects are limited [21].

Aspects of GM crops market

The global market of biotechnological agricultural crops reached the spectacular figure of over 186 billion dollars annually, of which approx. half the amount for the main GM crops (soybean, corn, cotton and canola), grown by farmers worldwide [12].

EU is one of the largest importers of agricultural products in the world. A substantial – and growing – share of these imports is transgenic crops. They are grown almost entirely in countries outside Europe, where farmers are free to choose between conventional and transgenic hybrids. The EU's import dependency is particularly high in the case of forage soybeans for the European livestock sector, as the production of bean soybeans in the EU states covers less than 5% of its own demand. The EU also imports significant quantities of GM maize and GM canola to meet domestic demand. For cotton, the EU is almost entirely dependent on imports in finished product form.

The amounts of transgenic soybeans imported annually by the EU are almost 34 million tons, i.e. over 60 kg for each of the approx. 500 million EU citizens. In terms of costs, the EU spends approx. €13 billion for imports of GM soybeans and groats, more than any other agricultural product. Almost all soybean production comes from America, where the adoption rate of GM technology exceeds 90%. The global agricultural biotechnology market for transgenic crops was USD 5.23 billion in 2021 and is expected to reach USD 12.07 billion by 2026, growing by 18.2% [20]. The respective estimates are stipulated in the US/Canada Report ″Global Agricultural Biotechnology Market for Transgenic Crops (2021-2026) by Type, Crop, Geography, Competitive Analysis and Covid-19 Impact″. The report provides a comprehensive assessment of the global agricultural biotechnology market for transgenic crops, including in-depth qualitative analysis, verifiable data from authentic sources, and market size projections. The projections are calculated using proven research methodologies.

Currently, given the context of the war between Russia and Ukraine, European farmers are preparing to buy more genetically modified feed from the US and Latin America, after the Russian invasion interrupted maize supplies from Ukraine [1]. The war in Ukraine has already forced companies to look for alternatives to sunflower oil, and the change in trade would also include maize, which is mainly used as animal feed. Non-genetically modified maize from Ukraine accounts for about half of the European Union's imports. Conversely, in the case of USA maize, approximately 92% is genetically modified, a similar percentage being valid in the case of that in Brazil. As the EU moves towards guaranteeing food security, the EU the community block also relaxes rules on imports [1].

The Academy of Agricultural and Forestry Sciences (ASAS) Romania has issued a statement regarding genetically modified plants, and the conclusion was that they do not pose risks to human health; the transgenic plants bring considerable benefits to farmers and are much more environmentally friendly than conventional technologies. Thus, as shown in the ASAS Communiqué, the use of transgenic plants in agriculture has a positive impact on the environment; globally, in the period 1996-2006, the use of these plants determined the reduction of pesticide consumption by 286 million kg, equivalent to the total amount of pesticide active ingredients used during one year on the arable surface of the EU [13].

While in Romania the uncultivated agricultural areas are increasing, in many countries of the world, both developed and developing, the areas cultivated with transgenic plants are expanding and the number and incomes of farmers which adopt new technologies constantly increase. At the same time, the ban without any scientific basis on the use of transgenic plants delays progress in agriculture, deprives farmers of the right to choose what they want to grow and reduces Romania's competitiveness on the global market.

According to ISAAA Report (2021), from 1996 to 2019, genetically modified agricultural crops contributed to food security, sustainability and environmental protection by:

- An increase in agricultural production valued at $150 billion;
- Avoiding the application of approx. 500 million kg of pesticides (in active substance);
- Reduction of CO_2 emissions, by reducing the number of pesticide treatments; for example, in 2016 alone, CO_2 emissions into the atmosphere were reduced by 28 billion kg, an amount equal to the amount of carbon dioxide that would no longer reach the atmosphere if 12.4 million automobiles were withdrawn from circulation; etc. [12].

CONCLUSIONS

With a rapidly growing population, humanity is increasingly dependent on the ability of biotechnology to develop and maintain a sustainable agriculture and a healthy environment. The innovative thinking of the specialists in the laboratories is doubled by concrete actions to create new GM plants with production and quality characteristics improved, safe for consumers and for environment.

Transgenic commercial crops have improved traits that give to the plant herbicide tolerance, disease and pest resistance, drought tolerance, health or nutritional benefits, a longer shelf life, or a industrial use more efficient, etc. Also, the GM crops contribute to sustainable ensuring of food security and environmental protection by agricultural production increase, reduction of the pesticides application amount and reduction of CO_2 emissions.

The main transgenic plant growing countries globally are: USA, Brazil, Argentina, Canada, India, Paraguay and China. The largest GM areas are occupied by soybean, maize, cotton, canola and alfalfa. Other transgenic plants authorized and grown worldwide are: sugar beet, potato, rice, papaya, tomatoes, sweet pepper, and various flower species.

GM foods production reduces the need for pesticides and increasing investment in the field of biotechnology research and development are fueling pace to growth of GM food market. The global agricultural biotechnology market for transgenic crops was 5.23 billion USD in 2021 and is expected to reach 12.07 billion USD in 2026, growing by 18.2%

The immense diversity of theoretical and practical implications that the field of genetic transformation in agriculture entails, as well as its future evolution, are not yet fully predictable, but the current information explosion creates the theoretical and practical framework necessary for continued research and, at the same time, opens new horizons.

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DETERMINANTS OF CASHEW NUTS EXPORTS SUPPLY IN NIGERIA (1980-2020)

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Abstract

Cashew is an emerging agricultural export crop in Nigeria. However, significant export earnings have not been recorded in recent years from cashew exports. The study investigated the determinants of the cashew nuts export supply in Nigeria between 1980 and 2019. Secondary data extracted from the publications of the Food and Agriculture Organization statistical database (FAOSTAT), the National Bureau of Statistics (NBS), and the Central Bank of Nigeria (CBN). Means, percentages, and coefficient of variations were the descriptive statistical tools used, while Augment Dickey-Fuller (ADF), Johansen co-integration and vector error correction model (VECM) were the inferential statistical tools employed in the study. ADF and Johansen's results show that the variables of the model were stationary after the first difference and co-integrated. Domestic production export supply and earnings fluctuated over the period of the study with a mean of 247,560.70 tonnes, 33,010.22 tonnes, and ₦47,462.43 million respectively. The average annual growth rate of cashew nuts production, export supply, and export earnings was 197.98 percent and 565.79 percent respectively VECM result reveals that domestic cashew nut production and exchange rate have asymmetric influence and cashew nuts export supply in the short run, while agricultural land area, cashew nuts production and inflation rate negatively influence cashew nuts export supply in the short run, but exchange rate positively influences cashew nut export supply in the long run. It is concluded that agricultural land area domestic production, of cashew nuts, exchange, and inflation rate significantly influence the export supply of cashew nuts in the study area. Thus, significant policy reform on the production of cashew nuts, exchange, and the inflation rate would improve exports supply of cashew nuts significantly.

Key words: *cashew nuts, value addition, exchange and inflation rates, error correction mechanism*

INTRODUCTION

Cashew is an important crop in the agriculture of many countries. According to Food and Agriculture Organisation (FAO), Nigeria ranks among the top five cashew-producing nations after Ivory Coast, India, Burundi and Vietnam. Other countries facing poverty, like Benin and Indonesia, cultivate cashew to diminish its effect and bring income to producers [8, 16].

In 2014, Nigeria was ranked the second largest producer of cashew with an annual production of 836,500 tonnes, behind Vietnam which was the highest producer with 1,190,900 tonnes [11]. Three main cashew products are traded in the international market: raw nuts, cashew kernels, and cashew nut shell liquid (CNSL) [3] and [5].

Annually, Nigeria generated ₦24b in 2012 from the cashew trade, providing about 600,000 jobs to people engaged in the cashew value chain [1]. Health-wise, cashew is of immense benefits; cashew apple contains five times more vitamin C than an orange which makes them unique among other fruits [2]. The apple is also used traditionally as a curative for scurvy and stomach ailments like dysentery and diarrhea. Fresh or distilled, it is a potent diuretic, possessing antiscorbutic properties, and is useful for kidney troubles and in advanced cases of cholera. Clinically, cashew nut consumption has also been proven to improve sperm count and reduce infertility among couples [20] and [9].

Cashew nut contains 47% fat, 21% protein, and 22% carbohydrate [19] and [23].

Cashew is widely cultivated in Nigeria with production spanning 27 out of 36 States in all the geo-political zones. The production of cashew nuts is estimated to be about 100,000 tons of raw nuts per annum. About 60 to 70% of the local output is commercialized of which about 90% is exported as raw nuts [21]. Cashew is a high-potential export-oriented agricultural crop and represents 7 to 8% of non-oil export earnings [13]. Despite the dominance of this crop in many states, yield per hectare is not encouraging.

According to [11], Nigeria's yield in terms of cashew nuts is relatively low at 23, 922 kg/ha in 2016, when compared to yields from other countries within the same period such as Peru (47,756 kg/ha), Philippines (75,521 kg/ha), Vietnam (43,447kg/ha) and Mexico (24,971 kg/ha). The yield potential is yet to be actualized as a result of varied factors ranging from low-yielding plantations to inadequate farm management, processing facilities, and marketing problems.

The average nut yield of a mature tree is in the range of 7-11 kg per annum [6]. Cashew is largely produced on small scale, and the average delivery per farmer is roughly 300kg per hectare per season. The export free on board price of raw cashew nuts has fluctuated between US$3,000 - 3,500 per tonne from January to August 2010, while the local market price of cashew nuts per ton ranges from US$2,667 to 3,333 (₦400,000.00 to ₦500,000.00) to deliver it to Lagos, Nigeria, point of export (1 USD = 150 NGN) [4] and [5].

Annually, Nigeria's export earnings from cashew nuts ranged from Nigeria varies from US$ 25 to 35 million. However, low-value addition has resulted in a low supply of high-quality cashew nuts with Nigerian raw nuts prices discounted in the world market (20% to 30%) compared to those of neighboring countries [22]. Cashew is a strategic export-oriented crop in Nigeria capable of providing enormous foreign exchange earnings and employment opportunities and curb desertification in Nigeria. The crop is of industrial importance in Nigeria, with rising demand in the confectioneries, food, and beverage industries. There is also an increasing demand for cashew nuts in the global market. Sustainable production and continuous rise in cashew nuts export earnings will rely on the production, export supply, international competitiveness, and the outcomes of policy interventions [15].

From the foregoing, the study investigated the determinants of cashew export supply in Nigeria between 1980 and 2020. The specific objectives of the study are to: examine the trend in cashew nuts production in Nigeria, examine the trend in cashew nuts export supply in Nigeria, examine the trend in the contribution of cashew nuts to agricultural exports in Nigeria, and determine the effect of significant factors on cashew nuts export supply in Nigeria during the period covered by the study.

MATERIALS AND METHODS

The study area for this research is Nigeria. Nigeria lies between 40 and 140 North of the equator and between longitudes 30 and 150 east of Greenwich. Nigeria has a total land area of 923,768.622 km or about 98.3 million hectares, and a population of 149,229,090140 million people (National Population Commission (NPC), 2009 [18]. It is bordered in the West by the Republic of Niger and the Republic of Benin, and on the East by the Republic of Cameroon. On the North, she shares her border with the Republic of Niger and the Chad Republic, and on the South the Gulf of Guinea.

The data for this research were in annual time series. The data set was obtained from secondary sources. These sources will include publications of the Central Bank of Nigeria (CBN) [7], the National Bureau of Statistics (NBS) [17], and Food and Agriculture Organization (FAO) Statistics (FAOSTAT) [10, 11, 12], International Trade Commission, ITC [14]. Specifically, data were collected on agricultural land area, cashew nuts production and export quantities, inflation rates, exchange rates, producer, and export and world prices of cashew nuts. The period for data analysis is between 1980 and 2019.

This study employed a number of analytical methods based on the objectives of the study as stated earlier. These include: means, standard deviation, coefficients of variation, percentages, and average growth rate. These were used to describe trends in cashew nuts production and export quantities.

The Augmented Dickey-Fuller statistics were used to examine the stationarity of time series data. Johansen's method was used in verifying co-integration among the variables of the model. The error correction mechanism (ECM) was used to investigate the determinants of cashew nut export supply over the study period. The implicit model that was utilized in this study is specified as:

$\Delta LnY_t = \alpha_1 + \alpha_2\Delta lnY_{t-1} + \alpha_3\Delta lnX_{2t-1} + \alpha_4\Delta lnX_{3t-1} + \alpha_5\Delta lnX_{4t-1} + \alpha_6\Delta lnX_{5t-1} + \alpha_7\Delta lnX_{6t-1} + \lambda_1 ECT_{t-1} + u_{t1}$……………………………………………(1)

where:

Y is the export supply of cashew nuts in metric tonnes

X_1 is the agricultural land area in square kilometres

X_2 is cashew nuts production quantity measured in metric tonnes

X_3 is the exchange rates was measured as amount of Naira exchanged for United States Dollar

X_4 is the interest rate in the economy measured in percentage

X_5 is the inflation rate in the economy measured in percentage

ECMt is the error correction factor.

Δ is the difference operator

$_{t-1}$ is the lagged values of variables

Ln is the logarithm operator

U_{ts} are stochastic random errors

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6,$ and λ_1 are parameters to be estimated.

RESULTS AND DISCUSSIONS

Trend in cashew nuts production in Nigeria (tonnes)

The trend in cashew nuts production in Nigeria between 1980 and 2020 is shown in the Table 1 and Figure 1. The result in the table reveals an increasing trend in cashew nuts production over the sub-periods averaging 247,560.70 tonnes between 1980 and 2020. However, the average annual growth rate of cashew nuts production stagnated between 1980 and 1989, improved significantly between 1990 and 1999, but suffers a serious decline in the 2000-2009 sub-period. The trend in the coefficient of variation shows a high degree of instability in cashew nuts production during the study period.

Table 1.Trends in cashew nuts production in Nigeria (1980-2020) (tonnes)

Sub-periods	Mean (tonnes)	Annual percent growth rate (%)	Coefficients of variation (%)
1980-89	2,500	00.00	0.00
1990-99	118,900	129.00	106.98
2000-09	59,926.60	71.67	571.71
2010-20	2,554,416.30	87.37	73.21
All Period	247,560.70	300.00	104.40

Source: Computed from FAOSTAT, NBS and CBN Statistical Bulletin, 2021 [10, 11, 12, 17, 7].

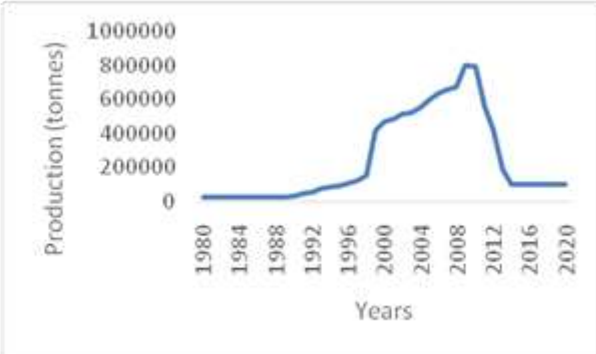

Fig.1.Trends in cashew nuts production (tonnes) in Nigeria (1980-2020)
Source: FAOSTAT, 2021 [12].

Trend in cashew nuts export supply (tonnes) in Nigeria

Table 2 and Figure 2 present the trend in the export supply of cashew nuts in Nigeria from 1980 to 2019. The table shows that the average export supply of cashew nuts fluctuated between 1980 and 2020. Average supply of cashew nuts ranged from 3,110.40 tonnes in the 1980-1989 sub-period to 95,961.70 tonnes in the 2010 to 2020 sub-period averaging 33,010.22 tonnes for the entire study period. The average annual growth rate of the export supply of cashew nuts decrease and increase alternately across the sub-periods, averaging 197.98 percent over the study period. The trend in the coefficients of variation reveals a high degree of instability in cashew nuts over the study period.

Table 2. Trend in cashew nuts export supply in Nigeria (1980-2020) (tonnes)

Sub-period	Mean (Tonnes)	Annual percentage change (%)	Coefficient of variation (%)
1980-89	3,110.40	847.70	86.11
1990-99	17,052.80	260.16	176.48
2000-09	15,916.80	532.88	243.29
2010-20	95,961.70	290.99	138.48
All period	33,010.22	197.98	152.36

Source: Computed from FAOSTAT, NBS and CBN Statistical Bulletin, 2021 [10, 11, 12, 17, 7].

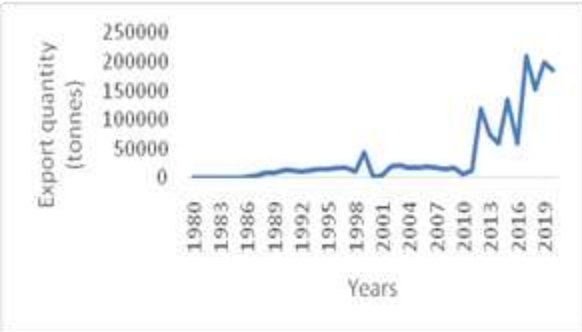

Fig. 2. Trend in cashew nuts export supply (tonnes) in Nigeria (1980-2020)
Source: FAOSTAT, 2021 [12].

Trend in cashew export earnings in Nigeria

The trend in cashew nut export earnings is presented in Table 3 and Figure 3.

Results in Table 3 and Figure 3 reveal an alternating increase and decrease in average cashew nut export earnings across the sub-periods, with an average of $47,462.43 thousands for the entire study period.

However, the average annual growth of cashew nut export earnings increases progressively across the sub-periods, averaging 565.75 percent over the entire period of the study.

Table 3. Trend in cashew nuts export earnings in Nigeria (1980-2020) (₦millions)

Sub-periods	Mean ($)	Annual percent growth rate (%)	Coefficients of variation (%)
1980-89	1,917.10	128.00	81.62
1990-99	10,344.40	766.55	114.43
2000-09	8,703.70	369.83	244.08
2010-20	168,884.43	402.91	11.46
All Period	47,462.43	565.75	30.58

Source: Computed from FAOSTAT, NBS and CBN Statistical Bulletin, 2021 [10, 11, 12, 17, 7].

The coefficient of variation range from 11.46 percent in the 2010-2020 sub-period, with an overall mean of 30.58 percent for the duration of the study, showing a high degree of instability in cashew nuts export earnings over the study period.

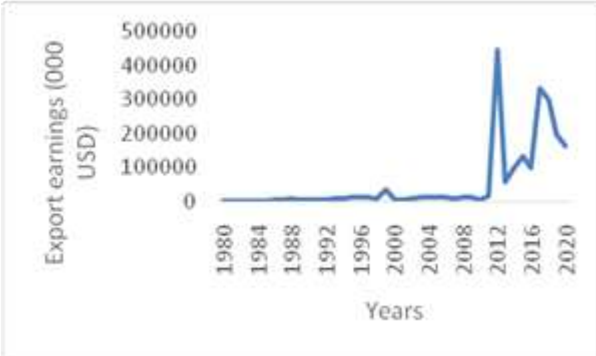

Fig. 3. Trend in cashew nuts export earnings ('000 USD) in Nigeria (1980-2020)
Source: FAOSTAT, 2021[12].

Results of time series analysis

Unit root test

In analyzing time series data, it is pertinent to examine the behavior of the data set over the analytical period. An important factor in this regard is to confirm if the series is stationary over time or if they are time-invariant. If the series is not stationary over time, it is evidence that the series contains a unit root or not. The presence of a unit root (when the data is not stationary) in a time series will lead to spurious results if such a series is used in regression analysis. Therefore, non-stationary time series data must be converted to a stationary form before they can be used in regression analysis for the results to be valid for statistical inference and policy recommendations.

The unit root test results using the Augmented Dickey-Fuller (ADF) technique are presented in Table 4. The table reveals that the variables of the model are not stationary in their original values, since the ADF statistics are less than critical values at 1%, 5%, and 10% respectively. Under this condition, the null hypothesis of the presence of unit roots in the variables of the model cannot be rejected. The variables cannot be used for regression analysis in their original form because they will give spurious results.

Table 5 presents the ADF unit root tests of the first difference of the variables of the model. The table shows that the ADF statistics are greater than the critical values at 1%, 5%, and 10% respectively. Hence, the null hypothesis of the presence of a unit root can be rejected. Thus, the variables of the model in their first difference form can be used for regression analysis because the results will be valid for statistical inference and policy formulation.

Table 4. Results of ADF unit root test for variables (original values)

Variables	ADF value	Mackinnon critical values			Decision
		1%	5%	10%	
LnY	-3.02	-3.67	-2.97	-2.62	Non-stationary
lnX_1	-1.61	-3.67	-2.97	-2.62	Non-stationary
lnX_2	-2.30	-3.75	-3.00	-2.63	Non-stationary
lnX_3	-2.11	-3.75	-3.00	-2.63	Non-stationary
lnX_4	-3.13	-3.75	-3.00	-2.63	Non-stationary
lnX_5	-3.47	-3.75	-3.00	-2.63	Non-stationary

Source: Data Analysis, 2021.

Table 5. Result of ADF unit root test for variables (first difference values)

Variables	ADF value	Mackinnon critical values			Decision
		1%	5%	10%	
DlnY	-7.88	-3.68	-2.97	-2.62	I(1)
$dlnX_1$	-5.03	-3.68	-2.97	-2.62	I(1)
$dlnX_2$	-4.45	-3.68	-2.97	-2.62	I(1)
$dlnX_3$	-5.02	-3.68	-2.97	-2.62	I(1)
$dlnX_4$	-6.10	-3.68	-2.97	-2.62	I(1)
$dlnX_5$	-4.62	-3.68	-2.97	-2.62	I(1)

Source: Data Analysis, 2021.

Co-integration test

The results of the Johansen co-integration test of the variables of the model are presented in Table 6. The results reveal that there is 1 co-integrating equation among the variables of the model. This reflects a long-run relationship among the variables of the model. Therefore, they can progress to vector error correction (VECM) regression analysis.

Table 6. Results of Johansen tests for co-integration

Maximum rank	Parms	LL	Eigen value	Trace statistics	5% critical value
0	42	-1271.7593		105.8961	94.15
1	53	-1252.7836	0.64146	67.9447*	68.52
2	62	-1238.1584	0.54641	38.6942	47.21
3	69	-1228.912	0.39335	20.2015	29.68
4	74	-1220.8324	0.35386	4.0423	15.41
5	77	-1218.8267	0.10275	0.0307	3.76
6.	78	-1218.8113	0.00083		

Source: Data Analysis, 2021.

Results of vector error correction model (VECM)

Results of short-run vector error correction model (VECM) regression analysis

The results of the short-run results of vector error correction mode (VECM) regression analysis are presented in Table 7.

Results in the Table show that the value of R^2 is 0.75 and is statistically significant at 1% level, showing that the estimated model has a good fit.

The error correction factor (-0.950) is negative and statistically significant at a 1% level as expected.

Short-run results show that the coefficient of cashew nuts production (X_2) is negative and statistically significant at the 1% level showing that the variable is inversely related to the export supply of cashew nuts (Y).

However, the coefficient of the exchange rate is positive and statistically significant at the 10% level, showing that an improved exchange rate will stimulate an increased export supply of cashew nuts (Y).

Table 7. Short run vector error correction model regression analysis results

Variables	Coefficients	Standard error	z-value	p-value
Ce_1	-0.955	0.289	-3.40	0.01*
Export supply of cashew nuts (Y)	-0.394	0.189	-2.08	0.037**
Agricultural land area (X_1)	23,324.400	19559.800	1.190	0.233
Cashew nuts production quantity (X_2)	-0.217	0.058	-3.77	0.000*
Exchange rate (X_3)	515.134	284.312	1.81	0.007*
Interest rate (X_4)	320.828	980.404	0.330	0.743
Inflation rate (X_5)	259.437	255.110	1.020	0.309
Constant	-1,623.513	4741.363	-0.340	0.732
R^2	0.750			
Chi-square	88.716*			
p-value	0.000			
AIC	77.425			

* mean significant at 1% level
** mean significant at 5% level
Source: Author computation 2021

Results long - run vector error correction model (VECM) regression analysis

The long-run results of the VECM regression analysis are shown in Table 8. From the Table, long-run results reveal that agricultural land area (X_1), cashew nuts production (X_2), and inflation rate (X_5) negatively affect the export supply of cashew nuts, while exchange rate (X_3) positively affects the export supply of cashew nuts in the study area.

Table 8. Long run vector error correction model regression analysis results

Variables	Coefficients	Standard error	z-value	p-value
Export supply of cashew nuts (Y)	1	-	-	-
Agricultural land area (X_1)	-14,735.010	6138.52	-2.40	0.016*
Cashew nuts production quantity (X_2)	-0.045	0.017	2.540	0.011*
Exchange rate (X_3)	596.160	125.218	4.760	0.000*
Interest rate (X_4)	41.907	657.903	0.330	0.949
Inflation rate (X_5)	631.955	183.599	3.44	0.001*
Constant	-120979.300			-

*mean significant at 1% level
Source: Author Computation, 2021.

CONCLUSIONS

Based on findings from the study, it is concluded that domestic production of cashew nuts and macroeconomic variables (exchange and inflation rate) significantly influence the export supply of cashew nuts in the study area. Hence, policy measures should ensure the production of high-quality cashew nuts that will command a premium price in the international market that will improve earnings from cashew nuts exports. Furthermore, there is a need to ensure a macro-economic friendly environment for cashew nuts exports through effective and efficient monetary policies on macro-economic variables such as exchange rate and interest rate in order to improve earnings from cashew nuts exports significantly.

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STATISTICAL MODEL FOR SOME CONSTRAINTS AFFECTING THE LEVEL OF RICE FARMERS' INCOME

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Abstract

Rice farming is one of the main sources of income in many rural areas in the Philippines. The purpose of this study is to model the different constraints that influence the level of rice farmers' income in Albuera, Leyte, Philippines. Survey data from an available sample of participants were gathered through a face-to-face interview consisting of the rice farmers' income and its determining constraints. Some descriptive measures were calculated to summarize the gathered variables and ordinary least square (OLS) regression analysis was employed to predict the significant constraints of farmers' monthly income. Results revealed that the rice farmers' monthly income is below the poverty line as the Philippine poverty threshold is concerned, that is, rice farmers in rural areas are considered "poor". The farmers have said that their rice production and income level are "affected" by the following constraints: "high prices of agricultural inputs", "inadequate capital", and "pest and diseases". Additionally, their rice production and income are moderately affected by "lack of credit facilities", "lack of technical services", and "weeds". Moreover, the two constructed statistical models showed that the following constraints are significant factors affecting the income level of rice farmers: "high prices of agricultural inputs", "lack of credit facilities", "high cost of transportation", "low educational attainment", and "land rent". Conclusively, farmers are in need of assistance from the local government concerning access to credit for capital, adoption of new technologies in farming, and other facilities that might improve their production. Furthermore, farmers must undergo some seminars and training to strengthen their knowledge of rice farming and improve their practices to increase their level of production, well-being, and monthly income.

Key words: *Rice farmers, level of income, constraints in rice production, statistical modeling, Philippines*

INTRODUCTION

In the Philippines, rice farming is one of the major contributors to the gross domestic product (GDP) in the country [2]. In the study of Casinillo [8], it is stated that rice is the main crop produced in the country and is considered one of the government focuses concerning laws and policies. In fact, rice production in the Philippines is the main source of income for many Filipino farmers in rural areas, especially for small-scale farm areas [7] [9]. Income is very important for every individual since it provides food security, basic needs, comforts, and other benefits. According to Ojo and Baiyegunhi [18], income in rice farming has a lot of influencing factors that need to be addressed especially the constraints that they are facing. Apparently, rice farming is a risky source of income due to the different problems encountered in the production such as pests and diseases, low soil fertility, bad weather, and inadequate capital for agricultural inputs, among other problems [4], [11], [22], [23]. In that case, to find a solution to the low economic income in rice farming, it is necessary to investigate the root cause and problems in the rice production process.

Farming in the rural areas in the Philippines has mostly been cultivated and managed by aging farmers with low educational attainment [7]. In fact, these rural farmers are in need of support from the local government in regard to knowledge in farming, innovative, latest, and advanced technologies that are suitable nowadays, agricultural inputs, and other vital needs in rice production [1], [22], [27]. Apparently, educational programs in agriculture are vital for farmers' knowledge, attitudes in farming, and practices towards newly discovered technologies since they influence them to adopt better rice production and profitability [22]. Hence, it is very crucial to investigate the determinants that influence their production process so that some policy-makers might formulate suggestions that may turn into laws that will help farmers and address their agricultural needs. The study of Nueva et al. [17] stated that investigating the farmers' point of view will provide empirical evidence that helps determine the issues and problems that they are facing in their farming activities due to existing laws in the country. Moreover, a survey concerning the income and constraints of rice farmers might provide necessary information that serves as a criterion to improve their way of earning and solve the poverty in the country [7], [19], [28].

Although many studies have been published in the literature concerning rice farmers' income, developing a statistical model for some constraints in the level of income in rice farming is scarce. In fact, it has never been done in rural areas and small-scale farmers in the Philippines, hence, this study was realized. To obtain the goal of this article, the study accomplished the following specific objectives: to describe the socio-demographic profile of rice farmers; to tabulate the different income levels of rice farmers; to characterize the different constraints in rice farming; to document the significant constraints in rice farming using a statistical model. The results of this survey article might help government agencies to improve the promulgated laws and policies concerning the well-being of rural farmers and rice production in the Philippines. Moreover, findings might serve as a piece of baseline information for agricultural extension agents and economics researchers.

MATERIALS AND METHODS

A complex correlational design was applied in this study to capture the association between several variables. In addition, it utilized some descriptive statistical techniques and statistical modeling in the form of econometrics. The survey study site is one of the Barangaysin Albuera, Leyte, Philippines that is considered rice producers. The name of the barangay is Poblacion where most of the farmers in this area are considered small-scale workers where they cultivate a paddy farm of at most 2 hectares or an average of 0.77 hectare. The area was chosen because of the existing problems and constraints that hindered the rice production level in the said barangay. Hence, the researcher has the desire to investigate and suggest a solution to improve the low production level in rice farming. Map 1 presents the study's research location, that is, Barangay Poblacion, Albuera, Leyte, Philippines using Google Maps.

Map 1. Location of Barangay Poblacion, Albuera, Leyte, Philippines
Source: [12].

The participants of this study were farmers who cultivate a paddy farm of at most two hectares and who experience some constraints during their production process. In addition, the dominant (60%) of these farmers were a tenant. And the researchers use primary data through a face-to-face interview with the activity of availability sampling. This means that the study considered only the rice farmers who are available during the time of the survey. Before the study has been conducted, it involves an ethical process such as a permission letter sent to the Municipal Agriculture Office (MAO) of the town of Albuera, Leyte to have prior consent in conducting the said survey. After the go signal of the head of MAO, the survey was immediately implemented. The farmers were informed that the said survey was voluntary and the information gathered was solely used for research only and treated confidentially.

The researchers developed a structured questionnaire that contains the following parts: (1) demographic profile; (2) level of income; (3) constraints in rice production. For the demographic profile, farmers were asked about their age (actual years), sex (0-female, 1-male), and educational attainment (0-no college degree, 1-with college degree). Secondly, farmers' actual monthly income was determined by the following formula:

$$Monthly\ income = \frac{total\ revenue - total\ cost}{4\ months} \quad \text{...(1)}$$

The above formula (1) is a calculation of the monthly income of rice production in one cropping season with a duration of about 4 months from soil preparation to harvesting [25]. Lastly, the farmers were asked to rate the following constraints in rice farming: land rent; inadequate capital; inaccessibility to farmland; pests and diseases; weeds; high inputs; lack of post-harvest facilities; lack of credit facilities; lack of technical services; high cost of transportation; and low soil fertility. The rating scale is from 1 to 4 with the following verbal description: 1-Not affected (1.00-1.75); 2-Moderately affected (1.76-2.50); 3-Affected (2.51-3.25); and 4-Severely affected (3.26-4.00).

After the data is collected, it is encoded in excel and undergoes clearing to remove or exclude the participants who have missing and extreme (outlier) response/s. Hence, the total number of participants is 63 rice farmers. Now, in summarizing the variables, descriptive statistics such as mean, standard deviation, minimum, maximum, counts, and percentages were used. In determining the significant constraints of rice farmers' income, a statistical model was constructed in the form of an ordinary least square (OLS) econometric regression analysis. The monthly income was the dependent variable, and the demographic and constraints in farming were the independent variable in the regression. The model equation is given by

$$I_j = c_0 + c_1X_{j1} + c_2X_{j2} + \cdots + c_pX_{jp} + e_j \quad \text{.....(2)}$$

where I_j is the farmers' monthly income, $j = 1, \dots, m$ and m is the number of rice farmers involved in the study, $c_t (\forall t \in \{0, 1, \dots, p\})$ are the parameters of the model (2), X_{jt} $(\forall t \in \{1, \dots, p\})$ refers to the independent variables and e_j refer to the random error. Diagnostic tests such as the heteroscedastic test, omitted variable test, multicollinearity problem test, and normality test for residuals were also employed to ensure the validation of the results of the regression. The said tests were subject to a 5% level of significance. Finally, STATA version 14.0 was used for all the calculations involved in this study.

RESULTS AND DISCUSSIONS

Farmers' Profile

In [9], it is stated that most of the rice farmers in rural areas are elderly since the young ones are sent to school for better educational attainment and later find decent work with higher income. A parallel finding was found in Table 1 where rice farmers are mostly older individuals (M=57.49, SD=9.59). The youngest is 36 years old and the oldest is 79 years old. Dominant (65%) of these farmers are male and about 35% of them are females (Table 1). It is worth noting that rice farming requires a masculine nature of work, hence, male individuals are more capable of doing the heavy part in the rice production. However, the easy and light part of rice production is mostly done by females, hence, women's participation in farming is also certain and essential [10]. Only 11% of these rice farmers are college level and the dominant (89%) of them are high school level and below (Table 1). This result is parallel to the findings in [8] and [9], wherein small-scale rice farmers are mostly with low educational backgrounds, that is, on average, they are only high school level.

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Table 1. Rice farmers' profile.

Variables	M	SD	min	max
Age	57.49	9.59	36	79
Male[a]	0.65	0.48	0	1
Educational Attainment[a]	0.11	0.32	0	1

Note: a-dummy variable
Source: Own calculation (2022).

Farmers' Income Level

Table 2 shows that about 41.27% of the rice farmers' income fell in the interval 4,000 (₱) and below. About half (50.79%) of these farmers are having a monthly income in the interval 4,001 (₱) - 7,000 (₱) and only 7.93% of them are having an income of 7,001 (₱) and above. This shows a small percentage of farmers with a good monthly income in rice farming. In fact, the average monthly income is close to 4,652.28 ($\pm$2,102.35)(₱). This implies that these rice farmers are living below the poverty threshold in the country Philippines [3]. In that case, it is sufficient to say that these farmers are in need of support concerning their agricultural inputs to somehow progress their production and increase their economic income in rice farming [7], [13].

Table 2. Rice farmers' monthly income.

Monthly income[b]	Frequency	Percentage (%)
4,000 and below	26	41.27
4,001 - 7,000	32	50.79
7,001 and above	5	7.93
M ($\pm$SD)	4,652.28 ($\pm$2,102.35)	

Note: b-in Philippine Peso (₱)
Source: Own calculation (2022).

Constraints in Rice Farming

Farmers said that their income in rice production is "affected" by "high prices of agricultural inputs" (M=2.51, SD=0.62) (Table 3). This result is in consonant with the findings in [7] and [9] that rice farmers' profitability is affected by the higher expense of farming inputs, especially for fertilizer, herbicides, and pesticides, among others. Farmers' rice production is also affected due to inadequate capital (M=3.19, SD=0.84) (Table 3). This implies that small-scale farmers are having difficulty acquiring capital for agricultural inputs and other requirements in production [7].

Another constraint that adversely affects production is the pest and diseases that destroy the rice crop (Table 3). It is worth noting that these farmers are having problems buying pesticides and fertilizer due to high prices and inadequate capital, hence, their yield is relatively decreasing [16]. Additionally, rice production is moderately affected by a lack of credit facilities (M=2.33, SD=0.84), and a lack of technical services (M=2.22, SD=0.99) (Table 3). Hence, these farmers must be supported by the Philippine government concerning their needs in agricultural inputs to continue and progress their production and income level [1], [6], [9]. Moreover, rice production is also moderately affected by weeds (M=2.44, SD=0.64) that adversely affects the nutrient consumption of rice crop due to competition (Table 3). In that case, farmers must adopt new technologies and techniques to naturally diminish the presence of weeds in the rice fields [22]. Overall, farmers' rice production and income level are moderately affected (M=2.10, SD=0.76) by the constraints mentioned in Table 3.

Table 3. Rice farmers' constraints in rice production

Constraints[c]	M	SD	Description
1. High Inputs	2.51	0.62	Affected
2. Lack of Post-harvest Facility	1.68	0.84	Not affected
3. Land Rent	1.48	0.64	Not affected
4. Lack of Credit Facilities	2.33	0.84	Moderately affected
5. Lack of Technical Services	2.22	0.99	Moderately affected
6. High Cost of Transportation	1.62	0.87	Not affected
7. Inadequate Capital	3.19	0.84	Affected
8. Inaccessibility to Land	1.46	0.69	Not affected
9. Pest and Diseases	2.60	0.83	Affected
10. Weeds	2.44	0.64	Moderately affected
11. Low Soil Fertility	1.59	0.59	Not affected
Overall	**2.10**	**0.76**	**Moderately affected**

Note: c-Scale of 1 to 4.
Source: Own calculation (2022).

Hence, their income from rice farming is somehow diminished due to the said constraints.

Statistical Models

The statistical model I in Table 4 is heteroscedastic concerning its variances (X^2=9.21; p-value=0.002). In that case, the model was corrected by robust standard errors command in STATA which is suggested in [14]. The model has omitted variables (F=3.02; p-value=0.038), however, no problem of multicollinearity (VIF=1.31) was found between predictors. Moreover, it is shown that the residuals are normally distributed (Z=1.102; p-value=0.135). On the face of it, it suffices to say that the model has no problem interpreting the findings.

Table 4 shows that model (I) is significant at a 5% level (F=2.47; p-value=0.023) and has a coefficient of determination of 0.226. This means that there are significant factors (constraints) that influence the income of rice farmers.

Firstly, the evident predictor of income level in model I is high inputs (p-value=0.058) and it is significant at a 10% level (Table 4).

Table 4. Statistical model (I) for constraints in rice income[d].

Predictors (Constraints)	Model I		
	Coefficient	*Std. Error*	*p-value*
Age of farmers	-0.0036[ns]	0.0027	0.191
Male[a]	-0.0411[ns]	0.0327	0.214
High Inputs[c]	-0.0518*	0.0267	0.058
Lack of Post-harvest Facility[c]	-0.0001[ns]	0.0276	0.996
Lack of Credit Facilities[c]	-0.0342*	0.0242	0.100
Lack of Technical Services[c]	0.0133[ns]	0.0184	0.474
High Cost of Transportation[c]	0.0601**	0.0250	0.020
Low Soil Fertility[c]	0.0429[ns]	0.0281	0.134
Constant	3.9142***	0.1964	<0.001
No. of Participants	63		
F-test	2.47**		
p-value (two-tailed)	0.023		
R^2	0.226		

Note: a-dummy variable; c-Scale of 1 to 4; d-one cropping season; ns- not significant; * - significant at 10%α level; ** - highly significant at 5%α level; *** - highly significant at 1%α level

Source: Own calculation (2022).

This means that farmers are struggling to acquire good agricultural inputs due to their expensive prices.

It is worth noting that quality inputs in rice production are necessary for the outcome of a good harvest that correspondingly increases farmers' economic income. On the face of it, rice farmers' productivity and satisfaction are affected because of the difficulty of buying essential inputs in farming [5], [7], [8], [9], [21], [29].

Secondly, it is significant at the 10% level that lack of credit facilities is a constraint in rice production. This means that farmers are having difficulty acquiring a budget for their expenses in rice production. In that case, farmers are encouraged to join an association of farmers or cooperatives where they can borrow a budget for inputs and other costs in rice farming [30]. The model revealed an inverse effect of the high cost of transportation and it is significant at a 5% level. This means to say that if the transportation is high, farmers are looking for an alternative to transporting their heavy equipment and rice outputs. Hence, farmers do need not to pay the high costs of transferring their heavy loads. Instead, farmers are finding some ways to lessen their costs concerning the transportation process in rice production.

Again, the statistical model II is considered heteroscedastic concerning the nature of variances (X^2=9.84; p-value=0.001) (Table 5), hence, the model was corrected by robust standard errors [14]. No omitted variables (F=0.67; p-value=0.577) and no problem of multicollinearity (VIF=1.34) between predictors were found in model II. Additionally, it is found that the residuals are normal (Z=0.418; p-value=0.338). Hence, the model has no trouble interpreting its results. Apparently, model II is highly significant at a 1% level (F=4.96; p-value<0.001) and possesses a coefficient of determination of 0.359. This implies that there are significant predictors (constraints) that influence the income level of rice farmers.

It is revealed that the educational attainment of farmers is a highly significant (at a 1% level) predictor of income level in rice farming (Table 5). This indicates that a farmer with more knowledge is more competitive as opposed to non-educated farmers. In [9], it is stated that the farmers' learned skills from school are very useful in the rice production process since it gives innovative and creative idea to progress their efficiency and sufficiency in the fieldwork. In that case, farmers must be supported by the government through extension agents by educating and facilitating them what are the new technologies and innovative techniques in improving rice yields that are suitable for time being [15], [20]. Apparently, if the farmers are properly informed by the said new advancement technologies, then they are more likely to adopt and practice the new knowledge for the sake of increasing their level of production and income [24], [26].

On the other hand, farmers' income level is adversely affected if the land rent is high and it is highly significant at a 1% level (Table 5). It is worth noting that the dominant (60%) of the farmers are tenants, hence, they have to pay some rent to their cultivated paddy farm which is an additional cost in the production. In the study by Casinillo and Seriño [9], it is said that farmers who owned the land are more likely happy and satisfied in farming since they don't have to pay economic rent.

Table 5. Statistical model (II) for constraints in rice income[d].

Predictors (Constraints)	Model II		
	Coefficient	*Std. Error*	*p-value*
Educational Attainment[a]	0.2407***	0.0787	0.003
Land Rent[c]	-0.0567***	0.0204	0.007
Inadequate Capital[c]	-0.0148[ns]	0.0211	0.486
Inaccessibility to Land[c]	-0.0058[ns]	0.0221	0.793
Pest and Diseases[c]	0.0009[ns]	0.0304	0.997
Weeds[c]	0.0215[ns]	0.0445	0.631
Constant	3.7234***	0.0906	<0.001
No. of Participants	63		
F-test	4.96***		
p-value (two-tailed)	<0.001		
R^2	0.359		

Note: a-dummy variable; c-Scale of 1 to 4; d-one cropping season; ns- not significant;*** - highly significant at 1%α level
Source: Own calculation (2022).

Hence, the Philippine government must take initiative to make a law that lessens the rental fee for borrowing the paddy farm to somehow increase the farmers' economic profit as well as their well-being.

CONCLUSIONS

The paper's main goal is to document the level of income of rice farmers and to predict its constraints. The result has indicated that the income level of rice farmers in Albuera, Leyte, Philippines is relatively low and most of these farmers are living below the poverty threshold in the Philippine standard of economic status. The findings have shown that rice farmers are struggling to have enough budget in acquiring agricultural inputs because they cannot afford them due to high prices. In that case, farmers cannot buy sufficient herbicides, pesticides, and fertilizers, among others, that are suitable for increasing their yield. Additionally, farmers don't have enough capital for their expenses in rice production and don't have access to credit facilities. Hence, these farmers are having difficulty managing their budget plan from soil cultivation and planting to harvesting. Moreover, farmers' income is also affected by land rental fees since these are additional costs. Furthermore, it is revealed that educational attainment is very helpful in progressing their level of production. In other words, farmers with low education levels are more likely to have a low production and income level.

In conclusion, the Philippine government must support small-scale rice farmers to continue and progress their production by providing them subsidies and other benefits that might help them in acquiring agricultural inputs. The local government also must form a rice farmers cooperative that may help poor farmers to access credit with a low-interest rate. Plus, it is suggested that farmers' associations must be initiated to discuss and address the farmers' needs, constraints, and problems, among others. Likewise, the local government must provide training and seminars that educate the farmers on the new development of technologies in agriculture to positively influence their practices in farming. It is recommended that a similar survey study must be conducted in other rural areas in the

Philippines and incorporate variables related to well-being, resilience, and satisfaction to strengthen the current findings.

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ASSESSING THE FARMERS' SATISFACTION WITH THE PARTICIPATORY COCONUT PLANTING PROJECT (PCPP) USING REGRESSION ANALYSIS

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Abstract

Farmers' subjective satisfaction can be a basis for the improvement of any development programs in agriculture. This paper intended to evaluate the farmers' satisfaction with Participatory Coconut Planting Project (PCPP) and predict its governing factors using a statistical model. This study utilized secondary and cross-sectional data from a current study in the literature to quantify the farmers' perception and its factors to PCPP that is organized by Philippine Coconut Authority (PCA). Hence, the study involved 145 coconut farmers who participated in the PCPP to increase their productivity and income level. The data were summarized through descriptive calculations and determine the association of variables with the aid of regression analysis. Results of the study have depicted that coconut farmers, on average, are satisfied with the different functions of PCPP in regard to their farming activities. This implies that farmers are being assisted with their needs and concerns involving the production process. The regression model has revealed that younger farmers are more likely satisfied with the project. In addition, farmers with higher incomes tend to appreciate the PCPP functions. Moreover, farmers who experienced some training and a member of some agricultural associations are more satisfied with PCPP. Conclusively, young and active farmers who involved themselves in government programs in agriculture are more productive, efficient, and appreciative of farming projects. Hence, it is suggested that PCPP must be strengthened to reach out to more coconut farmers to improve their production, income, and their lives.

Key words: *coconut products, Participatory Coconut Planting Project, perception of coconut farmers, statistical model, Philippine Coconut Authority*

INTRODUCTION

Coconut (*Cocos Nucifera* L.) farming in the Philippines is considered as an important source of livelihood for many Filipinos in rural areas in the country. Apparently, coconut products have a significant role in improving the national economy since it has a major contribution to the Gross Domestic Product (GDP) [10]. In [13], it is depicted that coconut is reasoned to be the lifeblood of agriculture in the Philippines since it provides an assortment of different products made from coconut.However, it is stated in [16], that the coconut industry in the country is characterized by a high frequency of poorness among rural and small-scale coconut farmers. On the face of it, several studies are dealing with the issues of coconut farming to improve the lives of coconut farmers and increase its production in the country [12], [16], [8].

In addition, there are government programs implemented to maintain sustainable development concerning the coconut industry in the country. In particular, the Philippine Coconut Authority (PCA) has initiated the program Participatory Coconut Planting Project (PCPP) to boost the engagement of coconut farmers in planting and replanting coconuts [12]. The project has recommended a proper protocol for planting which is guided by Good Agricultural Practices (GAP). The purpose of these PCA programs is to achieve increased productivity as well as improve the profitability and living status of coconut farmers [5].

Moreover, it aims to widen the plantation rehabilitation in the country to improve coconut production and forest conservation [14], [7]. A farmer with at least 0.5 hectares of land devoted to a coconut plantation is eligible to participate in PCPP which involves two phases of development in planting namely [5]: Phase 1: The nursery operation; and Phase 2: The field planting of seedlings.

To exhibit the effectiveness of PCPP, farmers' point of view on the project is a good source of information. According to Aguda et al. [1], it is imperative to assess the farmers' satisfaction with the program (i.e., PCPP) to assure its effectiveness and positive impact. Hence, the research article is conducted. In fact, the study on PCPP is very limited in the literature.

In general, the article aimed to elucidate the level of farmers' satisfaction with PCPP and predict its influencing factors by the statistical model. Specifically, the article's objectives are: (1) to summarize the coconut farmers' socio-demographic profile; (2) to quantify the level of satisfaction of farmers with PCPP; and (3) to predict the factors affecting the farmers' satisfaction level with PCPP. The significance of this study is to provide new information that might be a basis for the improvement of the PCPP implementation. Additionally, the results of the study may help farmers improve their participation in the project as well as their knowledge. Furthermore, this article might be baseline information for agricultural researchers focusing on coconut production and merchandise.

MATERIALS AND METHODS

This article employed a descriptive-correlational design that portrayed the summary and relationship among variables used in this study. Secondary data were utilized from the current study by Dargantes Jr. et al. [5], titled "Modeling farmers' involvement in the participatory coconut planting project of the Philippine coconut authority." The said study only focuses on the factors affecting the farmer's involvement in PCPP and does not explain the determinants of their satisfaction with the PCPP features. So, the study dealt with the farmers' perception (satisfaction) of the PCPP and its influencing determinants (demographic and socioeconomic profile). The coconut farmers involved in this study came from three municipalities in Leyte, Philippines namely: Mahaplag, Inopacan, and Hilongos.

The dependent variable of this study is the level of satisfaction of farmers with PCPP. The satisfaction involves a 5-point rating scale to the following 7 features of PCPP as follows [5]: (1) farmers' general assessment of the PCPP project; (2) sourcing procedure of own seed nuts; (3) usefulness of PCPP to the farmers' income; (4) dissemination of the ideas of PCPP program; (5) relevance of PCPP to the farmers' need; (6) application process to the access of PCPP project; (7) effect of the PCPP to the lives of farmers. The perception score for each feature has been summed to get the total perception score. A lower score means that farmers have lower satisfaction and a higher score implies higher satisfaction with the PCPP project. Table 1 presents the interval of satisfaction scores and their corresponding verbal interpretation.

Table 1. Satisfaction scores of PCPP

Satisfaction scores	Verbal interpretation
7.00 - 12.60	Very unsatisfied
12.61 - 18.20	unsatisfied
18.21 - 23.80	Undecided
23.81 - 29.40	Satisfied
29.41 - 35.00	Very Satisfied

Source: [5].

On the other hand, the independent variable is the various profile of coconut farmers such as age, sex, civil status, educational attainment, household size, annual income, tenurial status, farm size, number of years in farming, attended training in agriculture (yes or no), membership of farmers association (yes or no). The study utilized the following descriptive measures to summarize the said variables: mean, standard deviation, and percentages. It also used a bar graph to visualize the differences in values.

To depict the significant determinants of farmers' satisfaction levels, a multiple linear regression in the way of the ordinary least square (OLS) method was employed. In that case, we consider a data collection $\{S_i, X_{i1}, \ldots, X_{im}\}_{i=1}^{n}$ of n coconut farmers, the regression assumes that the relationship between the dependent variable S_i and the m independent variable X_{it} ($\forall t \in \{1, \ldots, m\}$) is linear. In light of it, the regression model portrayed the best fit line that minimizes the random errors of each independent variable incorporated in the model as it correlates with the dependent variable. Hence, the regression (OLS) model is given by

$$S_i = \partial_0 + \partial_1 age_i + \partial_2 male_i + \partial_3 married_i \\ +\partial_4 education_i + \partial_5 hhsize_i \\ +\partial_6 \log(income)_i + \partial_7 owner_i \\ +\partial_8 farmsize_i + \partial_9 yearsfarming_i \\ +\partial_{10} training_i + \partial_{11} membership_i + \epsilon_i$$

where: S_i refers to the level of farmers' satisfaction to PCPP, age_i refers to theage of coconut farmers (number of years), $male_i$ refers to a dummy variable that represents a male farmer (1-male, 0-female),$married_i$refers to a dummy variable that represents a married farmer (1-married, 0-otherwise), $education_i$ refers to the educational attainment of coconut farmers (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 household size or family member of farmers, $\log(income)_i$ refers to logarithm of annual income (₱), $owner_i$ refers to a dummy variable that represents a farmer who own the coconut farm, $farmsize_i$ refers to the coconut farm size (in hectares), $yearsfarming_i$ refers to the number of years in coconut farming, $training_i$ refers to a dummy variable that represents a farmer who undergone some training in agricultural farm, $membership_i$ refers to a dummy variable that represents a farmer who are member of some farmers association and ϵ_i refers to the remaining random error in the model. Post-estimation techniques for regression analysis were also employed and tested at a 5% level of significance to secure valid results. Furthermore, all statistical calculations and analyses were assisted by a statistical software called STATA to assure accurate results.

RESULTS AND DISCUSSIONS

Profile of Coconut Farmers

The summarized profile of coconut farmers is presented in Table 2. On average, coconut farmers are aging (M=54.89, SD=15.19) workers. In the study of Dargantes Jr. et al. [5], it is portrayed that age is not a hindrance in farming activities. In fact, farming is a good exercise to become an active and healthy individual. On the other hand, it is mentioned in the study of Casinillo [3], that most of the rural farmers are relatively old since the younger individual are pursuing better educational attainment. More than half (66%) of these farmers are male and about 34% are female. Approximately, 78% of these farmers are married and have more responsibilities as opposed to those not married (22%). In addition, the average educational attainment of these farmers is high school level (M=2.86, SD=1.52).

Table 2. Coconut farmers' profile

Variables	Mean	Std. dev.
Age	54.89	15.19
Male (dummy variable)	0.66	0.47
Married (dummy variable)	0.78	0.42
Educational attainment	2.86	1.52
Household size	4.17	1.99
Annual income (₱)	79,206.21	108,823.2
Farm owner (Dummy variable)	0.74	0.44
Farm size (in hectares)	1.52	1.36
Years in Farming	28.37	15.80
Training (Dummy variable)	0.30	0.46
Membership (Dummy variable)	0.53	0.50

Source: Authors' own calculation (2022).

It is worth noting that knowledge and information learned from school are helpful in their farm activities [4]. On average, the household size of these farmers is close to 4 family members. More or less, the annual income of farmers in coconut farming is close to 79,206.21 (₱). The large dispersion (SD=108,823.2 (₱)) of income is due to the differences in taking care of the coconut farm and farm size. About 74% of these farmers own the coconut farm and about 26% of them are a tenant. The average coconut farm managed by these farmers is close to 1.52 (SD=1.36) hectares and the average number of years in farming is approximately 28.37 (SD=15.80) years. Only 30% of these farmers have undergone some training related to agricultural farming and 70% of them are farming through their own experience. Note that seminars and training make them competitive over other farmers [15]. Furthermore, about 53% of these farmers are a member of some agricultural associations that might help them acquire information and obtain financial assistance [17].

Farmers' Satisfaction with PCPP

There are no farmers who are very unsatisfied with the features of PCPP and only 1.38% of them are unsatisfied. These are farmers who did not appreciate and do not get any benefit from the function of PCPP in their farming activities. About 15.86% of these farmers are neutral or undecided if they are satisfied with the project. However, there are 38.62% of these farmers are satisfied with a general assessment of the project. These are farmers who experience a positive impact from PCPP on their lives as coconut farmers.

Fortunately, the dominant (44.14%) of the coconut farmers are very satisfied with the features of PCPP in their coconut farming production experiences. The PCPP program has provided them with the basic needs of the farming system and experience the usefulness of the project to their lives as a farmer. On average, the farmers' satisfaction is close to 28.8 (SD=5.16) and is classified as "satisfied" (Based on Table 1). This implies that farmers are being assisted in their production activity and benefiting from the function of PCPP [5].

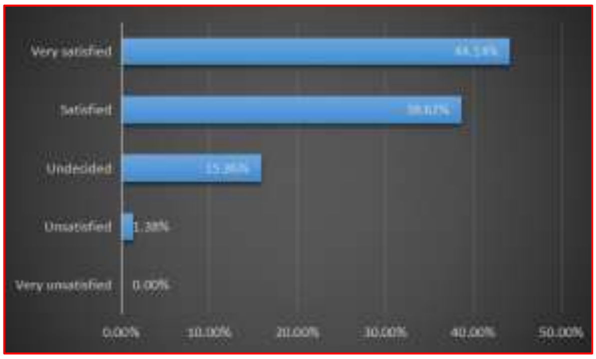

Fig. 1. Farmers' level of satisfaction with PCPP.
Source: Authors' construction (2022).

Regression Model

Post-estimation techniques were done to secure a valid finding in the regression equation model. The model was found to be homoscedastic (X^2=1.14; *p*-value=0.286) by the Breusch-Pagan test. This implies a constant variance in the model [10]. In addition, the model does not possess an omitted variable bias (F=2.63; *p*-value=0.053) with the assistance of the Ramsey RESET test [9]. Moreover, the model is free from the multicollinearity problem since the variance inflation factor (VIF) value is lesser than 10 (i.e., VIF=1.47). Hence, no significant correlation between the independent variables in the model exists [2].

Although the Shapiro-Wilk test has revealed that the residuals in the model are not normal (Z=2.087; *p*-value=0.018), the figure (Fig. 2) above shows that the kernel density estimate graph for residuals is close to the normal density graph. In other words, the residuals are almost normal. Hence, the model has valid results and provided a piece of reliable information and predictions.

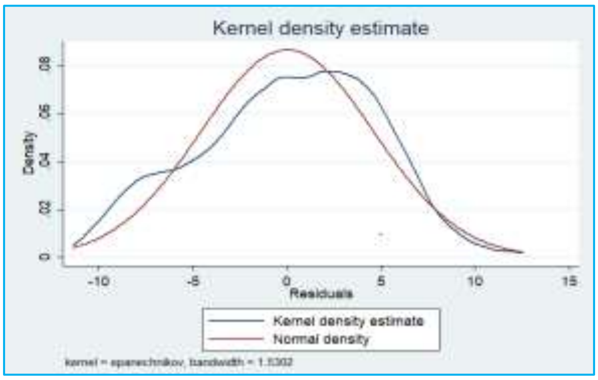

Fig. 2. Kernel density estimate and normal density graphs for the regression residuals.
Source: Authors' construction (2022).

Table 3 shows that the regression model (F_c=3.10; *p*-value=0.001) is highly significant at a 1% level. It is also shown that the goodness-of-fit is equal to 0.204 which indicates that there are independent variables that influence the farmers' satisfaction with PCPP. Firstly, the age (∂_1 =-0.082; p-value=0.037) of a farmer is considered a significant predictor of farmers' satisfaction at a 5% level. The negative coefficient indicates that younger farmers are more likely to appreciate the PCPP features. This means that younger farmers are more active in participating in the different activities of the said project.

Apparently, participation in agricultural projects may increase knowledge and gain innovative techniques in farming [11]. Secondly, the model reveals that farmers with higher income (∂_6=2.253; p-value=0.075) are more satisfied with the PCPP functions at a 10% level. This implies that farmers who gain more knowledge in the project and improve their income level tend to appreciate the usefulness of the project to their livelihood. In fact, the main purpose of the project is to improve the coconut plantation in the country and improve the lives of rural farmers [5], [6].

Table 3. Regression model for coconut farmers' satisfaction with PCPP and its causal determinants.

Independent Variables	Coefficient[a]	Std. error[b]
Constant	18.495*** (0.003)	6.189 (2.99)
Age	-0.082** (0.037)	0.038 (-2.11)
Male (dummy variable)	1.271[ns] (0.175)	0.932 (1.36)
Married (dummy variable)	-0.837[ns] (0.426)	1.048 (-0.80)
Educational attainment	0.151[ns] (0.665)	0.348 (0.43)
Household size	0.258[ns] (0.217)	0.207 (1.24)
log (Annual income (₱))	2.253* (0.075)	1.257 (1.79)
Farm owner (Dummy variable)	0.308[ns] (0.775)	1.074 (0.29)
Farm size (in hectares)	0.156[ns] (0.626)	0.319 (0.49)
Years in Farming	0.023[ns] (0.560)	0.039 (0.58)
Training (Dummy variable)	1.740* (0.069)	0.949 (1.83)
Membership (Dummy variable)	1.644* (0.058)	0.859 (1.92)
Observation	145	
F_c	3.10***	
p-value (Two-tailed)	0.001	
Coefficient of determination(R^2)	0.204	

Note: a - p-values are enclosed with parenthesis; b - t-values are enclosed with parenthesis; ns - not significant; *p<0.1; **p<0.05; ***p<0.01.
Source: Authors' calculation (2022).

Thirdly, the participation of farmers in the different agricultural seminars and training (∂_{10}=1.740; p-value=0.069) will provide them with more information that is useful for their coconut production and it is a significant predictor of the farmers' satisfaction with PCPP. In that case, they become better at doing their work and tend to appreciate the agricultural programs as they help them with their needs [14]. Lastly, being a member (∂_{11} =1.644; p-value=0.058)of a farmers' association is more likely to appreciate the government programs due to the information and benefits they have gained. In [17], an association of farmers is an organization that is responsible for disseminating innovative information suitable for agricultural production and allocating agricultural inputs.

CONCLUSIONS

The main aim of this article is to measure the level of satisfaction of farmers with PCPP and elucidate its influencing determinants. Results showed that farmers are satisfied with the different functions of PCPP in coconut farming. Farmers are being assisted with their needs and received the necessary information to improve production and their livelihood. The regression model revealed that younger and more active farmers are more involved in the project and tend to appreciate it more. It is also shown that the farmers who benefited from the project and had higher incomes from coconut farming are more satisfied with the said project. Moreover, training and membership are positively correlated to the farmers' satisfaction with the features of PCPP. Conclusively, the involvement of young farmers in agricultural projects makes them more knowledgeable and productive in farming. Hence, it is highly suggested that the PCPP must be strengthened to reach out and help more coconut farmers in rural areas and continually improve coconut farming in the country. In addition, the local government and PCA must also provide equipped extension agents to disseminate innovative technologies in coconut farming. Finally, it is recommended that for future research, one may consider the farmers' perception of the effectiveness of PCPP to supplement the findings of this current article.

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RURAL DEVELOPMENT FROM POLICY TO POLITICS. NATIONAL STRATEGIC PLANS AND THEIR POTENTIAL IMPACT ON SOCIAL STRUCTURAL TRANSFORMATIONS. COMPARATIVE OVERVIEW. CASE STUDY ROMANIA BETWEEN THE EUROPEAN AND NATIONAL CONTEXT

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Abstract

The question of rural development is of utmost for countries such as Romania. In the current climate of tension generated by the post-pandemic recovery and geopolitical turmoil, rural development has been more important than ever. We are living in a time of great structural duress and the solutions are becoming more political as the effects of the policy are political ones. There is a transformation of the policy into politics as the Common Agricultural Policy and the Rural Development policy by any other name would still be politics. In this context, the flexibilization provided by the National Strategic Plan is more than welcome. The purpose of the paper is to analyse how the policy elements from CAP are turning into politics and are influencing the Member States politics. As the CAP post-2020 unfolded new tools such as the National Strategic Plan were added to the EC toolbox, but often their design was influenced by national specificities. The paper performs a desk review analysis of the existing sources and has a case study the way in which this process unfolded in Romania. What is of importance in all that time-consuming process is the fact that for the first time we witnessed a large-scale reflection process throughout the European Union member states. It was partially favoured by the COVID-19 pandemic which put everything on hold for a couple of months. That combined with the need to reform made everything more democratic and more advanced and reformist than the initial proposals.

Key words**:** *National Strategic Plan, Common Agricultural Policy, change and reform, rural development*

INTRODUCTION

Any discussion on the future of the Common Agricultural Policy post-2020 must be routed in the provisions of Article 39 of the Treaty on the Functioning of the European Union on CAP's objectives: "to increase agricultural productivity […]; to ensure a fair standard of living for the agricultural community; to stabilise markets; to assure the availability of supplies […] ensure that supplies reach consumers at reasonable prices" [7]. Thus we are entering into an area where we are dealing more with politics than policy. For that purpose, a terminological clarification is needed as we are dealing with "policy" seen as "the content or material dimension of politics. It covers the objectives and roles through which political solutions are to be found to specific problems" and "politics" seen as "the more or less conflict-ridden process in which both diverging and common interests and political views of varying provenance, initially in opposition, are over time consolidated and developed through negotiation to reach a concrete political goal" [1]. This matters because more often then never the ideas (like the above-mentioned objectives of the CAP) rather than self-interest determines policy-making [5]. Having in mind such clear objectives, with significant social importance is it becoming clearer now that the CAP objectives are more than policy and are becoming politics.

The Policy agenda of agriculture has been steadily broadened with agricultural policy issues now interlinking with other policy domains (food safety, energy supplies, environmental protection, development aid, etc.). We are now dealing with the new politics of agriculture as a series of authors' state [9]. We are dealing with some political scientists called "agricultural exceptionalism" meaning the "idea that agriculture is a sector unlike any other economic sector, and, as such, warrants special government support", which still endures in the European Union [26].

This acceleration of the transition towards the realization that in the area of agriculture and rural development is not necessarily just policy but politics stem up rather early a couple of years ago only to be accelerated by the pandemics and the geopolitics. The CAP was developed based on the principles of the single market (unrestricted circulation of agricultural products within the EU), community preference (favouring the consumption of products originating in the European Union), and financial solidarity (common measures are financed from a common budget). Concerns about climate change and issues such as loss of biodiversity or water and soil quality show that agriculture has a role in the sustainable management of natural resources [19].

Thus in June 2018, the European Commission proposed the new Common Agricultural Policy 2023 – 2027, key to securing the future of agriculture and forestry, as well as achieving the objectives of the European Green Deal. This involved a series of key reforms with a strong socio-economic and political impact meant to have as a final result a CAP that is greener (with enhanced conditionality, etc.), fairer (redistribution of income support, social conditionality, supporting young farmers, improving the gender balance, etc.) and more competitive (crisis reserve, etc.) [13].

Climate change has a direct impact on ensuring the needs of agricultural production, as a result of the increase in average temperature, soil degradation, or the process of desertification that has affected many areas of the world. The pressure exerted on agricultural systems and processes can have a negative. Often, all these cumulative effects generate growth prices, vulnerability, and insecurity in the agricultural sector. Adapting to the effects of climate change involves managing in an integrated way the challenges of the present by encouraging sustainable investments in new, better technologies implementation of eco-conditionality rules and guidelines, promotion of exchanges of good practices, etc. [27].

After the outbreak of the COVID-19 pandemic, the EU faced a health and economic crisis unprecedented in its history, with a series of economic, health and mobility, and freedom of travel measures being taken, which in turn had an impact on the rural development., as the Green Deal and other measures impacting agriculture were put on the agenda [20].

In that context, a new concept (re)emerged often associated with rural development, that of resilience. It was at the very beginning related closely to food security and was defined as "the ability of an individual, a household, a community, a country or a region to withstand, to adapt, and to quickly recover from stresses and shocks" [10].

The structural lessons learned from the early beginning made resilience the red line (compass) guiding all European actions being defined now in a broader way, not policy but politics: "Resilience is the ability not only to withstand and cope with challenges but also to undergo transitions in a sustainable, fair, and democratic manner". The spotlight is on rural development as it emphasised the need for a long-term vision of rural areas: "taking into account social and economic development, infrastructure needs, access to basic services, and territorial cohesion; this long-term vision should cut across several policy areas and require an integrated and coordinated approach at European, national, and regional level." [11].

Romania's accession to the EU meant a radical change in the way of making policy and it generated a renewed interest in the importance of strategic planning, something that has been ignored all too much post the end of the communist period. As such in the area of agriculture there is a need for the political leaders to define and present their vision for the future and identify the national goals and objectives [3].

The purpose of the paper is to analyse how the policy elements from CAP are turning into politics and are influencing the Member States politics. As the CAP post-2020 unfolded new tools such as the National Strategic Plan were added to the EC toolbox, but often their design was influenced by national specificities.

MATERIALS AND METHODS

This research material is based on a desk research of the existing reports and studies. Due to the specificities of the research as well as the technical constraints this formula was adopted to have a better survey capacity of the area and its main challenges. A survey of the official documents of the European Commission on this topic has been done. Also the official documents of the Romanian administration in charge with drafting the National Strategic Plan have been taken into consideration. Of importance where also the articles and works showing the strategic role of the agriculture and its significance in the life of the society. At the end of the research we have tried to prove that the reform process of the CAP post-2020 lead to an increase strategic role of the agriculture at all the levels as the challenges ahead required this type of approach.

RESULTS AND DISCUSSIONS

The answer to the above questions came under the form of the National Strategic Plan – each Member State would design its National strategic plan meant to combine funding for income support, rural development, and market measures, in a series of specific targeted interventions all of that. "[…] based on a strength, weaknesses, opportunities, and threats (SWOT) analysis of their territory and agri-food sector" [12].

Romania, like other countries in the region such as Bulgaria, is facing similar challenges. Thus some of the lessons and conclusions learned from Bulgaria also apply back home as the recommendation can be translated back home: more focused policy, the importance of knowledge transfer, innovation, and cooperation, etc. [2]. All these findings came based upon previous analyses, pre-pandemic ones, showing the need for fundamental amendments as shown by the empirical data. Particular attention was given to Rural Development Programmes (RDPs) which are defined as purpose programmes that "focus on the funding purpose and the funding objective, with funding intended to be a vehicle for implementing and developing a diverse range of environmental and regional policy objectives" which to be more efficient need no depend on the willingness of those responsible for them [17].

This in turn is based upon other research that state that innovation is at the base of the European rural development policy. That implies a reach and innovative thinking and support better suited for politics and not policy. Social innovation is thus important and requires a whole-of-society approach [8].

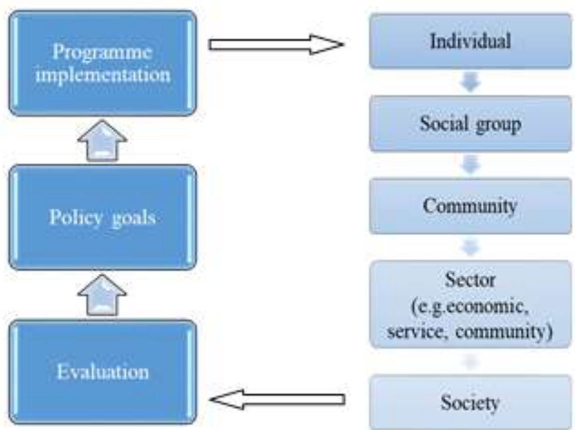

Fig. 1 The potential for innovation
Source: our design after [8].

As seen in Figure 1 the potential of innovation is first and foremost based on individual and then it goes higher in the food chain to social group and community toward the society as a whole. There is therefore a strong circular link as the society needs are evaluated, then policy goals are established and the programme is implemented.

This challenge requires "a paradigm shift regarding the concept of shared management of rural development between the Commission and Member States" and the need to show "whether the post-2020 CAP is marked by a "renationalisation" of rural policy in Europe, or whether the key principles inspiring the reform signify a new step for EU integration" [16].

Romania has had a direct interest in the absorption of the funds that can be used for rural areas both from European and national financing sources, like the National Rural Development Program (NRDP). The national-based studies identified with a shadow of a doubt. The analysis done has shown that the allocations should be concept-based, around new economic concepts such as "innovative potential", "smart village", "multifunctionality", "multisectoral approach", "social return on investment", and "territorial justice", which can identify the real and specific problems of each rural region" [21].

In that context, based on the lessons learned, the focus of the post-2020 perspectives from a national point of view became even more needed. From a Romanian perspective, the main request was to end the bureaucracy and simplify the policy to become more efficient. Also, there has been noticed a disbalance between the land consolidation and the welfare of the rural population – the more land consolidation or even land grabbing the poorer the population. Also capping direct payments is a solution that needs to be tailored to the local realities [15].

It is in line with the challenges that need to be addressed by CAP like economic, environmental, and territorial challenges. All these required "a reform of the priorities and programs of measures established by Romania, Poland and Hungary demonstrates the greater flexibility offered to the EU Member States by the New Approach of the CAP in establishing their hierarchies of rural development priorities and their financing" [6].

As the CAP 2023 – 2027 is being built around ten key objectives, they are going to be the basis upon which the Strategic Plans are going to be built, as they are supposed to mention a series of targeted interventions meant to address these EU-level objectives from a national perspective.

Fig. 2. The Ten Key Objectives.
Source: own representation after [14].

Ever since their inception, the process regarding the National CAP Strategic Plans has been surrounded by both cautious optimism and academic reservations, due to their complexity and the need to be simultaneously transparent and stakeholder inclusive. A series of analyses on both Old and New Member States have shown different levels of transparency from nationwide public debates (like in the case of France) to internal assessments (like was the case of Italy). Thus, in these early stages, the policy recommendations were to set up and update official communication channels, publish and update roadmaps, more transparent and effective consultation meetings, set up clearer written working procedures, better and larger involvement of scientists, civil society, and NGOs while having in mind a clear red line, that nowhere in the EU or the world we cannot have full transparency of public decision-making [18].

A couple of years later after the start of the process, we have had this intermediary stage of the so-called Observation Letters issued by the European Commission on the intermediate versions of the CAP Strategic Plans, documents meant to highlight all the deficiencies of these intermediary versions. What they brought in as new ideas is the emphasis on the new context, meaning the conflict in Ukraine and its impact. Also, there was a focus on the need for a fairer and greener CAP [28].
The new security environment in Europe where food security became out of the blue dominant made CAP national strategic plans to switch focus from the EU Green Deal. For some scholars, the Plans only tend to favour short-term gains over environmental concerns in a staggering lack of foresight and the conclusion is a dark one: "most, if not all, Member States are unlikely to reach the Green Deal target of increasing to 10% the agricultural area under high diversity landscape features by 2030" [4].
As regards Romania we need to have in mind the specificities of the country even before the creation of CAP Strategic plans. Thus as early as 2020 one key national security objective is that of ensuring food security and environmental quality [24]. This change was reflected in the Governing Programme 2021 – 2024 where a key objective was the completion of the National Strategic Plan 2023 – 2027 with a series of three key objectives: promoting an intelligent, resilient, and diversified agricultural sector; strengthening market orientation and increasing competitiveness; improving the performance of farmers in the value chain [23].
Romania has started a complex consultation period since the second half of the year 2020. A series of intermediary versions were drafted with three versions of the SWOT Analysis being done. Each and every one were being made publicly available. The latest major public consultation was the one held in 2022. To fully understand the importance of these meetings a series of raw data is in order. Thus we first had the so-called Thematic Consultative Committee made up of 24 stakeholders who met on: 1 time in 2020, 1 time in 2021 and 2 times in 2022 as a whole. Yet the most important were the numerous thematic sub-groups (SG) each of them bringing together an important number of stakeholders that proved the extent of the interest of the relevant actors, as seen in Figure 3.

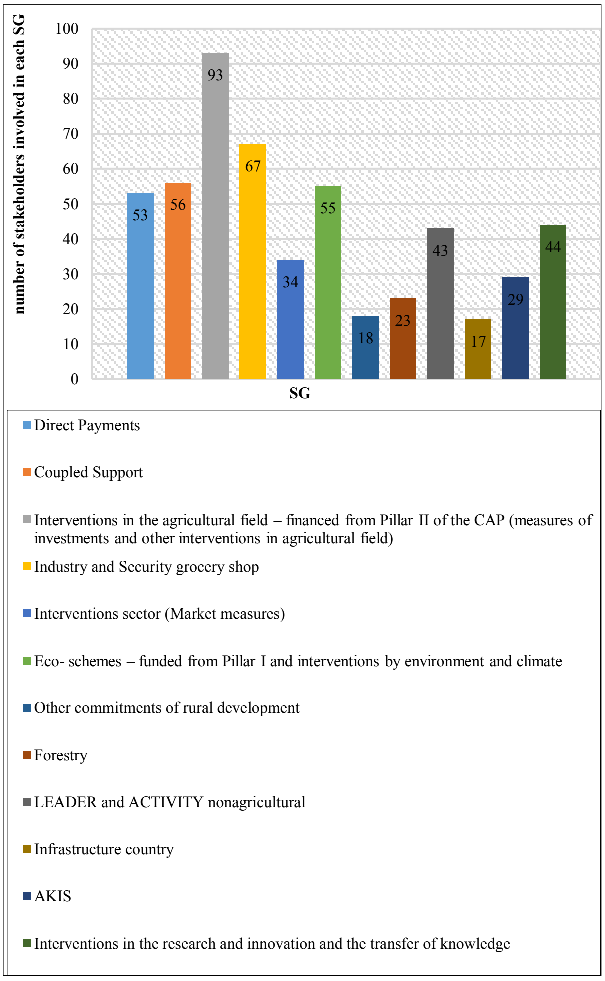

Fig. 3. Stakeholders involved in each subgroups (SG).
Source: Own representation based upon the available data from [22].

The subgroups met from 2020 till August 2022 following the data available on the website of the Ministry of Agriculture and Rural Development [22].
We have had a series of communications and replies between the European Commission and the Ministry of Agriculture and Rural Development based upon the first observation of the Romanian plan. Thus we have had a first version of the Plan on 28 February followed by a latter on 18 October 2022.

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It was a long-discussed plan that received a lot of internal attention. It was at the end of the day an organic consultation program that brought together all the relevant stakeholders, as the dedicated website page proves it. It was an open process also due to the comments and observations made throughout the two years dedicated to the finalization of the CAP National Strategic Plans.

What also needs to be mentioned is that this process has been backed as early as 2017 when the Romanian Parliament analysed the Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: the Future of Food and Farming COM/2017/0713 (mentioned also in relation with the CAP National Strategic Plan) where the Chamber of Deputies issued a series of ideas that received transversal political support. It stated that "a strong pillar of rural development will ensure a further modernization and the creation of new jobs, necessary for the vitality of these areas and considers that the capping of direct payments is not a viable solution because it would affect big and honest farms which highly contribute to the national economy" [25].

Fig. 4. The main actions to be pursued by Romania's CAP National Strategic Plan as stated in the Governing Programme 2021 - 2024
Source: [23].

CONCLUSIONS

What is of importance in all that time-consuming process is the fact that for the first time we witnessed a large-scale reflection process throughout the European Union member states. It was partially favoured by the COVID-19 pandemic which put everything on hold for a couple of months. That combined with the need to reform made everything more democratic and more advanced and reformist than the initial proposals.

Added to this the Ukraine conflict challenged the already settled conception of green transition and shift the focus on the idea of food security. Things were now once more down to basics and to the need to secure necessities. Yet this approach also received a series of critics who perceived it as inadequate.

As for Romania, it shares a series of common problems with Bulgaria and other Central and Eastern European countries. It was at the end of the day a process of soul-searching in the area of agricultural processes. What should be noticed is that rural development is on the agenda of all the key Romanian institutions (Parliament, Presidency, and Government) and that the current CAP National Strategic Plan is a sum of all these aspects.

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STUDIES REGARDING THE INFLUENCE OF THE PERIOD BETWEEN HARVESTING AND THE BEGINNING OF STORAGE UPON THE QUALITY OF SOME PEAR VARIETIES

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Abstract

The 3-year research on Alexander Lucas and Santa Maria pear varieties followed the influence of the time interval from harvest to storage of the fruit on quality characteristics, weight loss, quality depreciation and storage length. The results showed that in both varieties harvested at the optimal time and put into storage 24 hours after harvest (V1), the quality characteristics, weight loss, quality deterioration and storage length were significantly higher (better) than for the variants in which the fruit was kept for 6 days (V2) and 12 days (V3) at 10-14 C before being put into the cooling room. Thus, the weight losses at the end of storage varied between 9.2-9.6% in V3 (fruit stored 12 days after harvest) compared to 6.4-7.2% in V1 (fruit put into storage after 12 hours), as the storage period was longer in V1. The qualitative losses at the end of storage ranged from 5-5.8% in fruit placed in the cooling room 24 hours after harvest, compared to 7.6-8.2% in fruit where storage in the cooling room was delayed by 12 days. The optimal storage period of the pear fruits, stored as soon as possible after harvesting, belonging between 90 days for the summer variety Santa Maria and 115 days for the winter variety Alexander Lucas, in cold storage room.

Key words**:** *harvesting period, storage period, weight losses, organoleptic assessment*

INTRODUCTION

The quality and shelf life of pears are influenced by a number of factors in the preharvest and postharvest periods [1, 2]. Among these factors, the time period between harvesting and storage plays a determining role on the keeping capacity and quality of the fruit at the end of storage [3, 4]. In practice, at farm level, the time between harvesting and placing in cold storage is influenced by logistical aspects (organisation of transport, distance to the warehouse, possibility fruit conditioning).

It is known that pears continue to ripen after harvesting, this evolution being greatly influenced by the temperature at which the fruit is kept before being placed in cold storage and especially by the period of time between harvesting and placing in cold storage [5]. The storage conditions also influence the shelf life and quality of the pears [6]. Thus, under modified atmosphere or controlled atmosphere conditions, the storage time increases and the quality of the fruit reaches optimum values, but at the end of storage a post-ripening period of 6-8 days at a temperature of 16-20 °C is needed to achieve an organoleptic quality that is well appreciated by consumers [7, 8, 9, 10].

MATERIALS AND METHODS

The research was carried out on Alexander Lucas and Santa Maria pear varieties, from the 2020, 2021 and 2022 harvests, grown in a private farm, Voinești area, Dâmbovița fruit basin.

The characters of the two studied varieties are presented below as follows:

- ***The Santa Maria pear variety*** (Photo 1) was developed in Italy at the University of Florence and was introduced to the market in 1951.

The tree has high vigour and a medium to late flowering period. It is a summer variety, with fruit that ripens after 15 August and has an average weight of 160-230 grams, with a diameter of over 6 cm. The colour of the fruit is greenish-yellow, but on the side exposed to the sun it turns red.

Photo 1. Santa Maria pear variety
Source: Original.

The taste of the fruit is sweet (approx. 90 Brix) and flavoured. The pulp is white in colour, fine, juicy and free of sclereids. The fruit can be stored for up to 2 months in ambient conditions and up to 5 months in a controlled atmosphere.

-***The Alexander Lucas pear tree*** (Photo 2) originated in France, where it was identified by chance in 1870 in a forest in Blois. The tree is of medium vigour and has an early-mid flowering period.

Fig. 2. Alexander Lucas pear variety
Source: Original.

It is a winter variety, with fruit ripening after 15 October and an average weight of 160-350 grams, with a diameter of 7-9 cm. The colour of the fruit is green, which changes to yellowish, with shades of red on the side exposed to the sun. The taste of the fruit is pleasant, with a balanced sugar/acidity ratio, and the flesh of the fruit is white, juicy, crunchy, with sclereids in the central area. The fruit is harvested before it is ripe. The fruit can be kept for 2 months in ambient conditions and up to 5 months in a controlled atmosphere.

The fruit was harvested at the optimum time, determined on the basis of previous years' production experience, which ensured good keeping capacity. In the study, only extra quality fruit was used, assessed according to the rules of the standard in force (Reg. EU 543/2011).

They were placed in storage at different time intervals after harvesting, the variants studied being the following:

V1 - fruit placed in cold storage 24 hours after harvest;

V2 - fruit placed in the cold room after a 6-day holding period at 10-140C and 65-70% relative humidity (Photo 3 and 4);

V3- fruit placed in the cold room after a holding period of 12 days at 10-14 0C and 65-70% relative humidity.

Photo 3. Pear fruits from V2 and V3 variant, before cold storage
Source: Original.

Each variant was made up of 3 repetitions, each of 50 kg. Fruit storage was done in the cold room of the Horticultural Products Technology Laboratory of the Faculty of Horticulture Bucharest.

The storage temperature varied between 1 and 20C, and the relative air humidity between 86-90%, ensured by packaging the fruits with LDPE film, 15 microns thick.

Photo 4. Pear fruits from V2 and V3 variant, in cold storage
Source: Original.

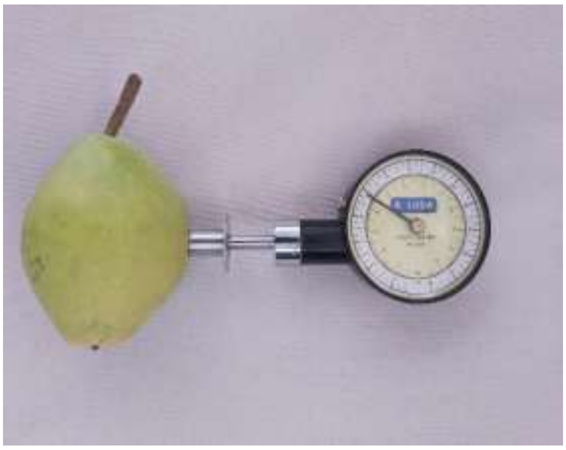

Photo 5. Fruit firmness testing, using the Effegi penetrometer
Source: Original.

Photo 6. Soluble dry matter determination, using the Atago refractometer
Source: Original.

The main physico-chemical characteristics of the fruit (average weight, pulp firmness, soluble dry matter, total titratable acidity and ascorbic acid) were determined at harvest and at the end of storage.

The pulp firmness was analysed by using the Effegi penetrometer with 11 mm diameter plunger (Photo 5).

The value of the soluble dry matter was determined using the Atago electronic refractometer (Photo 6).

The total titratable acidity (expressed in malic acid) was determined by titration with NaOH 0.1 N solution. The value of ascorbic acid was determined using the iodometric method.

At the end of storage, the organoleptic capacity of the fruit was assessed on the basis of a score according to STAS 6441/88.

The storage conditions with regard to temperature and relative air humidity were determined using the Hanhhart thermohygrometer.

The weight losses and quality depreciation were determined by weighing and expressed in percentage.

The shelf-life of pears, expressed in days, was considered to be completed when the fruit still had commercial value, expressed as a total loss (in weight and quality depreciation) of between 10% and 17%.

RESULTS AND DISCUSSIONS

The physico-chemical characteristics of fruit at harvest

As previously mentioned, the fruit was harvested at the optimal harvest time, determined based on observations made in previous years, which provided the best storage capacity.

From the data presented in Table 1, the differences between the two varieties can be seen. Thus, the average fruit weight, a variety-dependent characteristic, ranged from 185 g in Santa Maria to 230 g in Alexander Lucas, with flesh firmness values ranging from 5.5 to 6.2 kgf/cm^2.

The soluble dry matter content, determined by a refractometer, varied between 7.8% in the Santa Maria variety and 8.6% in the Alexander Lucas variety, and the titratable acidity had very similar values, between 0.24% and 0.28%.

The ascorbic acid content had a lower value of 6.86 mg/100 g in the Santa Maria variety, while in the Alexander Lucas variety, the value was higher at 7.48 mg/100 g.

The values determined for both varieties fall within the specific parameters for the optimum harvesting time recommended to ensure good storage capacity.

The evolution of the physico-chemical characteristics of the fruit during storage, depending on the time of introduction into the cold room

Fruit firmness, an important property which can be used to characterise the degree of ripeness of pears, has decreased continuously since harvest due to the transformation of insoluble protopectin into soluble pectin.

Firmness declined at a more pronounced rate in the time between harvest and the start of cold storage.

From the results presented in Table 2, related to the analyses carried out after 45 days of storage (the shortest storage period for Santa Maria - Variant 3), it can be seen that the firmness of the pulp decreased, compared to the value at the time of harvesting, in a high proportion in V3 (on average by 50% - 54%, depending on the variety) and in a lower proportion in V1 (on average by 19% - 21% depending on the variety).

Table 1. The main physio - chemical characteristics of the pear fruits at harvest

VARIETY	Average Weight - g -	Firmness Kgf/cm2	Soluble dry matter %	Total titratable acidity (ac malic) %	Ascorbic acid mg/100 g
ALEXANDER LUCAS	230	6.2	8.6	0.28	7.48
SANTA MARIA	185	5.4	7.8	0.24	6.86

Source: Own determination.

Table 2. The influence of the time period between harvesting and beginning of storage, upon the fruit firmness, after 45 days of storage in cold environment

VARIETY	VARIANT					
	A	B	A	B	A	B
ALEXANDER LUCAS	4.9	21	3.9	37	3.1	50
SANTA MARIA	4.4	19	3.5	35	2.5	54

Source: Own determination.

Legend: A = Firmness value, in kgf/cm^2; B = Decreasing of the fruit firmness (%) in comparison with the harvesting time.

The decrease in firmness during the 45 days was on average 0.02 - 0.03 kgf/cm^2/day when the fruit was placed in storage 24 hours after harvest (V1) and 0.06 - 0.07 kgf/cm^2/day when the fruit was kept for 12 days in an ambient environment before being placed in cold storage.

Soluble dry matter showed a continuous increase for both varieties and in all variants from the time of harvest due to the transformation of starch content into soluble carbohydrates. The evolution was different depending on the experimental variant. Thus, in the case of V1, the soluble dry matter content increased more, up to values between 13.8% in Santa Maria and 14.8% in Alexander Lucas. The increases were lower in the fruits of variety 3, with values between 12.6% in the Santa Maria variety and 13% in the Alexander Lucas variety.

Total titratable acidity, expressed as malic acid, at the end of storage had lower values compared to the time of harvesting, depending on the variant and length of storage. Thus, the highest values for both varieties were recorded at V1 (0.16 - 0.18%), while the lowest values were at V3, respectively 0.11% in the Alexander Lucas variety and 0.09% in the Santa Maria variety.

Ascorbic acid decreased sharply during storage and reached 4.12 mg/100 g (V1) for Alexander Lucas and 3.86 mg/100 g (V1) for

Santa Maria. In the case of fruit stored under V3 conditions, the decrease was more pronounced, i.e. by 62.5% compared to the initial value in the Alexander Lucas variety and by 61.5% in the Santa Maria variety.

From the analysis of the main physico-chemical characteristics of the fruit at the end of storage, it appears that fruit stored in cold storage 24 hours after harvest (V1) are superior in terms of nutritional value compared to fruit whose introduction to storage was delayed by 6-12 days, i.e. V2 and V3 (Table 3).

The fruit quality determined by organoleptic assessment

Following the assessment of fruit quality at the end of the storage period, by organoleptic assessment, from the results presented in Table 4 it can be seen that in both varieties, the fruit stored 24 hours after harvest (V1) had superior characteristics and were classified as Extra quality, as they obtained 30 points in the Santa Maria variety and 32 points in the Alexander Lucas variety.

Table 3. The main physio – chemical characteristics of the pear fruit at the end of storage period

VARIETY	VARIANT	Soluble dry Matter -%-	Total titratable Acidity -%-	Ascorbic acid -mg/100g-
ALEXANDER LUCAS	V1	148	0.18	4.12
	V2	14.2	0.14	3.40
	V3	13.0	0.11	2.80
SANTA MARIA	V1	13.8	0.16	3.86
	V2	13.0	0.12	3.12
	V3	12.6	0.09	2.64

Source: Own determination.

Table 4. The quality of the fruits, determined by organoleptic assessment

Characteristic analysed	Grading	Variety/ variant					
		ALEXANDER LUCAS			SANTA MARIA		
		V1	V2	V3	V1	V2	V3
Size	3……..1	3	3	2	3	3	2
Shape	3……..1	3	3	3	3	3	3
Skin colour	4……..1	4	4	2	4	3	2
Skin state	4……..1	4	3	2	4	3	1
Pulp colour	3……..1	3	3	2	3	3	2
Pulp firmness	3……..1	3	2	1	2	2	1
Pulp juiciness	3……..1	3	2	1	2	2	1
Taste	3……..1	6	6	4	6	6	4
Aroma	7……..1	3	3	2	3	3	2
Total points	4……..1	32	29	19	30	28	18
Quality class	Extra 30 – 34	x			x		
	First Quality 20 – 29		x			x	
	Second Quality 10 - 19			x			x

Source: Own determination.

This result was ensured by a suitable external appearance, juicy flesh and a characteristic taste and flavor. Fruits placed in storage after 6 days (V2) were slightly penalized for the characteristics: skin state, pulp firmness, pulp juiciness taste and aroma and fell into the first quality category as they scored 28 points (Santa Maria variety) and 29 points (Alexander Lucas variety) respectively.

Delaying the introduction to storage by 12 days (V3) resulted in a lower organoleptic quality (second quality category), with 18 points for Santa Maria and 19 points for Alexander Lucas.

The fruit of this variety showed some commercial defects, with small browned surfaces on the skin, the taste and flavor less characteristic, making these fruits no longer of commercial value to consumers.

The quantitative and qualitative losses of the pear fruits, during the storage period.

The weight losses were influenced by the temperature and relative humidity of the air in the storage space.

Thus, the highest losses were recorded at V3, because the higher temperature and lower relative humidity in the period before the introduction to storage favoured the sweating and respiration processes.

The values obtained varied between 9.2% for Alexander Lucas and 9.6% for Santa Maria, but after different storage periods (65 days and 45 days respectively), as shown in Table 5.

The introduction of the fruit into storage immediately after harvest (V1) as well as the optimal values of temperature and relative humidity in the cooling room resulted in much lower weight losses, respectively 6.4% for Alexander Lucas and 7.2% for Santa Maria, but after a much longer storage period compared to V3 (50 days for Alexander Lucas and 45 days for Santa Maria).

The qualitative losses were also higher in V3 and lower in V1, because the vulnerability (susceptibility) of pears to disease attack increases as they ripen.

Microorganisms also find optimal conditions for growth in the time between harvest and storage.

Thus, the qualitative losses ranged from 5% (Santa Maria) to 5.8% (Alexander Lucas) at V1 and from 7.6% (Santa Maria) to 8.2% (Alexander Lucas) at V3, but as mentioned above, after different storage periods.

Table 5. The weight and qualitative losses of the pear fruits, during the storage period

Variety	Variant	Storage Period -days-	Weight Losses -%-	Qualitative Losses -%-	Total Losses -%-
ALEXANDER LUCAS	V1	115	6.4	5.8	12.4
	V2	85	7.8	7.0	14.4
	V3	65	9.2	8.2	17.4
SANTA MARIA	V1	90	7.2	5.0	12.2
	V2	70	8.0	6.4	14.4
	V3	45	9.6	7.6	17.2

Source: Own determination.

The total losses during the storage period, resulting from adding the weight and qualitative losses, were very similar for all 3 variants for both varieties, but after very different storage periods (about 15-20 days between varieties, at the same grazing variant).

Thus, the values varied between 12.2% - 12.4% in V1 and 17.2% - 17.4% in V3, which once again highlights the advantage of storing the fruit as soon as possible after harvest.

The fruits storage period

In practice, the size of the losses definitely determines the storage period of a batch of fruit. In this respect, comparing the storage periods in which losses (quantitative or qualitative) of 7-10% were recorded, it can be seen that the fruit storage period was shorter by 45-50 days in V3 and 20-30 days in V2, compared to V1 (Table 5).

It is shown that by delaying storage by 6-12 days, the fruit storage period was reduced by 22% (V2) - 50% (V3) compared to fruit stored immediately after harvest (V1).

CONCLUSIONS

The pear fruits of the Alexander Lucas and Santa Maria varieties, harvested at the optimal time and stored in cold storage 24 hours after harvesting, kept much better compared to fruits whose storage was delayed by 6-12 days.

Fruit firmness during storage decreased, compared to the time of harvest, with values ranging from 50% to 54% when storage was delayed by 12 days and only 19-21% for fruit put into storage 24 hours after harvest.

The main chemical components of the fruit such as soluble dry matter, total titratable acidity and ascorbic acid, at the end of storage, had higher values, which determine a better taste quality, in the fruits that were introduced immediately to storage, compared to the variants in which storage was delayed by 6-12 days.

Following the organoleptic assessment of the fruit at the end of storage, they were classified as Extra quality, in the variants where the fruit was stored immediately after harvesting, respectively quality I and quality II when storage was delayed by 6-12 days.

The weight losses of the end of storage varied between 9.2 - 9.6% at V3, compared to 6.4-7.2% at V1, but after a longer period of fruit storage.

The qualitative losses at the end of storage ranged from 5-5.8% in fruit placed immediately after harvest, compared to 7.6-8.2% in fruit where storage was delayed by 12 days.

The obtained values of total losses showed the advantage of introducing the fruit into storage as soon as possible after harvest.

As a result of delaying storage by 6-12 days after harvest, the shelf life of the fruit was reduced by 22% (V2) - 50% (V3), compared to the variant where the fruit was stored immediately after harvest (V1).

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ECO-FRIENDLY MANAGEMENT OF POSTHARVEST DISEASES OF APPLE FRUITS: AN OVERVIEW

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Abstract

Apples (Malus × domestica Borkh.) are the most economically important fruits over the world due to their nutritional and bioactive constituents, with significant value for human healthy. Maintaining these attributes during the post-harvest period is a major concern of all those involved in the field, including researchers. In the present synthesis, the results obtained in the last period of time are reviewed, regarding the sustainable management of post-harvest apples diseases, considering the eco-friendly approaches applied both in the pre harvest period and after the fruit harvest. Promising results were obtained regarding: (i) improving plants growing environmental conditions and pre harvest practices using fungicides and the application of complementary, environmentally friendly measures; (ii) exploring the epiphytic and endophytic flora with a view to some microorganisms exploitation as biological control agents; (iii) nanomaterials using and of plant extracts, as well as of some resistance chemical inducers; (iv) genetic engineering, omics-based approaches and machine learning algorithms. With a view to the successful implementation of the most appropriate innovative strategies for apples fruits diseases post-harvest management it is necessary to continue such studies through a close collaboration between researchers and practitioners.

Key words: *apples, post-harvest, pathogens, eco-friendly control*

INTRODUCTION

Apples (*Malus × domestica* Borkh.) are the most economically important fruits over the world due to their nutritional and bioactive constituents with significant value for human healthy [57]. Therefore, the maintaining of these attributes during storage and the entire supply chain are challenges of interest for all implicated actors [54]. In a close link with several Sustainable Development Goals of the 2030 Agenda, United Nation General Assembly designated 2021 the International Year of Fruits and Vegetables [24].

It is estimated that about 45% to 55% of global fruit and vegetable production is lost, respectively [59]. Post-harvest losses of apples can be caused by many pre harvest and post harvest factors. From the first category can be mentioned: environmental factors variation during the growing period, harvest time and handling practices, qualitative indicators of the fruit, fruit health related to crop protection programs, calcium content, volatile terpenes (such as α- farnesane production) etc. [75, 30, 41, 72, 69, 12, 9, 29, 33]. Not unimportant are also the post-harvest practices, including various treatments based on fungicides to control pathogens [61, 41], which sometimes do not have effectiveness due to the appearance of fungicide resistance [78].

As [7] reviewed, in addition to the quantitative losses, there are also qualitative ones caused by the installation of fungi. From the economically point of view, *Penicillium expansum* determines the most significant post-harvest disease on fruits. It macerates the host tissue, with simultaneously secretion of toxic substances (e.g. D-gluconic acid and mycotoxins, as is patulin). *Alternaria* toxins have been identified as well, both in the case of fresh fruits and in products derived from them [58]. Therefore, specific, and rapid fungus detection, such as loop-mediated isothermal amplification (LAMP) assay developed by [25] before storage, as well as the optimization of apple storage conditions proved to be the ways to reduce the mycotoxins accumulation [7, 83, 4].

During post-harvest period various pathogens, have been identified and studied in detail and different means of their control have been (and are) applied [12]. Early detection of possible new pathogens, novel knowledge on fruit-fungus interaction and development new tools to do this are on researcher's agenda [53, 41]. Thus, the behavior of infected fruits with *Neofabraea* spp. and *Cadophora* spp. (identified by TaqMan PCR assays) during the growing season and their subsequent evolution after several months of storage, when symptoms occurred is absolutely necessary, in order to develop measures to prevent the risks of infection during the growing season [41]. It can be mentioned that *Neofabraea* spp. was also identified in Romania, in the case of post-harvest advanced cold storage [14].

In the Nordic countries, the increase of the demands for locally organic fruits imposed the need to consider adaptation to climatic conditions and disease resistance/tolerance, as the principal issues for apple breeding programs [55]. Alternative control approaches are also needed [19], including those that directed to reduce the losses in intelligent agriculture [62]. Additionally, the biological control, the bio-preservation approaches, and meta-omics techniques with a view to emerge new strategies to increase the shelf-life of fruits and vegetables are needed [46]. In the same vein, [15] noted that "the study of plants with traditional uses as - plant protectors - is essential for understand more about the inner value of flora" is still valid today, more than ever.

In view of the above, the purpose of this synthesis is to provide an overview of the concerns in recent years for the control of post-harvest apple fruits diseases, based on environmentally friendly, safe, and sustainable tools, such as:

(i) improving plants growing environmental conditions and pre harvest practices by the application of complementary, environmentally friendly measures;

(ii) exploring the epiphytic and endophytic flora with a view to some microorganisms' exploitation as biological control agents;

(iii) nanomaterials using and of plant extracts, as well as of some resistance chemical inducers;

(iv) genetic engineering, omics-based approaches and machine learning (ML) algorithms.

MATERIALS AND METHODS

In order to achieve the proposed objectives and produce a critical review approach that meets the readers' expectations, we proceeded to an exhaustive search process based on relevant key words or phrases, as regard as the research issue (e.g. "eco-friendly pathogens control", "apples postharvest pathogens management", "biocontrol agents", "epiphytic flora", "endophytes", "nanomaterials"), to access appropriate and actually relevant articles.

Clarivate Analytics databases (Web of Science; Science Direct Freedom Collection, Elsevier; Scopus, Elsevier; CAB Abstract) have been accessed, also, an advanced search on Google has been done. With a view to include or exclude criteria, the search filters available in the platform were used.

The information organization was carried out on the basis of the most current results of scientific research, which can offer new study topics in the future, as well as possibilities for implementation in practice, in accordance with current trends concerning the new theoretical frameworks and emerging perspectives, which revolve around the sustainable agriculture general concept.

RESULTS AND DISCUSSIONS

Improving plants growing environmental conditions and pre harvest practices by the application of complementary, environmentally friendly measures

The post-harvest quality of apples and increased tolerance to the attack of pathogens depend, among other factors, on environmental conditions (such as rainfall, air humidity and temperature) at certain phenophases of fruit evolution [9], as well as on management of tree health and vigor during orchard establishment (especially with regard to soil-borne pathogens) [31]. As a matter of fact, climate change itself impacts the physiology of the response to different pathogens and pests [3]. Global warming has also contributed to the emergence of new pathogens, such as *Colletotrichum acutatum*, which causes apple anthracnose and whose incidence is increasing [29].

Pre harvest practices designed to ensure improved conditions (e.g. pruning, nutrition, irrigation or drainage) are of interest, as [9] showed. High rainfall during flowering and early fruit development were correlated with improved fruits quality. Also, a humidity higher than 77% at the beginning of June led to the obtaining of more tolerant fruits at the attack of the fungus *Botrytis cinerea*. Moreover, harvesting at the right maturity level and proper post-harvest handling reduced the incidence of bruising, while storage of "Golden Delicious" apples by 93.3%, to 37.7% in the absence of treatment (dipping in calcium and fungicide). In addition, no symptoms of rot were detected [72].

In the case of organic orchards, attention was paid also to pre harvest practices (orchard floor management, summer pruning), establishing representative indices for fruit maturity (such as starch hydrolysis), as well as the use of natural products (such as ethanol), for apples phytosanitary protection during storage [71]. Besides to the specific effects of differently colored selective films [ChromatiNets (R)] on physiological processes in the plant canopy, [65] also highlighted their impact on pests and diseases. Also, [12] pointed out that anti-hail photo selective netting provides apples protection against key emerging pests (such as *Halyomorpha halys* and *Drosophila suzukii*), It has a beneficial effect on arthropods, protects against pathogenic fungi, and positively influences fruit quality.

Although the number of new diseases in apples has increased, treatment technologies have been directed towards reducing the number of sprays during the growing season, towards the application of complementary, environmentally friendly measures such as the use of organic fungicides, then systemic or therapeutic ergosterol biosynthesis inhibitors (EBI) [73], as well as of some physical strategies [12]. But, still more than 10 years ago, [73] specified that in order to make control decisions well-founded from the point of view of environmental safety, as well as from the economic viewpoint, it is necessary to integrate, correlate, transmit information on the evolution of the pathogen, weather monitoring and disease forecasting. As [77] stated, a more accurate prediction of the severity for rot pathogen *Neofabraea perennans*, as well as the recently discovered minor rot *Phacidiopycnis washingtonensis*, need to be carried out. A more targeted application of pre harvest fungicides, as well as post-harvest physical treatments are of interest, too.

Studies highlighted the growth inhibitory effect on *B. cinerea* fungus when 'Fuji' apples were dipped in 300 μg/mL of chlorogenic acid, for 30 minutes and the authors indicated its role in preventing gray mold disease [77]. This effect was due to the increase in enzymatic activity relative to phenol metabolism, as well as increasing the content of total phenols, flavonoids and lignin.

Another phenolic compound that has been shown to be effective *in vitro* against *B. cinerea* is phlorizin [32]. In a dose of 1.0 g/L it significantly reduced the incidence of the disease and inhibited the lesions diameter spread. The application of a combined treatment (dipping in a solution of 5% calcium chloride $CaCl_2$+5 mM salicylic acid - SA for 10 min) has been shown to be effective in inhibiting the fungus *Colletotrichum gloeosporioides* [82]. In addition, it was noticed a preservation of the quality by reducing the decline in the total content of soluble substances, titratable acidity and firmness.

In order to reduce losses during the storage period, one of the primary conditions is the direction to store only healthy fruits. Otherwise, in the case of storage in a controlled atmosphere, the ability to suppress diseases is reduced. If we talk about traditional storage, the fruits are almost completely destroyed. In Romania, [35] noticed that after four months of organic fruits storage in cold conditions (1^0 C, 90% humidity), without any post-harvest treatment, the fruits damages were caused mainly by fungal pathogens (such as *Gloeosporium* sp. originated from field) and wounds infections caused by *Penicillium* sp. and *Fusarium* sp.

Last but not least, the development of molecular methods for the early detection of the most important pathogens and a precise diagnosis of apples diseases may be key factors. To these depends to make a correct decision with a view to assure an economic and sustainable growth of farmers, storage owners and managers [74, 68].

Exploring the epiphytic and endophytic flora with a view to exploitation of some microorganisms as biological control agents

In addition to the initial use of synthetic fungicides, which have been proven to cause some inconvenience, later on, researchers in the field resorted to the development of alternative methods, such as compounds generally recognized as safe (GRAS) [60], or so named good agricultural practices (GAP) [66]. Application of environment-friendly natural compounds (plants extracts, essential oils, and active compounds or secondary metabolites) [36] and using of antagonistic bacterial and fungal microorganisms are viable alternatives, along to refrigeration [80, 18, 10, 22, 84, 81].

The effectiveness of biological control methods was also demonstrated. Exploring fruit microbiomes and their association with their hosts have been addressed [8], when the yeast *Metschnikowia fructicola* was used as bio control agent during apples cold storage. It was shown that the yeast persisted in high abundance (>28% relative abundance) on the fruit surface and significantly reduced the richness and fungal microbiome, as regard as its composition and structure, relative to the control. Fungal pathogens (such as *Alternaria*, *Aspergillus*, *Comoclatris*, *Stemphylium*, *Nigrospora*, *Penicillium*, and *Podosphaera*) have been reduced as presence. Nowadays, DNA metabarcoding approach to explore the fungal and bacterial epiphytic microbiota changes is carried out [4, 5]. Also, the mechanism of action [11, 22] and effectiveness [38, 39] were analyzed. There was also used the DNA metabarcoding approach and characterized the fungal and bacterial community in three/four-year-old shoots (old bark) or one-year-old shoots (young bark) of 'Golden Delicious' and 'Gala' cultivars [5]. It was highlighted the microbiota dependence on apple tree age and genotype.

Besides, research are focused on microorganisms' isolation, their mechanisms of action, the application methods, the efficacy enhancement, products formulation and commercialization of biological control agents (BCAs) designed for post harvest control of fungal diseases of fruits and vegetables [10, 22].The characterization of the microbiome in *Malus triloba* [39] and its exploitation as a source of new BCAs on pathogens such as *B.cinerea* and *P.expansum* allowed the identification and molecular characterization of some genera (e.g. *Bosea*, *Microlunatus*, *Microbacterium*, *Mycetecola*, *Rhizobium* and *Paraphoma)*. Also, from 237 screened strains, 92 inhibited *P.expansum* (39%) and 87 strains inhibited *B.cinerea* (38%). Such results can be used in the future to develop new post-harvest formulations. Exploitation of the indigenous microbiota of cider-apples cv. "Bedan" conducted to promising results [4]. It exerts not only antifungal effect, but also anti-patulin activity in relation with *P.expansum*.

Lactic acid bacteria (e.g. *Lactobacillus plantarum* DSM 20174) has been shown to have antimicrobial activity against pathogens (*A. flavus*, *C. acutatum*, *C. gloeosporioides*, and *Fusarium avenaceum*), both *in vitro* and *in situ*, with a stronger inhibitory effect on spore germination (89.62%–97.61%), than on mycelia growth. *In situ,* necrosis inhibition ranged from 42.54% for *C. acutatum* to 54.47% for *A. flavus* [84]. Studies performed by [18] regarding the antagonistic effects of mycobiota of apple fruits (forty-nine isolates) against *C. acutatum* that cause bitter rot on fruit emphasized that eight isolates inhibited growth of *C. acutatum* by more than 50%, and 6 out of 8 fungal isolates prevented disease developing on the inoculated apples. *Pestalotiopsis guepinii* was not able to control bitter rot effectively. But, still an inoculation at 4x10(6) conidia/mL, together with a 0.1-mL conidial suspension of *C. acutatum* (1x10(6) conidia/mL) inhibited bitter rot by 39.5%.

Regarding the mode of action of *Rhodotorula glutinis*, [47] highlighted and explained the ability of the yeast to attach to spores and hyphae of *B. cinerea*, due to some protein components located on the yeast cell surface and which might contain glycosylation modification. In addition, [64] showed the inhibitory effect on *P.expansum* of three antagonistic yeasts (Y33, Y29 and Y24) of *Metschnikowia pulcherrima*, as well as their patulin degradation capacity. The most effective was proven to be Y29. Exploitation of epiphytic microflora characteristics was also demonstrated by [38] following the selection of 60 yeasts, of which 10 were tested *in vitro* against *B. cinerea* fungus. The isolates antagonist action properties were tested *in vivo*, too. Three of them (L7 of *Aureobasidium pullulans*, L2 of *Citeromyces matritensis*, and L10 of *Cryptococcus flavescens*) proved to be effective as potential biological control agents.

As early as about 10 years ago, [43] emphasized the urgent need to develop appropriate formulations when using BCAs during the pre harvest period, based on the results of their own studies using the yeast *Pichia anomala* strain K, as an antagonist against the fungus *P. expansum*. A density threshold of 1×10^4 cfu cm^{-2} of strain K on the apple surface seemed to be required just after harvest, for high protective activity, whatever the method and time of application. Pre harvest biological treatments may have remarkably effects on strain K population density and its efficacy, according to the variations in meteorological conditions. Later on, the same author [44] by *in vitro* and a semi-commercial large-scale trials demonstrated the antagonistic activity of some bacterial strains (*tAlcaligenes*, *Bacillus*, *Brevibacteriwn*, *Pantoea*, *Pseudomonas*, and *Serratia*) to control the brown rot caused by *Monilinia fructigena*, and *M. laxa*. The efficacy of these antagonists (ACBC1, SF14, SP10 and ACBP1) capable of producing lytic enzymes and lipopeptides was comparable to that of commercial products (e.g. *B. subtilis* Y1336 and *P. agglomerans* P10c), but slightly lower than that of the thiophanate-methyl fungicide.

In addition to these approaches, [70] directed research including the genetic characterization of BCAs. In the case of the *Candida oleophila* I - 182 yeast, a genome similar in size to that of the model yeast strain *Saccharomyces cerevisiae* S288c was shown to be present. Authors stated that such results may contribute to a better understanding of the properties of bio control at the molecular level. According to the results of [10] in the fruits treated with *C.oleophila* incidence of *P.expansum* and the diameter of the lesions were significantly reduced. A rapidly colonizing of apple peels and an increasing of the activity of some enzymes induced the disease resistance. Because freeze-drying is widely used for the preservation of microorganisms, [11] considered different possibilities for optimizing cryoprotective components for *C. oleophila*. The optimal formulation was represented by 15% trehalose, 2% sodium glutamate, and 10% skim milk powder, when a survival rate of 69.7% has been obtained. The effect on blue mold has been promising, too.

Promising results as BCAs of some plant root-associated rhizobacteria (RAB) have been also obtained [52, 40]. RAB isolated from legumes (such as *Pseudomonas* and *Serratia*) suppressed the growth of *P.expansum*, *B.cinerea* and *Mucor piriformis* during apples cold storage [52]. By studies performed *in vitro*, but also *in vivo* by using the antagonistic rhizobacterium *Paenibacillus polymyxa* (APEC128), against anthracnose caused by *Colletotrichum gloeosporioides* and *C. acutatum* it was emphasized that a suspension concentration of APEC128 (1×10^8 colony forming units (cfu)/mL) assured a diseases suppression (by 83.6% and 79%, respectively) [40]. This effect has been explained by an increasing of protease and amylase, which might inhibit mycelial growth. Further, based on studies carried out by [44] on the ability of bacteria isolated from natural soil to produce lytic enzymes (amylase, cellulase and protease), hydrocyanic acid (HCN) and lipopeptides (bacillomycin, fengycin, iturin and surfactin) two bacterial isolates (*Bacillus amyloliquefaciens* B10W10 and *Pseudomonas* sp. B11W11) have been found to be most effective. These reduced the brown rot incidence caused by *M. fructigena*, as against to the synthetic fungicide, in a semi-commercial large-scale trial. It has also been shown that fengycin is a primary active compound of *B. amyloliquefaciens* against a broad range of foodborne pathogenic microorganisms [49].

The beneficial effects of the *Botryosphaeria dothidea fungus* control by endophytic bacterium *Bacillus velezensis* (strain P2-1) have also been recently demonstrated [81], without significantly affecting fruits qualitative characteristics. Its action is due to the ability to synthesize of antifungal lipopeptides and polyketides, as well as to enhance the expression levels of pathogenesis-related genes (*MdPR1* and *MdPR5*).To these effects is added the ability to be effective against *B. dothidea* fungicide-resistant forms.

Nanomaterials using and of plant extracts, as well as of some resistance chemical inducers

The use of nanotechnology within the agricultural system has proven to be beneficial and has led to an increase in agricultural yield. In particular, nano-phytopathology represents a new era in the early detection of plant pathogens, in monitoring the pathogens populations, as well as their interaction with the host plant. The transfer of genetic material between the pathogen and the host can be also done [2].

Nanoparticles (NPs) can assure a control of post-harvest decays in the case of various fruits, including apples [60]. In the case of climacteric fruits (such as apple fruits), beside zinc, silver and chitosan, the most effective to significantly delay ripening by reducing weight, moisture and fruit firmness losses were zinc NPs. Also, by their biopolymer-like features, a superior antibacterial, antifungal, and antiviral properties have been emphasized, as against the edible coatings [56].

It was recommended the introduction into the *P.expansum* management programs of chitosan NPs [1]. The exogenous applied as NPs or bulk form induced in apple (cv.Anna) a strong systemic acquired resistance (SAR) against the fungus. An over expression of the studied defense-associated genes (chitinase, peroxidase, β-1.3-glucanase, xyloglucan endotransglycosylase, pathogenesis-related protein - PR8, and phenylalanine ammonia lyase-1) was noticed. A potent, economical and environmentally friendly measure regarding the use of nano preservatives proved to be the use of green synthesis of nano silver (AgNPs) using black tea extract [50]. This prevented post-harvest damage caused by *M. fructigena* and increased the apple fruits shelf life. No adverse effects were detected to human health. In the case of the application of polyphenols (exposed to rapid decomposition under normal conditions of temperature, oxygen and light), their encapsulation or intercalation into NPs has proven effective. There was tested the antifungal effect on blue mold of the polyphenols of pomegranate fruit peel into silica NPs [6]. The inhibitory action was significantly higher as compared to NPs and extract alone, in agar well diffusion method. Moreover, the stability of the plant extract was improved.

Some authors remark that "the study of plants with traditional uses as - plant protectors - is essential for understand more about the inner value of flora” is still valid today, more than ever [15]. The use of essential organic oils (such as those extracted from *Thymus vulgaris*, *Lavandula angustifolia*, *Rosmarinus officinalis*) has been shown to be effective for the integrated control of pathogenic fungi, such as *Fusarium avenaceum, B. cinerea, P. expansum,* and *Neofabraea vagabunda*. At the same time, the potential to inhibit mycelium growth (especially by *T. vulgaris* and L. *angustifolia.*) by applying it through dipping treatment can be correlated with their chemical composition [19].The treatment moment (curative or protective), as well as the mode of application are also important, as it was noticed by tests performed using of garlic extracts and clove oil directly or through volatile exposure, *in vivo,* against postharvest pathogens *B.cinerea*, *P.expansum* and *Neofabraea alba* [17]. When garlic extract was curative applied directly to the fruit, the postharvest decay caused by *B. cinerea* and *P. expansum* has been reduced.

The effectiveness of some resistance chemical inducers (such as chitosan, methyl jasmonate, salicylic acid, silicon, and thiabendazole) was also highlighted [42] in controlling the fungi *B. cinerea* and *P. expansum*. Thus, for *B. cinerea* the 80-96% reduction in incidence was due to silicon, while chitosan provided a 92-100% reduction for *P. expansum*. In addition, high doses of chitosan and silicon increased phenylalanine ammonia-lyase levels for *B. cinerea*. Chitosan (regardless of the dose) favored the activity of scopoletin and scoparin from fruits in the case of both pathogens. Added to this it was an increase in lignin content when the doses of the two inducers were high [42].

The pre-cooling of freshly harvested apples (cv. Royal Delicious) associated with their surface coating with neem (*Azadirachta indica*) oil and marigold flower (*Tagetes erectus*) extract highlighted the ability to effectively maintain the fruits physico-chemical and physiological characteristics, especially for the neem oil (1.5 - 2%). This also induced a significant reduction of diseases incidence [79]. Methanolic extract of mulberry leaves (4%) ensured the inhibition of mycelial growth of *P.expansum* (40.3% effectiveness), as well as reduced of sporulation [45]. Ethyl acetate extract (8%) was found to have similar effects to the chemical control (imazalil with 75.1% inhibition). Some color changes of the fruits have been produced by using the second solvent.

Tests performed *in vitro* showed the ability of essential oils extracted from lavender and oregano to inhibit mycelial growth in *B.cinerea* and *P.expansum*, by up to 90% for both pathogens [16]. The efficacy of neem extract (as compared with fennel, lavender, thyme, pennyroyal, salvia and asafetida extracts) both *in vitro* and *in vivo* studies, against *B. cinerea* was also emphasised [28]. During apples storage, a 25 % neem aqueous extract determined a decrease of disease severity by 89.11 % as against the control. Generally, plants extracts determined an increase of the activity of different enzymes (peroxidase, phenylalanine ammonia-lyase, β-1.3-glucanase and polyphenol oxidase) in apple fruits, when the pathogens have been present. On the other hand, cinnamon, pimento, and laurel extracts had a high *in vitro* antifungal activity against *B. cinerea*, but at that concentration the postharvest effect was not so good. Even for cinnamon extract (the most promising one), higher concentration should be applied to be effective *in vivo*, during fruits storage [63].

Promising results (e.g. high efficacy, low cost, and safety to human health) for a natural fungicides exploitation against the apple ring rot produced by *Botryosphaeria dothidea* have been obtained in China [48], by using the alkaloid berberine extracted from the *Coptis chinensis* (a medicinal plant). Its effect was a successful inhibition the hyphal growth, while the *B. dothidea* membrane permeability was increased, as well as the activity of some energy metabolism implicated enzymes (succinate dehydrogenase and malate dehydrogenase) has been repressed. The aqueous extract from the epicarp of pomegranate fruits applied *in vivo* at a concentration of 50 mg/mL (and proven to contain high amounts of phenols -2737.44 mg GAE/L and flavonoids -309 mg QE/L) was shown to reduce by 21.03 and respectively, by 42% the severity of the disease caused by *Monilia laxa* and *M. fructigena* [23].

Genetic engineering, omics-based approaches and machine learning (ML) algorhitms

The role of genetic manipulation was highlighted [21], regarding that the silencing of the APPLE VACUOLAR PROCESSING ENZYME 4 (MdVPE4) which causes a decrease in *B. dothidea* disease resistance. Its over expression has the opposite effect, increasing resistance and, respectively, influencing the genes involved in disease resistance in the case of fruits (APPLE POLYGALACTURONASE 1 (MdPG1), APPLE POLYGALACTURONASE INHIBITOR PROTEIN 1 (MdPGIP1), APPLE ENDOCHITINASE 1 (MdCHI1) and APPLE THAUMAINTIN-LIKE (MdCHI1) MdTHA1). APPLE CYSTEINE PROTEINASE INHIBITOR 1 (MdCPI1) was also found to be involved in the process of modulating MdVPE4 activity.This highlights the interaction between MdVPE4 and MdCPI1 in the framework of modulating fruit resistance to *B. dothidea* attack.

Genetic studies for the manipulation of terpenes have been in attention [37]. It is well known the production of the sesquiterpene (E,E) -α-farnesene, by apples fruits. There were identified four quantitative trait loci (QTLs) in a segregating 'Royal Gala' (RG) x 'Granny Smith' (GS) population and it was elucidated their implication in fungal pathogenesis of some post-harvest pathogens (*Colletotrichum acutatum*, *P. expansum* and *Neofabraea alba*).

On the same note, investigations carried out by [37] focused on understanding and controlling the virulence of the *P.expansum* fungus have led to the identification of the Blisteringl gene. This gene affects the internal and external processing of a protein (with a DnaJ domain) involving vesicle-mediated transport in a family of fungi with medical, commercial, and agricultural importance. The researchers' attention was also directed to understanding the action of *Bacillus amyloliquefaciens* (the function of fengycin) in *P.expansum* control. There were done the construction of BA-16-8 (a fenC gene deletion mutant), by PCR approaches and testing the inhibitory effect of the mutant via high-performance liquid chromatography, mass spectrometry, and *P.expansum* growth inhibition assay *in vitro* [26]. It has been shown that fengycin is the key component of *B. amyloliquefaciens* BA-16-8 in the control of blue mold disease. As [13] noticed, the development of genetic resources in order to investigate at the molecular level the mechanisms that characterize the bio control activity on *P.expansum* by the basidiomycetes yeast *Papiliotrema terrestris*, is an urgent need to promote biological (and integrated) means of control and to reduce the fungicides treatments.

In addition to genetic studies, the analysis of metabolic changes during *P.expansum* infection based on the ultra performance liquid chromatography and the quadrupole-time of flight mass spectrometry (UPLC-Q-TOF/MS) technique performed by [67] led to the identification of significant metabolomic differences between control and infected samples. The differences were especially as regard as to the secondary metabolite biosynthesis, ATP-binding cassette transporters, amino acids and carbon metabolism in early infection time.This information can be used to characterize the mechanism of the pathology and the discovery of biomarkers for quality control. The use of antifungal proteins (AFPs), such as those from *Penicillium chrysogenum* (PAF, PAFB and PAFC) and *Neosartorya fischeri* (NFAP2), has been shown to act in a species-specific manner, in controlling post harvest pathogens. PAFB was the most efficient against *P. digitatum*, *P. italicum* and *P. expansum*. PAFC and NFAP2 showed moderate antifungal activity, whereas PAF was the least active protein [27].

Besides different other researches which are performed in this field, digitization and digitalization are also important components of the agriculture development in the global economy [76]. Application of machine learning (ML) algorhitms (the state - of - the art technology) in agriculture domain, in each activity area (pre harvesting, harvesting and post harvesting) allows more efficient and precise farming, with less human manpower and with high quality production [51]. In addition, the application of ML-based techniques for forecasting, detection, and classification of diseases and pests proved to be of interest for a smart, precise and environmentally friendly agriculture. Furthermore, further developments are needed [20], advances that come in support of improving the quality and yield of crops, along with increasing the degree of tolerance to abiotic and biotic stress factors [34].

CONCLUSIONS

Non-chemical treatments to sustainable control of post harvest apple fruits diseases include a large range of different approaches.

The most suitable cultivar must be chosen, to be cultivated in the environmental conditions corresponding to it. The appropriate techniques applied during the growing period, fruits harvesting at the corresponding moment, as well as their manipulation during the entire link between the farm and consumer must be taken into account.

It is necessary to improve plants growing environmental conditions and pre harvest practices by using small doses of fungicides and the application of complementary, environmentally friendly measures.

Exploring the epiphytic and endophytic flora with a view to exploitation of some microorganisms as biological control agents have been proved to give very good results. Nanomaterials using and of plant extracts, as well as of some resistance chemical inducers can reduce the costs, increase the efficiency and safety of applied treatments.

Genetic engineering, omics-based approaches and machine learning algorithms are nowadays promising innovative means that can be applied to early pathogens detection, as well as to better diseases management.

It is necessary to continue such studies, through a close collaboration between researchers and practitioner, with a view to the successful implementation of the most appropriate innovative strategies for post-harvest management of apples.

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LAND-GRABBING PHENOMENA IN THE CONTEXT OF RURAL DEVELOPMENT

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Abstract

The paper presents the characteristics of the agricultural sector in Romania, through the lens of the land grabbing phenomena. It is one of the latest additions to an already full agenda of challenges that rural development must address. Land grabbing deprives the population of the ability to make decisions about the national land (what is cultivated, what agricultural practices are used, what is the purpose of the land), nullifying food sovereignty. Also, the possibility of young people to choose agriculture as a field of activity is restricted by the privatization of land, although they receive subsidies for establishing themselves as young farmers. The analysis carried out in the period 2015-2021 indicated that approximately 40% of Romanian agricultural land is owned by foreign owners, while 46% of the population lives in the countryside and 1.6 million people are employed in agriculture, forestry and fishing. The results showed that the largest areas are owned by Italy, Denmark, Germany, Sweden, Lebanon and the United Arab Emirates. The main fields of activity are the following: agriculture, forestry, conservation and renewable energy. At the same time, subsidies can represent significant income for large areas of land. For the studied period, an increase in the prices of arable land in Romania was found, although they are lower than in other European countries. The biggest increases in arable land prices were recorded in the West, South-East and South-West Oltenia Regions.

Key words**:** *agricultural land, land-grabbing, land price, Romania, rural development*

INTRODUCTION

Land-grabbing or land seizure is the phenomenon whereby large areas of land (of agricultural, forestry or other utility) together with the related resources (e.g. hydrographic bodies) are taken/controlled by various entities (individuals, corporations, governments etc.), to the detriment of the welfare of the local population and the environment.
The phenomenon of seizure has several forms: land-grabbing, forest-grabbing, resource-grabbing, water-grabbing. In this paper will be treated only the land-grabbing topic, with a special look on agricultural land, although land grabbing generally includes the grabbing of resources on that land surface (forests, water).
The phenomenon has not been precisely defined, nor are its limits and dimensions clearly known. It is considered land-grabbing even if it happens inside a country and is practiced by the conational of the affected population. Land grabbing does not necessarily involve their purchase, but also their rental/lease at derisory prices for long periods (25-99 years) or concession by the governments of the countries concerned.
The main indicators of the land-grabbing phenomenon are the large areas of land owned by a single entity and the share of these areas in the total area of a certain population.
The problems raised by land-grabbing are the following: social inequity; environmental problems (deforestation; land degradation through intensive agriculture - monocultures, fertilizers and chemical pesticides, overexploitation of resources; reduction of biodiversity through large-scale monocultures; land transformation into a speculative object; privatization of public

goods, e.g.: water resources); damage to the rural environment (decrease of the standard of living; loss of jobs; the loss of the meaning of rural life; the displacement of local communities; the disappearance of traditional working practices, methods and cultural heritage of the respective areas; the violation of human rights; the loss of food sovereignty) [4, 18].

Factors favouring the extension of the phenomenon of land-grabbing are the following:

a) Clear non-regulation of property rights/non-registration of land;
b) The food crisis and population growth have led to greater demand on the food market;
c) State control over the activities of companies outside their national territory is very low;
d) The desire of the companies in various fields (pharmaceutical, cosmetic) to control all the production levels of the final product;
e) Globalisation and the principle of free movement of capitals;
f) Urbanisation.
g) European policy pressures for the transition to green energy and biofuel production;
h) Single payment scheme per hectare under the Common Agricultural Policy.

The Common Agricultural Policy subsidises each agricultural land with a fixed amount, irrespective of the use of the land, or with minimum conditions. This constitutes a motivation for the accumulation of land, deepening the phenomenon of land-grabbing.

From the analysis of the distribution of direct payments at EU-27 level, in 2019, it is observed that 14,000 farms in the EU received 11% of the total payments, while 1.4 million small farms received only 1.2% of the payments [8].

The paper aims to present aspects related to the sale and accumulation of land in Romania, in order to conclude whether this phenomenon leads to the development of rural areas.

MATERIALS AND METHODS

This article is based on a literature review and an analysis of existing reports and studies. Due to the specificity of the research, this formula was adopted in order to have a better research capacity of the topic and its main challenges.

The following indicators were analysed to highlight the existing situation in Romania: the structure of active population by age group and area of residence, the labour force used in farms, the number of agricultural holdings, the structure of the ownership of land and agricultural holdings, the sales of agricultural land and the price of arable land.

The data were taken from statistical sites, such as the National Institute of Statistics and Eurostat, as well as from the Ministry of Agriculture and Rural Development of Romania, the European Commission and from specialized documents, which were mentioned in the References.

The period in which the studies were carried out is 2015-2021.

RESULTS AND DISCUSSIONS

In Europe, the phenomenon of land-grabbing is more widespread in the Eastern area (the former communist states).

The European agricultural model is that of family farming, with 96.3% of farms in the EU classified as family farms in 2016. Also, two-thirds of European farms work on areas under 5 ha [12]. Nine out of ten people working in agriculture at EU level (89.8%) represent the farmer or members of his family.

An important role in agricultural land grabbing in the EU is played by a new category: banking entities, pension and insurance funds, which were not part of the agricultural world in the past. This is an important signal of the transformation of the soil into an ordinary commodity, an investment object and speculation, at the cost of affecting the rights of human communities regarding access to land.

In 2020, according to the National Institute of Statistics [14], the resident population in rural areas in Romania was of 8.9 million out of 19.2 million total (46%).

The active population of Romania was 8,972,820 people, of which 4,053,134 in rural areas (Table 1).

Table 1. Active population by age group and area of residence, 2020

Age groups	Environments of residence	Number of people
Total	Total	8,972,820
-	Urban	4,919,687
-	Rural	4,053,134
15-24 years	Total	607,199
-	Urban	197,934
-	Rural	409,266
25-34 years	Total	1,986,999
-	Urban	1,193,280
-	Rural	793,719
35-49 years	Total	3,735,468
-	Urban	2,173,832
-	Rural	1,561,636
50-64 years	Total	2,393,303
-	Urban	1,320,253
-	Rural	1,073,050
65 years and over	Total	249,851
-	Urban	34,388
-	Rural	215,464

Source: [14].

It can be seen from these data that in the segments aged 15-24 years, the active population is larger in rural areas, the situation being reversed from 25 years upwards, probably due to the lack of opportunities and jobs, which cause emigration to urban areas. Half of Romania's active population operates in rural areas.

At the level of 2020, the Romania's civilian population employed was of 8.4 million people, of which 1.6 million were employed in the agriculture, forestry and fisheries sector (Table 2).

Table 2. Labour employed on farms

Year 2016	Farm labor (AWU*)
Romania	1,640,120

*1 AWU is a person working full-time (i.e. 2 people working part-time = 1 AWU).
Source: [9].

It is noted that Romania uses a large volume of human work on farms, although the utilised agricultural area of Romania is about 14.7 million ha. It is also useful to distinguish between unpaid (family) and salaried labour (typical of industrial farms in general, but not only). Wage labour generally reveals greater economic power on a farm. From the available data, it appears that Romania uses mainly unpaid labour, and its share tends to remain constant [9].

These characteristics of the Romanian population make it vulnerable to the phenomenon of land-grabbing, as the land is the resource of existence of the rural environment, along with the activities related to agriculture and services performed by the agricultural population (e.g. education).

Characteristics of the agricultural sector, from the perspective of the acquisition of lands:

Romania has the largest number of farms in the EU representing one third of the total number, but accounting for only 3.4% of EU's production [13].

Table 3 shows that 87% of the Romanian farms are subsistent. At least 2,956,380 peasant families in Romania depend directly on the land for survival.

Table 3. Agricultural holdings in Romania

2016	Number of farms	Farms which consume more than 50% of their production internally
Romania	3,395,930	2,956,380

Source: [10].

A small percentage of entities (natural or legal persons), 1% in the case of Romania, own more than 50% of agricultural land. Small landowners who are the majority (74%) work only 13% of the agricultural area (Table 4).

Table 4. Structure of land ownership in Romania

Specification	Romania
Average area/holding (ha)	3.4
Major landowners and the percentage of agricultural land they own	<1% own 57%
Minor landowners and the percentage of agricultural land they own	74% own 13%

Source: [5].

According to data published at the level of 2016, agricultural holdings in Romania under 1 ha represent 53% of their total number, but exploit only 5.1% of the agricultural area used (UAA) at national level (Table 5).

Given that 84.6% of Romanian farms are not economically strong, they constitute a threat, indicating the possibility of their disappearance in the coming years.

Table 5. Agricultural holdings in Romania

Agricultural holdings	Share in the total number of holdings	Utilized Agricultural Area (% of total UAA)
Less than 1 ha	53%	5.1
1-5 ha	38.6%	23.6
Exceeding 50 ha	0.5 %	51.1

Source: own design after [7].

Land Sales Regulation

The liberalization of land sale to non-citizens took place in 2014, by Law 17/2014 (amended and supplemented by Law no. 175/2020) which provides that the extravilan land may be sold to natural or legal persons or from EU Member States or third states, after the prior exercise of the pre-emptive right for 1st and 7th pre-emptors.

The lands located less than 30 km from the state border or the Black Sea coast, as well as those located at distances of up to 2,400 m from the special objectives, can be sold only with the approval of the Ministry of National Defence. Also, the lands with archaeological potential can be alienated only with the approval of the Ministry of Culture.

If on the purchased land there are agricultural investments for fruit crops, vines, hops and exclusively private irrigation, the new owners have the obligation to preserve the agricultural destination of these investments. Moreover, the agricultural use of the land purchased may not be changed.

The alienation of the lands, as well as the alienation of the control package of the legal persons who own agricultural lands representing more than 25% of the company's assets at less than 8 years from the date of purchase, is sanctioned by the taxation of 80% of the amount representing the difference between the price for which the initial land was purchased and the price for which it was subsequently sold. This measure aims to discourage speculation on agricultural land [19].

Given that in Romania lease agreements are not established by law or government, upon the expiry of a lease agreement, the lessor may give the land to another lessee, after a prior notice of the first lessee on the intention not to renew the agreement. This may discourage investment in land, the lessee being rather interested in investments that pay off in the short term.

At the level of 2021, the average price of one hectare in Romania was of 4,700 euro, but if we take into account the value of the most expensive traded land in 2021 (a land located in the extravilan of Iasi), the average price was 10,000 euro [22].

Under Law 17/2014, agricultural land was sold to foreign entities, as follows (Table 6):

Table 6. Agricultural land sales in Romania, for the period 2014-2018

Year	Number of hectares
2014	58,875.14
2015	172,353.79
2016	144,350
2017	153,927.46
2018	154,076.23

Source: own presentation after [20].

A study by the Transnational Institute, from 2015, estimated that about 5.3 million ha of agricultural land (40% of the approximately 13.3 million ha) are exploited by foreigners [23].

Data on global land-grabbing are provided by the Land Matrix Initiative, a partnership between the Centre for Development and Environment (CDE) of the University of Bern, Centre de Cooperation Internationale en Recherche Agronomique pour le Développement (CIRAD), the German Institute for Global and Area Studies (GIGA), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the International Land Coalition (ILC) at global level, together with the Asian Farmers' Association for Sustainable Rural Development (AFA), the Centre for Environmental Initiatives Ecoaction, Fundación para el Desarrollo en Justicia y Paz (FUNDAPAZ) and the University of Pretoria at regional level. This formation has a site that monitors large land transactions (over 200 ha), from certain countries considered to be highly vulnerable to land-grabbing, including Romania [15].

Figure 1, taken from the Land Matrix, shows the states that invested in land in Romania in 2018. The main fields of activity are the following: agriculture, forestry, conservation and renewable energy. Thus, the largest areas are owned by Italy, Denmark, Austria and Lebanon.

Fig. 1. Map of transactions with agricultural lands concluded in Romania, at the level of 2018
Source: [17].

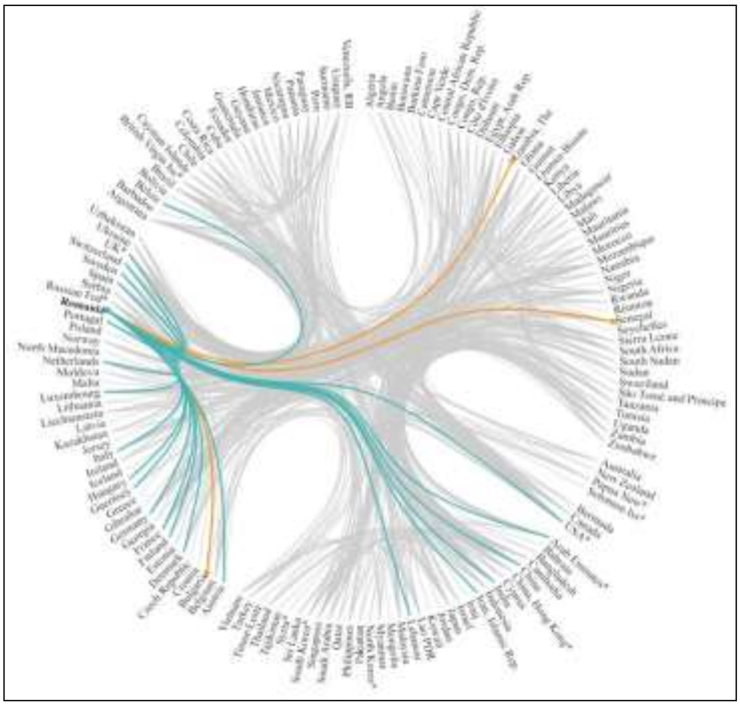

Fig. 2. Map of Romania's land transactions, at the level of 2023
Source:[16].

Legend:

Countries that have invested in Romania (blue lines):

Austria: 2 deals; 28,054 ha
Belize: 1 deals; 12,500 ha
China: 2 deals; 8,372 ha
Denmark: 10 deals; 55,405 ha
Finland: 1 deals; 12,000 ha
France: 3 deals; 8,330 ha
Germany: 12 deals; 52,552 ha
Hungary: 1 deals; 5,772 ha
India: 1 deals; 2,500 ha
Iran: 1 deals; 2,600 ha
Italy: 8 deals; 48,446 ha
Lebanon: 9 deals; 66,320 ha
Luxembourg: 4 deals; 24,036 ha
Netherlands: 3 deals; 29,321 ha
Portugal: 3 deals; 16,300 ha
Spain: 1 deals; 5,717 ha
Sweden: 5 deals; 78,583 ha
Switzerland: 1 deals; 7,967 ha
United Arab Emirates: 1 deals; 55,639 ha
United Kingdom: 1 deals; 5,516 ha
Guernsey: 1 deals; 13,600 ha
United States of America: 3 deals; 38,327 ha

Countries in which Romania has invested (orange lines):

Bulgaria:7 deals; 64,171.40 ha
Gambia: 1 deals; 30,000 ha
Senegal: 1 deals; 100,000 ha

Figure 2 shows the Romanian land transactions available at the beginning of 2023, available on the Land Matrix website. Compared to 2018, we can see the appearance of new states that have traded land in Romania, the increase in the areas owned by some states, but also the fact that Romania owns land in 3 states.

The analysis of arable land prices in the 8 Development Regions of Romania for the period 2015-2021 (Table 7) indicates that there was a strong upward trend. With the exception of the Bucharest - Ilfov Region, which is in close proximity to the metropolis, the biggest increases in arable land prices were recorded in the West, South-East and South-West Oltenia Regions. These increases exceeded the national average.

Table 7 Arable land prices in Macroregions and Regions of Romania, Euro/ha

Specification	2015	2016	2017	2018	2019	2020	2021	2021/2015 %
ROMANIA	2,039	1,958	2,085	4,914	5,339	7,163	7,601	372.78
MACROREGION ONE	2,046	1,932	2,129	4,516	5,681	6,648	6,470	316.23
North-West	2,046	1,906	2,022	4,181	4,921	6,261	6,206	303.32
Centre	2,026	1,870	2,256	5,051	6,895	7,267	6,893	340.23
MACROREGION TWO	1,988	1,913	2,017	4,802	4,859	7,337	7,539	379.23
North-East	2,083	2,033	1,961	3,849	4,036	6,621	6,773	325.16
South-East	1,999	1,863	2,028	5,484	5,448	7,849	8,086	404.50
MACROREGION THREE	2,042	2,040	2,229	4,782	5,887	6,369	7,835	383.69
South-Muntenia	2,048	2,059	2,227	4,688	5,833	8,245	7,730	377.44
Bucharest- Ilfov	1,783	1,999	1,958	7,378	7,394	11,615	10,707	600.50
MACROREGION FOUR	2,066	1,951	2,284	5,443	5,315	7,946	8,211	397.43
South-West Oltenia	2,007	1,966	2,227	5,730	5,591	7,856	7,957	396.46
West	2,101	2,036	2,216	5,102	4,986	8,053	8,513	405.19

Source: [11].

Although the prices of agricultural land in Romania increased between 2015-2021, they are much lower than those recorded in other EU countries, such as: Italy, Germany, Poland and Bulgaria. The same growth trend is expected to continue in the coming period [24].

Land accumulation in order to obtain EU subsidies is one of the reasons for the land-grabbing phenomenon. On large areas of land, subsidies can be a significant income. Thus, if we take into account the 2019 subsidy, the single area payment scheme was of 102,6082 euro/ha [2]. For the area of 5.3 million ha owned by foreign investors, according to the Transnational Institute, results an income of 543.8 million euro.

It should be noted that, in the Top 10 companies that received subsidies from APIA in 2019, 5 companies with foreign capital were ranked [3].

Supporters of land grabbing consider that it is useful in developing the economy, attracting foreign investment, creating jobs and opening national economies to the world market.

Romania's agricultural potential is suffering due to excessive fragmentation of properties, which makes it impossible to practice intensive agriculture. However, the merging of land, which will allow the application of innovative technologies in agriculture, must be done rationally [6].

Regarding the creation of jobs in intensive agriculture, which will be practiced on the large areas formed, at least at the level of Romania, it can only be a myth. Intensive agriculture, by definition, uses a small number of workers.

Romania already has a very high percentage of the population employed in agriculture, and the loss of land will only lead to a reduction of the population employed in agriculture, with very little chance of employment in another sector, the only remaining alternative being emigration, which is already on a very large scale in Romania.

Romania is the country with the highest rate of emigration from the EU, the diaspora of Romania being the fifth highest in the world, according to a report issued by the OECD in 2019 [21]. According to the same report, 1 out of 4 Romanian emigrants plan to return home, and the land inherited from their parents is likely to become an objective for them to develop and invest their savings from abroad.

The Government of Romania granted support to the young people who returned to the country, in the form of non-refundable funds that were allocated through Submeasure 6.1, of the 2014-2020 PNDR, Support for the installation of young farmers [1], which was opened in 2021, especially for young people from the diaspora.

CONCLUSIONS

The phenomenon of land grabbing is presented as it follows: a small number of landowners control a large part of the agricultural area, disadvantaging small farmers and blocking the entry into the agricultural sector for those who want to exploit the land. The takeover of the land by the giant companies operating on thousands of hectares of land has the effect of making it impossible for other aspiring farmers to enter the sector, without holding an important capital.

In Romania, a significant part of the owners are foreigners, controlling about 40% of the Romanian agricultural land. The specificity of the Romanian population (almost half living in rural areas and with a very high share of occupation in the agricultural sector) makes it extremely vulnerable to the negative effects of land-grabbing.

Romania, like other formerly communist Eastern European states, was strongly affected by the rapid transition from communism to capitalism. Deprived of means of production and financing, excluded from granting subsidies, small farms do not have a real chance of catching up with large industrial farms, which exposes them in particular to the phenomenon of land-grabbing.

A possible solution to the scale of the land-grabbing phenomenon could be to restrict the maximum area that a single natural or legal person can have. Since the land is a public good belonging by right to the local communities, which are entitled to the preservation of their traditional way of life, that restriction would not constitute a breach of the principle of the free movement of capital. The agricultural model must be one based on peasant family farms, not a model of private companies employing agricultural workers.

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ASPECTS REGARDING THE PRODUCTION AND MARKETING OF CEREALS IN THE BLACK SEA BASIN AREA

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Abstract

Cereals are the most produced commodity worldwide, according to statistical data. Among the top ten countries in the list of the most important producers of corn and wheat respectively, as well as among the largest exporters of these categories of cereals, there are two countries located in the Black Sea basin, Ukraine and the Russian Federation. Other important competitors in the region were Romania and Turkey, who took 3rd or 4th place in corn or wheat production. At the same time, Romania occupied the 6th place in the ranking of corn exporters worldwide and 9th in that of wheat exporters in 2021. In addition to the four states mentioned before, in the paper, in the area related to the maritime basin, Armenia, Bulgaria, Georgia, Azerbaijan, Republic of Moldova and Greece were also included. The paper aimed to provide a coherent picture of competitiveness on the grain market, at the Black Sea basin level, and, at the same time, to highlight the position that Romania occupies in the economy of the area and in the world grain trade. For this purpose, the areas cultivated with corn and wheat were presented, as well as the productions obtained in the period 2015-2021 in the countries of the area related to the Black Sea basin, then the value imports and exports of corn and wheat that these countries recorded.

Key words: *Black Sea basin, maize, wheat, production, export, import, Romania*

INTRODUCTION

With the planet's population growing at an accelerated pace, the agricultural pioneers of the world's countries have sought and continue to seek solutions to ensure food security. In this context, cereals are needed to provide some of the food to the world's population. In addition to their nutritional properties, grains are preferred because they can be transported long distances and are less perishable [14]. Currently, the importance of cereals for human nutrition is enormous, as it accounts for about 45% of the world's energy source. Due to this, it was observed from the statistical data that half of the global arable area is cultivated with cereals [12]. Cereals occupied the first place in the most produced commodities worldwide between 2015 and 2021, with an average production for the mentioned period of 2,952,032,308.99 thousand tons [5]. Estimates predict an increase in average production per hectare for the most important cereals [13]. Cereals have found favourable growing conditions in the Black Sea Area. The variety of pedoclimatic conditions, as well as the technologies applied, made the difference in terms of the results obtained in the cereal sector in the mentioned area. It should be noted that both the area cultivated with cereals and the production differ in the countries of this region, which has led to a differentiated contribution to the economy of the area. Wheat and corn are the most cultivated of the cereal category. The Black Sea represents, according to specialists, a unique sea basin, characterized among others by biodiversity, abundant wildlife, varied and valuable natural resources [11]. From a geopolitical point of view, the Black Sea Basin includes the Black Sea area, the riparian states (Ukraine, Russia, Georgia, Turkey, Bulgaria and Romania), as well as states or regions from states in their vicinity such as: Armenia, Republic of Moldova, Azerbaijan (which are part of the

Extended Black Sea Area [4]) and Greece [11].

Fig. 1. Countries in the Black Sea Basin
Source: [6].

Currently, the Extended Black Sea area is of major importance both for the main actors in the region as well as for the international ones, as this area represents an important pole from several points of view, geoeconomic, geostrategic and geopolitical [4]. Thus, the cities and villages in the Black Sea region have an important role in the development of the economy of the riparian states, by carrying out activities in areas such as tourism, construction, water transport, extraction of marine resources, trade [16]. The Black Sea Region, due to its strategic location, is an important area not only for cereal production, but also for the supply of raw materials, especially for the less developed regions, as well as for the world grain trade [9]. The existence of several ports along the Black Sea coast, on the Danube River and on the important rivers in the region are facilities for international trade [2, 17]. It should be noted that this activity was flourishing since the time of the Geto - Dacians, who cultivated grain and traded by sea [10].

Today, the change of consumer preferences, rising incomes and technological progress have led to a reshaping of the global food trade, and especially of the wheat market. This aspect is evidenced by two representative trends as follows:

1) the Euronext futures market, which highlights the important elements related to the demand and supply in the EU and the Black Sea Region has become important in terms of the international price of wheat;

2) the growing demand for wheat coming from Asia and Africa is largely covered by the EU and the Black Sea Region [1].

According to specialty studies, over the past two decades, Ukraine and Russia have become world leaders in grain production [15].

The Black Sea Region is a key hub for wheat and maize exports. Wheat exporters from this area, together with the leader represented by Russia, dominated Egypt's wheat imports in the analysed period [7]. The paper presents the competitors from the Black Sea basin, but also Romania's position in the region and in the world grain trade. Romania's position is not determined only by the need to ensure the food security of the population. Tradition and experience testify Romania's vocation as a country with a predominantly cereal agriculture, which has always been in the group of exporters, and its place among producers with a share in the world's cereal production is also determined by the natural conditions favourable to this group of agricultural crops.

MATERIALS AND METHODS

In this article we compared the evolution of corn and wheat areas and productions, as well as the trade with cereals corresponding to the countries of the area related to the Black Sea basin (Romania, Bulgaria, Turkey, Georgia, Russia, Ukraine, Republic of Moldova, Armenia, Azerbaijan and Greece).

The period studied was 2015–2021, and the indicators analysed were: the areas cultivated with corn and wheat, the yields obtained for the 2 types of cereals and the value exports and imports of corn and wheat. The indicators were processed based on statistical data obtained from the Faostat website, Eurostat and the International Trade Centre (ITC) and were presented in tabular and graphical form.

Thus, the position of Romania on the cereals market was highlighted.

RESULTS AND DISCUSSIONS

According to data provided by Faostat, in the top 10 maize producers worldwide, ranking based on the average production achieved between 2015-2021, USA, China and Brazil ranked first. Ukraine ranked 5th, with an average of 31,450,317.14 tons of corn, and the Russian Federation ranked 10th, with 13,783,347.43 tons of corn.

The first three countries in the top 10 wheat producers where China, India and the Russian Federation. The latter obtained an average wheat production in 2015-2021 of 75,668,063.56 tons. Ukraine was the 7th largest producer of wheat in the world, thanks to the 26,994,097.14 tons, the average of wheat production for the 7 years in the study period [5].

Given these data, it will come as no surprise that these two states are ranked at the top of maize and wheat producers in the area adjacent to the Black Sea Basin.

Figure 2 shows the areas that were cultivated with maize in the Black Sea Basin area in the period 2015-2021.

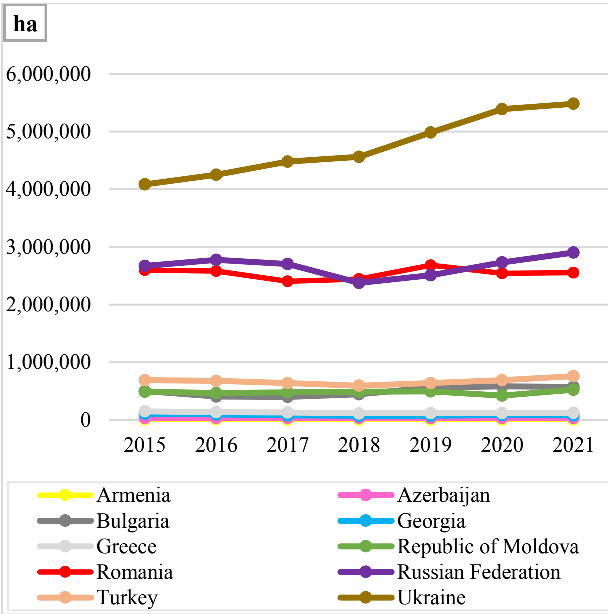

Fig. 2. Area cultivated with maize in the states of the Black Sea Basin, in the period 2015-2021
Source: own design after [5].

The presence of Ukraine on the first places stands out, with 5,481,800 ha in 2021, followed by the Russian Federation – 2,901,612 ha and Romania – 2,554,680 ha. It is worth noting that Ukraine has cultivated an area almost double compared to the next ranked, the Russian Federation. If for Romania we recorded a decrease in the area cultivated with maize by 1.69% in 2021 compared to 2015, for the first 2 ranked states there were increases by 34.24% for Ukraine (the highest growth percentage in the analysed area) and by 8.67% for the Russian Federation.

Other important growers in the area were Turkey – 758,032 ha, Bulgaria – 573,020 ha and the Republic of Moldova – 522,300 ha. The smallest areas were found in Greece, Georgia, Azerbaijan and Armenia. The largest decrease in corn areas was recorded by Armenia, by 65.94%.

Corresponding to the cultivated area, Ukraine was the largest maize producer in the Black Sea Basin area, achieving a production of 42,109,850 tons in 2021 (Figure 3) and an increase in production in the period 2015-2021 by 80.52%. The second and third places in the ranking were occupied by the Russian Federation – 15,239,865 tons and Romania – 14,820,690 tons.

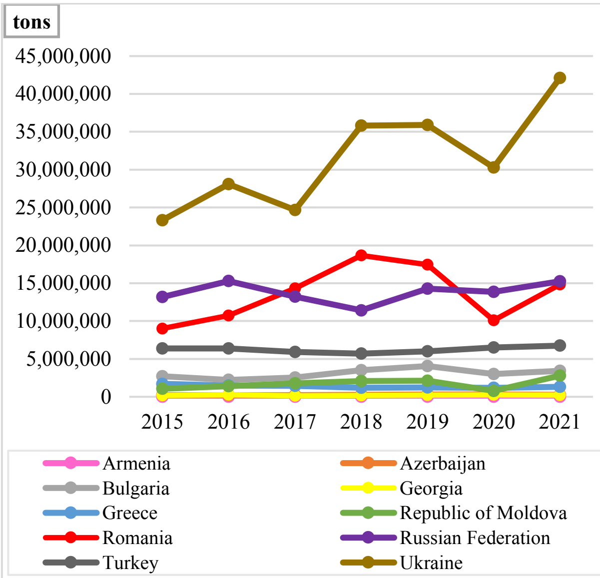

Fig. 3. Production of maize obtained in the states of the Black Sea Basin in the period 2015-2021
Source: own design after [5].

It should be specified that, as in the case of corn-grown areas, the outputs obtained by the two states fluctuated, so that there were years when Romania cultivated or produced more corn than the Russian Federation. It is worth noting that Ukraine has achieved a production almost triple compared to the next ranked, the Russian Federation.

Romania was in a leading position (2nd place) also in the top corn producers in the EU, where the first place was held by France [3].

Of the states under analysis, small maize yields were obtained by Azerbaijan, Georgia and Armenia.

Despite the problems caused by the Covid pandemic, the states in the Black Sea Basin area have recorded, except for Greece and Armenia, increases in maize production. Thus, the Republic of Moldova registered the highest percentage of growth, 159.36%, and Armenia the highest decrease, 72.38%. Romania had a 64.28% increase in maize production between 2015-2021.

The largest wheat grower in the analysed area was the Russian Federation, with 27,916,725 ha in 2021, about 4 times more than the next ranked, Ukraine – 7,099,400 ha (Figure 4).

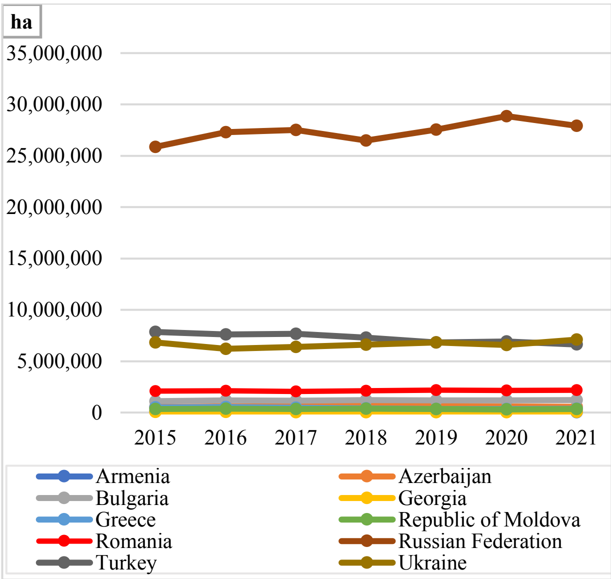

Fig. 4. Area cultivated with wheat in the states of the Black Sea Basin in the period 2015-2021
Source: own design after [5].

It was followed on the 3rd place by Turkey – 6,623,061 ha, and Romania was on the 4th place, cultivating 2,175,080 ha. Under 1,000,000 ha cultivated with wheat were found in Azerbaijan, Greece and the Republic of Moldova. In Georgia and Armenia wheat was encountered on the smallest areas of the Black Sea Basin - 50,300 ha, respectively 39,288 ha. The largest increase in wheat-grown areas for the period 2015-2021 was recorded in Bulgaria, with 9.07%, and the largest decrease was recorded in Armenia, 63.78%. Romania had an increase of 3.45%.

Figure 5 shows the evolution of wheat production in the period 2015-2021, in the 10 states of the Black Sea Basin area. The Russian Federation was the largest wheat producer, achieving a production of 76,057,258 tons in 2021 and an increase in production in the period 2015-2021 by 23.10%.

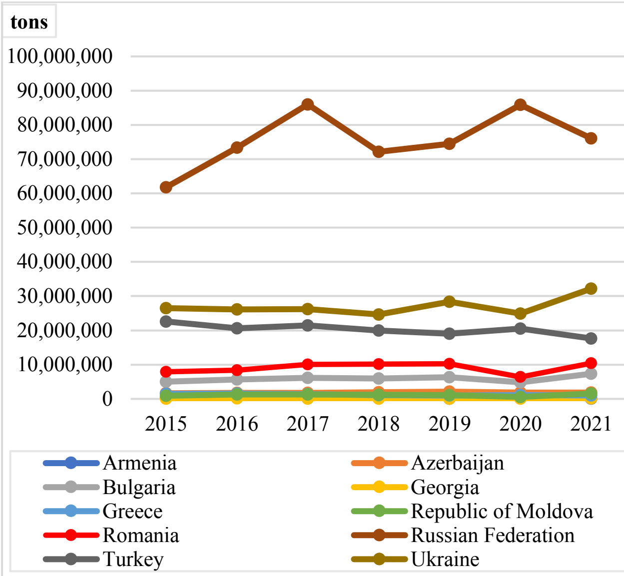

Fig. 5. Production of wheat obtained in the states of the Black Sea Basin, in the period 2015-2021
Source: own design after [5].

On the following places were Ukraine – 32,183,300 tons and Turkey – 17,650,000 tons. It is worth noting that the Russian Federation has achieved a production double compared to the next ranked. Romania was the 4th wheat producer, with 10,433,750 tons in 2021 and an increase compared to 2015 of 31.04%.

Also, Romania took the 4th place in the list of wheat producers in the EU, after France, Germany and Poland [3].

Bulgaria was also an important wheat producer in the analysed area, harvesting 7,343,990 tons in 2021, but instead small wheat productions were obtained in Georgia – 135,900 tons and Armenia – 97,000 tons.

With a few exceptions (Turkey, Greece and Armenia), the countries in the Black Sea Basin Region recorded increases in wheat production between 2015 and 2021. Thus, the Republic of Moldova registered the highest

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percentage of growth, 69.71%, and Armenia the highest decrease, 73.26%.

The value exports of corn worldwide, presented in Table 1, indicate that three of the 10 countries in the Black Sea basin area were in the top 10, at the level of 2021. It is Ukraine (3rd place - 5,854,587 thousand $), Romania (6th place - 1,936,164 thousand $) and the Russian Federation (10th place - 694,207 thousand $), the first place being held by the USA. The places occupied by the other analysed countries are shown in the table below and it can be seen that Azerbaijan, Georgia and especially Armenia were not major players in the corn trade. The states in the Black Sea basin area generally recorded increases in the value of maize exports in the period 2017-2021, with the exception of the Russian Federation and Greece. The largest increase in value was recorded for Turkey (270.70%), and the largest decrease was for the Russian Federation, 21.74%. Romania doubled the value of its exports during the analysed period (234.35%).

Table 1. The position occupied by the states in the Black Sea Basin in the ranking of global maize exporters -1,000 $

Place	Exporters	2017	2018	2019	2020	2021	2021/2017 %
1	United States of America	9,578,197	12,916,097	8,061,803	9,575,477	19,112,373	199.54
2	Argentina	3,885,188	4,233,392	5,948,632	6,046,745	9,064,172	233.30
3	*Ukraine*	2,989,133	3,506,065	5,218,275	4,883,689	5,854,587	195.86
4	Brazil	4,631,046	4,109,859	7,421,383	5,853,003	4,188,846	90.45
5	France	1,454,163	1,670,170	1,371,812	1,719,245	1,937,359	133.23
6	*Romania*	826,180	1,026,597	1,390,729	1,225,773	1,936,164	234.35
7	Hungary	908,309	771,325	860,304	1,015,880	1,045,652	115.12
8	India	157,552	254,688	143,858	389,280	935,608	593.84
9	South Africa	474,080	456,038	281,052	564,615	809,266	170.70
10	*Russian Federation*	887,036	854,371	616,676	395,244	694,207	78.26
15	*Bulgaria*	184,141	269,597	465,587	503,542	486,382	264.14
22	*Turkey*	53,038	43,878	173,324	121,037	143,575	270.70
23	*Republic of Moldova*	53,655	109,929	125,150	79,545	127,207	237.08
56	*Greece*	6,370	4,905	4,112	5,526	5,718	89.76
69	*Azerbaijan*	0	50	8	0	2,630	0.00
78	*Georgia*	608	610	967	622	967	159.05
143	*Armenia*	0	0	0	0	1	0.00

Source: Own calculation after [8].

Table 2. The position occupied by the states in the Black Sea Basin in the ranking of wheat exporters worldwide, 1,000 $

Place	Exporters	2017	2018	2019	2020	2021	2021/2017 %
1	*Russian Federation*	5,791,013	8,432,493	6,399,310	7,918,294	7,301,689	126.09
2	United States of America	6,093,290	5,456,303	6,278,593	6,322,649	7,286,648	119.58
3	Australia	4,674,071	3,082,017	2,514,432	2,712,736	7,247,149	155.05
4	Canada	5,091,888	5,711,364	5,385,361	6,301,250	6,639,162	130.39
5	*Ukraine*	2,759,757	3,004,359	3,658,402	3,595,472	4,722,745	171.13
6	France	2,993,366	4,124,151	4,355,355	4,540,749	4,550,825	152.03
7	Argentina	2,362,463	2,418,449	2,295,535	2,029,494	2,973,036	125.84
8	Germany	1,595,492	1,163,946	1,254,530	2,103,668	1,982,255	124.24
9	*Romania*	1,129,408	1,223,154	1,272,159	948,815	1,820,092	161.15
10	India	55,233	46,642	54,009	243,067	1,723,431	3,120.29
12	*Bulgaria*	777,257	865,695	947,262	700,292	1,372,280	176.55
24	*Greece*	53,593	87,176	76,505	89,206	209,095	390.15
25	*Republic of Moldova*	105,238	93,831	97,645	27,494	207,713	197.37
33	*Turkey*	14,828	23,906	48,212	39,492	97,828	659.75
58	*Armenia*	18	5	11	30	592	3,288.89
62	Georgia	2,260	2,154	877	13	393	17.39
119	*Azerbaijan*	0	0	315	0	0	0.00

Source: Own calculation after [8].

Global wheat exports by value, shown in Table 2, are dominated in 2021 by the Russian Federation (7,301,689 thousand $), the third world wheat producer and the first in the Black Sea basin area. Ukraine (5th place - 4,722,745 thousand $) and Romania (9th place - 1,820,092 thousand $) are also present in the top 10. Bulgaria was in 12th place, with 1,372,280 thousand $, a better position than the one held in terms of value exports of corn. It can be seen that Armenia, Georgia and Azerbaijan are not major players in the wheat trade.

All states in the area related to the Black Sea basin recorded increases in the value of wheat exports in the period 2017-2021. With the exception of Armenia, for Greece the highest increase was recorded (390.15%). In the same period, Romania recorded an increase in value exports by 161.15%.

Table 3 shows the value of corn imports of the 10 states in the area related to the Black Sea basin. They are not in the top corn importers, and in Table 3 the positioning was done according to the values related to 2021. It can be seen that Turkey was in the first place, with 680,343 thousand $, and the lowest values for corn imports have been registered by Azerbaijan, 11,852 thousand $.

Increases in the value of maize imports were recorded by Turkey, Romania, Greece, Georgia, the Republic of Moldova and Armenia, and decreases were recorded by the Russian Federation, Ukraine, Bulgaria and Azerbaijan. The largest increase in value was recorded for Romania (252.68%), and the largest decrease was for the Russian Federation, 39.15%.

Table 3. Imports of maize from states in the Black Sea Basin area, 1,000 $

Importers	2017	2018	2019	2020	2021	2021/2017 %
Turkey	425,673	438,015	847,519	485,439	680,343	159.83
Romania	142,967	145,576	192,254	363,961	361,254	252.68
Greece	152,907	170,061	161,798	155,620	200,829	131.34
Russian Federation	182,271	156,413	108,203	132,704	110,914	60.85
Ukraine	132,015	142,703	133,042	105,443	89,451	67.76
Bulgaria	101,187	42,731	50,104	56,590	74,539	73.66
Georgia	15,998	21,466	18,391	24,079	21,397	133.75
Republic of Moldova	10,119	14,618	15,866	25,023	18,639	184.20
Armenia	7,877	11,745	12,091	13,241	14,046	178.32
Azerbaijan	19,242	12,143	18,435	14,158	11,852	61.59

Source: Own calculation after [8].

Table 4. Imports of wheat for the states in the Black Sea Basin area, 1,000 $

Importers	2017	2018	2019	2020	2021	2021/2017 %
Turkey	1,043,327	1,289,234	2,303,139	2,334,510	2,692,623	258.08
Azerbaijan	227,168	205,968	340,537	296,905	331,946	146.12
Greece	243,100	251,020	237,894	210,959	311,942	128.32
Romania	229,155	136,169	177,125	254,430	257,186	112.23
Georgia	110,639	149,854	105,082	111,864	93,442	84.46
Armenia	60,544	62,858	50,851	72,416	62,383	103.04
Russian Federation	39,709	60,466	46,768	64,839	49,158	123.80
Bulgaria	15,319	14,583	14,469	9,425	18,859	123.11
Ukraine	3,032	2,806	1,947	3,645	5,388	177.70
Republic of Moldova	748	888	570	1,041	1,080	144.39

Source: Own calculation after [8].

Table 4 shows the value of wheat imports from the Black Sea Basin region for the 10 analysed states. With the exception of Turkey (4th position in the top world wheat importers - by value), they did not rank among the main wheat importing countries, and the ranking in Table 4 is based on the relevant values in 2021. It can be seen that Turkey occupied the first place with 2,692,623 thousand $, and the

lowest value was for the imports of the Republic of Moldova, 1,080 thousand $.
Wheat imports increased in all of the above states except Georgia. Turkey had the highest increase (258.08%) and Georgia had a decrease of 15.54%.
Compared to 2015, Romania's wheat import values increased by 112.23%.

CONCLUSIONS

The existing pedoclimatic conditions in the area related to the Black Sea basin have favoured the cultivation of cereals in these lands, since ancient times,
Currently, some of the world's leading corn and wheat growers, producers and exporters, Ukraine, the Russian Federation and Romania, come from this area.
Following the analysis of the data presented in the paper, the following conclusions were drawn:
-The most important corn growers in 2021 were Ukraine (5,4481,800 ha), the Russian Federation (2,901,612 ha) and Romania (2,554,680 ha); the productions obtained were as follows: Ukraine - 42,109,850 tons, Russian Federation - 186,529. tons and Romania – 14,820,690 tons;
-The first three wheat growers in the analysed area, in 2021, were the Russian Federation (27,916,725 ha), Ukraine (7,099,400 ha) and Turkey (6,623,061 ha); the following productions were obtained: Russian Federation - 76,057,258 tons, Ukraine - 32,183,300 tons and Turkey - 17,650,000 tons;
-There were three countries from the Black Sea region in the world ranking according to the values of corn exports: Ukraine (3rd place - 5,854,587 thousand $), Romania (6th place - 1,936,164 thousand $) and the Russian Federation (10th place - 694,207 thousand $) in 2021;
-Worldwide wheat exports in value were dominated in 2021 by the Russian Federation (7,301,689 thousand $), Ukraine (5th place - 4,722,745 thousand $) and Romania (9th place - 1,820,092 thousand $);
-The states in the area related to the Black Sea basin did not represent important importers on the grain market, but among them Turkey was the main importer of corn at the regional level, with an import value of 680,343 thousand $ and at the same time it occupied the 4th place in the list of importers of wheat worldwide with 2,692,623 thousand $ in 2021;
-For Romania, in the period 2015-2021, an increase was noted, both in the value of corn and wheat exports, and in imports.

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EUROPEAN FUNDING WITHIN SUB-MEASURE 6.1. CASE STUDY APPLIED IN HUNEDOARA COUNTY, ROMANIA

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Abstract

In the 15th edition of the NRDP, more than 12 billion Euro were allocated for the development of the rural environment in Romania, of which 3.68% went to Sub-measure 6.1 "Support for setting-up young farmers". The document shows the amount allocated to this section, the number of funding applications submitted and selected, funding contracts/decisions completed and terminated, and disbursements through January 26, 2023. At country level, the uptake of funds related to Sub-measure 6.1 was very good, with 434 million Euro disbursed out of an allocation of 467 million Euro, resulting an absorption rate of 92.98%. The purpose of the paper is to identify the projects that were implemented in Hunedoara county, through NRDP 2014-2020 and Transition 2021-2022, Sub-measure 6.1. Hunedoara is located in the West Region and has a predominant mountainous area, suitable for the development of animal husbandry, but at the same time it is ranked second, following Bucharest, in terms of urbanization degree.

Key words*: *Sub-measure 6.1, European funds, young farmers, Hunedoara county

INTRODUCTION

NRDP (National Rural Development Program) 2014-2020 was approved by the European Commission on 15 May 2015 and was later amended several times, so that the last version, the 15th, was signed on 16 September 2021. NRDP included a development plan of rural areas in Romania, for which 9,363 billion Euro were made available, of which 8,015 billion Euro from EAFRD (European agricultural fund for rural development) and 1,347 billion Euro from national contributions. Initially, 14 Measures were financed, and the period in which it was carried out was 7 years [10].

Two more years have been added to the mentioned period, which correspond to the transition period to the New CAP 2021-2022. The NRDP budget for the transition period 2021-2022 was 3.26 billion Euro, of which 2,569.10 million Euro - EAFRD 2021-2027 multiannual financial framework funds and 692.09 million Euro - EURI funds (European Union Recovery Instrument). From this fund, Sub-measure (Sm) 6.1 received 100 million Euro [16].

Table 1 shows the implementation of NRDP 2014-2020 on January 26, 2023. The total allocated according to the 15th edition of the NRDP 2014-2020 is 12,699 million Euro, of which 3.68% were allocated to Sm 6.1 "*Support for setting-up young farmers*" 2014-2020 - for the national level; 0.08% for *Sm 6.1 - ITI (Integrated Territorial investments) Danube Delta* - only for projects implemented on the Danube Delta ITI territory and 0.79% for *Sm 6.1 – Next Generation EU (EURI)* - opened in the Transition period 2021-2022 and supported by EURI funds. The payments made on the date of presentation of the report represented 5.09%, 0.10%, respectively 0.80% of the total - in order for the three Sub-measures mentioned above. It should be emphasized that out of a total of 50,927 completed financing contracts / decisions, approximately 20% were for Sm 6.1 related to the 2014-2020 period.

Table 1. Stage of implementation of Sub-measures 6.1 (NRDP 2014-2020 and Transition 2021-2022) on 26.01.2023, Euro

Sub-measure	NRDP public allocation Version 15.0 2014-2020	Funding applications submitted		Selected funding applications		Contracts / Funding decisions: Contracts / Ongoing and completed funding decisions		Contracts / Funding decisions: *Contracts / Funding decisions completed*		Contracts / Funding decisions: Contracts / Funding decisions terminated		Payments made
		No.	Value	No.	Value	No.	Value	No.	*Value*	No.	Value	
TOTAL	12,699 million	111,529	12,436 million	74,611	7,039 million	70,751	6,378 million	50,927	2,998 million	1,062	188 million	8,533 million
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
6.1	467 million	15,143	623 million	10,878	446 million	10,734	440 million	10,017	411 million	68	2.7 million	434 million
	3.68% share	13.58% share	5.01% share	14.58% share	6.34% share	15.17% share	6.91% share	19.67% share	13.72% share	6.40% share	1.48% share	5.09% share
6.1 - ITI Danube Delta	10 million	233	9.5 million	204	8.3 million	201	8.2 million	197	8 million	0	0	8 million
	0.08% share	0.21% share	0.08% share	0.27% share	0.12% share	0.28% share	0.13% share	0.39% share	0.27% share	0.00% share	0.00% share	0.10% share
6.1 – Next Generation EU (EURI)	100 million	4,277	199 million	2,130	100 million	2,057	96 million	0	0	2	140,000	69 million
	0.79% share	3.83% share	1.60% share	2.85% share	1.42% share	2.91% share	1.51% share	0.00% share	0.00% share	0.19% share	0.07% share	0.80% share

Source: own calculation and approximation, after [15].

Other Sub-measures that had a high percentage of completed financing contracts / decisions were: Sm 6.3 "*Support for the development of small farms*" - 25.25% (12,859 contracts / decisions) and Sm 17.1 "*Crop, animal and plant insurance premium*" – 29.24% (14,890 contracts / decisions) [15].
At the national level, the amount of payments made for Sm 6.1 2014-2020 represented 92.98% of the total allocated. For the exchange of generations in agriculture, for new ideas and approaches that lead to the revitalization of the Romanian rural space and its economic development, NRDP has made available funds addressed to young people (people over 18, but who have not turned 41 at the time of submitting the application) for the development of agricultural and non-agricultural businesses. According to AFIR (Agency for Financing Rural Investments) [2], at national level 19,230 young farmers accessed funds for agriculture, both in the mountain area (20%) and in the rest of the territory (80%) – Figure 1.

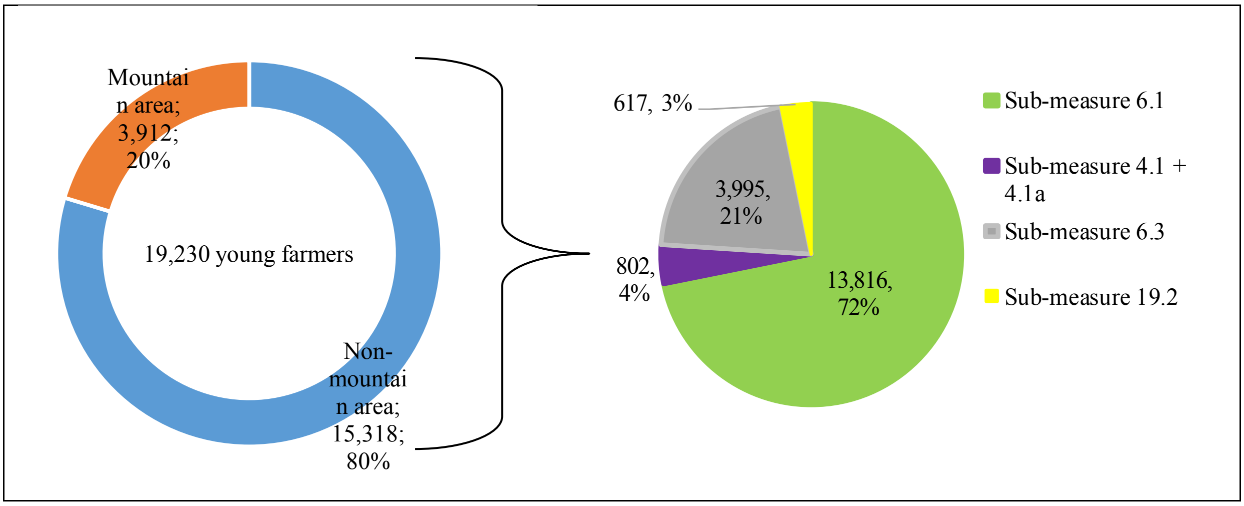

Fig. 1. The number of young people financially supported by NRDP 2020 and Transition 2021-2022
Source: own representation according to [2].

From Figure 1 we can observe that the most frequently accessed Sub-measures are: 4.1 "*Investments in agricultural holdings*" and 4.1a "*Investments in fruit-growing holdings*", 6.1, 6.3 "*Support for the development of small farms*" and 19.2 "*Support for implementation of operations under the Community-led local development strategy*". Most young people chose the Sm 6.1 (13,816 people), followed by the Sm 6.3 (3,995 people).

The contribution of Sm 6.1 is to encourage young people to work in the agricultural sector (vegetable or livestock sector), work as managers/administrators and settle in the countryside [13].

At the same time to support young farmers who access Sm 6.1, financed through Pillar I of the CAP, accessible to all eligible farmers, also worked. They benefited from this support after setting up on the farm and it consisted in granting an annual payment per hectare [5].

Young people from rural areas represent a vulnerable group and this support measure is necessary to attract them to the agricultural sector. Thus, it can serve as a prerequisite to grow the level of farmers' education by the professional training courses they benefit from, but also as a tool to preserve the population in the rural area and stop the exodus from village to city, which represent a threat to EU agriculture [6, 14].

Sm 6.1 was one of the most accessed in the NRDP. According to Cuc et.al., the funds were exhausted in the first 5 days after the opening of the sessions and this type of funding will continue in the new National Strategic Plan 2023-2027 [9]. In the context of young people's interest in the funds available for rural businesses development, this paper aims to identify how many projects were implemented in Hunedoara County through Sm 6.1 of the NRDP 2014-2020 and Transition Period 2021-2022.

MATERIALS AND METHODS

In this study, a bibliographic approach was used to analyse the uptake of funds allocated to Sm 6.1 at the Hunedoara county level. Available data from MADR (Ministry of Agriculture and Rural Development), NRDP, AFIR and websites was used, from which information was extracted regarding publicly allocated funds, the number and amount of submitted and selected funding applications; the number and value of funded and terminated contracts and the amount of payments made. Also, documents related to the mountain area and the national territory were studied, such as: final and monthly selection reports, errata for these reports, ancillary reports assessing eligible projects challenged in Court and declared eligible following Court decisions, appeal reports out of which only declared projects are drawn for funding.

In the case of the documents referring to the Danube Delta ITI, only general data were extracted, without analysing the projects broken down by year, since there is a distinct allocation for this area.

An important element in this analysis is the interpretation of the data represented in tabular and graphical form.

RESULTS AND DISCUSSIONS

Located in the central-western part of Romania, Hunedoara County is part of the West Region (Map 1).

Map 1. Hunedoara county map and location
Source: [4, 11].

The relief is predominantly mountainous (68% of the county's area), and the agricultural area of approximately 280,350 ha is distributed as follows: pastures, hayfields, arable land, vineyards and vine nurseries, orchards and fruit nurseries.

Animal husbandry is also a local occupation, cattle, pigs, sheep and goats are found here [8].

Table 2. The administrative division of the territory of Hunedoara County

Specification	Number
Municipalities and cities	14
- municipalities	7
- communes	55
- villages	457
of which: villages belonging to municipalities or cities	42

Source: [4].

It is considered that, after the capital Bucharest, Hunedoara county has the highest degree of urbanization in the country (75%), where municipalities, cities, communes and villages meet (Table 2). At the last agricultural census, 59,571 agricultural holdings were registered in Hunedoara county, of which 58,853 were without legal personality and 718 with legal personality. The 718 holdings with legal personality were structured as follows: an autonomous management, 5 agricultural associations, 273 companies with majority private capital, 3 companies with majority state capital, 70 public administration units, 3 cooperative units and 363 other types [12]. In Hunedoara County there are 69 Territorial Administrative Units. Of these, 45 are in the Mountain Zone and three are classified as Areas with significant constraints, as shown in Table 3.

Table 3. Hunedoara county Territorial Administrative Units list

No	Territorial Administrative Units	Areas with constraints	No	Territorial Administrative Units	Areas with constraints
1	Băcia	Areas with significant constraints	36	Brad Municipality	Mountain zone
2	Baia De Criș	Mountain zone	37	Deva Municipality	
3	Băița	Mountain zone	38	Hunedoara Municipality	
4	Balșa	Mountain zone	39	Orăştie Municipality	
5	Bănița	Mountain zone	40	Petroşani Municipality	Mountain zone
6	Baru	Mountain zone	41	Aninoasa city	Mountain zone
7	Bătrâna	Mountain zone	42	Călan city	
8	Beriu	Mountain zone	43	Geoagiu city	Mountain zone
9	Blăjeni	Mountain zone	44	Haţeg city	
10	Boşorod	Mountain zone	45	Petrila city	Mountain zone
11	Brănişca		46	Simeria city	
12	Bretea Română		47	Uricani city	Mountain zone
13	Buceş	Mountain zone	48	Orăştioara De Sus	Mountain zone
14	Bucureşci	Mountain zone	49	Pestişu Mic	
15	Bulzeştii De Sus	Mountain zone	50	Pui	Mountain zone
16	Bunila	Mountain zone	51	Răchitova	Mountain zone
17	Burjuc		52	Rapoltu Mare	Mountain zone
18	Cârjiți	Mountain zone	53	Râu De Mori	Mountain zone
19	Cerbăl	Mountain zone	54	Ribița	Mountain zone
20	Certeju De Sus	Mountain zone	55	Romos	
21	Crişcior	Mountain zone	56	Sălaşu De Sus	Mountain zone
22	Densuș	Mountain zone	57	Sântămăria-Orlea	Mountain zone
23	Dobra		58	Sarmizegetusa	Mountain zone
24	General Berthelot		59	Șoimuș	
25	Ghelari	Mountain zone	60	Teliucu Inferior	
26	Gurasada		61	Tomești	Mountain zone
27	Hărău		62	Toplița	Mountain zone
28	Ilia		63	Totești	Areas with significant constraints
29	Lăpugiu De Jos		64	Turdaș	
30	Lelese	Mountain zone	65	Vălișoara	Mountain zone
31	Lunca Cernii De Jos	Mountain zone	66	Vața De Jos	Mountain zone
32	Luncoiu De Jos	Mountain zone	67	Vețel	Mountain zone
33	Mărtinești	Areas with significant constraints	68	Vorța	Mountain zone
34	Lupeni Municipality	Mountain zone	69	Zam	
35	Vulcan Municipality	Mountain zone	-	-	

Source: [3].

Thus, 65.21% of the county's Territorial Administrative Units are in the mountain area, a very important element for accessing European funds through Sm 6.1, due to the distinct allocation for this field in sessions for 2015, 2016 and 2017. The distinct allocation was very important due to the selection criteria, in particular to the PS4 criterion "The principle of the agricultural potential of the area", because most of the areas in Hunedoara county are classified at medium or low potential. Due to this, the projects in the mountain area had difficulty competing with projects from areas with high potential. However, for the animal husbandry sector point of view, the mountain/hill area is favourable for animal husbandry, so that areas with medium or high potential are rich, especially in milk cattle.

The West Region, of which Hunedoara County belongs, had a degree of absorption of European funds through Sm 6.1 out of 15% of the total in the country. In the counties ranking, Hunedoara was 10th with the number of projects above the country's average of about 192 projects [7] – Table 4.

Table 4. Detailing the selected projects for funding in Hunedoara County

Year / Area	2015	2016	2017	2018	2020	2021	Total
Non-Mountain	18	15	6			16	55
Mountain	38	128	116			3	285
Mixed				3	3		6

Source: own calculation after [15].

The number of projects selected for funding through mountain area allocations far exceeds the number of projects selected through non-mountain allocations - Table 4. Nationally, Hunedoara County ranks 2nd for the total number of projects selected in the mountain area, immediately after Bistrița - Năsăud county and before the counties Bihor- 3th place, Caraș - Severin 4th and Cluj 5th [7]. During the sessions for the submission of projects for the years 2015 and 2016, the applicants from the mountain area of Hunedoara county enjoyed a longer period of project deposits, with several stages of selection and lower quality thresholds than in non-mountain area. In 2017, the number of stages of financial appropriation for mountainous areas and non-mountainous areas was the same, financial appropriation for mountainous areas being slightly faster.

In the application process of 2018 and 2020, the number of selected projects has dropped significantly, whether compared with previous years or with projects funded by other counties in the same period.

Among the main reasons for lowering the number of selected projects for financing are:

- Mixed allocation of funds, without distinct allocation for the mountain area,
- The high quality threshold from which the projects started to submit,
- the amount of money allocated to these sessions, significantly lower than the amount allocated in the previous sessions.

In 2021 the projects for the Non-mountain area predominated.

From the analysis of 214 financing files selected in the period 2015-2018 [1], submitted for the applicants from Hunedoara County, we have extracted the following information about applicants' educational level and the main purchases made by projects:

- The most common investment was the purchase of a tractor along with a minimum of a machine,
- Another purchase represented a lower capacity machine, either for the tractors they already had, either small motorized motor machines such as sewing, digging etc.
- Of the total of 214 analysed files, 3 applicants had higher education in the agricultural field and 2 high school studies in the agricultural field,
- The other applicants either had a recently obtained qualification diploma, waiting for the financing request or they were going to take a specialized course until the second instalment of money.

CONCLUSIONS

Benefiting from a public allocation of 467 million Euro, Sm 6.1 attracted 10,017 farmers to start an agricultural business and absorbed 92.98% of the allocated amount.

Sm 6.1 was very successful among young people, being the most accessed. Moreover, the funds were exhausted within 5 days of the opening of the project reception sessions, and the percentage of completed Contracts / Financing Decisions approached 20% of the total. Other Sub-measures for which young people applied were: 4.1, 4.1a, 6.3 and 19.2.

Concerning the number of projects financed through the Sm 6.1, which exceeded the national average, Hunedoara County ranked 10th. Because it is a county with a predominantly mountainous relief, the largest weight went to the projects submitted for the mountainous area with a distinct allocation. Nationally, the number of selected projects in the mountainous area of Hunedoara County ranks second at the country level. Compared with previous years, and compared with other regions, the number of selected projects has decreased, mainly in the following aspects: mountainous areas are no longer allocated funds separately; the quality threshold for project submissions is very high; less funds are allocated to project receptions. Since Sm 6.1, which supports rural development, is popular within young farmers, there is a need to continue funding such projects.

At the same time, new forms of maintenance and development of holdings established in previous programs must appear, as well as other forms of support (subsidies).

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TENDENCIES AND CHANGES IN THE REGIONAL STRUCTURE OF WINE GRAPES AND WINE PRODUCTION IN BULGARIA

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Abstract

The article presented the results of a study carried out of the tendencies and changes in the regional aspect of the production of grapes and wine in Bulgaria in the years after the accession to the EU. The dynamics in absolute and relative values of the indicators gross output of grapes, area of harvested vineyards with wine grape varieties, average yields, production of wine grapes and wine by statistical regions was examined. The characteristic of the changes that occurred in the regional plan during the period 2007-2020 was based on the values of the coefficient of structural changes. The levels of the indicator were higher during the first period of application of the CAP in the country (2007-2013), which was mainly due to the contraction of production in the northern regions. In the second period (2014-2020), the impact of financial mechanisms slowed down the negative trends, but they have not been overcoming. Grape and wine production is mainly concentrated in the Southeast and South Central regions. During the next program period, it is necessary to expand and target the set of measures and mechanisms applicable within the Common Agricultural Policy to achieve synergy between economic, social and environmental results in a regional plan.

Key words*: *grape, wine, production, regions, gross output

INTRODUCTION

Traditions of grape and wine production in Bulgaria have existed for centuries. However, the dynamics of the viticulture sector outlines both years of growth and years of severe crises, depending on the trends in the economic development of our country [1, 6, 12]. EU membership defines a new role for viticulture and wine sector in the context of the objectives of the Common Agricultural Policy for viable food production, sustainable management of natural resources and climate action and balanced territorial development. The imbalances in the regional economic development of our country are a widely discussed problem that requires urgent solutions. Viticulture, as a labor-intensive production activity, has the potential to create employment [2, 3, 10]. The number of permanently employed persons in the sector as of 2016 was 23,223, and of seasonal workers, who were employed mainly during the grape harvest – 450,232 [11]. The number of persons employed in wine-producing enterprises in the same year was 3 398 [11]. In some regions and small municipalities, viticulture and winemaking are among the main sectors driving the regional economy, creating prerequisites for the development of related industries, such as trade and tourism [17]. The combination of traditional, local wines and specialties provides additional benefits and experiences for tourists [18]. Besides being an opportunity for family business, the development of wine grape and wine production ensures positive effects in social and economic terms, contributing to the preservation of traditions, the diversity of genetic resources and the specificity of the viticultural landscape for future generations [5, 7].

The aim of the study was to outline the tendencies and changes in the regional structure of the production of wine grapes and wine in Bulgaria during the period after joining the EU.

MATERIALS AND METHODS

The object of the analytical activity was the state and development of the production of wine grapes and wine by statistical regions, NUTS 2 level of the European Classification of Territorial Units – Northwest, North Central, Northeast, Southeast, South Central and Southwest. The changes in the absolute and relative values of the indicators gross output of grapes (million BGN), area of harvested vineyards with wine grape varieties (ha), production of wine grapes (tons), production of wine (hectoliters) were analyzed.

The study period was 2007-2020, after the accession of Bulgaria to the EU. Sources of primary data were Eurostat, the Ministry of Agriculture, Food and Forestry (MAFF), the Agrostatistics department and the National Statistical Institute (NSI).

The deviations of the values of the investigated indicators (areas, quantity of production, average yields, gross output) by statistical regions and by years around their average values for 2007-2020 period were established by means of the coefficient of variation, using the following formula [4, 16]:

$$CV(\%) = \frac{SD}{\bar{Y}} * 100 = \frac{\sqrt{\frac{\sum_{i=1}^{n}(Y-\bar{Y})^2}{n}}}{\bar{Y}} * 100 \quad .....(1)$$

where:
SD – standard deviation,
$\bar{Y}$- average value of the concrete indicator for the studied period.

In order to evaluate the structural changes in the areas of the harvested vineyards with wine grape varieties and in the production of wine grapes and wine by statistical regions during the period after our country's accession to the EU, a summarizing measure - integral coefficient of structural changes was used. It was calculated according to the formula [9, 19, 20]:

$$K_S = \sqrt{\frac{\sum(v_1 - v_0)^2}{\sum v_0^2 + \sum v_1^2}}, \quad ....(2)$$

where:
v_0 – relative shares of the structural elements during the base period;
v_1 – relative shares of the structural elements during the current period.

In order to track the dynamics of structural changes year by year, the coefficient was calculated on a chain base method. The value of the indicator varies between 0 and 1. The scale of interpretation is shown in Table 1 [9, 21]:

Table 1. A scale for interpreting the coefficient of structural changes

Coefficient value	An economic interpretation
0.00	No structural changes have occurred
From 0.01 to 0.05	Very weak structural changes
From 0.06 to 0.10	Weak structural changes
From 0.11 to 0.20	Moderate structural changes
From 0.21 to 0.40	Significant structural changes
From 0.41 to 0.60	Strong structural changes
From 0.61 to 0.99	Very strong, intensive structural changes
1.00	Total, diametrically opposite changes

Source: Gospodinova (2021), Todorov (2010) [9, 21]

Statistical data processing was performed using MS Excel. The methods of comparative analysis, structural analysis and descriptive statistics were applied [4, 16, 19, 22].

RESULTS AND DISCUSSIONS

The gross output of grapes, created at the national level, decreased from 158.24 million BGN on average for the period 2007-2013 to 115 million BGN on average for 2014-2019 (-27.3%). This was a result of the contraction of production activity in all statistical regions. The dynamics of the relative shares of the gross output, created by statistical regions, in the total amount of the indicator for the country, manifested during the years of EU membership, were demonstrated in Figure 1.

The declining percentage participation of the northern regions in the value of the national production of grapes was clearly highlighted. The reduction of the relative shares of the Northwest and North Central regions was very serious. During the first four years of the studied period, the gross output from the Northwest region had a weight between 12.0% and 19.5% in the total value of the indicator. Critically low levels were recorded in 2011 and 2012, after which the region's percentage participation in national gross output of grapes increased, but remained below the levels established at the beginning of the period, varied between 6.2% and 7.2%. An exception was observed only in 2019 (4.9%), when the gross output decreased sharply as a result of both the smaller quantity of grapes produced and the strong decrease in the purchase prices of wine grapes. The official data of the National Statistical Institute showed that the average price per producer decreased to 0.55 BGN/kg, which have been the lowest level recorded since 2015.

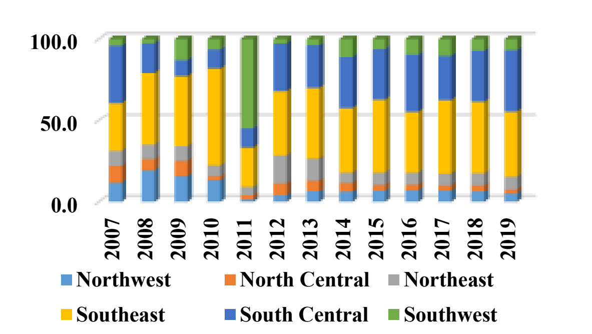

Fig. 1. Relative shares of the gross production of grapes by statistical regions in the total value of the indicator for the country, %
Source: Own calculation on the basis of data from Eurostat and NSI [8, 15].

The situation was similar in the North Central region, with its share in the total value of gross output decreased from 10.1% in 2007 and 9.2% in 2009 to between 3.4% and 4.2% during the period 2015-2018. The reduction in the Northeast region was not so drastic. At the beginning of the period, the relative share of the gross output, created in the region, was between 9.0% and 9.3% of the total value of the indicator, with its level decreased to 7.2-7.9% during the 2015-2019 period.
The dynamics of development of the indicator values in the southern regions of the country was slightly different. The contraction of gross output in the Southeast region was taking place at a slower pace than in the northern parts of the country. The share of the value of grapes production of the region in the total value of the gross output varied between 39.6% and 45% during the period 2014-2019. A similar situation was in the South Central region, whose percentage participation in the gross output during the second program period of CAP application even increased to 31.1-37.4%. This was the result not so much of the rising in the value of the indicator, realized at the regional level, as of the drastic reduction of the share of the northern regions.
The strong annual variation of the gross output of grapes in the Southwest region, dued to both fluctuations in production volume and price changes, affected on the volatility of the weights of the region in the total value of the indicator by year.
The values of the coefficient of variation showed significant deviations of the annual amounts of the gross output of grapes from all statistical regions compared to the average during the period 2007-2019 (Table 2).
The smallest, but still significant, were the deviations found in the Southeast region with a coefficient of variation of 31.80%. In all other regions, the impact of production and market risk on the dynamics of production value was much more tangible, especially in the Northwest (88.0%) and North Central regions (80.16%).

Table 2. Analysis of the variation of the gross output of grapes by statistical regions during 2007-2019

Statistical regions	Indicators						
	n	R	Min	Max	Mean	SD	CV (%)
Northwest	13	36.35	1.42	37.77	12.90	11.36	88.00
North Central	13	22.09	2.31	24.40	8.14	6.53	80.16
Northeast	13	18.35	4.78	23.13	12.36	6.26	50.60
Souteast	13	55.66	29.78	85.44	55.65	17.69	31.80
South Central	13	73.34	11.30	84.64	35.04	18.40	52.54
Southwest	13	66.60	3.67	70.27	14.17	17.64	124.46

Source: Own calculation on the basis of data from Eurostat and NSI [8, 15].

The values of the integral coefficient of structural changes, characterizing the amendments of the shares of the gross output of grapes by statistical regions, showed a high degree of intensity of the changes during the first period of CAP application in our country - 2007-2013 (Figure 2). Moderate to significant structural changes were observed in the first three years. The index reached levels between 0.70 and 0.72 in 2011 and 2012 respectively, which indicated the presence of very strong, intensive structural changes. The outline trend was due to the substantial variation, both in the quantity of grapes production by region, and to fluctuations in producer prices. After 2013, structural changes were not so dynamic. Integral coefficient values ranged from 0.07 to 0.16, indicating weak to moderate structural changes. They were the result mainly from the greater degree of variation in the relative shares of Southeast, Northwest and Southwest regions in the total gross output of grapes.

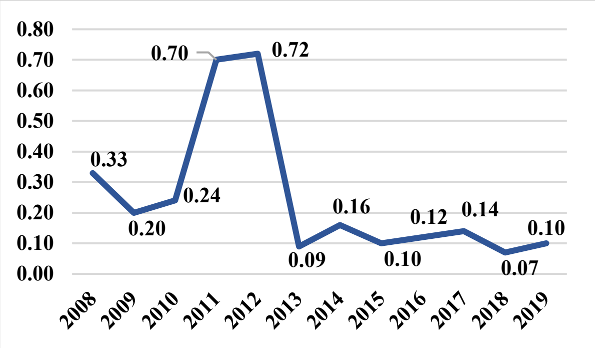

Fig. 2. Dynamics of the integral coefficient of structural changes in the gross output of grapes by statistical regions during the period 2008-2019.
Source: Own calculation on the basis of data from Eurostat and NSI [8, 15].

The total area of vineyards with wine grape varieties in the country was 56,669 ha on average for the period 2007-2013, and decreased to 31,039 ha average during the next program period of application of the CAP 2014-2020. The negative trend regarding the development of the area of vineyards for the production of wine grapes was registered in all statistical regions. The reduction for the two compared periods was the most significant in the North Central region - by 63.3%, followed by the Northeast and South Central regions, respectively by 49.2% and 48.8%. The decrease in the area of harvested vineyards with wine grape varieties was the weakest in the Southwest region - by 11.6%. This region traditionally occupies the smallest relative share of the area under vines in the country, in result of the strong reduction in the other regions, its share increased from 5.4% on average for 2007-2013 to 8.7% on average for 2014- 2020.

The area with vineyards for wine grapes production in the Northwest region decreased at a slightly slower pace than the average for the country. The established reduction in relation to the average values for the two compared periods was by 44.7%.

Figure 3 presents the relative shares of the area of harvested vineyards with wine grape varieties by statistical regions in the total area of harvested vineyards in the country during the period 2007-2020. The concentration of production potential of the wine sector in two main regions - Southeast and South Central, which both occupied 19,026 ha or 71.6% of the total area in 2020, was clearly visible. In terms of dynamics, the two regions almost maintain their positions in all the years covered by the study. Some reduction observed in the South Central region, compared to 2007 and 2008, when the areas under vineyards in the region represented respectively 39.9% and 39.8% of the total area.

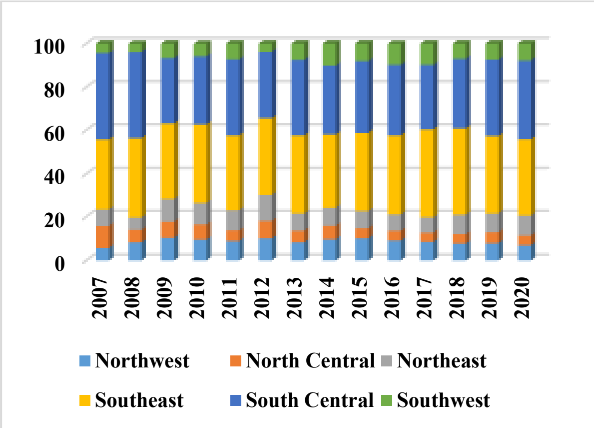

Fig. 3. Structure of the area with harvested vinieyards with wine grape varieties by statistical regions during the period 2007-2020, %
Source: Own calculation on the basis of data from the MAFF [13].

The share of the harvested vineyards, located in the North Central region, shrank the most, because of the rate of decrease of the area for the studied period was the strongest. Observed changes were to some extent due to the new distribution of the administrative districts in the six statistical regions carried out in 2008.

The values of the coefficient of variation calculated for the annual size of the harvested area under vineyards with wine grape varieties in a regional plan showed significant deviations in almost all statistical regions except the Southwest region (Table 3).

Table 3. Analysis of the variation of harvested areas with wine grape varieties by statistical regions during the period 2007-2020

Statistical regions	Indicators						
	n	R	Min	Max	Mean	SD	CV (%)
Northwest	14	4664	1,855	6,519	3,786	1,407	37.16
North Central	14	5929	1,182	7,111	2,725	1,736	63.71
Northeast	14	5000	2,233	7,233	3,732	1,500	40.19
Souteast	14	19510	9,403	28,913	15,679	5,521	35.21
South Central	14	21952	9,425	31,377	15,061	6,895	45.78
Southwest	14	1535	2,089	3,624	2,886	544	18.85

Source: Own calculation on the basis of data from the MAFF [13].

The most serious fuctuations were in the size of the areas in the North Central region with a value of the indicator of 63.71%. This can be explained by the influence of climatic factors, the unfavorable manifestation of which in individual years compromised the quantity of vintage, respectively limited the size of the areas from which grapes were harvested.

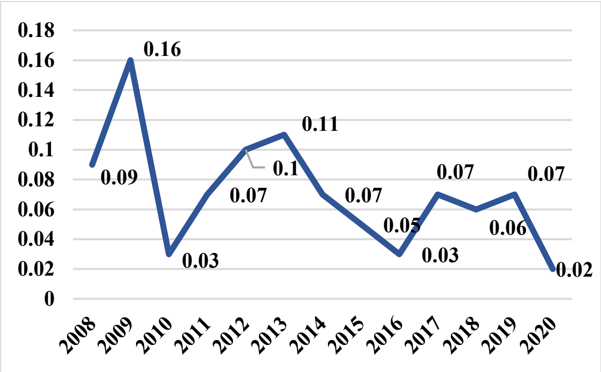

Fig. 4. Dynamics of the integral coefficient of structural changes of the areas with wine grape varieties by statistical regions during the period 2008-2020.
Source: Own calculation on the basis of data from the MAFF [13].

The values of the integral coefficient during the period 2008-2020 ranged from 0.02, which indicated very weak, negligible structural changes, to 0.16 - moderate structural changes in the harvested areas with wine grape varieties (Figure 4). The fluctuations by region were more significant in the years from 2007 to 2013, which determined the relatively higher levels of the indicator, especially in 2009 and 2013.

In the following seven years, the variation, both in the absolute size of the harvested vineyards by region, and of their weights in the total area were weaker, which led to lower values of the indicator - between 0.02 and 0.07 (weak structural changes).

The level of the average yields of wine grapes, calculated on average for the country, showed a slight growth of 15.5% in 2014-2020 period compared to 2007-2013 from 4,948 kg/ha to 5,714 kg/ha (Table 4).

The increase was due to the impact of a complex of factors. Probably, the impact of the abandonment of a significant part of the areas under vineyards with an expired depreciation period and in poor agrotechnical condition was stronger than the improved technological level in some farms.

This was evidenced by the quantity of productivity per unit area - 5,714 kg/kg on average for 2014-2020, which was significantly lower in accordance with the biological potential of the wine grape varieties grown in Bulgaria.

Considered in a regional aspect, the Southeast region stand out with the highest level of average yields - 6,493 kg/ha on average for the period 2014-2020, which was indicative of the more effective management of the synthesis of production factors and natural, economic, organizational, management and market conditions.

The level of productivity per unit area increased by 22.9% during the two compared periods, which was the strongest growth rate compared to the other statistical regions.

Average yields of grapes obtained in the Northeast region were also higher than the average level for the country during the same period.

Increase in the level of the indicator showed a growth of 18.2% based on the average quantity for the period 2014-2020 compared to 2007-2013.

Table 4. Average yields from harvested vineyards with wine grape varieties by statistical regions during the period 2007-2020, kg/ha

Years	Statistical regions						Total
	Northwest	North Central	Northeast	Southeast	South Central	Southwest	
2007	3,342	3,252	5,047	5,187	5,126	5,279	**4,855**
2008	4,056	3,980	5,920	4,902	3,686	5,903	**4,390**
2009	4,777	5,523	5,035	4,740	4,653	6,786	**4,944**
2010	3,101	4,392	3,662	5,378	4,281	3,986	**4,495**
2011	4,978	4,861	5,043	5,127	5,460	5,257	**5,219**
2012	4,130	4,870	2,637	5,249	3,362	8,016	**4,305**
2013	5,500	7,622	6,711	6,415	6,119	7,797	**6,430**
Average 2007-13	***4,269***	***4,929***	***4,865***	***5,285***	***4,670***	***6,146***	***4,948***
Index to the average for the country, %	***86.3***	***99.6***	***98.3***	***106.8***	***94.4***	***124.2***	***100.0***
2014	2,863	4,035	3,465	4,750	3,927	4,221	**4,102**
2015	4,772	5,958	6,748	8,323	5,949	5,388	**6,702**
2016	4,789	4,786	5,925	5,993	5,909	5,795	**5,777**
2017	5,224	5,071	6,520	6,547	4,857	6,056	**5,819**
2018	5,183	6,151	5,483	6,948	5,798	6,046	**6,214**
2019	3,944	3,465	5,726	6,756	5,917	5,356	**5,880**
2020	5,590	4,528	6,390	6,135	4,784	5,393	**5,501**
Average 2014-20	***4,624***	***4,856***	***5,751***	***6,493***	***5,306***	***5,465***	***5,714***
Index to the average for the country, %	***80.9***	***85.0***	***100.6***	***113.6***	***92.9***	***95.6***	***100.0***
2014-20/2007-13, %	***108.3***	***98.5***	***118.2***	***122.9***	***113.6***	***88.9***	***115.5***

Source: MAFF, the Agrostatistics Department [13] and own calculations.

In South Central region - one of the two regions with the largest area of vineyards with wine grape varieties in the country, the level of productivity per unit area lagged behind both average for Bulgaria and average realized in the Southeast region during the studied periods. Although average yields increased in this region as well, this happened at a slower pace than in the Southeast and Northeast regions, as well as compared to the average for the country.

The average yields of wine grapes in the North Central and Northwest regions were significantly lower than the national average level, with the lag was getting worse in the second period of the study. An unfavorable trend was the decrease in average value of the indicator in 2014-2020 compared to 2007-2013, observed in the Southwest region.

Values of the coefficient of variation did not show significant annual deviations of the average yields by region compared to the average levels during the studied period (Table 5).

Table 5. Analysis of the variation of average yields by statistical regions during the period 2007-2020

Statistical regions	Indicators						
	n	R	Min	Max	Mean	SD	CV (%)
Northwest	14	2,727	2,863	5,590	4,446	887	19.94
North Central	14	4,370	3,252	7,622	4,892	1,153	23.57
Northeast	14	4,111	2,637	6,748	5,308	1,274	24.00
Souteast	14	3,583	4,740	8,323	5,889	1,035	17.57
South Central	14	2,757	3,362	6,119	4,988	918	18.40
Southwest	14	4,030	3,986	8,016	5,805	1,140	19.63

Source: Own calculation on the basis of data from the MAFF [13].

The weakest were the fluctuations observed in the Southeast region (17.57%). This indicated that applied measures and mechanisms in the sector were important for improving the production activity, but not to a sufficient extent for obtaining satisfactory economic results, both at the farm level and at the regional and national level.

Decrease in the production of wine grapes in the country was by 35.6% in the period 2014-

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2020 compared to average for 2007-2013 from 276.7 thousand tons to 178.3 thousand tons. The most significant decline was in North Central region - by 61.4%, followed by Northwest and South Central regions, where was the same falling rate - by 40.4%. In remaining three regions, the decrease was as follows: by 21.6% in Southwest region, by 28% in Southeast region and by 37% in Northeast region. Although average wine grape yields increased in most of the regions considered, with exception of North Central and Southwest regions, this growth was not sufficient to compensate for large reduction in the area of harvested vineyards with wine grape varieties.

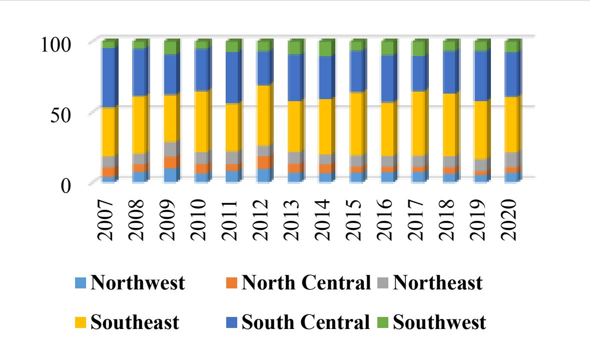

Fig. 5. Relative shares of the quantity of wine grapes produced by statistical regions in the total production for the country, %
Source: Own calculation on the basis of data from the MAFF [13].

Southeast region stand out with largest relative share in the total quantity of production on average for seven years period from 2014 to 2020 (42.1%), with its share increased compared to the period 2007-2013 (37.7%), as illustrated on Figure 5.
South Central region provided 30.6% of the total quantity of wine grapes produced in Bulgaria, but the comparison between these two studied periods showed that the percentage participation of region in national production shrank by 3%. The share of region was highest in 2007 at 42.1%, after wich it decreased to 33.1% in 2013 and to 31.5% in 2020.
The development of idicator was similar also in the North Central region - its share decreased from 6.6% on average for the period 2007-2013 to 4.0% on average for 2014-2020, in the Northwest region - from 7.5% to 6.9% and in the Northeast region – from 8.4% to 8.1%. The percentage share of wine grapes produced in Southwest region in the total national quantity expanded, but this was due to the shrinking share of production from the three regions mentioned above.
The results of the analysis of variation of wine grape production by statistical regions were presented in Table 6.

Table 6. Analysis of the variation of wine grape production by statistical regions during the period 2007-2020

Statistical regions	Indicators						
	n	R	Min	Max	Mean	SD	CV (%)
Northwest	14	18,049	8,388	26,437	16,510	6,118	37.06
North Central	14	18,239	4,886	23,125	12,696	6,718	52.91
Northeast	14	18,381	8,592	26,973	18,740	5,656	30.18
Souteast	14	92,958	48,783	141,741	89,770	25,169	28.04
South Central	14	106,061	37,845	143,906	72,944	29,438	40.36
Southwest	14	17,291	10,967	28,258	16,803	4,976	29.62

Sources: Own calculation on the basis of data from the MAFF [13].

Considered for the entire period, a significant variation of the produced quantities by year compared to the average values for period between 2007 and 2020 observed in North Central region with a coefficient value of 52.91%, in South Central region (40.36%), in Northwest region (37.06%) and in Northeast region (30.18%). The degree of variability of the production quantity was the weakest in the Southeast region (28.04%).
The values of the integral coefficient showed moderate to significant structural changes during the first period from the membership of Bulgaria in the EU, when the levels of the indicator range were mostly between 0.15 and 0.17 (Figure 6). The structural changes were significant only in 2012, when the indicator reached 0.22, due to contraction of production in South Central region and its increase in Southeast region. The observed structural changes in 2014-2020 were weak to moderate, indicating a relative stability of production positions highlighted regionally, with the Southeast and South Central regions dominating.

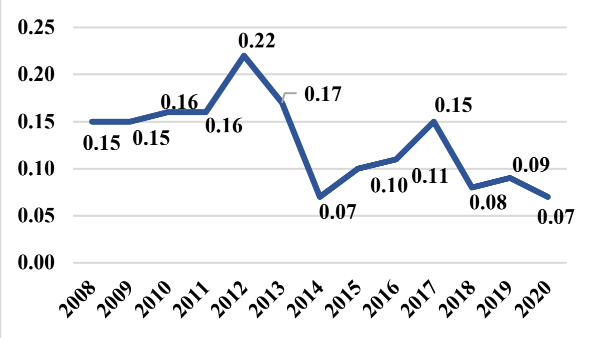

Fig. 6. Dynamics of the integral coefficient of structural changes in the production of wine grapes by statistical regions during the period 2008-2020.
Source: Own calculation on the basis of data from the MAFF [13].

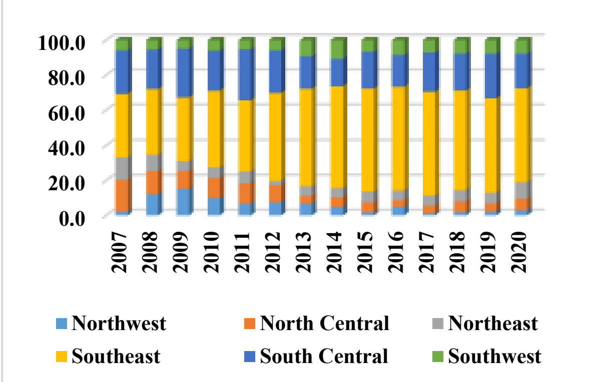

Fig. 7. Relative shares of the quantity of wine produced by statistical regions in the total production for the country, %
Source: Own calculation on the basis of data from the MAFF [14].

Total wine production recorded a decrease of 20.1% from 1,251.7 thousand hectoliters on average for the period 2014-2020 to 999.8 thousand hectoliters average for 2007-2013. A decline in the quantities produced, established on basis of the averaged levels for two seven-year periods, was observed in almost all statistical regions, with exception of Southeast and Southwest regions. The quantity of wine produced in the Southeast region increased by 5.3% for the two compared periods (from 542.8 thousand hl to 571.6 thousand hl) and in the Southwest region – by 4.3%. The noted growth in these two regions did not compensate for the reduced production in the rest of the country. The most significant decrease in the quantity of wine produced was in the Northwest region, where the decline was by 73.8% based on average for 2014-2020 compared to the level in 2007-2013.

The production in the North Central region also decreased extremely strongly - from 138.6 thousand hl on average for the first period to 51.4 thousand hl on average for the second period (by 62.9%), which was a logical consequence of the reduced production of grapes. Reported falling in South Central region was by 31.9%, and in Northeast region - by 25.5%.

The dynamics illustrated in Figure 7, clearly shows the expansion of the relative share of wine production in Southeast region in the total quantity produced in Bulgaria. The weight of the region increased from 36.2-37.5% in 2007-2009 to 53.3-56.5% in 2018-2020.

Bearing in mind that over the past three years, the quantities of wine produced in the region have shown a constant decrease - from 588 thousand hectoliters in 2018 to 403.3 thousand hectoliters in 2020, the enlarged percentage participation was rather due to the contraction of the volumes and relative weights of wine produced in most of the remaining regions.

The most obvious was the decrease in the share of wine production in the Northwest region in the total production. While at the beginning of the period, in 2010 and 2009 respectively, regional economy of the area provided between 10.0% and 15.3% of the total quantity of wine produced in the country, in 2018 this share was only 2.0%, and in 2020 – 3.0%.

The variation observed in the annual quantities of wine produced was within wider limits than that of wine grape production. This was due to the strong influence of market factors complementing the impact of agro-ecological and technological determinants. The coefficient values indicated on the Table 7, outlined stronger annual fluctuations in the volumes in the northern regions of the country. The quantity of wine produced by year varied most significant in the Northwest region (82.88%), followed by the North Central (62.17%) and Northeast region (47.48%). Of the three statistical regions located in Southern Bulgaria, significant annual fluctuations in the quantities of wine produced observed only in the Southwest region.

Table 7. Analysis of the variation of wine production by statistical regions during the period 2007-2020

Statistical regions	Indicators						
	n	R	Min	Max	Mean	SD	CV (%)
Northwest	14	167680	13,433	181,113	67,422	55,876	82.88
North Central	14	203168	38,945	242,113	94,975	59,049	62.17
Northeast	14	141332	29,860	171,192	75,534	35,861	47.48
Souteast	14	534840	403,316	938,156	557,201	160,783	28.86
South Central	14	219153	116,172	335,325	252,270	67,314	26.68
Southwest	14	106510	51,131	157,641	78,361	26,880	34.30

Sources: Own calculation on the basis of data from the MAFF [14].

The contraction of wine production during the years from 2007 to 2013, especially in the northern part of the country, led to moderate structural changes, which was indicative of value of the integral coefficient, ranging between 0.11 and 0.17 (Figure 8).

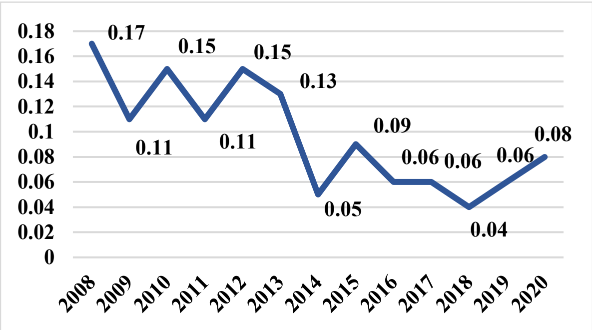

Fig. 8. Dynamics of the integral coefficient of structural changes in wine production by statistical regions during the period 2008-2020.
Sources: Own calculation on the basis of data from the MAFF [14].

In the years after 2014, weaker fluctuations in the quantities of wine produced at the regional level, and their reflection on the weights of the regions in the total production, led to lower values of the indicator - between 0.04 and 0.09, which outlined very weak structural changes.

More than half of the quality of wine produced in Bulgaria originated from the Southeast region (Burgas, Sliven, Yambol and Stara Zagora districs), which defines the need to ensure conditions for the stable production of wine grapes and wine in this region, in view of its significant place within the national wine sector.

CONCLUSIONS

Comparison between the values of coefficient of variation and the integral indicator of structural changes calculated for the harvested area of vineyards with wine grape varieties, the production of grapes and wine and the gross output of grapes by statistical regions showed that they were lower in the second period of CAP implementation in Bulgaria (2014-2020). Weaker fluctuations imply some stabilization in the development of the sector, but at a lower level of production volumes.

Although the negative rates of development slowed down in the second period of CAP implementation in the country, the downward trends in gross output, harvested areas, grape and wine production, both in the national and regional plan, have not been overcome.

The wine grapes and wine production was mainly concentrated in Southeast and South Central regions, which limited the possibilities for synergism in the direction of balanced territorial development.

During the next program period, the complex of measures and mechanisms applicable in Bulgarian wine sector within the framework of the Common Agricultural Policy should be expanded and aimed primarily at stabilizing the production potential and improving the technological level of production, but also at increasing the added value, taking into account the regional specificity.

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THE NATIONAL AND INTERNATIONAL IMPORTANCE OF THE DEVELOPMENT AND PLANNING OF RURAL SPACE - A VITAL PILLAR OF SUSTAINABLE DEVELOPMENT

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Abstract

The purpose of our article is to contribute with a complementary analysis to different conceptual and practical perspectives in relation to the approach, estimation and concrete evaluation of the classification of agricultural land, in direct relation to the rural space, in Romania and in the EU. Along with the land use for agriculture we are also bring to attention other uses of land, including land required for human settlement. In the economic literature, according to their origin, goods are classified into: ***a) free goods*** *– air, solar heat, natural light – whose consumption is unrestricted, being in themselves gifts of Nature, and consumed according to time and place and* ***b) economic goods*** *- either materials, or services, information - i.e. that type of goods, which, unlike free goods, have a limited character, being the result of an economic activity and a consumption of resources. In principle, natural resources are limitless, their consumption being free, unrestricted. However, under conditions of excessive exploitation, these natural resources become depletable, limited due to the exponential evolution of the "artificial" development in all economic fields, as well as a result of unsustainable (over)consumption. Among the goods - assets, of strategic importance, are the lands, both agricultural and non-agricultural. The paper has the purpose to analyze the concept of rural space, in Romania and the European Union. for this purpose the official statistical data and corresponding processing methods, also reports, the strategic European directives and recent researches and scientific articles were used. The results emphasized the importance of its integrated development and planning as a vital pillar of durable development and sustainability in direct connection with the agricultural land use. According to a report of the European Charter of Rural Areas "the rural area of Europe represents 85% of the total area, affecting - directly or indirectly - more than half of the European population". Romanian agriculture proved to be still of a low competitiveness compared to the other EU member states, as production factors are still being used below the optimal level. Therefore, rural areas are ecosystems where the progress in reducing poverty and increasing the quality of life is very slow.*

***Key words*:** *economic assets, rural management, rural sustainability, quality of life*

INTRODUCTION

Going beyond the current meaning of the concept of "*rural space*", namely the one that focuses mainly on geographical positioning or economic reality, and taking into account the current "readjustments" of modernity, one of the first significance of the concept of "rural space" contains "the related agricultural land crops and animal husbandry and the non-agricultural land area affected for uses other than agriculture, respectively the habitat and human activity in the rural environment" [1]. Complementary to this meaning are added other attempts to clarify the concept, namely: "rural space includes the inland and coastal area, as well as villages and small towns, where most of the land is used for agricultural and forestry purposes, and mountain areas are used for leisure, nature reserves, other residential or craft, cultural activities" [13].

In specialized literature the concept is defined in regard to own perspective of rural, meaning of each country: the actual model of agriculture, the housing density per km², rural population, the perception of heterogeneity of rural space, and the changes that took place in the communities due to the social dynamics.

We know the fact that urbanization and the accelerated pace of industrialization have contributed significantly to the distribution of the land - all land of any kind, regardless of destination, of ownership (public/private), registered within the territorial administrative unit (UAT).

From the Organisation for Economic Co-operation and Development (OECD) [10] perspective there are two main hierarchical levels: **local** and **regional** with three subgroups:

- **predominantly rural,** more than 50% of population lives in rural areas
- **significantly rural** in which 15-50% of population lives in rural areas
- **predominantly urban**, with only 15% rural population.

Within the land fund, two main categories of land are distinguished:

-**agricultural land** = represents the main object of work in agriculture

-**non-agricultural lands** = represents the forest fund, non-productive lands, roads, yards, etc.

In this context, the purpose of the paper was to analyze different conceptual and practical perspectives in relation to the approach, estimation and concrete evaluation of the classification of agricultural land, in direct relation to the rural space, in Romania and in the EU.

MATERIALS AND METHODS

In addition to quantitative methods and statistical-mathematical techniques, we consider various theoretical models from various scientific fields. Also NIS statistics [9], OECD [10], and Eurostat reports [5, 6, 7,], World Bank data [11, 14], as well as economic and sociological theories are the basis of analysis for the research we carry out and bring to light here.

In a global context, the functioning of society is mainly determined by the way in which social changes act at the level of the social structure and the social system.

The dynamics of the social reality present in Romania, but also anywhere in the world, presupposes equally both the knowledge and description of the components of the parts of the whole, as well as the understanding of the social reality itself, a reality that is always changing.

RESULTS AND DISCUSSIONS

An invaluable asset and the main natural resource on which agriculture as human activity depends is the land.

From the statistical data provided by the National Institute of Statistics, it appears that in 2018, Romania's land fund was 238,398 km² (23,839,700 ha) total area, of which the total area of rural areas is 207,522 km² (20,752,200 ha), i.e. 87.1%.

As statistics show, at the European level, in terms of land, Romania ranks 9th among the 27 EU states, meaning. 5.33%. Although it has an important potential for development, it is insufficiently used, registering significant discrepancies between what exists in terms of the number of agricultural holdings and the agricultural land actually used in agriculture. Under this aspect, Romania occupies an "honorable" ***first place*** in terms of the ratio of agricultural holdings versus used agricultural area (Fig. 1).

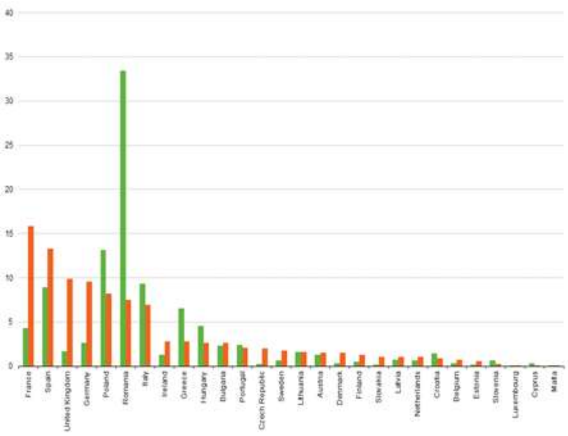
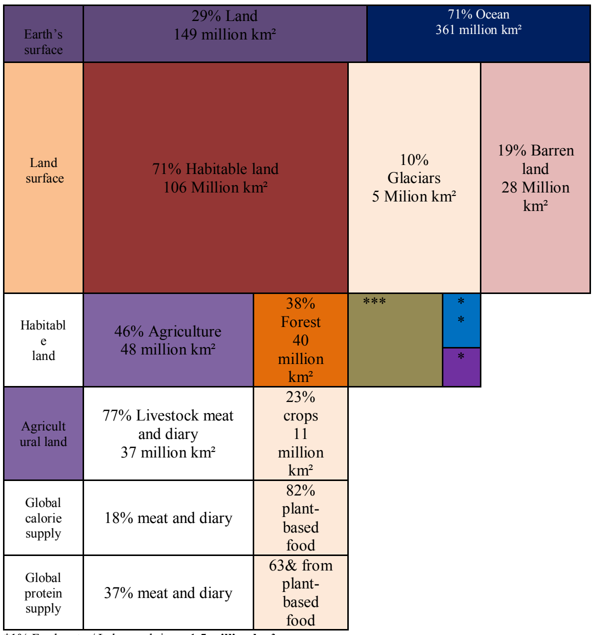


Fig. 1. Number of agricultural holdings vs Agricultural Area Used
Source: Personal processing based on the data from Eurostat, 2013 [7].

As we pointed out in one of our previous article [2] „Natural land resources, although vast, actually have a low potential for use in the cultivation and agricultural production of major crops. This is mainly due to natural factors - agriculture being the economic sector with high economic risk due to the fact that it depends to a large extent on naturally unpredictable conditions. Political, economic and social factors, which are constantly changing, also contribute", and we may add -

along with the massive urbanization that take place nowadays.



*1% Freshwater/ Lakes and rivers 1.5 **million km²**;
**15% Urban and build-up land 1.5 million km²;
***14% Shrub 17 m km²

Fig. 2. Global land use
Source: Personal processing based on the data from [11].

As many studies and statistics show, by 2050 the global population on Earth would grow from 7.5 billion to 11 billion, which imply that ***food demand will increase by 70%.***

Globally, of the world's agricultural area of about 4.152 billion hectares, arable land is between 1.524-1.804 million hectares (Figure 2).

India, China, Russia, which own more than half of the cultivated area - 723.5 million hectares.

The distribution of land use (less/more land) at the global level in the last decade 2010-2020 is shown in Figure 3.

The countries with a stronger concentration of the population represent about three quarters of the world's population.

The question imposed is: *has agricultural land increased or decreased over the last decade?*

Currently humanity consumes an equivalent of 1.5 planets per year to provide all the resources need to ensure not only the global food production but also the quality of air, the biodiversity, quality of water etc.

In terms of usage of the land the Earth needs more than one and half year to regenerate, and to continue to provide in sanate condition the resources we need to live.

The concept of sustainability addresses the very principle that we need to make use of our natural and artificial resources in such way that we, the current generation and the next generations after us, would be able live in terms of well-being, prosperity and resourceful environment, economically, socially, cultural.

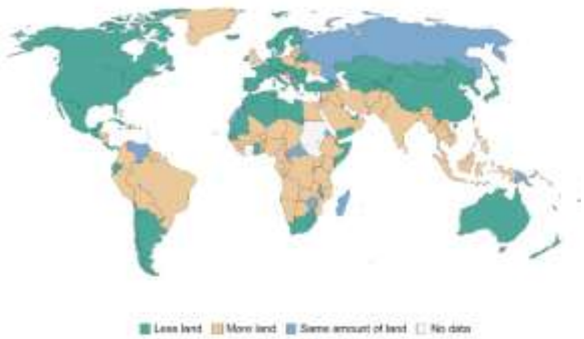


Fig. 3. The world map less/more land in the last decade 2010-2020
Source: Personal processing based on the data from [8, 11].

Along with sustainability emerge the paradigm of *Traditional economy* versus the new paradigm of *Green Growth* which in short would point the aspects presented in Table 1.

The paradigm of ***Green Growth*** in agriculture would be reflected and would be measured by the progress of providing overall social well-being thorough services and sufficient goods in sustainable ways that are economically efficient, environmentally beneficial in long terms. „Ensuring global food production depends to a large extent on a rational, efficient and sustainable management of the land, and in general on everything involved in organizing and planning the economic system in which agriculture remains, not only in theory, an important field of economic activity and a primary sector of the economy" [2].

"Following the global trend and the shortcomings that endanger the existence and balance of the ecosystem itself, the aim is a reorientation of agricultural policies by implementing environmental policies that respect and protect the environment” [2].

Table 1. Traditional Economic vs. Green Growth Policy Paradigm

	Traditional Economic Paradigm	Green Growth Paradigm
Economic-environment links	Environmental protection as detracting from economic growth	Environmental protection as a driver of economic growth
Planning perspective	Short and medium-term perspective	Long-term perspective and planning
Policy perspective	Government policy interventions to correct market gaps and failures	Government interventions for structural changes and facilitating policy adjustment
Scope of environment al responsabilit y	Government agencies, private sector units responsible for environmental management	Corporate departments and wider society, government agencies
Environment al policy interventions	Modalities of consumption and production Improvements	New and innovative patterns of economic activity to reduce environ-mental pressures
Economic policy interventions	Environmental externalities Taxes and charges	Fiscal incentives to green innovation, active-ties, businesses jobs
Economic indicators	GDP/ Measuring the rate and level of economic and productivity growth	Qualitative aspects of growth or well-being including environmental quality
Environment al indicators	Measuring the resources use and output of pollutants	Measuring the connection bet-ween economic activity and output of environmental goods and services

Source: Personal processing based on the information from [12].

With a growing rate of human population of 78 million people per year, humanity is facing nowadays the greatest challenge and agriculture as the most strategic domain in supplying food would have *the duty* to provide. In this respect, adopting Green Growth practices, sustainable practices, would be not only possible but also mandatory.

It became clear that *„ORGANIC is not just a fancy word for NORMAL Food*".

As we mentioned in a previous article The continuity of rurality worldwide, in the current conditions of modernity, over-technology and globalism, makes the evolution of all the conditions themselves, whether geographical, climatic, social, political conditions, leading into a differentiation within the essence, in the core of the concept of rurality, and, in some areas, even at a decrease in the boundaries between rural and urban. Maintaining the ecological balance is a desire that is naturally part of the very essence of the concept of sustainable development [4].

Also, the ecological balance is ensured, by the very quality of human life, the well-being, by the "*health of the whole living being*" [3].

In terms of rural space, urbanization and population growth will directly be felt in the shortage of the available land in rural areas, which mean not only the decrease of agricultural activities but also the drastic decrease of rural population. For example, according to World Bank data [14] it`s predicted that by 2050, Africa could lose 247 million acres of farm land. This also could mean an accelerated and exponential competition for the resources.

Between the traditional rural space and urban space the following characteristic: economical structure and occupational structure, would make a significant difference with long term effect on the stability of the living itself, the lifestyle, the behavior.

By definition, the rural lifestyle implies certain traditions, certain customs of regional and cultural patrimony.

In comparison with the urban lifestyle where the manifestation of life itself has a different tempo, in rural we see the authenticity of the a national ethos.

Life in the countryside would be diminish by the modernity of an invasive technology (Photo 1).

It is estimated that by 2050 almost 70% of global population would live in the cities of the future –***Biodiver Cities***.

Photo 1. Life in the country side
Source: Own design.

CONCLUSIONS

The current global demographic crisis is in itself a threat that has overwhelming effects along with others effect such as climate change, pollution, economic crises, increasing poverty, water availability, the dependency on technology, urbanization and less and less land for agriculture. These threats require a very detailed analysis not only in terms of land management but also at the level of quantifying the consequences of such changes without putting something sustainable in place.

In order to find solutions and make good decision together with consistent scientific methods, sustained efforts of governments and civil society are needed. In a society where land registration is not even half done, it shows not only the heavy level of bureaucracy, social anomie but also the mentality refractory to progress.

Agriculture is the only domain that can provide in practice, not in theory, the food Humanity need to survive, and to thrive.

As we mentioned in our article „Although it has a high potential in terms of pedo-climatic conditions, Romanian agriculture remains at a modest level of competitiveness, compared to the other EU member states, the use of production factors being below the optimal level. This leads to a poor integration of the labor force in the rural environment, as well as the migration of the population from the countryside to the more attractive urban areas in terms of earnings. As a result, rural areas are ecosystems where the progress in reducing poverty and increasing the quality of life is very slow" [3].

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TRENDS IN RURAL TOURISM DEVELOPMENT IN LVIV REGION BASED ON FORECASTING

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Abstract

The rural tourism is a promising type of tourism in rural areas that increases the socio-economic level and well-being of the population. The entrepreneurial activity in villages provides an opportunity to expand employment, increase investment attractiveness and contribute to the improvement of rural infrastructure. Based on the analysis of data for the period 2012-2020, the forecast trends in the number of rural tourism farmsteads and their visitors in Lviv region are presented using trend analysis and the FORECAST.ETS.STAT function for the period 2021-2025. The Russian military aggression against Ukraine and the COVID-19 pandemic significantly affect the activities and prospects for the development of rural tourism in the country. Having built logarithmic, linear, exponential, power and polynomial trend models, the probable indicators for the specified period were forecasted. The current state and trends of rural tourism development during the COVID-19 pandemic and in the context of Russia's military aggression in Eastern Ukraine are considered. The formation and sale of quality products and services in the field of rural tourism involve providing a favorable environment and improving the quality of functioning of rural tourism estates. The development of rural tourism depends on the desires and demands of tourists, which form the demand in this area, which in turn creates supply in the market of tourist services and further development of business activities in the field of services in rural areas.

Key words: *rural tourism, rural tourism farmstead, tourist, economic forecasting*

INTRODUCTION

Rural tourism is a promising type of entrepreneurial activity in rural areas, which expands the sphere of employment, promotes socio-economic development, improves infrastructure, increases investment attractiveness, ensures the rational use of natural resources and historical and cultural heritage, and most importantly - preservation of human potential, revival and dissemination of Ukrainian folk traditions, customs and culture. The activity of rural tourism will contribute to the increase of incomes of villagers, the development of self-education and training in the service sector, learning foreign languages and the overall socio-economic development of the village population

Accelerated development of rural tourism involves ensuring demographic stability in Ukraine and solving socio-economic problems of rural areas. The comprehensive scientific and methodological approach to the study of rural tourism is based on human resources, availability of free housing stock, quality and level of development of social infrastructure, ecological situation, tourist and recreational potential, land and water resources, production of organic products, geographical location, natural and climatic conditions, seasonal fluctuations in supply and demand.

The prospects for the formation and development of rural tourism are determined on the basis of the analysis of the conducted research by the forecasting method. The method of economic forecasting is a set of methods and techniques for developing forecasts that allow, based on the analysis of retrospective data (analyzing the number of farmsteads and visitors for a certain period), external and internal factors of influence, as well as their quantitative changes, to make convincing predictions about the future development of business activities in the field of rural tourism for the coming years in the Lviv region.

Rural tourism, ecotourism and agritourism have become very popular in recent years, as a significant number of citizens in various fields of activity have switched to remote work and study for a long time with a trip to rural areas. At the same time, renting houses, cottages, separate rooms in private farms. During the COVID-19 pandemic in Lviv region and throughout Ukraine, domestic tourism began to develop significantly, and much attention was paid to rural tourism. The problems of rural tourism in the market of tourist services, the possibilities of rational use of tourist and recreational resources of rural areas, the factors influencing the development of tourism activities in the countryside, the classification and categorization of rural tourism estates, the importance of regional clusters for rural areas, and the application of new scientific approaches for the effective organizational and economic functioning of rural tourism in the Lviv region are considered. For the successful functioning of rural tourism, its activities cannot be reduced only to responding to changes that occur in the tourism sector. Therefore, there is a need to manage these changes on the basis of scientifically based procedures, namely the regulation, forecasting and adaptation of rural tourism and the farmsteads themselves to quality tourist services, the introduction of innovations and investment activities to improve the socio-economic situation in rural areas.

A modern management tool is the methodology of strategic business management. The study of the essence, role and tasks of rural tourism and the processes of forming a development strategy, which contain generalization and deepening of theoretical and methodological foundations, as well as the development of relevant scientific and practical recommendations on the prospects for the formation and forecasting of rural tourism development strategy on the basis of entrepreneurship, are relevant. In this context, the purpose of the paper was to analyze the trends in rural tourism in Lviv region based on foresecasting.

MATERIALS AND METHODS

Having analyzed the statistical information, the forecast trends in the development of rural tourism farmsteads in Lviv region until 2025 and the number of tourists who will use the services of rural tourism farmsteads are presented. [2].

Based on the results of the study, the activity of rural tourism estates during 2012-2020 was analyzed. The forecast trends in the number of rural tourism farmsteads for the period 2021-2025 is based on the parameters of the trend line of the following models: linear; logarithmic; exponential; polynomial; power [4, 6].

The reliability of the obtained trend equations was checked using the determination coefficient R^2 and Fisher's statistical criterion. Depending on how close the value of the coefficient of determination R^2 is to 1, respectively, the model is considered reliable. The best estimate of the adequacy of the model to the nature of the original data is given by the Fisher's statistical criterion, which was calculated by the formula:

$$F_{calc.} = \frac{R^2}{1-R^2} \cdot \frac{k_2}{k_1} \quad ....(1)$$

If the calculated value of Fisher's criterion according to formula 1 is greater than the table value, the model is considered adequate to the empirical data. In our case, the table value of the criterion F_{table} ($k_1 = 1$, $k_2 = n-1-1 = 9-1-1 = 7$, $\alpha = 0.01$) = 12.25 at a probability of p = 0.99 or the criterion F_{table} ($k_1 = 1$, $k_2 = 7$, $\alpha = 0.05$) = 5.59 at a probability of p = 0.95, or for the significance equation $\alpha = 1 - p$ and degrees of freedom $k_1 = 1$, $k_2 = 7$. The value of n is the number of periods under study.

Also, for the forecasting of the studied indicators, the spreadsheet processor Microsoft Office Excel 2016 with the built-in forecasting function and the inclusion of additional statistical information in the forecasting sheet was used. A table of statistics was created in the forecasting sheet using the FORECAST.ETS.STAT function. The advantage of using the STAT function is that it contains such measures as smoothing coefficients (Alpha, Beta, Gamma) and error rates (MASE, SMAPE, MAE, RMSE). The seasonal factor was also used in the forecast calculations [5]. To better assess the accuracy

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of the forecast, the standard value of the confidence level was applied - 95%. As a result of the forecasting analysis, three acceptable trends were identified on the graph: prediction, upper and lower confidence limits.

RESULTS AND DISCUSSIONS

The development of rural tourism is aimed at meeting the needs of tourists in recreation and leisure, improve the physical and emotional health of the population, as well as the state of the environment. During the creation of amalgamated territorial communities, great importance is attached to the regional clustering of the tourism sector, as rural tourism is able to form a positive image of a particular territory of a particular region and provide financial revenues for the development of territorial communities.

Tourist activity in the field of rural tourism deserves important attention, as it does not require significant capital investments, but provides an opportunity to use free living space and natural resources. But in order for rural tourism to be a promising business activity, regional strategies for the development of the tourism sector should be developed, which would meet the requirements of European standards with the aim of entering the international market. Important attention should be paid to the clustering of rural areas using tourism activities, as this will contribute to the overall development of a certain region. For the development of rural tourism, it is necessary to identify the problems of functioning and legal regulation of this activity, improvement of the legal framework in the field of rural tourism. [3].

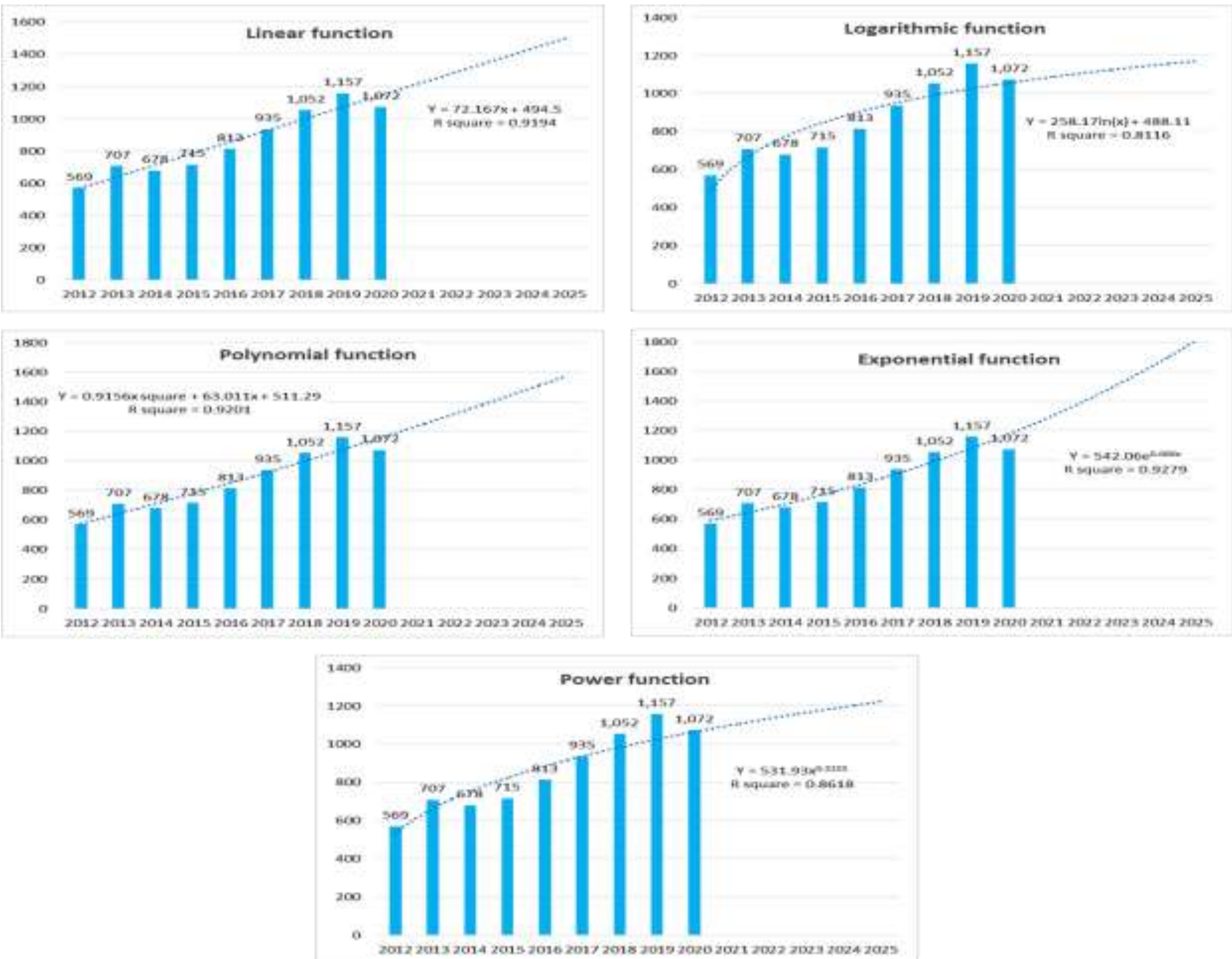


Fig. 1. Forecasting the number of rural tourism estates in Lviv region using trend analysis for the period 2021-2025.
Source: Authors' drawing.

In the modern world, the implementation of statistical analysis of the phenomena and processes that occur in rural tourism is of great importance. Especially relevant was the development of economic forecasts of rural tourism development for the near future in conditions of constant uncertainty and a certain lack of statistical information [10].

Information aimed at the future, i.e. forecast trends, is of great importance. Forecasting is the modeling of the real situation, its implementation in the abstract sphere with the verification of the final results and analysis of the course of the forecasted situation. Forecasting is an integral part of the management process of any business activity. This is especially true in the field of economic phenomena, in which the result of decisions made today largely depends on what will happen tomorrow. Forecasting reduces uncertainty and helps to increase the accuracy of decisions, and thus eliminate losses of business entities.

In order to identify the most reliable forecasts of the number of rural tourism farmsteads in Lviv region, a trend analysis was carried out using linear, logarithmic, exponential, polynomial and power functions, which showed reliable forecasts for the period 2021-2025 (Fig. 1).

The obtained models were tested for reliability of the initial data by Fisher's F-criterion with a significance level of α = 0.99 and α = 0.95 and using the determination coefficient R^2. It was found that the forecast of the number of rural tourism farmsteads in Lviv region changed according to the regression equation (Table 1).

Table 1. Forecast values of the number of rural tourism farmsteads in Lviv region based on trend analysis

Type of model	Trend equation	R^2	$F_{calc.}$	Year				
				2021	2022	2023	2024	2025
Linear	$y = 72.167x + 494.5$	0.9194	79.84**	1,216	1,288	1,361	1,433	1,505
Logarithmic	$y = 258.17ln(x) + 488.11$	0.8116	30.15**	1,083	1,107	1,130	1,150	1,169
Polynomial	$y = 0.9156x^2 + 63.011x + 511.29$	0.9201	80.61**	1,233	1,315	1,399	1,485	1,573
Exponential	$y = 542.06e^{0.086x}$	0.9279	90.09**	1,281	1,396	1,521	1,658	1,807
Power	$y = 531.93x^{0.3155}$	0.8618	43.65**	1,100	1,133	1,165	1,195	1,223

Notes: 1. * - reliability of the model to the original data with probability p = 0.95 (significance level α = 0.05);
2. ** - reliability of the model to the original data with probability p = 0.99 (significance level α = 0.01).
Source: Authors' drawing.

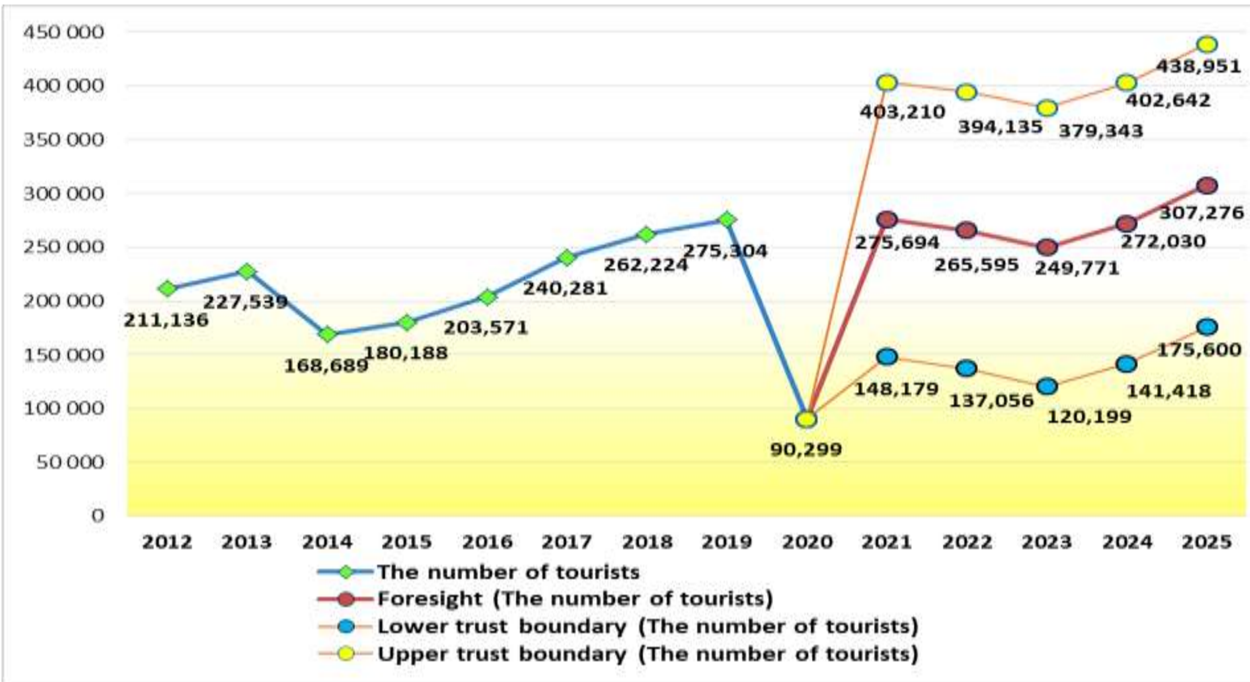
According to the linear trend equation y = 72.167x + 494.5, the number of rural tourism farmsteads in Lviv region is likely to increase by 72 dwellings annually with a determination coefficient of $R^2 = 0.9194$. It is found that in 2021 the number of rural tourism farmsteads is likely to increase to 1,216, while in 2025-1505. Checking for compliance of the linear trend model with the initial data by Fisher's criterion indicates a sufficiently high reliability of the forecast, since the calculated value of the criterion $F_{calc.} = 79.84$ is significantly higher than table $F_{table.} = 12.25$ with probability p = 0.99 and degrees of freedom $k_1 = 1$, $k_2 = 7$. Thus, the linear regression equation indicates a positive dynamics of increasing the number of rural tourism farmsteads in Lviv region for the next five years. The forecast according to the logarithmic regression equation y = 258.17ln(x) + 488.11 demonstrates a slow growth in the number of rural tourism farmsteads in Lviv region, which is similar in nature to the power model. It is noted that the coefficient of determination ($R^2 = 0.8116$) and the F-criterion in this model was the smallest ($F_{calc.} = 30.15$). Thus, among all the other trend models that were used, it is the logarithmic model that shows the smallest tendency to increase the number of rural tourism estates. It was determined that in 2021 the number of rural tourism is likely to increase to 1,083, in 2022-1,107, and in 2025-1,169.

According to the results of Table 1, it was established that according to the polynomial function with the regression equation $y = 0.9156x^2 + 63.011x + 511.29$, the number of rural tourism estates in the Lviv region is gradually increasing ($R^2 = 0.9201$). So, in

2021, the number of rural tourism estates according to the polynomial function will be 1,233 farmstead, and in 2025 it will increase to 1,573.

It was determined that the exponential model with the regression equation y = 542.06e0.086x describes the most positive forecast for the increase in the number of rural tourism estates in the Lviv region.

It was determined that at the highest value of the coefficient of determination $R^2 = 0.9279$, the calculated Fisher's criterion was $F_{calc.} = 90.09$. Checking for compliance of the selected model with the Fisher criterion to the tabular indicators indicates the highest compliance of the studied model with the initial data with a probability of $p = 0.99$. It is predicted that in 2021 the number of rural tourism farmsteads will be 1,281, in 2022 - 1,396, while in 2025 there will be 1,807 (at a significance level of $\alpha = 0.01$).



Year	The number of tourists	Foresight (The number of tourists)	Lower trust boundary (The number of tourists)	Upper trust boundary (The number of tourists)	Statistics	Value
2012	211,136				Alpha	0.13
2013	227,539				Beta	0.00
2014	168,689				Gamma	0.00
2015	180,188				MASE	0.94
2016	203,571				SMAPE	0.22
2017	240,281				MAE	43.074.05
2018	262,224				RMSE	65.060.15
2019	275,304					
2020	90,299	*90,299*	*90,299*	*90,299*	Confidence interval	95%
2021		**275,694**	**148,179**	**403,210**	Seasonality	4
2022		**265,595**	**137,056**	**394,135**		
2023		**249,771**	**120,199**	**379,343**		
2024		**272,030**	**141,418**	**402,642**		
2025		**307,276**	**175,600**	**438,951**		

Fig. 2. Forecasting the number of tourists who will use rural tourism services in the Lviv region using the FORECAST.ETS.STAT function for the period 2021 – 2025
Source: Authors' drawing.

The program forecasts the number of tourists in Lviv region for the period 2021-2025 using the FORECAST.ETS.STAT function. Accordingly, according to the results of the research, having received the trend of changes in the number of tourists in Lviv region for the period, we will determine the values of indicators that are taken outside the empirical series (Fig. 2).

The results of forecasting the number of tourists in Lviv region who will use the services of rural tourism indicate that in 2021, according to the trend "Forecast", their number is likely to increase compared to 2020 by 185,395 people, or 205.31% to 275,694 people. However, it should be noted that from 2022 to 2023, there is a tendency to decrease the number of tourists to 249,771 people, while from 2024 to 2025, a probable increase in their number is projected from 272,030 to 307,276.

As can be seen from Figure 2. The "Lower Confidence Boundary" and "Upper Confidence Boundary" are in a fairly wide range of the forecast at the 95% confidence interval and the fourth seasonality parameter. However, taking into account the COVID-19 pandemic and Russia's armed aggression against Ukraine, it is worth taking indicators in the range of trends of the "Lower confidence limit" and "Prediction". It is worth considering the fact that any statistical function is not able to take into account the huge amount of factors that change daily and affect the trend of the future forecast. In addition, the existing trend-based forecasting models are essentially a projection of the past and are largely based on historical data, which may not have a similar cyclicity in future forecasts and similar trends

Taking into account that the used models of statistical forecasting functions do not take into account many objective factors, therefore, we have developed our own forecast of the number of rural estates and tourists who will use their services in Lviv region for the period 2021 - 2025, taking into account many factors, trends and in-depth economic analysis.

To build a trend forecast of the number of rural tourism farmsteads and tourists in Lviv region, social, political, economic factors, as well as current information and forecasts from leading world organizations were taken into account: military aggression of the Russian Federation against Ukraine; the incidence of COVID-19; the state of the socio-political situation in Ukraine; forecasts from the World Health Organization and the Ministry of Health of Ukraine; forecast of the World Tourism Organization; forecast of the World Bank [12]; real wage index in Ukraine; GDP dynamics of Ukraine; forecasts of leading analysts, experts and scientists.

It should be noted that the biggest factors that currently affect the development of rural tourism in Ukraine and Lviv region are the COVID-19 pandemic and the "hybrid" war between Ukraine and Russia.

In addition, the purchasing power of the population, the level of fight against corruption, the implementation of reforms, political and social tensions in society are also important. The economic factors that were taken into account in the forecasting of rural tourism development are interrelated with political, social and other global processes. Having analyzed the above factors, the author has developed forecast trends in the development of rural tourism in Lviv region. (Fig. 3).

Analyzing the forecast of the number of rural tourism farmsteads in Lviv region for the period 2021-2025, we note that their number probably does not have such a rapid tendency to decrease, or vice versa - to increase. Another thing is when it comes to the temporary suspension of their activities to provide rural tourism services during the COVID-19 pandemic, the introduction of a lockdown or "red zone" in the region, which physically restrict the movement of tourists. It is projected that the number of rural tourism farmsteads in 2021 and 2022 will increase by only 34 and 90 farmsteads, or 3.17 and 8.39%, compared to 2020. Based on the economic analysis, it is expected that from 2023 to 2025 their number will increase significantly, for which there are all the prerequisites and arguments below.

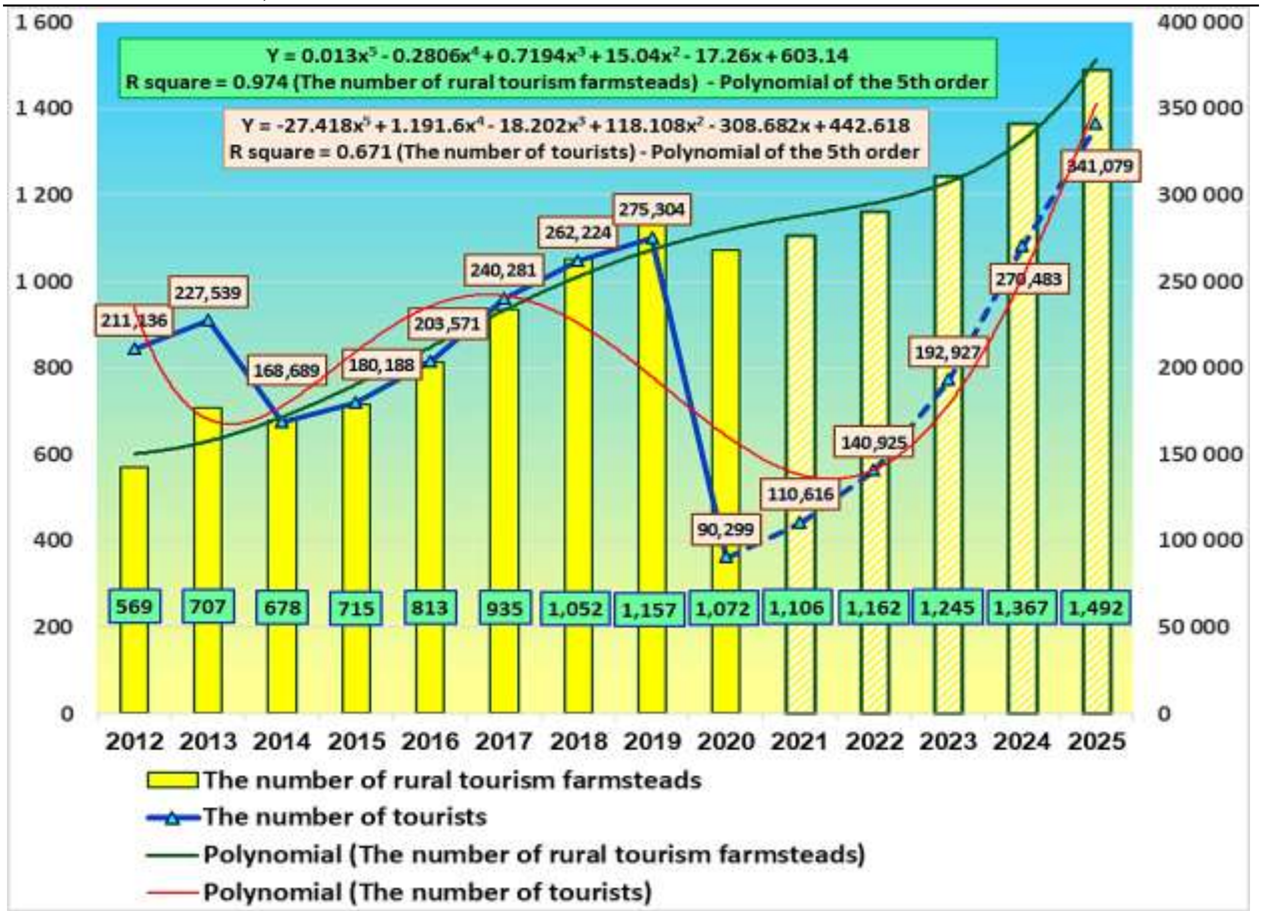


Fig. 3. Forecasting the number of rural tourism farmsteads and tourists who will use the services of rural tourism in Lviv region for the period 2021 - 2025
Source: Authors' drawing.

General trends in the number of tourists visiting rural tourism estates in Lviv region for the period 2021-2022 will increase gradually. So, in 2021, the number of tourists is likely to increase compared to 2020 by 20,317 people, or 22.5%, while in 2022 their number will increase compared to the previous year by 30,309 people, or 27.4% with a determination coefficient of R^2 = 0.671 (5th order polynomial regression equation). The situation with the flow of tourists should improve in 2023-2025. It is projected that the number of tourists who will use the services of rural tourism is likely to increase in 2023 to 192,927 people, which is more than in 2022 by 52,002 people, or 36.9%. In 2024, their tourist activity will increase to 270,483 people, while in 2025 their number is projected to increase to 341,079 people. It should be noted that only in 2025 the number of tourists who will use the services of rural tourism in the Lviv region will increase by 65,775 people, or 23.89%, compared to 2019 and will actually reach a positive trend in the period.

Nevertheless, it is worth considering that most experts predict the duration of the COVID-19 pandemic to be at least three years. However, some skeptics predict stabilization of the situation in the world in 2024.

It should be noted that of all types of tourism, it is rural tourism that limits mass crowds of tourists and to some extent reduces the number of contacts. Also, rest in rural estates involves tourists staying in the fresh air and consuming natural, environmentally friendly food. In a pandemic, this type of tourism is more accessible, as there are quarantine restrictions on the activities of hotels, hostels, boarding houses, sanatoriums, campsites and other tourist facilities that are in the red zone. However, receiving tourists in rural estates under such conditions is a personal matter of the owners of the estates at their own risk and responsibility.

Due to the COVID-19 pandemic, the share of domestic tourists has increased significantly due to the closure of borders to many countries. In addition, the rules for crossing the entry-exit border have become more complicated (negative PCR test, certificate or certificate of vaccination, self-isolation) [8]. Under such circumstances, domestic tourism, in particular rural tourism, is gaining intensive development. However, today there are still new challenges and threats to the development of rural tourism due to the cyclical nature of the disease and the spread of new aggressive strains of the virus, which can significantly limit the movement of all tourists, especially in regions with a red zone.

Urgent steps are needed to stem the rising death toll and the economic strain caused by the COVID-19 pandemic, which are exacerbating an already steep recovery. Pandemic policy is also economic policy, as there is no lasting end to the economic crisis without ending the health crisis [1, 7]. In the global world, no country will be able to return to normal until all countries can overcome the pandemic.

Also, in case of Ukraine, the hostilities between Russia and Ukraine have also affected the whole economy, including tourism and created a social tension [9].

The world is faced with an unprecedented global health emergency - the COVID-19 pandemic, which is why tourism has been the most affected of all sectors of the economy (suspended flights, closed hotels and travel restrictions in almost all countries of the world). According to the World Tourism Organization (UNWTO), international tourist arrivals fell from almost 1.5 billion in 2019 to approximately 380 million in 2020, a decrease of 74%. This represented a loss of approximately US$1.3 trillion. UNWTO forecasts two scenarios for the development of international tourist flows in 2021. In 2020, foreign tourist arrivals to Ukraine decreased by 75%. It is projected that the recovery of tourist flows will take place no sooner than 2023-2024.

Today, the tourism industry in Ukraine has lost more than $ 1.5 billion and may lose another $ 3-5 billion if strict quarantine restrictions continue. If the quarantine continues, the lion's share of companies and establishments in the tourism sector will not be able to survive it, as approximately 80% of hospitality establishments are small businesses (individual entrepreneurs) [11].

Thus, a positive scenario for the development of rural tourism for the next five years is possible only if the rate of vaccination of the population increases and basic quarantine measures are observed.

Rural tourism is a type of tourism that has every chance to recover most quickly after the pandemic, compared to other types of tourism. An important condition for the development of rural tourism is also the end of the war and the continuation of effective reforms in all spheres of life in the country.

CONCLUSIONS

Statistical trend analysis contributes to a better understanding of the forecast of rural tourism development not only in Lviv region and in Ukraine, but also in the tourism industry as a whole. Scientific research will allow to make more effective management decisions in the field of rural tourism and tourism business in general, on which tomorrow's result will largely depend. It should be noted that forecasting reduces uncertainty and helps to increase the accuracy of decisions in the tourism sector.

Based on the trend analysis, the number of rural tourism farmsteads in the Lviv region, as well as the number of tourists who used the services of rural tourism, was forecasted.

According to the forecast trends, it was found that rural tourism has all the necessary resources for further development.

Rural tourism has all chances to revive the fastest after the pandemic, compared to other types of tourism, as domestic tourism and recreation in rural areas are becoming popular.

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MANAGEMENT OF PRODUCTION RESOURCES OF AGRICULTURAL ENTERPRISES IN UKRAINE: A CASE STUDY OF VOLYN REGION

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Abstract

The article aimed to analyze resources management of an agricultural enterprise in Ukraine. It proved that the resource potential of agricultural enterprises is a necessary element of the management system. The need for strategic management of resource potential is determined by the fact that in modern conditions, inefficient use of resources reduces the competitiveness of enterprises and makes their activities irrational. According to the results of the study, we substantiated that the development of a methodology for the formation of a resource strategy offers an opportunity for the enterprise to ensure the effectiveness of the process of providing its own resources. The given factors and conditions of strategic management of the resource potential of agricultural enterprises contribute to the further development of applied aspects of the use of the theory of resource potential by enterprises in the field of agriculture.

Key words: *agricultural sector, agricultural enterprises, resource potential, production resources, regression equation*

INTRODUCTION

The peculiarities of the functioning of agrarian enterprises in the conditions of a significant increase in the market competition provide for the objective necessity of the formation of sufficient resource potential for the implementation of operational activities. In addition, another important aspect of ensuring the efficiency of such business entities is the rational use of available production resources, taking into account their limitations. At the same time, a sufficient level of providing the agricultural sector of the economy with production resources acts as a key and necessary condition for the general improvement of the efficiency of economic activity, improvement of production technology, as well as improvement of the working conditions of employees.

At the same time, as business practice shows, the economic efficiency of agricultural enterprises largely depends on the level of their provision of land, material, labour, and financial resources. In turn, efficiency implies the need to ensure a rational ratio of available resources and ensure optimal use of them in the process of production. To ensure such efficiency, specialized mathematical and econometric models are used, which provide for the construction of an effective system of management of production resources of enterprises. Such management involves the need to balance the supply of production resources of the enterprise and their optimization, as well as to ensure the most effective use of them in production activities under existing conditions.

The study of practical aspects of the optimization of the use of production resources of agricultural enterprises is characterized by a significant diversity of research, which is mainly concentrated in the field of substantiation of methods of increasing the efficiency of the use of production resources. It is worth noting that a significant contribution to the study of the peculiarities of the formation of the resource potential of agricultural enterprises and ensuring its rational use was made in the works of such researchers as I. Balaniuk [1], O. Binert [2], I. Britchenko [3-11], Y. Chaliuk [12], Y. Danshina [13], M. Dziamulych [14-21], N. Khomiuk [23], S. Koshova [24-25], M. Kryshtanovych [26], A. Marcuta [28], N. Onyshchenko [30], A. Popescu [31-40], T. Shmatkovska [41-43], R. Sodoma [44-49], O. Stashchuk [50-52], I. Tofan [54], I. Tsymbaliuk [55], I. Yakoviyuk [56], V. Yakubiv [57], O. Yatsukh [58], and others.

However, significant and dynamic changes taking place in world markets force agricultural enterprises to look for new models of optimizing the use of production resources that could provide them with the most effective use of available resource potential under existing restrictions to ensure maximum profits.

MATERIALS AND METHODS

It has been established and substantiated that the effective method of resource potential management does not take into account the action of specific factors inherent to each of the resources, which does not allow to give an adequate assessment of the real state of affairs in the activity of an agricultural enterprise and therefore necessitates the continuation of scientific research in this direction.

Considering the purpose of the article, the main task of the research is to determine the factors and factors affecting the formation and use of the resource potential of agricultural enterprises and the further development of the industry at the regional level in Ukraine.

To ensure the implementation of the research, the method of correlation-regression analysis was used. Note that in the case of a correlation relationship, depending on the change in the factor characteristic or the ordered set of factor characteristics, the average value of the resulting characteristic changes.

Depending on the direction of action, direct and inverse connections are distinguished. In the presence of a direct connection with the increase of the factor characteristic, the resulting characteristic also increases, when the factor characteristic decreases, it decreases. If an increase in the factor characteristic is accompanied by a decrease in the resulting characteristic, we have an inverse relationship.

Depending on the form of the formula that establishes the connection between the factor and the resulting features, linear and non-linear connections are distinguished. The linear relationship between the factor characteristic x and the resulting characteristic y has the form $y=ax+b$, its graph is a straight line. If there are several factors, then the linear dependence has the form: $y=a_1x_1+a_2x_2+\ldots+a_nx_n$. Other types of relationships are non-linear [29].

According to the number of factors that influence the resulting characteristic, unifactorial and multifactorial relationships are distinguished. One-factor relationships are also called pairwise. If the relationship is multifactorial, then all factors act simultaneously and in a mutual relationship.

The tasks of correlation analysis include the quantitative measurement of the density of the connection between the factor and the resulting features, the determination of unknown connections, and the assessment of the factors that have the greatest influence on the resulting feature. The purpose of regression analysis is to find an analytical expression (formula) that establishes the relationship between the factor and the resulting feature. The degree of influence of factor characteristics on the resulting character is also determined. Regression models can be used to predict outcome trait values.

RESULTS AND DISCUSSIONS

The main meaning of the concept of

«enterprise potential» consists in the integral reflection (assessment) of the current and future opportunities of the economic system to transform input resources with the help of the entrepreneurial abilities inherent in its personnel into economic goods and to satisfy corporate and public interests as much as possible.

It is worth paying attention to the fact that the concept of «resource potential» includes the totality of the potential of all resources of the enterprise, which are necessary for the implementation of the process of production of products and provision of services to meet the needs of society. In our opinion, it is important to include such resources as labour, production, natural, financial, and informational. In addition, in their totality, the specified resources create prerequisites for the formation of the investment and innovation potential of the enterprise.

Almost a third of the entire economy of our country is directly related to agricultural production. One job created in the field of agriculture allows for the employment of 5-6 people in other areas of the economy, and an increase in the production of agricultural products by 1% ensures the growth of the entire economy of the country by 2.0-2.3% [53].

In addition, agriculture is the main area of the economy. Agriculture accounts for 1/4 of the gross regional product.

The agricultural sector of the Volyn region has certain potential and competitive advantages, which under certain conditions can be involved in the regional economy.

At the same time, agriculture in the region is characterized by small-scale production and the absence of large-scale production commodity agricultural production inhibits the development of the processing industry and logistics infrastructure of the agricultural sector.

Due to the large possibilities of using innovative equipment and the latest technologies in production, large agricultural organizations have advantages over small farms in terms of labor productivity. Small farms can only get access to the results of scientific and technical development by uniting various cooperatives.

Demonstrating the success of agriculture in developed countries, the main producer of products is the farmer [22]. At the same time, it should not be forgotten that each farmer is a member of several communities – for the sale of products, for the use of equipment, for veterinary services, for receiving loans, etc. However, the hopes that the farmer will become the main breadwinner in Ukraine have not yet come true.

In the structure of land plots of agricultural producers, the area of land used by the population has increased. The largest specific weight among agricultural enterprises is the land of economic associations, although there is a tendency for a gradual decrease. In the structure of the cattle population during 2017-2020, the share of agricultural enterprises decreased from 63.5% to 11.2% [27]. In private households, the specific resource potential (per 1 ha of agricultural land) is 1.4 times higher than in agricultural enterprises, which is a consequence of the high level of employment of live labor in them (0.76 workers per 1 ha versus 0.08 in enterprises). In the structure of the resource potential of households, the main specific weight is occupied by land and labor resources (90%), while in agricultural enterprises – land and material and technical resources (92.5%) [27]. 1/4 of the resource potential of agricultural products is concentrated in households [53].

Based on the calculation per unit of resource potential of the economy, the population, in general, receives 4.4 times more gross agricultural products, and 2.5 times more net gross agricultural final products than agricultural enterprises. The production of agricultural products in households is carried out with 9% lower costs per conventional unit of gross agricultural products, including. in crop production – by 43.5%, in livestock production – by 4.5% [27]. The results of the conducted research testify to the low level of effectiveness of the functioning of almost all organizational and legal forms of management in the agricultural economy of Ukraine. Some positive developments in performance are not sustainable and are not large enough to claim that there is an improving trend.

To a large extent, the formation of the dynamics of management efficiency in various organizational and legal forms in the Volyn region was influenced by the negative dynamics of resource provision of the studied farms, which is a consequence of the decrease in investment activity of agricultural enterprises as a result of the deterioration of their financial and economic condition, which was largely facilitated by the lack of specific state support for the development and necessary conditions for this.

The main organizational and legal forms of agricultural enterprises that have become widespread in the Volyn region are limited liability companies as one of the forms of economic companies and private (private-lease) enterprises, which include individual farms that have the status of farms. Certain differences in the results of the functioning of enterprises of these two different organizational and legal forms made it possible to establish the processing of information about agricultural enterprises in certain districts of the Volyn region (Table 1).

Table 1. Relationship between the organizational and legal form of agricultural enterprises and the results of their operation in the Volyn region, 2021.

Indicator	Limited liability companies	Private enterpri-ses Total	Total
Number of enterprises	37	25	62
Area of agricultural land per enterprise, ha	707	947	804
Average annual value of assets per enterprise, thousand UAH	1,659.5	3,140.2	2,256.6
The number of employees employed in agricultural production per 1 enterprise, persons	44	74	56
The number of workers employed in agricultural production per 100 hectares of agricultural land, persons	6	8	7
Administrative costs for 1 ha of agricultural land, UAH	51	59	55
Ratio of administrative costs to production costs, %	5.4	3.9	4.5
Profit from the sale of products per 1 ha of land, hryvnias	-115	42	-52
The level of profitability of agricultural products, %	-24.4	8.3	-12.4

Source: Built based on [27].

In total, data on 62 agricultural enterprises were processed, of which 37 are limited liability companies, and 25 are private enterprises. The level of intensification of agricultural production in private enterprises is generally higher than in limited liability companies. The natural result is higher economic efficiency of agricultural production in private enterprises. If in the studied group of enterprises in limited liability companies agricultural production is unprofitable, then in private enterprises - due to the better state of the material and technical base, higher intensification of production, and more efficient activity of the administrative apparatus - production is profitable.

The effectiveness of the use of resource potential by enterprises in the field of agriculture is determined by the influence of a number of factors, which we divided into two groups: factors of the formation of resource potential and factors of its effective use (Fig. 1).

The presented factors are divided into managed and unmanaged in relation to a separate business entity. Controlling should be considered those factors of influence, the occurrence and strength of which can be regulated by the enterprise itself. This category includes the quality of material and labor resources, the company's marketing policy, the level of organization and management at the company, etc. Uncontrollable are factors of external influence, the appearance and intensity of which the enterprise can predict, but is unable to influence them. A correlation-regression analysis was carried out for the examined agricultural enterprises in order to identify the influence of individual factors, which are related to the peculiarity of the organization of agricultural production, on the efficiency of the latter.

In order to reveal the objective influence of individual factors on the efficiency of agricultural production, a correlation-regression analysis of the assessment of the activity of a group of agricultural enterprises was conducted. At the same time, in the process of analysis, the income from the sale of products based on 1 hectare of agricultural land (u) was taken as a functional criterion of efficiency.

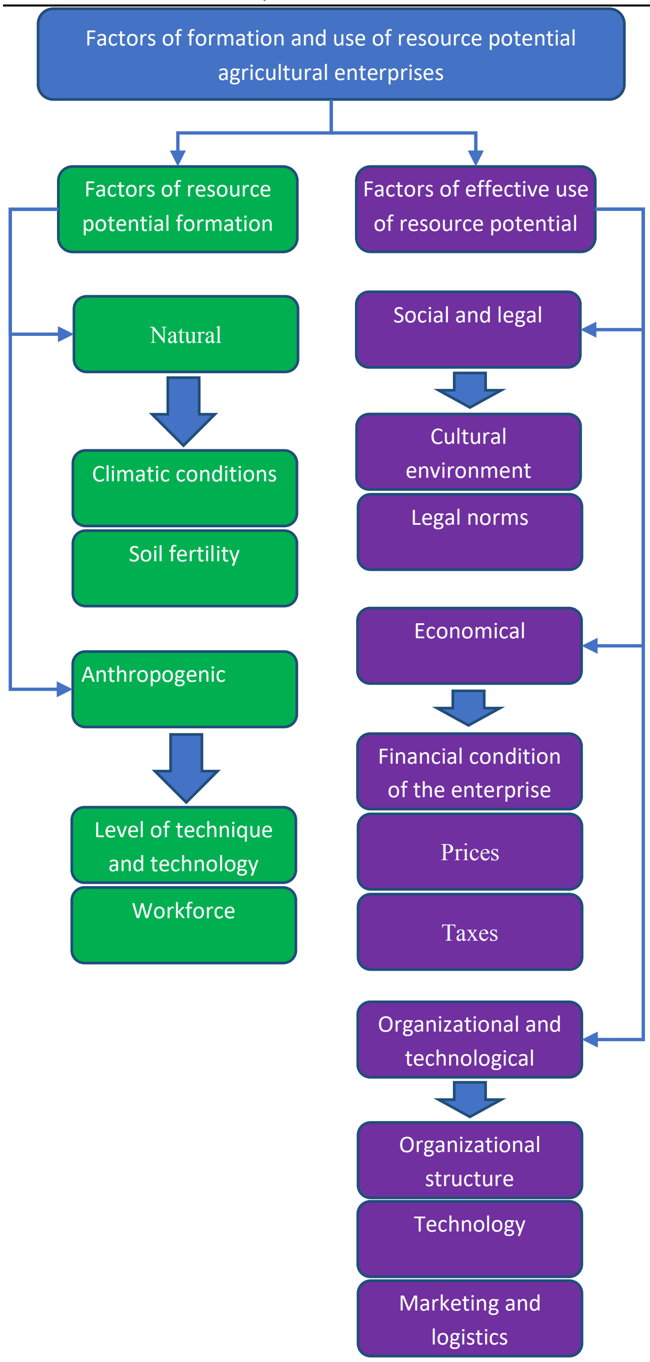

Fig. 1. Factors of formation and use of resource potential of agricultural enterprises
Source: Systematized by the authors.

Among the factors whose impact was assessed in the analysis process, the following are included:

– an average annual value of enterprise assets based on 1 ha of agricultural land, UAH (x1);
– production costs per 1 ha of agricultural land, UAH (x2);
– administrative costs per 1 ha of agricultural land, UAH (x3);
– the share of wages in the structure of production costs, % (x4);
– labor costs per 1 ha of agricultural land, man-hours. (x5);
- the share of income from the sale of animal husbandry products in the overall structure of the company's income, % (x6);
– the area of used land, which characterizes the scale of production, ha (x7).

According to the research results, the obtained regression equation has the form:

$$y = -20.2 + 0.0055x_1 + 0.6568x_2 + 0.8382x_3 -4168x_4 + 0.4071x_5 - 2.0533x_6 + 0.0234x_7$$

On the basis of the paired correlation coefficients between the effective and separate factor characteristics, it was established that there is no influence on the income from the sale of products per 1 ha of agricultural land, the value of assets per 1 ha of land (x1), the economic importance of livestock enterprises (x6) and the scale of production (x7). This indicates the irrationality of the composition of assets. A significant amount of faulty equipment or livestock premises are not used in production at all.

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In the studied group of enterprises, which had from several hundred to several thousand hectares of land at their disposal, no significant dependence of the level of income on the scale of land use was recorded. This is due to the fact that in agricultural enterprises, the land is used with varying intensity. The share of unsown arable land in agricultural enterprises of the region is marked by a growing trend. Due to the decline of livestock industries, natural fodder lands are used extremely inefficiently in many enterprises.

The influence of other factors from the population we studied is more significant. This is evidenced by the multiple correlation coefficient between them and the resulting feature, which is 0.92.

The results of the correlation-regression analysis indicated the importance of problems with the optimization of the resource potential of agricultural enterprises, a large variation in the economic efficiency of the production of certain types of products, which does not allow to form a rational specialization of the enterprise under the existing conditions, to ensure the effective use of land and labor resources, etc. This means that in order to increase the efficiency of the functioning of enterprises of the industry, it is necessary to talk not only about improving the financing of their activities, but also about improving the principles of forming and strengthening the material and technical base, developing new approaches to the use of labor resources, and developing the system of agrarian land use.

CONCLUSIONS

Therefore, the resource potential of agricultural enterprises is a necessary element of the management system. The need for strategic management of resource potential is determined by the fact that in modern conditions, inefficient use of resources reduces the competitiveness of enterprises and makes their activities irrational.

The development of a methodology for the formation of a resource strategy provides an opportunity for the enterprise to ensure the effectiveness of the process of providing its own resources. The existing situation, when the resource strategy is either not developed at all, or is part of the production strategy, leads to the fact that resources are considered as means to ensure the production process, and not as sources of competitive advantages that provide the opportunity for further development.

The given factors and conditions of strategic management of the resource potential of agricultural enterprises contribute to the further development of applied aspects of the use of the theory of resource potential by enterprises in the field of agriculture.

Further research in the resource potential management system of agricultural enterprises should, in our opinion, be aimed at identifying trends and changes regarding the expansion of economic reforms in the industry. A modern management system should promptly respond to changes in the forms of ownership in the agricultural sector, to the expansion of production and social infrastructure, various forms of small business and entrepreneurship, etc.

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DETECTION OF CUCURBIT POWDERY MILDEW, *SPHAEROTHECA FULIGINEA* (SCHLECH.) POLACCI BY THERMAL IMAGING IN FIELD CONDITIONS

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Abstract

Plant diseases are one of the leading causes of yield losses in agricultural areas. In the fight against these diseases, chemical control methods are frequently used. However, this method of combat usually begins after the disease has spread throughout the entire field. The most essential thing here is to control the disease before it spreads throughout the entire country. Thermal imaging methods can now be used to accomplish this. Plant diseases stress the plant as a result of infection. The plant's stress causes activities that cause a temperature increase or reduction in the area where the infection has occurred or has begun. Thermal imaging technologies can be used to identify this condition. This work focuses on the potential early detection of Cucurbit powdery mildew (Sphaerotheca fuliginea (Schlech.) Polacci), which causes considerable yield loss in Cucurbitaceae, utilizing thermal imaging technologies. According to the findings, the lowest temperature in infected leaf tissues was 8.2 °C, whereas the maximum temperature in plant tissues without infection was 10.2 °C. The findings suggest that thermal imaging technology could be used to identify powdery mildew in cucurbits. In this case, early detection will potentially enable the detection of the disease that has started to spread in a certain region and will allow the disease to be potentially controlled with less labor and chemical use.

Key words**:** *thermal imaging, cucurbitaceae, powdery mildew*

INTRODUCTION

Plant diseases and pests are the most significant causes of production loss in agriculture. The control generally begins after the signs of diseases and pests have spread throughout the entire field [1]; [4]. Chemical control measures are usually utilized in this instance [21]. However, the primary focus should be on preventing the spread of diseases and pests across the agricultural cultivation field [2]. At this point, early detection methods are being used. Thermal imaging technologies are typically used for this. Thermal imaging technologies are commonly used to do this [6]; [11].nStress develops in the region where the plant is damaged as a result of infection or infestation by diseases and pests. An invisible temperature increase or reduction happens in the region where this damage originates. These temperature changes are potentially detected using by thermal imaging technologies [19]; [12]; [23].

Cucurbit Powdery Mildew, *Sphaerotheca fuliginea* (Schlech.) Polacci, one of the most important diseases of *Cucurbitaceae*, causes yield loss in the areas where this plant is grown [9].
The disease appears initially on the plants' old leaves, then spreads to the young ones. Piecemeal, somewhat spherical dots form first on the top side of the leaf, then coalesce and cover both surfaces of the leaf, the petiole, and the stem. The spots look like a layer of powder of white color at first, browning as time goes on. The plant's growth halts as the leaves dry up and fall off.
As a result, product loss happens [14]; [7]; [18]; [16].nThe aim of this study was to maked a potential detection of *S. fuliginea*, which is a powdery mildew disease factor in cucurbits by using thermal imaging methods. With the detection of the disease at an early stage, it will be easier to put the cucurbits under pressure using the necessary control

methods without spreading the disease in the areas where the disease is grown.

MATERIALS AND METHODS

Temperature changes induced by the infection in the plant can be identified using thermal imaging technologies [17]. That study was carried out in the agricultural areas where cucurbits are grown in Bursa Uludağ University. The study concentrated on the potential detection of temperature changes induced by disease stress using thermal imaging technologies.

A portable thermal camera with 464 x 348 pixels and a thermal sensitivity of less than 40 millikelvin (mK) was utilized in the study.

A lens with a spatial resolution of 0.90 m/rad pixels was employed to provide more accurate imaging. Leaf surfaces that started to be infected by *S. fuliginea*, uninfected leaf surfaces and temperatures of the environment were recorded simultaneously. Samples were taken from the infected Cucurbits leaves in order to examine them in the laboratory. Conidia morphology and germ tubes were examined under a light microscope (1,000x) and the disease was confirmed as *S. fuliginea*. The FLIR Thermal Studio program was used to measure the temperatures of infected leaves, while healthy leaves served as a control.

Because various external factors might cause temperature fluctuations on the plant [5], temperature readings were taken every 30 minutes between 05.00 and 16.00 for three weeks. Furthermore, the ambient temperature was collected instantly using a portable thermometer. Performing the imaging process from a close distance during thermal imaging reduces the margin of error during imaging [15].

Therefore, in this study, all thermal imaging processes were carried out at a distance of 0.3 m from the plant leaf surface and with 90°. The statistically significant difference of the temperature differences was determined using the analysis of variance (ANOVA) technique in the JMP®7.0 program. The Student's t test was used to analyze the difference between the means (0.05).

RESULTS AND DISCUSSIONS

For three weeks, the mean temperature of the leaf surface affected with powdery mildew (*Sphaerotheca fuliginea*) and the healthy leaf surface was monitored everyday between 5:00 and 16.00. It has been discovered that the temperature differential between the diseased leaf surface and the healthy leaf surface can vary by up to an average of 4 °C depending on the period of day (Figure 1). Significant variations were found when the average weekly (21 days) temperature values of ambient, *Sphaerotheca fuliginea*-infected leaves and healthy leaves surfaces were analyzed.

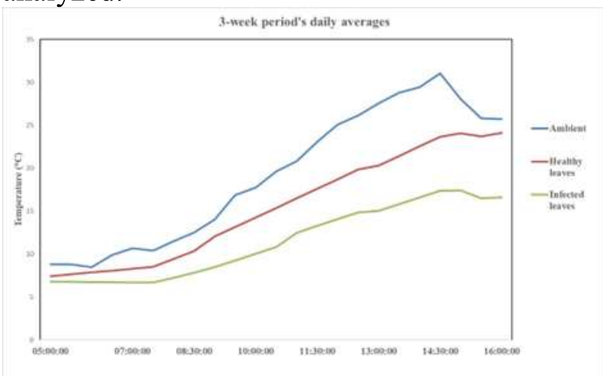

Fig. 1. The mean temperatures of infected and healthy leaves were monitored every 30 minutes between 5:00 and 16:00 on a daily basis, and their weekly (21-day) averages were shown with ambient temperature.
Source: The author's Excel calculations based on field data

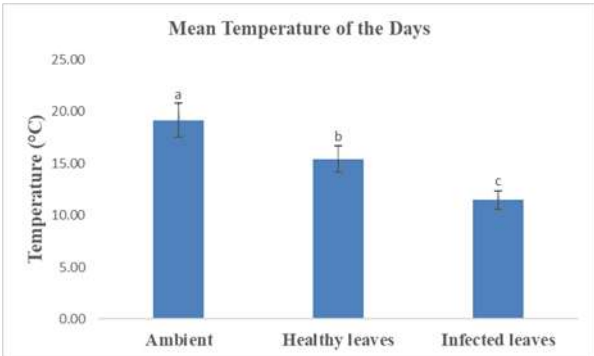

Fig. 2. Analysis of variance and Student's t test were performed with the mean of ambient, infected leaf surface and healthy leaf surface temperatures measured daily for three weeks (df: 2;66, F:8.6027, $P < 0.0001$).
Source: The author's JMP®7.0 program calculations based on field data.

According to statistics, the average weekly (over 21 days) ambient temperature is 19.17 °C, which is greater than the temperatures at the surfaces of infected and healthy leaves.

However, the mean temperature of diseased leaf surfaces (11.48 °C) is statistically lower than that of healthy leaf surfaces (15.44 °C) and ambient temperatures (Figure 2).

As illustrated in Figure 1, measurements taken between 5:00 and 16:00 in the Cucurbit production area revealed that the infected leaf surfaces were typically cooler than the healthy ones. Similarly in Photo 1, the temperature of completely infected leaf vary between 8.2 °C and 9.4 °C according to thermal imaging. However, the temperature values on the newly infected leaf were found to vary between 8.3 °C and 10.2 °C (Photo 2).

Photo 1. The lowest temperature value on the infected leaf was found to be 8.2 ^{0}C.
Source: Original thermal images taken by the authors from field

Photo 2. Temperature differences were seen on the leaf completely infected (Fig. 3.) by the disease and on the leaf where the symptoms of the infection are newly formed.
Source: Original thermal images taken by the authors from field

Cucurbit powdery mildew *S. fuliginea*, one of the most serious diseases of cucurbits, reduces the yield considerably [9]. Disease agents spread relatively quickly by wind, precipitation, and other means, especially in plant diseases. For this reason, early detection and timely control of plant diseases are of great importance [20]; [8]. Early control of diseases prevents the spread of the disease to the whole field and brings benefits such as less chemical use, less waste of time, and labor [10]; [3]. Thermal imaging methods are one of the most effective approaches for early detection. In response to infections produced by plant diseases, a temperature shift occurs in the part of the plant where the infection occurs compared to the region where the infection does not exist. These temperature changes are determined using thermal imaging methods [13]; [22]; [23].

Thermal imaging has already been used to detect certain plant diseases. Pineda et al. (2020) found that leaves infected with the tobacco mosaic virus had a significantly higher temperature increase compared to healthy leaves.

Zia-Khan et al. (2022) found a temperature differential of more than 3 °C between plant leaves contaminated with vineyard mildew and healthy plant leaves, with the temperature being greater in disease-infected plant leaves [23].

CONCLUSIONS

According to the findings of this study, the temperature of the powdery mildew-infected region ranges between 8.2 °C and 8.3 °C, while it ranges between 10.2 °C in healthy tissue. With this result, not only powdery mildew in cucurbits, but also numerous plant diseases, may be detected at an early stage without spreading to the entire field. Approaches such as the development of these approaches and their incorporation into other agricultural equipment will allow for early disease management. Thus, although the disease spreads from a specific location before spreading to the entire land, controlling it will need less manpower and chemical use. Thus, while the disease spreads from a certain area before it spreads to the whole land, it will provide less labor and chemical use by taking it under control.

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NATURAL EXTRACTS AS ALTERNATIVE ELEMENTS IN PLANT CULTIVATION TECHNOLOGIES. CASE STUDY IN OATS

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Abstract

The study evaluated the possibility of using a plant extract in the perspective of alternative plant cultivation technologies. An extract based on the herba (Urtica dioica L.) was used in aqueous solution, in a ratio of 1:10. Foliar treatment solutions were prepared from the base solution (UdE) with concentrations of 25% (V2), 50% (V3), 75% (V4) and 100% (V5), which were tested together with a control variant (V1). The biological material was represented by the Mureșana oat variety. The prepared solutions were applied in four treatments, on consecutive days, the first treatment at the stage of 4-5 leaves (15-19 BBCH code). The effect of the treatments on some biometric and plant productivity parameters was evaluated: plant height (PH), stem diameter (SD), root length (RL), plant weight (PW), root weight (RW), panicle length (PL), number of branching levels (NBL), and distance between branching levels (DbBL). Very strong correlations were recorded between SD and UdE (r=0.969), between PW and UdE (r=0.947), between RW and UdE (r=0.976), between PH and RL (r=0.961), between PW and SD (r=0.974), between RW and SD (r=0.945) and between PW and RW (r=0.951). Biometric parameters of the plants were taken into account, and based on the regression analysis it was possible to estimate with high precision the panicle length (PL) depending on the biometric parameters RL, PW and RW (p=0.0042, RMSE=1.85750), parameters which showed a close correlation with the extract concentration (UdE) applied (r=0.707 in the case of RL; r=0.947 in the case of PW; r=0.976 in the case of RW).

Key words: *agricultural technologies, alternative inputs, natural extracts, oats, prediction models*

INTRODUCTION

The innovative plant cultivation technologies are always analysed, adapted and improved, in relation to the crop plants and the agricultural production system, the climatic conditions, the level of harvests and quality indices, aspects of the product market, costs and benefits [1, 9, 19, 21, 23, 28, 34].

In the category of agricultural inputs, respectively agricultural technologies, fertilizers, biostimulators and different bioactive products occupy an important place, in the context of sustainable agriculture, and integrated agricultural practices [10, 26, 31].

In relation to the purpose of sustainable agricultural systems, the significant reduction of synthetic agrochemical products, environmentally friendly technologies, as well as from the perspective of environmental protection, there are more and more concerns, studies and research for the use of natural biostimulatory substances (plant bioactive substances, different plant extracts), which improve certain metabolic and physiological processes in crop plants (rooting, flowering, plant growth, fruiting, etc.) or production quality indices [4, 6, 7, 14, 15].

Different methods and techniques for obtaining plant extracts and bioactive compounds have been studied and developed in relation to the plant source (species), the plant part used, the category of active principles, their properties in relation to stability and bioactive effect [2, 8, 15, 17, 29].

Extracts from different plant species were studied, tested and used in order to evaluate the effectiveness of plants of economic interest (field crops, vegetables, ornamentals, etc.) [5, 24, 25, 36].

The mode of action of plant biostimulators has been studied in different plants in order to develop new biostimulators, but also to effectively integrate these products into culture technologies [29].

This study aimed to evaluate the influence of a natural extract based on the herba, *Urtica dioica* L., on some elements and parameters of productivity in crops from the grasses group (oats) and to develop some models for estimating panicle sizes, as the main element of productivity, under the influence of applied treatments.

MATERIALS AND METHODS

The study evaluated the influence of a plant extract based on the herba, *Urtica dioica* L. (UdE) on some plants of economic interest. The study took place under controlled conditions, during the 2021-2022 agricultural year.

To make the extract, plant material (herba) from the species *Urtica dioica* L. was used, harvested during the flowering phase of the plants, according to a studied methodology [25]. The extract was made in water (herba:water ratio, 1:10), from plant material (herba) collected from the species *Urtica dioica* L., figure 1. The obtained *U. dioica* extract (UdE) was used in four concentrations in aqueous solutions, 25% (V2), 50% (V3), 75% (V4) and 100% (V5), along with a control variant (V1).

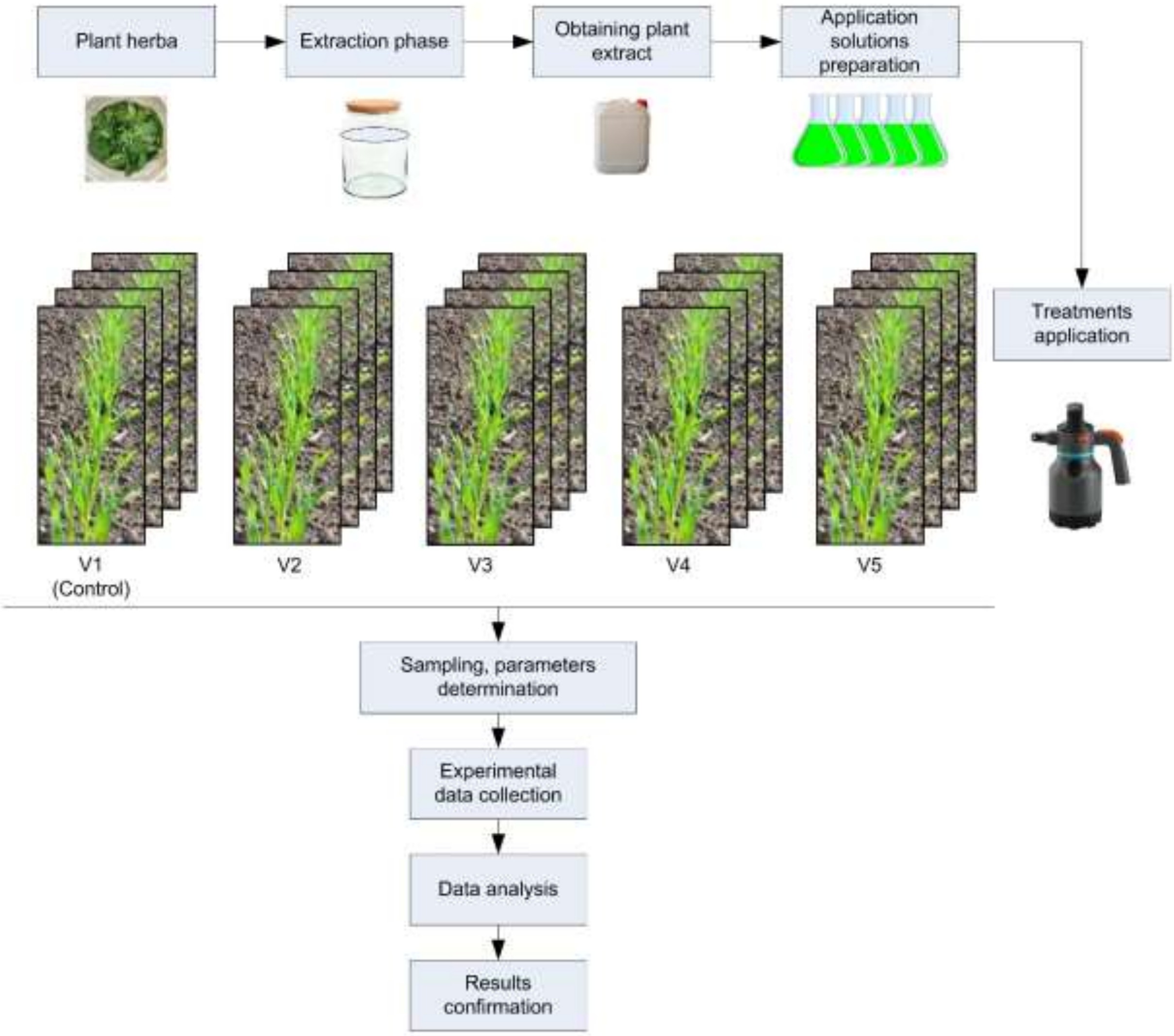

Fig. 1. The logical scheme of the experiment with plant extracts (UdE) at oats, the Mureșana variety
Source: original figure.

Oats were used as the test plant, the biological material being represented by the Mureșana oat variety. The plants were grown experimentally in pots measuring 70 × 20 × 15 cm (L × W × H). A growth substrate consisting of garden soil and compost (ratio 1:1) was used.

The treatments were applied at the 4-5 leaf stage of the plants (15-19 BBCH code, Principal growth stage 1; Leaf development)

[27]. Four treatments were applied, on consecutive days, in the mentioned concentrations and equal amounts of solutions (150 ml solution/variant). The application of the treatments was done with a manual sprayer (Figure 1).
In order to record the influence of the used extract (UdE), biometric and physiological parameters and indices were determined for the oat plants, regarding plant growth and development, biomass accumulation and productivity elements. Thus, the following parameters were determined: plant height (PH), stem diameter (SD), root length (RL), plant weight (PW), root weight (RW), panicle inflorescence length (PL), number of branching levels (NBL) and distance between branching levels (DbBL). Seven plant samples were determined on each variant.
The experimental data were analyzed according to the processing methodology and statistical interpretation of the results. ANOVA test, Correlation analysis, Regression analysis, Clusters analysis were used, and appropriate statistical safety parameters were used for the statistical safety of the results. Appropriate software applications [16, 18], and the statistical calculation module in EXCEL were used for data analysis and processing.

RESULTS AND DISCUSSIONS

The treatments with extracts of *Urtica dioica* L. (UdE, %) applied in different concentrations to the oat plants influenced the vegetation state of the plants, the rate of growth and development, aspects highlighted by parameters and physiological indices determined and the average biomass production recorded. The data set, average values, is presented in Table 1.
In relation to the experimental variants, given the extract concentrations (UdE, %), the variation in plant height was recorded between PH=97.71±1.59 cm (V1, control) and PH=108.71±3.11 cm (V4), the biomass variation between PW=9.43±1.81g (V1) and PW=21.14±1.99 g (V4), respectively of the panicle length between PL=15.00±1.02 cm and PL=18.86±0.70 cm (V4), with a number of branches BLN=3.29±0.18 and BLN= 4.00±0.22 (V3).
The ANOVA test confirmed the safety of the data and the presence of variance within the experimentally recorded value series, table 2.

Table 1. Parameter values for oat plants, depending on the foliar treatment (UdE, %) applied

Experimental variants	UdE	PH	SD	RL	PW	RW	PL	BLN	DbBL
	(%)	(cm)	(mm)	(cm)	(g)	(g)	(cm)	(no)	(cm)
V1	0	97.71±1.59	3.31±0.10	13.86±3.54	9.43±1.81	2.71±0.52	17.43±1.49	3.57±0.20	5.29±0.36
V2	25	99.00±1.00	3.69±0.20	15.93±1.68	11.86±1.91	4.14±0.63	15.00±1.02	3.29±0.18	4.14±0.34
V3	50	104.29±3.57	3.89±0.06	18.29±1.25	13.57±1.02	4.29±0.28	18.14±0.63	4.00±0.22	4.86±0.32
V4	75	108.71±3.11	4.32±0.17	19.86±1.62	21.14±1.99	6.29±0.64	18.86±0.70	3.29±0.18	5.51±0.24
V5	100	101.14±3.57	4.31±0.20	17.00±1.94	20.57±4.51	7.70±2.06	17.71±0.78	3.43±0.20	5.37±0.47

Source: original data recorded from the experiment.

Table 2. ANOVA test

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	148.2237	15	9.881578	17.2972	1.33E-22	2.8035
Within Groups	63.98347	112	0.571281			
Total	212.2071	127				

Source: original calculated data

A normal distribution of values was recorded within each series of data, on parameters determined for oat plants, under the influence of foliar treatments with plant extracts (UdE, %), under statistical safety conditions (r=0.942 for PH, r= 0.994 for SD, r=0.985 for RL, r=0.961 for PW, r=0.913 for RW, r=0.957 for PL, r=0.843 for BLN and r=0.966 for DbBL). The graphic representation of the values series distribution, for each analyzed parameter, is given in Figure 2, as a normal probability plot.

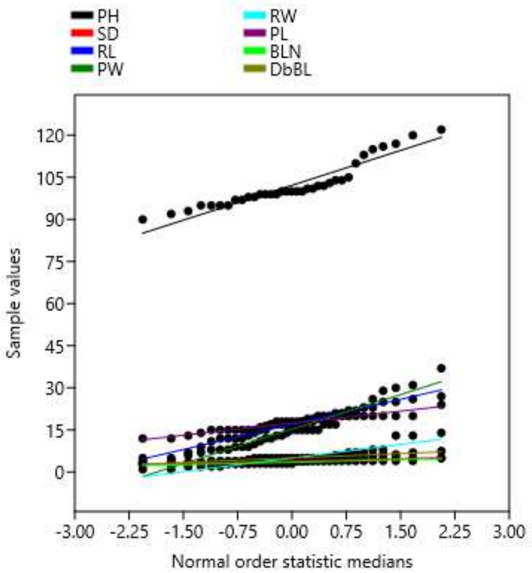

Fig. 2. The graphic distribution of the series of values within the parameters analyzed for oats
Source: original figure.

The correlation analysis highlighted the level of correlations (Figure 3) between the parameters analyzed for oats (average values), in relation to the treatments applied with plant extracts (UdE) in different concentrations. Very strong correlations were recorded between SD and UdE (r=0.969), between PW and UdE (r=0.947), between RW and UdE (r=0.976), between PH and RL (r=0.961), between PW and SD (r=0.974), between RW and SD (r=0.945), and between PW and RW (r=0.951).

Strong correlations were recorded between RL and SD (r=0.833) and between DbBL and PL (r=0.870). Other levels of correlations were also recorded, and the entire set of values of the correlation coefficient (r) is presented in Figure 3.

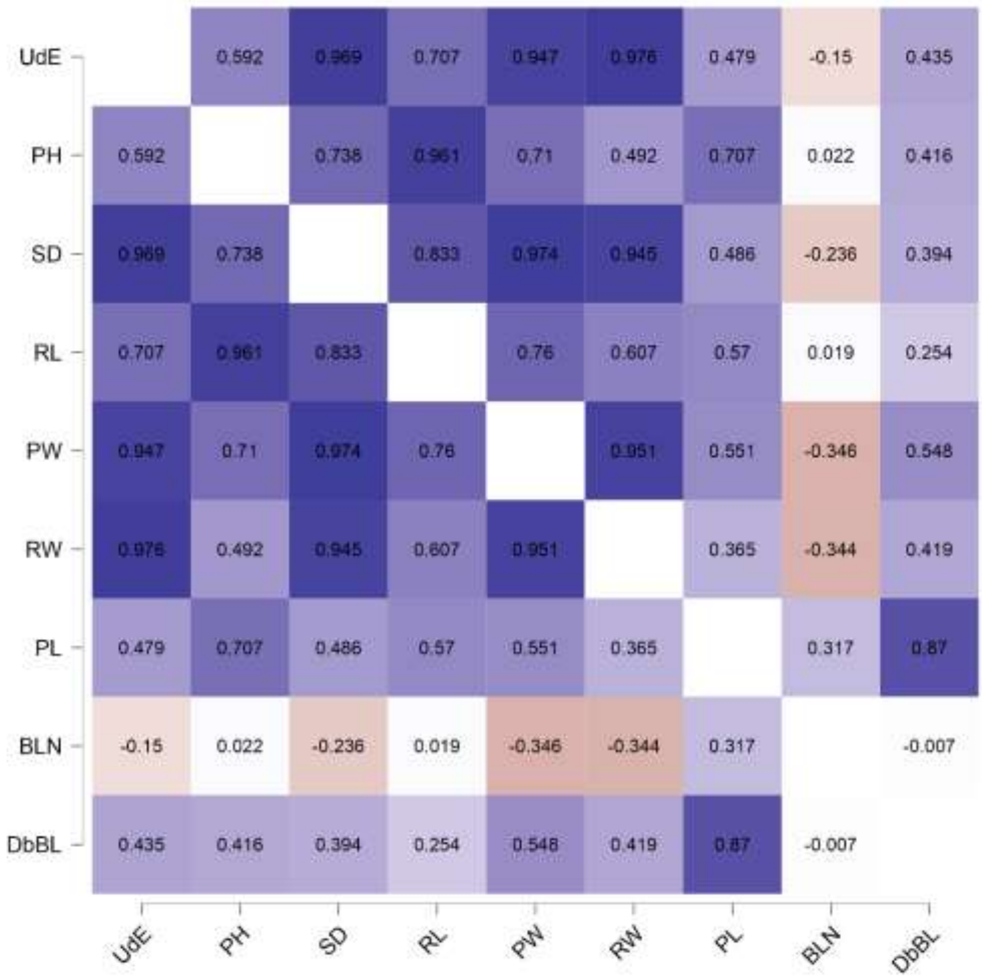

Fig. 3. The level of correlations between the studied parameters and indices, in Pearson's heatmap format
Source: original data, results by calculation.

The level of variability within the data series, for each parameter, was analyzed and quantified based on the coefficient of variation (CV). High level of variability resulted in the case of the RW parameter (CV_{RW}=62.51226), followed by the PW parameter (CV_{PW}=51.72667). The lowest level of variation was recorded for the PH parameter (CV_{PH}=7.83172). In the other parameters, intermediate values of the coefficient of variation were recorded, in descending order, CV_{RL}=33.91392, CV_{DbDL}= 20.23965, CV_{BLN}=15.99497, CV_{PL}=15.88408, and respectively CV_{SD}=14.24221.

The variation of some plant parameters and indices was evaluated in relation to the plant extract concentration (UdE, %) used.

The root system of the oat plants responded favourably to the applied treatments, so that the variation of the root length (RL) in relation to UdE was described by equation (1) under conditions of R^2=0.995, p=0.085, and the root weight (RW) was described by equation (2) under conditions of R^2=0.968, p=0.0317.

The graphic distribution of RL and RW values in relation to UdE is presented in Figure 4, respectively in Figure 5.

$$RL = -2.517E-05x^3 + 0.002559\,x^2 + 0.02725\,x + 13.9 \quad (1)$$
$$RW = 0.0002069\,x^2 + 0.02783\,x + 2.859 \quad (2)$$

where, x – UdE (%)

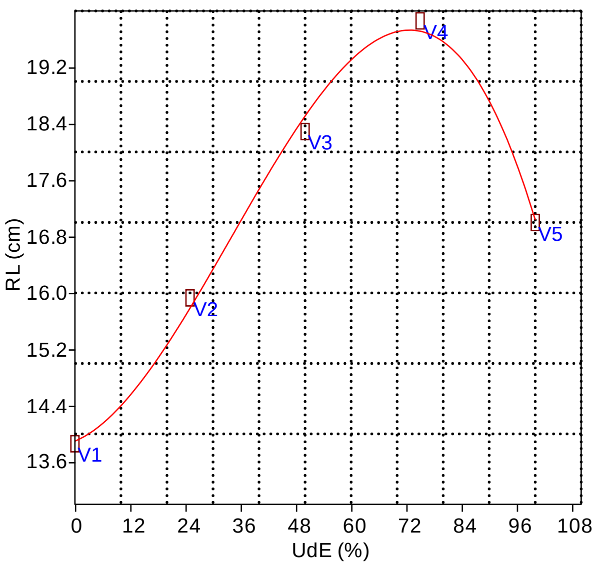

Fig. 4. RL variation depending on UdE concentration, Mureşana oat variety
Source: original figure.

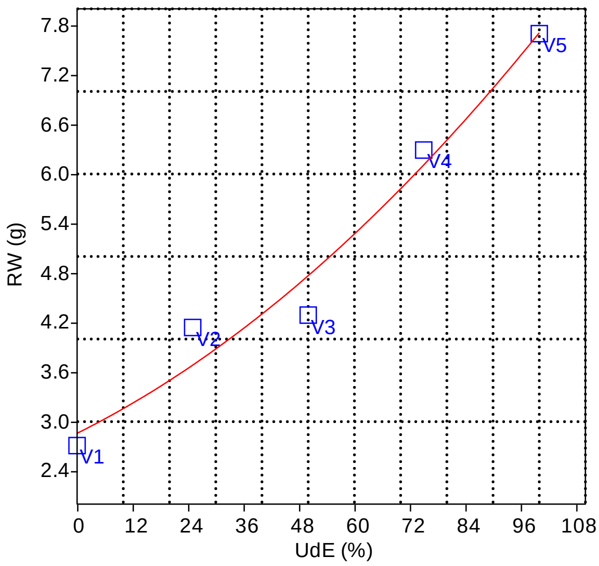

Fig. 5. RW variation according to UdE concentration, Mureşana oat variety
Source: original figure.

The variation of the SD parameter according to the concentration of UdE used was described by equation (3), under conditions of R^2=0.977, p=0.190, and the variation of plant weight according to UdE (%) was described by equation (4) in conditions of R^2=0.945, p=0.294. The graphic distribution of the SD and PW values depending on the UdE concentrations is shown in Figures 6 and 7.

$$SD = -1.387E-06x^3 + 0.0001451\,x^2 + 0.009352\,x + 3.325 \quad (3)$$
$$PW = -3.957E-05x^3 + 0.00592\,x^2 - 0.08487\,x + 9.724 \quad (4)$$

where: x – UdE (%)

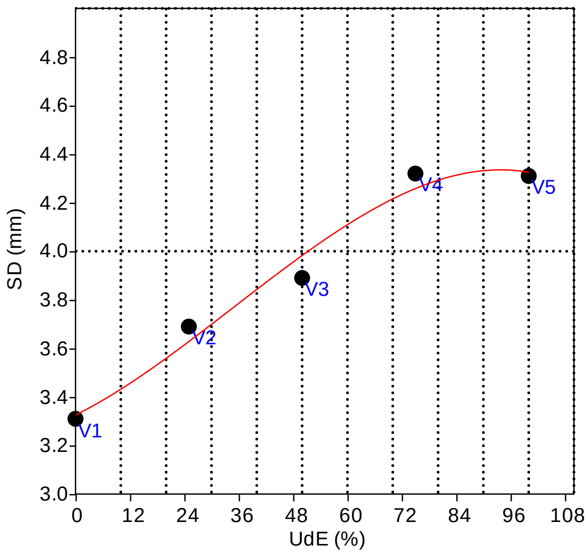

Fig. 6. SD variation according to UdE concentration, Mureşana oat variety
Source: original figure.

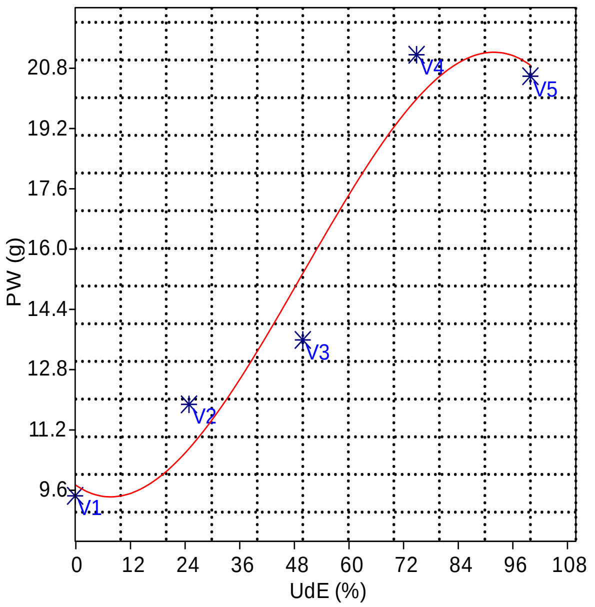

Fig. 7. PW variation according to UdE concentration, Mureşana oat variety
Source: original figure.

The oat inflorescence is of the panicle type, and the length of the panicle is a main criterion that underlies productivity and production, through length (PL), number of branching levels (BLN), distance between branching levels (DbBL), number of seeds (SN), and their weight (SW).

Based on the recorded experimental data, the variation of the panicle size (PL), in relation to the biometric parameters of the plants, under the influence of the treatments applied with plant extracts (UdE, %) was estimated, through the quadratic regression analysis. The results obtained based on the morphological parameters of the plants (PH, SD, PW, RL and RW) in different combinations, and the equation coefficients and statistical safety parameters (p, R, F test, RMSEP) are presented in Table 3.

Table 3. Panicle length estimation based on plants parameters in relation to UdE treatment, Mureşana oat variety

Statistical categories	Model code used to estimate petiole length (PL)									
	PL E1	PL E2	PL E3	PL E4	PL E5	PL E6	PL E7	PL E8	PL E9	PL E10
	Parameters and indices considered									
x	PH	PH	PH	PH	PH	PH	SD	SD	SD	RL
y	SD	SD	SD	PW	PW	RL	RL	RL	PW	PW
z	PW	RL	RW	RW	RL	RW	PW	RW	RW	RW
	Values of statistical safety coefficients									
Multiple R	0.618	0.532	0.510	0.705	0.645	0.488	0.640	0.535	0.709	0.732
R Square	0.382	0.283	0.260	0.498	0.416	0.238	0.410	0.286	0.502	0.537
Adjusted R Square	0.154	0.024	-0.006	0.305	0.206	-0.035	0.190	0.028	0.310	0.355
Observation	35	35	35	35	35	35	35	35	35	35
F	2.0117	1.2829	1.1442	3.2187	1.9775	1.0154	2.2579	1.3029	3.2772	3.7622
p	0.0810	0.2941	0.3705	0.0099	0.0861	0.4543	0.0522	0.2843	0.0090	0.0042
RMSEP	2.14439	2.31036	2.34656	1.93400	14.04880	2.38170	2.09590	2.30520	1.92530	1.85750
	Values of the coefficients of the equation									
Intercept	87.200742	-84.957308	17.827862	10.559692	32.0000000	23.5537518	-3.2092194	-20.5447880	-7.6981447	13.4422538
x^2	0.0035284	-0.0126794	-0.0005674	-0.0017037	0.0018576	-0.0015701	-0.3040822	-2.5927415	-1.9768483	0.0077124
y^2	-0.8707363	-2.3260131	-3.3456918	-0.0283810	-0.0126461	0.0001024	0.0069172	0.0146503	-0.0026943	-0.0392965
z^2	0.7093195	-0.7224707	1.3470472	2.8880152	-5.56E+15	1.7598494	0.5161569	0.3755704	-2.5029394	0.1510441
xy	0.1491629	0.1539415	0.2009427	0.0322145	0.0001576	0.0237679	-0.0885063	0.1086374	-0.1867650	0.0450109
xz	-0.0043452	0.0199062	-0.0351867	-0.0744669	-0.0008165	-0.0200645	-0.1676011	0.1573323	1.1383155	-0.1514663
yz	-0.1782185	-0.1707053	0.2511219	0.0547829	0.0010009	-0.0586626	-0.0045808	-0.0655436	-0.0291711	0.0928092
x	-1.3034940	1.8054678	-0.4518278	0.1785011	-0.3829435	0.0389372	6.1707411	19.4696865	12.654958 0	-0.2259743
y	-6.0123569	6.7792460	5.8618700	-2.0853626	0.6593543	-2.1816505	0.0629362	-0.6275692	1.5275039	0.5074138
z	0	0	0	0	1.112E+16	0	0	0	0	0

Source: original data resulting from calculation based on experimental data.

Based on the considered biometric parameters, 10 series of analyzes (PW E1 to PW E10) were made to estimate PL values, as an important parameter in the formation of useful agricultural production.

By analysis of p parameter values, it was found statistically safety in the case of PL E4 estimation ($p=0.0099$; PH, PW and RW parameters were used); in the case of PL E9 estimation ($p=0.0090$; SD, PW and RW parameters were used); in the case of PL E10 estimation ($p=0.0042$; RL, PW, RW parameters were used).

According to RMSEP parameter, equation (5), and based on the recorded values (better the lower RMSEP value), it was found that in the case of PL E10 estimation (based on the RL, PW, RW parameter) were registered the highest level of statistical safety (RMSEP=1.85750), from the entire series of estimates made.

$$\mathrm{RMSEP} = \sqrt{\frac{1}{\mathrm{n}}\sum_{j=1}^{\mathrm{n}}\left(\mathrm{y}_{\mathrm{j}} - \hat{y}_j\right)^2} \qquad (5)$$

In the respective estimation (PL E10), the root length (RL), plant weight (RW) and root weight (RW) parameters were used, important parameters in defining the level of plant development, the fruiting capacity and the formation of agricultural production.

From the correlation analysis, Figure 3, it was found that the three parameters (RL, PW, RW) used to estimate the petiole length (PL) showed very strong, positive correlations with UdE, a fact that confirms the positive influence of the treatment applied on some parameters and physiological indices of the plants, and based on these indices the size of the panicle (PL) was built, as a functional determination of the plants.

The panicle length values estimated by the 10 models (PL E1 to PL E10) were used in the cluster analysis and resulted the dendrogram presented in Figure 8, under statistical safety conditions (Coph.corr.=0.999).

The independent positioning of the PL E5 model with the highest estimation error and the grouping of the other models into two sub clusters, according to the similarity level for the productivity parameters estimated, were found.

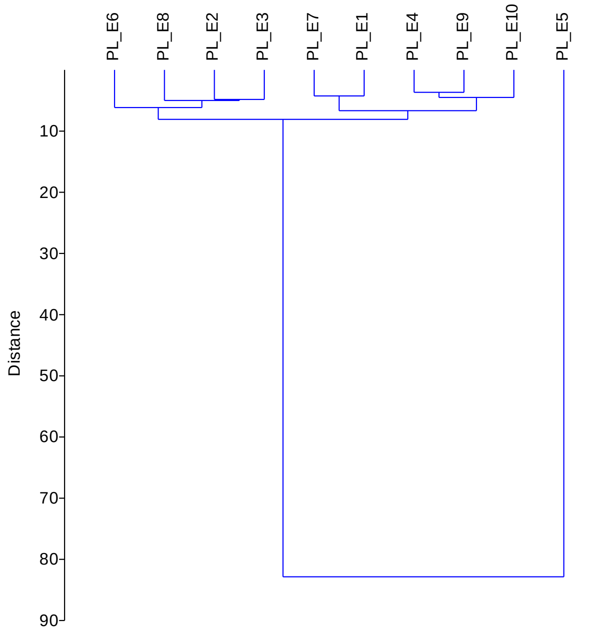

Fig. 8. Dendrogram of the models used for estimation of a productivity parameter for oats, the Mureșana variety
Source: original figure.

Based on analysis of the models grouping (Figure 8), as well as based on the SDI values (Table 4) and the statistical safety results (Table 3), it was found that the highest level of safety in the estimation of panicle size (PL) was provided by the PL E10 model. The highest level of similarity was between the models PL E4 and PL E9 (SDI=3.6572) with which it was associated (SDI=4.2399 between PL E10 and PL E9, and SDI=4.7529 between PL E10 and PL E4, respectively).

The use of bioactive substances and biostimulators in plant cultivation technologies is of great interest for the purpose of regulating plant growth, stimulating metabolic processes, alleviating effects generated by different stress factors, with favourable effects on agricultural production (quantitative and qualitative) and of the environment [20, 22, 30, 32, 35].

As a result of the bioactive compounds, *Urtica dioica* L. showed interest for pharmacy, medicine and therapeutic applications, for food (functional foods), but also for plant culture techniques [3, 8, 33].

Table. 4. SDI values in relation to PL prediction certainty based on plant parameters

	PL E1	PL E2	PL E3	PL E4	PL E5	PL E6	PL E7	PL E8	PL E9	PL E10
PL E1	0	7.2193	5.8394	6.3349	82.6970	7.4850	4.2471	6.7846	5.9423	7.2855
PL E2	7.2193	0	4.8252	8.9668	82.6500	6.2315	7.1651	5.0284	8.9695	8.9176
PL E3	5.8394	4.8252	0	8.2257	82.5640	6.7379	7.3014	4.9674	8.3625	9.2862
PL E4	6.3349	8.9668	8.2257	0	83.8710	9.6812	6.8662	8.6674	3.6572	4.7529
PL E5	82.6970	82.6500	82.5640	83.8710	0	81.7730	82.3310	83.3150	83.4480	82.9700
PL E6	7.4850	6.2315	6.7379	9.6812	81.7730	0	6.9762	5.4560	9.7223	9.0942
PL E7	4.2471	7.1651	7.3014	6.8662	82.3310	6.9762	0	6.0550	6.4433	7.0734
PL E8	6.7846	5.0284	4.9674	8.6674	83.3150	5.4560	6.0550	0	8.5816	8.2929
PL E9	5.9423	8.9695	8.3625	3.6572	83.4480	9.7223	6.4433	8.5816	0	4.2399
PL E10	7.2855	8.9176	9.2862	4.7529	82.9700	9.0942	7.0734	8.2929	4.2399	0

Source: Original data calculated based on experimental results.

Plant extracts based on nettle (*Urtica dioica* L.), applied alone or in association with extracts from other species (*Taraxacum*, *Artemisia*, *Polygonum*, *Equisetum*) exerted biostimulating activity on cabbage seedlings [11, 12]. The authors communicated the favourable influence of the treatments on the root system (length and weight), a similar effect was also recorded in this study, based on tests on oats, Muresana variety.

Favourable effects of the *Urtica dioica* extracts, along with other plants species, were also recorded and communicated regarding to leaves chlorophyll content (a+b), some root properties, the production of leaves, and some vitamin content in celery [13].

The results registered in this study, regarding the effects of *Urtica dioica* extracts in the concentrations applied to oats and under the studied conditions, are in agreement with other results communicated regarding the favourable influence of *Urtica dioica* extracts, applied alone or associated with other plant extracts, to different species of cultivated plants. The communicated results contribute to the completion of the information base regarding the effects of plant extracts in the controlling of plant vegetation, for sustainable technolo-gies, quality products and environmental protection.

CONCLUSIONS

The extracts of *Urtica dioica* L., in the concentrations used for oats, the Mureșana variety, had favourable effects on the root system, the dimensional parameters of the plants, and the size and structure of the inflorescence. At the root level, there were favourable effects on root length (RL) and root weight (RW), with increases between 14.95-43.30% in the case of RL, and 52.63-183.68% in the case of RW, respectively.

At the plants level, the applied treatments (UdE) generated different response in plant height (PH), in stem diameter (SD), and in plant weight (PW), with increases of 1.32 - 11.26% in the case of PH parameter; increases of 11.71 - 30.58% in the case of SD parameter; and increases of 25.76 – 124.24% in the case of PW parameter. At the level of the panicle-type inflorescence, there was an increase in length (PL), a positive variation in the number of branches (BLN), with increases of 1.64 - 8.20% in the case of PL parameter, and 12% in the case of BLN parameter.

Based on the regression analysis, it was possible to estimate with high precision the length of the panicle (PL) according to the biometric parameters RL, PW and RW, as determining elements in the formation of PL, and the correlation analysis confirmed the close connection of RL, PW and RW with the applied extract concentration (UdE) ($r=0.707$ in the case of RL parameter; $r=0.947$ in the case of PW parameter; $r=0.976$ in the case of RWparameter).

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COMPARATIVE ANALYSIS OF MARKETING OF BRANDED AND UNBRANDED LOCAL RICE IN BIDA, NIGER STATE, NIGERIA

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Abstract

The profit accruing to local rice especially through a well branded package generally depends on the market share of the marketers as it connotes the fastness of the time to sell off the product. The study examined the marketing of branded and unbranded local rice in Niger State, considering a data set obtained through a three stage sampling technique from 150 local rice marketers. Several analyses were conducted on the data using the descriptive statistics, marketing margin and efficiency and the binary logistic regression. A figure of ₦25, 795.40 and ₦15, 778.80 were estimated as the returns to branding and unbranded local marketing respectively. Apparently, the branded marketers are more efficient in the marketing of local rice as they have a higher marketing efficiency of 190.61 %. The enterprise is therefore concluded to be profitable and economically efficient. Educational level, marketing experience, access to grant, and cooperative society involvement were the determining factors that significantly influence branding among the local rice marketers. The recommends branding be encouraged among local rice marketers, as they stand to make more profit that their counterparts. Consequently, financial institutions such as agricultural banks should provide access to funds and facilities that would help local marketers cover for their marketing cost.

Key words: *rice, marketing, profitability, branded, un-branded, efficiency*

INTRODUCTION

The agricultural sector of Nigeria provides food for the growing population and income for millions of smallholders farmers. Considering the rate at which the country's population increases, the need arise to match the population increase with food production [15]. However, a consumer's demand deficit exists as only 60 % of such demand is met through local production and the rest via importation [21], making Nigeria the largest importer of rice in Africa [5, 7] and second in the world [3, 16].
As rice has become an important component of Nigeria's food and imported rice represents a major share of the nation's food products imports, policymakers have an increasing urge to increase the local level of rice production. Assuring technical efficiency in rice production will boost productivity and increase rice supply in Nigerian market and diminish import [1].
This is in response to the prevailing production and consumption deficit situation and attempt to achieve that, successive governments had intervened by increasing tariffs so that local production could be encouraged and a broad range of policies have been implemented in the sector aimed at self-sufficiency in the production as such high priority was given to rice production in the Agricultural Transformation Agenda (ATA) due to the growing concern about the foreign currency drains resulting from rice import [15].
Rice is a highly marketable staple and its marketing covers the performance of all business activity in the flow of paddy and milled rice from the point of production to the consumer in the right place and form. Though, with some peculiar difficulties linked to the

awareness of grading, information on market, lack of group marketing choices (coops/unions), storage as a strategy of marketing, unnecessary intermediaries, seasonal prices, limited buyers, market deficits as well as low production. Improving local rice quality by the stakeholders plays a key role in the development of the local rice market through enhanced marketing efficiency [8].

Customer acceptance through improved rice quality is germane for increased efficiency. This becomes apt as most rice in West Africa is milled by small, often portable milling machines which produces mainly low-quality, impure, mixed whole and broken grains [6]. Often times, there is lack of stock homogeneity, as the final milled rice appears discolored with stones, sand and other contaminants and with grain damaged [11]. This decreases rice quality and customer acceptance [4].

Variations exist between local rice processing and imported rice ranging from color, swelling, taste, and uniformity, thus, consumers of local rice brands prefers it because of the flavour, availability and limited use of ingredients. These variations form the major price factors between local branded rice, local unbranded rice and imported rice [3, 12]. Over time, there have been little or no changes in consumer's preferences as regards local rice. This came to bear as a result no branding as evident from products that has undergone little or no processing and packaging. In addition to the physical and sensory attributes, branding is an important determinant of consumer's preference. It is pertinent that manufacturers in the rice production industry become familiar with the concept of branding. It is against this backdrop that the study analyzed the marketing of branded and unbranded local rice in Nigeria.

In this context, the purpose of the paper was to examine the marketing of branded and unbranded local rice in Niger State, considering a data set obtained through a three stage sampling technique from 150 local rice marketers.

MATERIALS AND METHODS

Study area

Bida doubles as a city and a Local Government Area. Bida town is a Local Government Headquarter in Niger State, North-Central zone, Nigeria, located on the A124 highway (a regional road) that linked Ilorin to Minna and the Federal Capital Territory [13]. The LGA has an area of 1.698km^2 and a population of 266,008 persons [14]. It is situated between Latitudes 9°05′ and 9°083′N and Longitudes 6°01′ and 6°017′E. Located southwest of Minna, capital of Niger State is Bida, the second largest city in the State. The major ethnic group is the Nupe and the town serves as the headquarters of the Nupe Kingdom led by the Etsu Nupe. The city experiences extreme seasonal variation. Widely cultivated in Bida, is paddy rice which is grown as a cash crop.

Sampling Procedure and Sample Size

The target population for the study was the branded and unbranded rice marketers. A three stage sampling technique was used to select the sample for the study. The first stage comprised the purposive selection of four marketing clusters within the Local Government Area. This was due to the preponderance of local rice marketers in these markets. From each cluster, a snowballing technique was employed in the identification of marketers that branded their rice and those that did not. In the final stage, rice traders were randomly selected for the study across the cluster markets, giving a total of 150 marketers as shown in Table 1.

Table 1. Sample size selection across the markets

Name of markets	Number of selected marketers
Doko	65
Etsu Musa	34
Makwala	30
Union Bank Rice Traders	21
TOTAL	**150**

Source: Authors computation.

Method of Data Collection

Primary data were used in the study. This was obtained with the aid of semi-structured questionnaire designed to elicit relevant information on the socioeconomics characteristics of the marketers such as age, sex, marital status, educational status and so on. Information was also sourced on costs and returns accruing to the marketing of rice in the area.

Analytical technique

Descriptive statistical tools such as frequencies and percentages; marketing margin and efficiency; and binary logistic regression were used.

Marketing margin and efficiency

The performance of the marketers was analyzed via marketing margin and marketing efficiency, as adopted by [17, 18]. The marketing costs and profits of market participants are both integrated. The marketing margin is mathematically expressed as:

$$\text{Marketing Margin} = \text{Retail price} - \text{Farm gate price} \quad (1)$$

Marketing Efficiency is as the maximization of the ratio of output to input in marketing [19]. Marketing efficiency is calculated as:

$$\text{Marketing Efficiency} = \frac{\text{Value added by marketing (Net profit)}}{\text{Total marketing cost}} \times 100 \quad (2)$$

where:

$$\text{Value added by marketing activities} = \text{Selling price} - \text{Cost price} \quad (3)$$

Binary logistic regression

Ensuing the work of [2, 10], the model was expressed implicitly as:

$$Log\left[{}^{P_i}/_{(1-P_i)}\right] = Z\beta + E \quad (4)$$

where:

Z = matrix of observations of the explanatory variables, β = column vector of the coefficients; and E = disturbance term.

Pi = probability that a particular condition occurs.

Explicitly, the model is written thus:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + E \quad (5)$$

where:

Y = $Log\left[{}^{P_i}/_{(1-P_i)}\right]$ = Branding status of the marketers (1 if marketer brands and 0, otherwise)

X_1= Educational status of the processors (years);

X_2 = Experience (years);

X_3 = Age (years);

X_4 = Access to grant (dummy);

X_5= Credit (naira);

X_6 = Market barriers (dummy);

X_7 = Membership of cooperative (dummy);

Ɛ = error term;

$\beta_0 - \beta_7$ = regression estimate.

RESULTS AND DISCUSSIONS

The socio-economic characteristics of the two categories of marketers are presented in Table 2. Majority (66.67 % and 80.55 %) of the branded and un-branded marketers were within the age range of 31-50 years. This is an indication that marketers in the study area are still young and in their active age. This possibly will influence their ability to undergo the stress involved in the marketing activities while at the same time making rational decisions. Female marketers dominated the enterprise as the majority reported to that. This however, does not corroborate the work of [9] who reported that males are better positioned than females. The level of literacy in terms of marketers' education revealed that 65.28 % of the un-branded marketers had no formal education, with the others having primary education (23.61 %); secondary education (4.17 %) and tertiary education (6.94 %). This can however, explain their decision on not branding. The marketers who brand their rice tend to be more educated than their counterpart. Married marketers dominated the business, the likelihood of having access to a larger proportion of family labor to work for them. Experience which serves as an indicator to the marketers efficiency, showed that majority of them had an experience range of 1-10 years. This is quite enough as they are expected to be well grounded in the activities of the business. A quite surprising report was observed that majority of the marketers belong to a cooperative society or the other and their source of fund were not reported to come from such society, rather, personal savings was the major means of sourcing for funds by the marketers.

Table 2. Socioeconomic characteristics of the local rice marketers

	Branded Marketers		Unbranded Marketers	
Variables	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Age (years)				
≤ 30	16	20.51	10	13.89
31-40	28	35.90	23	31.94
41-50	24	30.77	35	48.61
51 years and above	10	12.82	4	5.56
Sex (dummy)				
Male	36	46.15	29	40.28
Female	42	53.85	43	59.72
Educational status (dummy)				
No formal education	25	32.05	47	65.28
Primary education	27	34.61	17	23.61
Secondary education	14	17.95	3	4.17
Tertiary education	12	15.39	5	6.94
Marital status (dummy)				
Single	7	8.97	2	2.78
Married	49	62.82	69	95.83
Widowed	22	28.21	1	1.39
Experience (years)				
1-10	68	87.19	50	69.44
11-20	6	7.69	11	15.29
21-30	2	2.56	5	6.94
>30	2	2.56	6	8.33
Cooperative society				
Yes	63	80.77	40	55.56
No	15	19.23	32	44.44
Source of fund				
Personal savings	23	29.49	55	76.39
Relatives and friends	55	70.51	17	23.61

Source: Survey Data, 2020.

Profitability and efficiency of the marketers

In any marketing process, costs are incurred in producing output and returns are earned from the sales of such output. Table 3 presents the summary of average costs and returns to the marketing of branded and unbranded local rice expressed in naira/tonne, which is usually used for marketing of rice in the study area.

Efforts were made to determine the cost associated with marketing of local rice and the revenue accruing to the marketers' efforts, considering the variable and fixed costs components with the profitability measured as the net marketing margin.

A difference of ₦59,088.80 was observed on the purchasing price for local rice. In the same vein, the total marketing cost incurred by the marketers of branded local rice was₦13,533.00/tonne. This was quite lesser on the part of the marketers who didn't brand their rice. Consequently, the total cost incurred by marketers not branding the rice were computed using the total marketing cost and the cost of the purchase of rice and was valued at ₦341,065.60/tonne, against a higher value of at ₦402,251.00 for those that branded. This was however attributed the cost for branding materials incurred by those who branded their product which was missing in those that didn't brand.

An average of ₦428,047.40 and ₦356,844.40 accrued to a typical local rice marketer that branded and those that didn't brand respectively and ₦25,795.40 and ₦15,778.80 is left as the net marketing margin after the removal of the total cost component respectively.

This signifies higher margin for the branded local rice marketers.

Table 3. Average marketing margin per tonne of unbranded and branded local rice

Cost Items	Unbranded local rice	Branded local rice
Purchase price of local rice (A)	329,629.20	388,718.00
Marketing Costs		
Variable costs (a)		
Bagging	4,222.20	4,661.60
Loading	791.60	666.60
Transport	3,133.40	5,302.60
Levies	569.40	153.80
Offloading	791.60	1,051.20
Fixed costs (b)		
Rent	1,000.00	1,000.00
Sanitation fee	100.00	100.00
Security fee	500.00	500.00
Storage	328.20	297.20
Total marketing cost (a+b) = (B)	11,436.40	13,533.00
Total Cost	341,065.60	402,251.00
Selling price (C)	356,844.40	428,047.40
Gross marketing margin (D) (C-A)	27,215.20	39,328.40
Net marketing margin (D-B)	15,778.80	25,795.40

Source: Survey Data, 2020.

The result in Table 4 showed the marketing efficiency for unbranded and branded local rice marketers in the study area.

For the unbranded marketers, marketing cost was ₦11,436.40, values added were ₦15,778.80 and a marketing efficiency of 137.97 % was recorded.

For the branded marketers on the other hand, marketing cost was ₦ 13,533.00, the values added to marketing of was ₦25,795.40 and190.61 % was recorded as the marketing efficiency.

This implies that marketing of local rice was efficient in the study area, though, more efficient among the branded marketers compared to the unbranded marketers.

Table 4. Marketing efficiency of unbranded and branded local rice marketers

Marketers Status	Estimates	Average cost/tone
Unbranded local rice	Marketing cost (₦)	11,436.40
	Value added (₦)	15,778.80
	Marketing efficiency (%)	137.97 %
Branded local rice	Marketing cost (₦)	13,533.00
	Value added (₦)	25,795.40
	Marketing efficiency (%)	190.61 %

Source: Survey Data, 2020.

Status of the local rice marketers

The marketers were disaggregated into two mutually exclusive groups as branded and unbranded marketers and presented in Table 5.

Table 5. Distribution of the status of rice marketers

Status	Frequency	Percentage
Unbranded	72	48.00
Branded	78	52.00
Total	150	100.00

Source: Survey Data, 2020.

Considering the snowballing approached outlined in the methodology, findings revealed that majority (52.0 %) of the marketers were those that branded their rice. The unbranded marketers constituted 48.00 % of the sampled marketers.

Factors influencing local rice marketing

The factors influencing marketing by local marketers is presented in table 6 and it states the different level of significant of the different variables.

The effects of the exogenous variables on the marketing status of the local rice marketers were investigated. Given the cross-sectional statistical nature of the data, the overall power of the model was modest with a pseudo R^2 value of 56 %. The log likelihood ratio test indicated that the overall model was statistically significant (for rejecting the null hypothesis of zero slopes). Based on the statistical significance level for the parameters used for the study, four out of the seven modelled exogenous variables were significant. The significant independent variables influencing the marketing status of the local rice marketers were educational level, experience, access to grants and membership of cooperative society.

Table 6. Determinants of local rice marketing

Variable	Coefficient	Standard error	P value
Constant	-5.049*	3.058	0.099
Educational level	0.599**	0.256	0.020
Experience	0.135***	0.043	0.002
Age	0.052	0.043	0.221
Access to grant	0.029**	0.013	0.028
Credit	0.533	1.287	0.678
Market barrier	-0.498	0.372	0.180
Cooperative society	4.456***	0.973	0.000
Diagnostic statistics			
LR Chi^2 (7) = 115.99			
Prob > Chi^2 = 0.00			
Log likelihood = - 45.86			
Pseudo R^2 = 0.56			

Source: Survey Data, 2020.
Note: *, **, *** Significant at 10%, 5% and 1 % respectively

The respective positive signs of the regression coefficients tend to explain the relationship between the variables and the branding as a status of marketing. Educational level was positive and significantly (5 %) influenced the extent of branding amongst the rice marketers. Higher educational attainment reflects on the marketers' probability of going into branding of product. The result is consistent with the findings of [20]. The likelihood exists for improvement on means of marketing via experience as this was found to be statistically significant at 1 % level. The more the numbers of years that marketers have being engaged in marketing, the higher the likelihood of incorporating branding into their marketing activities.

Access to fund and membership of cooperative society significantly influences branding by local rice marketers. By implication capital becomes an important asset that influences marketers' decision to brand. Likewise, the latter increases the probability of a marketer's propensity to brand their product.

CONCLUSIONS

Local rice marketing in the study area is profitable as revealed, having an average net margin of ₦15,778.80 and ₦25,795.40 for the un-branding and branding status respectively. This is an indication that the performance of local rice marketing based on profit is good and equally viable. Consequently, educational attainments of the marketers and their experience coupled with access to grant and their involvement in cooperative society were found to influence branding positively. Based on the findings, it was recommended that local rice marketers enlightened on the importance of branding as this will serve as a means to increase their market efficiency.

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DESIGN CONSIDERATIONS AND STRESSES ANALYSIS OF LOCAL RICE TRANSPLANTING MACHINE

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Abstract

The research aimed to design, simulate, analyze stresses then manufacture a rice transplanting machine with local materials suitable for small rice holdings. The machine was designed and the stresses were simulated by Solidworks software to ensure the integrity of the design before manufacturing themachine. The transplanting machine consists of several parts, the most important of which are: Main frame, seedlings mat, and power transmission system. The main frame and the seedlings mat were designed and stresses affecting it were simulated in order to make sure that the design is suitable for the loads placed on them. The power transmission system is one of the most important parts in the rice transplanting machine. It contains important three unit of shafts namely: the intermediate reduction unit shaft, the transplanting unit shaft, and the wheel axle unit shaft. The sprockets and rotation speed of power transmission system were determined and synchronized to achieve the desired forward speed of 1.00, 1.25, 1.50, and 1.75 km h^{-1} and achieve the recommended hill spacing of 16, 18, 20, and 22 cm.Also, the diameters of the transmission shafts were calculated based on the torsional moments exposed to them and the stresses on shafts were analyzed and simulated. The design results concluded that the shafts diameters were 25, 20 and 40 mm and the maximum von Mises stress recorded 6.75e+001,4.34e+001and 5.39e+001 MPa for the intermediate reduction unit shaft, the transplanting unit shaft, and the wheel axle unit shaft, respectively. From simulation results, it was concluded that this parts will not fail under the given stresses and the parts will not carry out any significant deformations according to the applied loading conditions then the machine was manufactured based on these results.

Key words*: *mechanical transplanting, design rice transplanter, mat,power transmission system, stress analysis

INTRODUCTION

Machine design is the creation of new and better machines and improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. In designing a machine component, it is necessary to have a good knowledge of many subjects such as mathematics, mechanics engineering, materials strength, workshop processes and engineering drawing [5]. Mechanical transplanting refers to using a mechanical seedling picking mechanism instead of workers' hands to extract seedlingsfrom the tray holes and feed them by the plantingmechanism of the transplanting machine, and then the planting mechanism drives the transplanter totransplant the seedlings into the field. The whole operation needsto ensure that, the movements areaccurate and the connection is systematic [3]. Rice transplanting machine is a specialized machine equipped with a transplanting mechanism (usually having some form of reciprocating motion) driven by the power source from the axles, to transplant rice seedlings into rice fields [6]. Mechanical transplanting using a manual transplanter is a useful transplanting machine for small and marginal farmers due to its greater capacity compared with manual transplanting [8]. Karthik [4] designed and fabricatedof manual operated women friendly paddy transplanter and stated that the designed machine should be simple in design, it should have simple mechanism to transfer power from ground wheel to planting unit, the material used for various components should be of proper strength, durability and should perform intended functions with ease, It should be light in weight and easily portable, and the machine should be of modular structure with provision for easy assembly and dismantling. Ahmed and Imran [1] designed and fabricated of engine powered two rows rice transplanting machine, they carried out the solid modelling of their machine parts by ptc creo 2.0 software package then they analyzed the different stresses on machine parts before beginning manufacture the machine. They stated that choice of parts material relayed upon the strength required and material available.Fouda et al. [2] manufactured a rice transplanting machine with local materials suitable for small rice holdings, and achieve the technical recommendations of Egyptian conditions. Also, testing and evaluating the manufactured machine under different operation conditions. The manufactured machine consists of several parts such as main frame, transplanting unit, power source, power transmission system, guide rail, seedlings mat, floats, and drive wheels. The machine contains five rows, and the distance between each row is 20 cm. Patel et al. [7] fabricated a manual rice transplanting machine and mentioned that the operator should provide the first motion. The wooden plate boards are used to keep the constant spacing between the two following seedlings. The largest sprocket is installed on the same shaft with the drive wheels; thus, the sprocket will also rotate simultaneously. The largest sprocket is connected with the smaller sprocket by using a driven chain. When the power is transmitted to the smaller sprocket, it will rotate. The speed ratio between the driver and follower sprocket is 3:1. At the same shaft transplanting finger will be fixed at the four-bar linkage mechanism so as to it will swing at a certain angle. Since the operator delivers the drive, it will not have high speed, so through this sprocket arrangement, they have increased the transplanting finger speed. As the transplanting finger oscillates, it will pick up the rice seedlings from the mat and transplant them in soil. The transplanting finger is designed so that it is easy to pick rice seedlings during the mechanism motion and also, it must pick the seedlings during the downward motion only.Rajamanickam et al. [9] fabricated a manual rice transplanter machine; they manufactured and fabricated a special wheel type that can move in puddle soil. The wheels are installed ona shaft that rotates the wheel in the same direction. This shaft is installed on a base plate through the support of the shaft plate. The driver sprocket is installed at the shaft center. The mat is made in such a way that the transplanting mechanism can pick and transplant the rice seedlings in the wet soil. The mat is connected to theplate through the mat support. The support of the mat is welded to the base plate. The mat is inclined at an angle of 60 degrees. The follower sprocket is installed at the center of the shaft. Both sprockets are connected used to a chain. As the drive wheel rotates, the power is transmitted from the driver sprocket to the follower sprocket. The follower sprocket makes the transplanting arm pick the rice seedlings and transplant themin mud. The research problem in this study lies in not following the design considerations in the manufacture of agriculture machines, which leads to breakdowns and failure in the parts of the machines during operation.Rajput et al. [10] designed and developed a hand cranked rice transplanter. The machine aimed in eliminating the hand cranking efforts. Power from the wheels was using for operating the transplanting mechanism and in order to convert force of pulling into torque. The necessary tasks like design of chain drive, design of wheel shaft, bending of wheel spokes and selection of bearings were all accomplished using appropriate considerations. After the testing it was found that the chain drives transmitted the motion in required speed ratio. Seedling spacing of 15-16 cm was also achieved as per the standard required seedling spacing. Sisay et al. [11] developed manual rice transplanting machine. They mentioned that manual transplanter is consist of a main frame assembly made of MS tube which supports the seeding mat that made of metal sheet, lever for pushing indexing mechanism of the tray, transplanting arm assembly and pull arm. The developed manual transplanter is operated by one person in puddled soil with having no standing water by pull and push action. The operator has to do multiple task in operation of the transplanting machine, first the operator moves backward, pull the transplanting machine and then push the handle arm to pick the seedling and transplanting it in mud soil. Yuvraj [12] developed a power operated paddy transplanter and the transplanter driven with petrol engine. The power from engine was transmitted for transplanting operation through the gear box that reduced the engine power to the required gear ratio. The design features of the developed transplanter involved a wooden float in place of metal sheet float. Therefore, the objectives of the current study are todesign, simulate and analyze the stresses thenmanufacture a rice transplanting machine with local materials suitable for small rice holdings and achieve the technical recommendations of Egyptian conditions.

MATERIALS AND METHODS

The rice transplanting machine was designed and simulated at Agricultural Engineering Department, Faculty of Agriculture, Tanta University then manufactured and tested at the Rice Mechanization Center, Agricultural Engineering Research Institute, Egypt.

Solid modelling

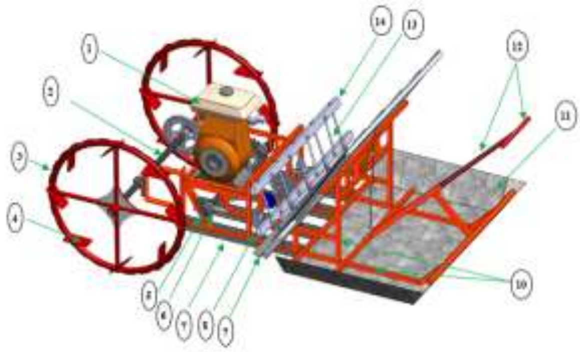
Solid modelling and stresses analysis simulation of the different machine parts carried out by Solidworks software package 2016. After the solid modelling and important calculation has been finalized, the machine was built and manufactured according to the simulation and analysis results.

Description of the manufacturing rice transplanting machine

The manufacturing rice transplanting machine consists of several major parts as shown in Fig. 1. The machine was designed and manufactured to transplant 5 rows, the distance between one row and the other is 20 cm.

Working theory

As the engine runs, the main sprocket rotates and operates the transmission system (intermediate reduction unit, transplanting unit, and wheel sprockets). The transplanting unit delivers its motion from the intermediate reduction unit using sprockets and chains, the crankshaft transfers the movement to the transplanting arm using four bar linkage mechanism and makes it rotate in an elliptical path.



No.	Item	No.	Item
1	Engine	8	Tine holder
2	Wheel axle shaft	9	Guide rail
3	Drive wheel	10	Main frame
4	Drive wheel lug	11	Main float
5	Intermediate reduction unit shaft	12	Handle arm
6	Bearing	13	Tension spring
7	Secondary float	14	Pushing rod holder

Fig. 1. Isometric of the rice transplanting machine
Source: Authors' drawing.

While, the transplanting arm is reached to its upper position, the planting tines pick up the seedlings from the seedling mat through the holes in the guide rail, and at the same time, the cams press on the levers which lift the seedling push holder with five pushing rods upwards until the planting tines can pick up the seedling. As the rotation continues, the transplanting arm is reached to its lower position and the planting tines carry the seedlings to the soil surface in a standing position at this moment the cams release the levers and the springs pull the seedling push holder downwards to push the seedlings into the soil in a specified depth by seedling push rods. Drive wheels delivered their motion from the intermediate reduction unit using sprockets and chains tomove the rice transplanter forward. The wheels are provided with fins so that they can travel easily in the mud. The drive wheels are used to maintain a constant distance between seedlings.

Main frame Design

The frame is the main component of the transplanting machine, which supports different parts such as the transplanting mechanism, transmission system mechanism, drive wheels' assembly, seedlings mat assembly and mat movement mechanism. Square mild steel hollow sections (20×20×1.25 mm, height, width, and thickness, respectively) was selected to manufacture the main frameof rice transplanting machinebecause it is high yield strength and is light in weight at the same time. The square mild steel hollow sections sticks were cut to several different lengths and welded together by 43 welding points to fit the machine parts, as shown in Fig. 2. The frame was designed and perform a stress analysis simulation on it by the Solidworks software and then it was implemented. The main frame dimensions were 1,500×950×500 mm, length, width, and height, respectively

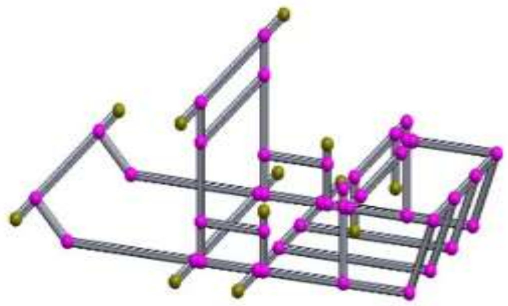


Fig. 2. Welding point of the rice transplanting machine main frame
Source: Authors' drawing.

Seedlings mat Design

The seedlings mat is the main component, which carries the seedlings to be transplanted. Basic factors (width, length, angle, speed of movement) are considered in designing the mat mechanism. Seedlings mat width depends on the number of rows to be transplanted. It should be adjusted to the required angle necessary for the continuous downward movement of seedlings. The inclination angle of the mat was determined by placing the seedlings on the mat, then raising the mat until the seedlings began to descend downward, then measuring the inclination angle of the mat, which was 55 degrees. The mat was designed on the Solidworks software, and all its measurements were set; then it was manufactured from galvanized steel sheet with dimensions of 1,045 × 740 mm, width and length, respectively, with a thickness of 0.7 mm to reduce the weight, and it was divided into 5 parts by a square mild steel hollow sections with a dimension of 15×15×1,000 mm height, width and length, respectively, and the width of every part was 191 mm, then supported from the rear side by a 20×20 mm square mild steel hollow sections frame as shown in Fig. 3.

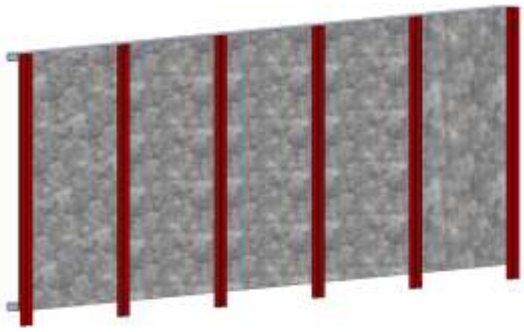


Fig. 3. The seedlings mat
Source: Authors' drawing.

Power transmission mechanism design

Engine

The maximum output power of the engine is 2.5 kW attached with internal gearbox give rotational speed (depending on the fuel throttle position) between 60-120 rpm and we fix the rotation speed at 85 rpm. The engine output shaft is supplied with four different sprockets with 20, 25, 30, and 35 teeth to change the machine's forward speed in the field.

Drive wheel

The diameter of the ground wheel D = 60 cm. The circumference of the ground wheel was calculated using the following equation:

Circumference of drive wheel = πD…....(1)

Circumference of the drive wheel = π (60) = 188.4 cm.

Power transmission system

Velocity of machine

The normal human walking speed is 1 m/s (3.6 km/h), butwalking speedsin the mud are lower,whichis taken as 0.5 m/s (1.8 km/h).

The angular speed of the wheel was determined according toKhurmi and Gupta [5] as following equations:

$$\omega = V/r \quad \text{......(2)}$$

$$N = 60\omega/2\pi \quad \text{......(3)}$$

where:
ω = Angular speed of the wheel, rad/seconds
v = Average walking speed of a man, m/s
r = Radius of the wheel, m
N = Revolution of the wheel in a minute
Adopted walking speed of a man v = 0.5 m/s
Radius of the ground wheel r = 0.3 m
ω =0.5/0.3=1.66 rad/sec
N = (60×1.66)/2π=15.93 rpm
So N of wheel is 15.93 rpm.

Velocity ratio

It is the ratio between the velocities of the driver and the follower or driven. It may be express, mathematically, determined according toKhurmi and Gupta [5] as following equations:
Let:
N1 = rotation speed of the driver (engine output sprocket), rpm
N2 = rotation speed of the follower (drive wheel sprocket), rpm
T1 = number of teeth of engine output sprocket. (Assumed 30 teeth)
T2 = number of teeth of drive wheel sprocket

$$\boldsymbol{Velocity\ ratio} = \frac{\boldsymbol{N1}}{\boldsymbol{N2}} = \frac{\boldsymbol{T2}}{\boldsymbol{T1}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (\mathbf{4})$$

N2= (30×85)/15.93=160 teeth
Unfortunately, that sprocket is not available in stores, so the machine was provided with an intermediate reduction unit to obtain the required rotation speed with the available materials.

Intermediate reduction unit

The intermediate reduction unit contains three different sprockets, the first one delivers the motion from the main engine sprocket and it calls the main intermediate reduction unit sprocket. The second one transfers motion from the intermediate reduction unit to the transplanting unit and the third transfers the motion from the intermediate reduction unit to the drive wheel unit. There must be a synchronization between the rotation speed of the drive wheel and the rotation speed of the transplanting unit in order to obtain the required transplanting spacing.
To reduce the rotation speed, the follower sprocket must be larger than the drive sprocket; therefore, an available sprocket with 49 teeth was installed as a main intermediate reduction unit sprocket. Also, another sprocket of 49 teeth was installed on the wheel axle.
So, the velocity ratio of the machine was as presented below.
Let:
N1 = rotation speed of the driver (engine output sprocket), rpm
N2 = rotation speed of the follower (main intermediate reduction unit sprocket), rpm
N3 = rotation speed of the driver (wheel driver sprocket on intermediate reduction unit), rpm,
N4 = rotation speed of the follower (wheel follower sprocket on wheel axle), rpm,
N5 = rotation speed of the driver (transplanting unit driver sprocket on intermediate reduction unit), rpm,
N6 = rotation speed of the follower (transplanting unit follower sprocket), rpm,
T1 = number of teeth of engine output sprocket. (Assumed 30 teeth)
T2 = number of teeth of main intermediate reduction unit sprocket (Assumed 49 teeth)
T3 = number of teeth of wheel driver sprocket
T4 = number of teeth of wheel follower sprocket
T5 = number of teeth of transplanting unit driver sprocket
T6 = number of teeth of transplanting unit follower sprocket

$$\boldsymbol{Velocity\ ratio}\ (\mathbf{1}) = \frac{\boldsymbol{N1}}{\boldsymbol{N2}} = \frac{\boldsymbol{T2}}{\boldsymbol{T1}} \qquad = \frac{\mathbf{85}}{\boldsymbol{N2}} = \frac{\mathbf{49}}{\mathbf{30}}$$

N2 = (30×85)/49=52 rpm
Rotation speed of main intermediate reduction unit sprocket = 52 rpm
So, N3 = N2 = 52 rpm, because they installed in the same shaft

$$\boldsymbol{Velocity\ ratio}\ (\mathbf{2}) = \frac{\boldsymbol{N3}}{\boldsymbol{N4}} = \frac{\boldsymbol{T4}}{\boldsymbol{T3}} = \qquad \frac{\mathbf{52}}{\mathbf{15.93}} = \frac{\mathbf{49}}{\boldsymbol{T3}}$$

T3 = (49×15.93)/52= 15 teeth
Number of wheel drive sprocket teeth = 15 teeth

$$\boldsymbol{Velocity\ ratio}\ (\mathbf{3}) = \frac{\boldsymbol{N5}}{\boldsymbol{N6}} = \frac{\boldsymbol{T6}}{\boldsymbol{T5}}$$

N5 = N6 = 52 rpm, because they were installed in the same shaft

As, the recommended intra-row hill spacing is 20 cm and it must be a synchronization between the rotation speed of the drive wheel and the rotation speed of the transplanting unit in order to obtain the required transplanting spacing.

$$\boldsymbol{Transplanting\ spacing = \frac{\pi \times D \times N4}{N6}} \ldots\ldots\ldots \mathbf{(4)}$$

$$20 = \frac{\pi \times 60 \times 15.93}{N6}$$

N6 = 154 rpm, rotation speed of the transplanting unit follower sprocket.

A cassette sprocket with seven sprockets (speeds) starting from 12 to 28 teeth is used as a transplanting unit follower sprocket to obtain different intra-row hill spacing. Its purpose is to change the number of hits of the transplanting unit per unit distance). So,

$$\frac{52}{154} = \frac{(assumed)\ 16}{T5} \qquad = \frac{154 \times 16}{52} = 47.38\ teeth$$

So, number of teeth of transplanting unit drive sprocket = 48 teeth.

The forward speed and intra-row hill spacing changed in the field due to slippage, so the slip ratio, % was determined by using the following equation:

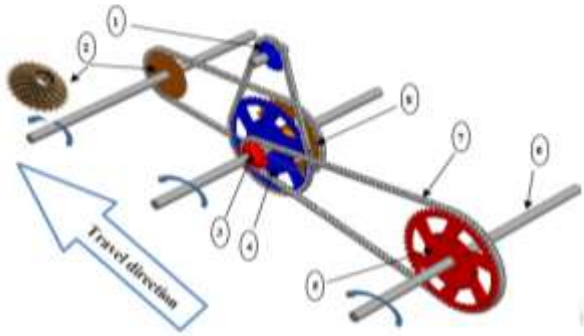
$$\boldsymbol{S = \frac{L1 - L2}{L1} \times 100} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(5)}$$

where:
S = Slip ratio, %;
L1 = Advance per 10 revolutions of the wheel on asphalt, m;
L2 = Advance per 10 revolutions of the wheel on the tested surfaces, m;
S = (18.84-15.73)/18.84×100=16.50%.

<u>Design of machine shafts</u>

The material used for shafts should have the following properties:
1. It should have high strength.
2. It should have good machinability.
3.It should have high wear resistant properties

The transplanting machine contains three main shafts namely, intermediate reduction unit shaft, transplanting unit shaft and wheel axle shaft, as shown in Fig. 4. When the shaft is subjected to a twisting moment (or torque) only, then the diameter of the shaft may be obtained by using the torsion equations according to Khurmi and Gupta [5].



No.	Item	No.	Item
1	Main engine sprocket	5	Wheel follower sprocket
2	Transplanting unit follower sprocket (cassette sprocket)	6	Shaft
3	Wheel driver sprocket	7	Chain
4	Main reduction unit sprocket	8	Transplanting unit driver sprocket

Fig. 4. Schematic view of the power transmission system
Source: Authors' drawing.

Equivalent twisting moment (T_e)

$$\boldsymbol{T = \frac{\pi}{16} \times \tau \times d^3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(6)}$$

Torque transmitted by the shaft,

$$\boldsymbol{T = \frac{P \times 60}{2\pi \times N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(7)}$$

where:
T = Twisting moment acting up on the shaft, Nm
P = Power transmitted by the shaft, W
N = Rotation speed of shaft, rpm
τ = Torsional shear stress, N/m^2
d = Diameter of the shaft, m

The power generated by the engine based on fuel consumption will be P= 1,300 W.

Tangential force on the gear

$$\boldsymbol{Ft = \frac{2T}{D}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(8)}$$

where:
Ft = Tangential force on the gear, N
D = Diameter of sprocket

The normal load acting on the tooth of the sprocket

$$\boldsymbol{W = \frac{Ft}{cos \propto}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(9)}$$

where:

W = Normal load acting on the tooth of the sprocket, N
Ft = Tangential force on the gear, N
∝ = Pressure angle, deg
Since the sprocket is mounted in the middle of the shaft, therefore,

The maximum bending moment at the center of the gear

$$M = \frac{W \times L}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

where:
M = Maximum bending moment at the center of the gear, Nm
W = Normal load acting on the tooth of the sprocket, N
L = Length of the shaft, m

Equivalent twisting and bending moment

$$T_e = \sqrt[2]{M^2 + T^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$

Twisting stress

$$\tau = \frac{16\,T}{\pi d^3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

where:
τ = Torsional shear stress, N/m^2
T = Twisting moment acting up on the shaft, N. m
d = Diameter of the shaft, m.

RESULTS AND DISCUSSIONS

The data obtained from the present study could be summarized under the following headings.

Static stress and displacement simulation analysis of the transplanting machine main frame.

The main frame of the transplanting machine was designed and the staticstress analysis simulation wasperformed on it by the Solidworks software to know if the design is safe ore not as shown in Fig. 5 and Fig. 6.The data in the Fig. 5 indicated that the maximum upper bound axial and bending stress was 1.755e+2 MPaand from the simulation results, it is concluded that this part will not fail under the given stresses as the maximum stress are much lower than the yield strength of the part. Also, the minimum and the maximum displacement occur on the main frame was very small and recorded 1.00e-030 and 4.159e+000 mm, respectively as shown in Fig. 6. From the simulation results, it is concluded that this part will not carry out any significant deformations according to loading conditions applied.

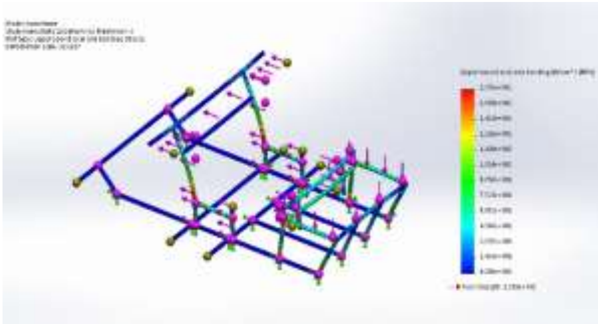


Fig. 5. Upper bound axial and bending stress simulation of the machine main frame.
Source: Authors' determination.

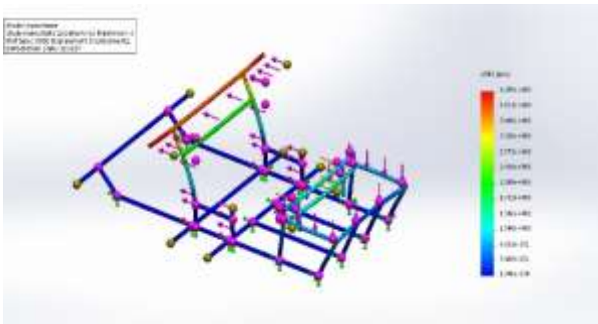


Fig. 6. Static displacement simulation of the machine main frame.
Source: Authors' determination.

Static stress and displacement simulation analysis of the transplanting machine seedling mat

The seedlings mat is the main component, which carries the rice seedlings trays to be transplanted.The loads affecting the seedling mat, which is the weight of the seedlings, were placed on the Solidworks software, and then the simulation was performed. The maximum static von Mises stress was too low compared with material yield strength, where it was recorded at 4.267e-002 MPa compared with 2.500e+002 MPa for the part material, as shown in Fig. 7. In addition to that, the data in Fig. 8 show very low deformation and the maximum static displacement recorded 5.903e-005 mm, and from this results, it is concluded that the design is safe.

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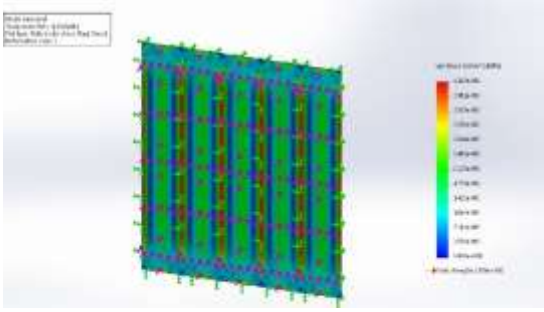

Fig. 7. Von Mises stress simulation of the machine seedlings mat.
Source: Authors' determination.

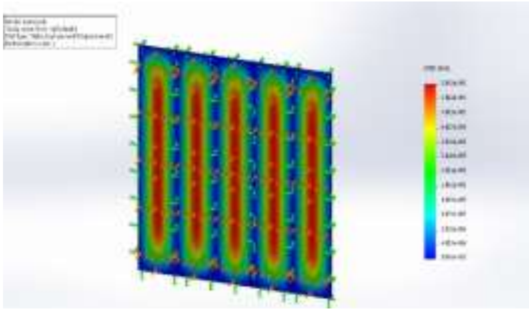

Fig. 8. Static displacement simulation of the machine seedlings mat.
Source: Authors' determination.

Transplanter velocities and hill spacing

It is very important to determine the required forward speeds for the transplanting machine and the desired and recommended hill spacing; even we can determine the shaft's rotational speeds and the sprocket teeth number, which achieve this desired aim. The data in Table 1 illustrate all of the shafts' rotational speeds as well as the sprockets that have been calculated in the design and installed in the machine to obtaindesired forward speeds of 1.00, 1.25, 1.50, and 1.75 km h^{-1}, as well as the rec ommendedintra-row hill spacing of 16, 18, 20, and 22 cm. It is also clear from the table that the synchronization between the rotation speeds of the drive wheel and the rotation speeds of the transplanting unit with the forward speeds of the machine was taken into account precisely so that the hill spacing is kept constant while changing the forward speeds of the machine.

Power transmission system design

Table 1. Specifications of sprockets, forward speeds and intra-row spacing of the transplanting machine

Main engine sprocket		Main intermediate unit sprocket		Wheel driver Sprocket		Wheel follower sprocket		Transplanting unit driver sprocket		Transplanting unit follower sprocket		Forward Speed, km/h		Intra-row hill spacing, cm	
teeth	rpm	teeth	rpm	teeth	rpm	teeth	rpm	teeth	rpm	teeth	rpm	Out field	In field	Out field	In field
20	85	49	34.69	15	34.69	49	10.62	48	34.69	16	104.08	1.20	1.00	19.24	16
										18	92.51			21.64	18
										20	83.26			24.05	20
										22	75.69			26.45	22
25	85	49	43.36	15	43.36	49	13.27	48	43.36	16	130.10	1.50	1.25	19.24	16
										18	115.64			21.64	18
										20	104.08			24.05	20
										22	94.61			26.45	22
30	85	49	52.04	15	52.04	49	15.93	48	52.04	16	156.12	1.80	1.5	19.24	16
										18	138.77			21.64	18
										20	124.89			24.05	20
										22	113.54			26.45	22
35	85	49	60.71	15	60.71	49	18.58	48	60.71	16	182.14	2.10	1.75	19.24	16
										18	161.90			21.64	18
										20	145.71			24.05	20
										22	132.46			26.45	22

Source: Authors' determination.

Dimensions analysis of machine shafts

It is very necessary to design the power transmission shafts in the machines to determine the required diameter of the shafts, as well as the type of material it is manufactured from, in order to avoid any collapses in the machine during operation. The diameter of the shafts is determined according to the aforementioned design equations by determining the engine powerand therotation speeds of shafts, then determining the torque transmitted by this shaft. The data in Table 2 shows the diameters of the transmission shafts for the different parts of the machine that were calculated with taking into consideration the of a safety coefficient in the calculation as well as all the moments, forces and stresses that effect on those shafts. The shaft diameters of the intermediate reduction unit, transplanting unit, and wheel axle unit were 25, 20, and 40 mm, respectively, and the calculated twisting stress for the three units were, 66.65, 43.38, and 53.16 MPa, respectively.

Table. 2. Dimensions analysis and the moments affecting onthe power transmissionshafts

Unit	Intermediate reduction unit shaft	Transplanting unit shaft	Wheel axle unit shaft
Engine power, Kw	1.30		
Shaft rotation speed, rpm	60.71	182.14	18.58
Torque, N.m	204.48	68.15	668.14
Diameter of sprocket, m	0.20	0.07	0.2
Tangential force on the gear (Ft), N	2,044.81	1,947.33	6,681.42
Normal load acting on the tooth of the sprocket (W), N	2,176.04	2,072.31	7,110.22
Length of the shaft, m	0.7	0.4	1.2
Bending moment at the center of the gear (M), N.m	380.80	207.23	2,133.06
Twisting moment (Te), N.mm	432,220	218,140	2,235,250
Shaft material yield strength, MPa	250	250	250
Shaft diameter, mm	20.64	16.44	35.70
Shaft diameter with 25% safety factor	25	20	40
Twisting stress (τ), MPa	66.65	43.38	53.16

Source: Authors' determination.

Stresses analysis simulation of the machine shafts

Intermediate reduction unit shaft

The diameter of the intermediate reduction unit shaft was calculated, which was 25 mm, and then the shaft was designed on the Solidworkssoftware in order to simulate the stresses on the shaft, as well as the deformation that occurred as a result of those stresses, in order to ensure the integrity of the design as shown in Fig. 9 and Fig. 10.

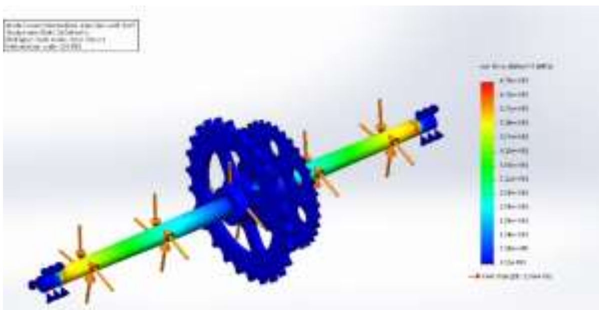

Fig. 9. Von Mises stress simulation of the intermediate reduction unit shaft
Source: Authors' determination.

The data in Fig 9 show the von Mises stresses of the shaft, which was much lower than the yield strength of the shaft material. The maximum von Mises stress was 6.75e+001 MPa and the minimum von Mises stress was 4.31e-006 MPa, while the yield strength of the shaft material was 2.50e+002MPa.

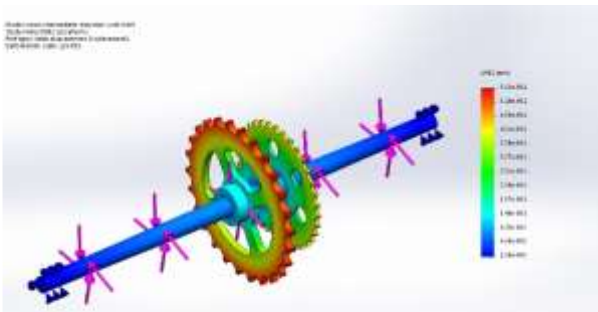

Fig. 10. Static displacement simulation of the intermediate reduction unit shaft
Source: Authors' determination.

Also, Fig. 10 shows the static displacement simulation of the shaft and from the figure, it is clear that the displacement occurred with a small amount in the sprockets installed on the shaft andthe maximum static displacement was 5.61e-001 mm.

Transplanting unit shaft

The transplanting unit shaft is one of the most important shafts in the machine because it transfers the movement to the transplanting arm. The transplanting unit shaft is designed and simulated by the Solidworks software, as shown in both Fig. 11 and Fig. 12. From the simulation results, it is concluded that this part will not fail under the given stresses as the maximum von Mises stress was 4.34e+001 MPa which are much lower than the yield strength of the part which was 2.50e+002 MPa as shown in Fig. 11. Also, from the simulation results shown in Fig. 12, it is concluded that this part will not carry out anysignificant deformations according to the loading conditions applied. In addition to that, the minimum and the maximum static displacement recorded, 6.47e-008 mm and 1.63e-001 mm respectively.

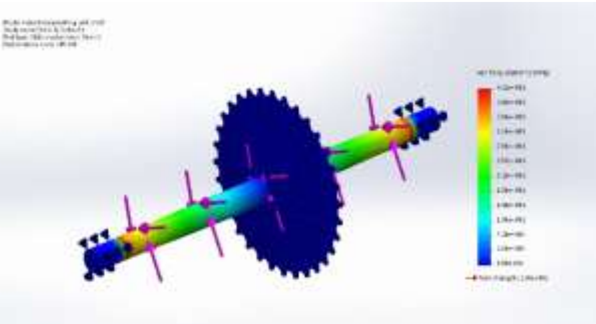

Fig. 11. Von Mises stress simulation of the transplanting unit shaft
Source: Authors' determination.

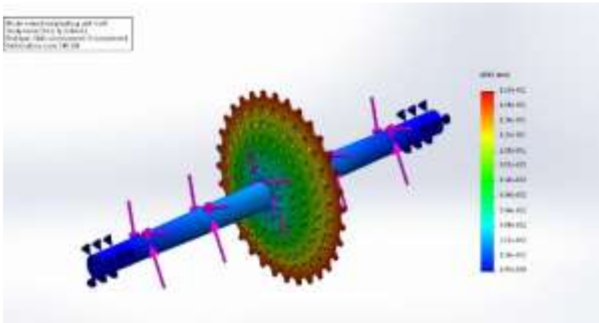

Fig. 12. Static displacement simulation of the transplanting unit shaft
Source: Authors' determination.

Wheels axle unit shaft

The diameter of the drive wheel shaft was calculated to be 40 mm, in order to withstand the torque applied to it, especially since the drive wheels of the transplanting machine are moving in the mud. The data of the axle shaft was placed in the Solidworks software, then the shaft was designed and a simulation of the stresses on it was performed. The von Mises stress simulation of the shaft is shown in Fig. 13 and the minimum von Mises stress recorded 1.49e-005 MPa and the maximum von Mises stress recorded, 5.39e+001 MPa, which was lower than the yield strength of the shaft material. Whereas, the maximum static displacement was 5.10e-001 mm, as shown in Fig. 14. From simulation results, it is concluded that this part will not fail under the given stresses as the maximum stress is much lower than the yield strength of the part and this part will not carry out anysignificant deformations according to the loading conditions applied.

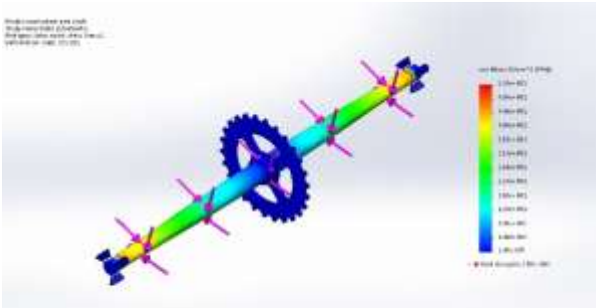

Fig. 13. Von Mises stress simulation of the wheel axle unit shaft
Source: Authors' determination.

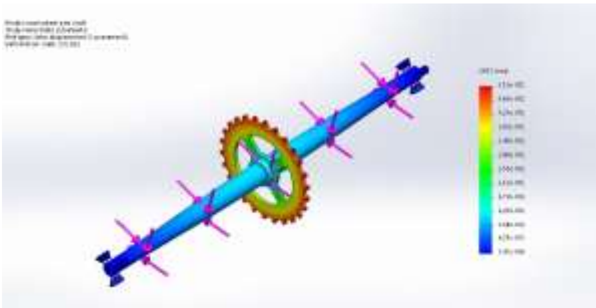

Fig. 14. Static displacement simulation of the wheel axle unit shaft
Source: Authors' determination.

CONCLUSIONS

The research aimed to design, analyze stresses and simulate then manufacture of a rice transplanting machine with local materials suitable for small rice holdings. The machine was designed and the stresses were simulated by Solidworks software to ensure the integrity of the design before manufacturing it. The power transmission system was designed to achieve the desired forward speed of 1.00, 1.25, 1.50, and 1.75 km h^{-1} and achieve the recommended intra-row hill spacing of 16, 18, 20, and 22 cm. Also, the main frame and the seedlings mat were designed and simulated. Finally, the diameter and the torsional moments of the different machine shafts were calculated then the static stresses and displacements on the shafts were simulated. From simulation results, it is concluded that this parts will not fail under the given stresses and the parts will not carry out any significant deformations according to the loading conditions applied.

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3D PRINTING TECHNOLOGY AS AN EFFECTIVE SOLUTION TO BUILD THE FABA BEAN SEED METER PLATE WITH VARIOUS MATERIALS

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Abstract

The difference in some dimensions of the seeds prevents the optimal determination of the dimensions and shape of the holes in the feeding device, which reduces the efficiency of seed distribution during planting. The design and building of metering plates suitable for the faba bean seeds from material that is affordable and appropriate for the environmental and operational conditions during their onset on the land to cultivate the crop and enhance productivity. The plates were built by 3D printing by Tanta Motors - Egypt and tested at the Department of Agricultural Engineering - Faculty of Agriculture, Egypt. This research study was conducted for the design and development of plates. The discs were designed and built through a series of processes that were defined and plotted in proportion to the main dimensions and shape index of the seed. The materials analysis was tested by (Solidworks). Changes in materials (Acrylonitrile butadiene styrene- Polyamide Nylon and Thermoplastic polyurethane) and shape index 1.7674 and 1.8782 were tested at Stress, displacement, Strain analysis, mesh, Deformation, and plate safety factor. Moreover, the simulation results indicated that the computational values were in agreement with the theoretical values. They all showed that the model and boundary conditions were correct and logical, and would provide a scientific basis for the optimal design.

Key words: *metering plate, seed planting, solid works, 3D printer, 3D max*

INTRODUCTION

Since the 19th century, the lateral shape of some seeds has been described as reniform, which is derived from the Latin rein, kidney, so reniform means kidney-shaped. Kidneys, on the other hand, are not geometric shapes, their shape is not well defined. Thus, the term "kidney" corresponds to descriptive rather than analytical language. On the other hand, seeds are similar to cardioid curves, and the expression "cardioid curve" belongs to the language of analysis because it defines a graph with the precision of an algebraic equation, allowing the graph to be explicitly represented and the similarity quantified in different images to which it resembles. The shapes of seeds of different species are explained by comparing them to geometric models [13], [15].

Seed morphological variety includes variations in terms of seed size and shape. The form of the seed is the most important factor in plant identification and categorization. It is particularly important in agriculture since it represents genetic, physiological, and ecological components, all of which have an impact on production, quality, and market price. The advancement of quantification and modelling methodologies, as well as the application of digital technologies, allows for a more precise description of seed morphology.

Image processing technologies are being used to estimate seed size and morphology automatically. Shape quantification methods are mainly based on these models and are essential for an appropriate depiction, allowing for comparison across polymorphisms or developmental phases, as well as calculating the degree of variation in specific types of seeds [3].

Shape quantification techniques usually on these models are crucial for an accurate reflection, allowing for comparison across polymorphisms or developmental phases, as well as calculating the degree of variation in specific types of seeds [6].

The results of seed morphology are important in systematics because they help with genotype differentiation. Seed size and shape measurements, as well as their connection and interaction, are crucial in seed yield breeding [1].

Understanding the relationship between seed form and agronomic factors may help enhance yield or quality [24].

Computer-aided image analysis systems can examine morphological seed characteristics, and data may be swiftly processed and saved on a hard disc, displayed, or statistically elaborated. Digital imaging may be a quick and dependable tool for a wide range of discrimination [5].

Although seed shape is a significant characteristic in the phenotypic description as well as plant identification and categorization, its usage in plant science and agronomy requires measurement. Accurate seed shape estimation may give new data in morphology and taxonomy. Furthermore, seed form is the end product of genetic, physiological, and environmental variables, and it influences quality and market price. Thus, quantifying seed shape is of interest in many aspects of plant science and is also important in agriculture [4].

A recent study of several approaches for seed shape estimation based on the comparison of seed photos with geometric shapes was published. Geometric figure modelling contributes to enhanced precision in seed equations to describe, permitting for the discovery of morphological variation such as variations in imbibition, mutations, variances among related genotypes, or shape changes in response to environmental influences [12].

The appearance of seeds is a crucial factor in differentiating them. The form of the seeds is easy to discern, and shape is a convenient and cost-effective technique to examine the seed. Seed shape and size are essential aesthetic characteristics for determining diversity and quality. The form is also employed in classification, breeding, and the design of equipment. Identifying such characteristics will also help in the drying, storing, packing, and shipping operations. Furthermore, form, size, area, and mass-like physical characteristics are employed in a variety of critical operations such as processing, dehulling, cleaning, and separation [2].

Grain seeders are essential pieces of field planting technology. The seed meter is an essential component of the planter. The effect's quality will have a direct impact on the cost and quality of crop planting and post-workload. Precision seed metering devices are classified into mechanical and pneumatic types based on their operating principles. The pneumatic seed metre is highly adaptable to seeds, has low light damage, and so on, but its construction is complex, and its cost and technical requirements are high [21].

There are several techniques for planting seeds, including seedling transplantation, manual broadcasting, and direct sowing. The planting pattern is the most traditional planting method, which is arduous, time consuming, and expensive, as well as broadcast and rigorous in environmental conditions. As a result, these parameters must be satisfied in order to avoid unequal distribution and low output [9].

all precision seed meters built on the idea of seed singulation have seed miss issues. focuses on identifying methods and exploring the potential for eliminating seed misses. Modelling single and double miss provided evidence for the proposed method's potential [17].

a mechanism that releases just one seed at a time is the seed metering device of a precision seeder. The majority of the seed metering equipment in use today uses a revolving metering mechanism to singulate and measure the seeds. There may likely be an accuracy issue while handling singulation and uneven seed shape [25].

precision seeding technology has become a widely used seeding technology in the process of agricultural development to increase efficiency and get higher economic benefits. Future agricultural progress will focus heavily on the high-speed and small-spacing sowing method [26].

SolidWorks is the industry standard for 3D solid modeling, automated design, engineering analysis, and product preparation for any complexity and purpose. Depending on the type of work to be solved, three main system configurations are available: Solid Works Standard, Professional, and Premium are the three editions of Solid Works [14].

The polymers Acrylonitrile-Butadiene-Styrene are made up of three monomer units: Acrylonitrile, Butadiene, and Styrene. Plastic has numerous adaptable features such as heat resistance, light weight, easy formability, reflectivity, and so forth [23].

3D printing technology is a type of rapid prototyping technology, also known as additive manufacturing technology. It is a type of technology based on digital model files, using adhesive materials such as polymer materials or metal powder to construct objects by printing layer by layer. On a computer, the 3D model is simulated and sliced to decompose it into a multi-layer 2D structure. The printing consumables are then fused at high temperatures before being extruded layer by layer through a nozzle. Finally, a 3D structure that is identical to the design model is created. Polymers have attracted a lot of attention because they cannot only be formed quickly but also have good mechanical strength and functionality. The most common polymer is acrylonitrile butadiene styrene copolymer (ABS), which is one of the most widely used polymers with the highest output at the moment. It has heat resistance, impact resistance, low-temperature resistance, chemical corrosion resistance, excellent electrical performance, and consistent product size. Its application range includes almost all daily necessities as well as engineering supplies [28], [8], [27], [11].

Nylon, ASA, PLA, TPU, PMMA, and PETG are common polymers used in product preparation [20].

This study designed and evaluated modern metering plates for faba bean seeds that needed simple movement for seeds that are crucially moving during metering plate filling. The primary goal of this study is to discover the form shape index and the optimal material for manufacturing of faba bean discs that are both environmentally and operationally acceptable.

MATERIALS AND METHODS

Design of the faba bean plates

The plates were designed in solid works software with version 2018, and manufactured by the 3D printer and the realistic 3D model of the faba bean was designed in 3D max software with version 2017 as shown in Figures (1 - 6).

Solidworks Analysis

The model was analyzed by the 2018 version of Solidworks software. Used to analyze the material properties of discs to determine materials that are compatible with environmental and operational impacts during planting operations.

The static simulation steps of exposure mainly include:

(1) Create 3D geometric models and meshes
(2) Define the material of the model
(3) Identify fixtures parts
(4) Define the external load
(5) Define the contact surface

Material Data

1-ABS (Acrylonitrile butadiene styrene)

Table 1. Material properties of ABS

Item	*Value*
► elastic modulus	► 2,000 N/mm^2
► poison's ratio	► 0.394N/A
► shear modulus	► 318.9N/mm^2
► mass density	► 1,020Kg/m^3
► tensile strength	► 30N/mm^2
► thermal conductivity	► 0.2256W/M.K
► specific heat	► 1,386 J/Kg.K

Source: Own results.

2-PA (Polyamide Nylon)

Table 2. Material properties of PA

Item	*Value*
► elastic modulus	► 2,620 N/mm^2
► poison's ratio	► 0.34N/A
► shear modulus	► 970.4N/mm^2
► mass density	► 1,120Kg/m^3
► tensile strength	► 90N/mm^2
► thermal conductivity	► 0.233W/M.K
► specific heat	► 1,601J/Kg.K

Source: Own results

3-TPU (Thermoplastic polyurethane)

Table 3. Material properties of TPU

Item	***Value***
elastic modulus	0.621GPa
Flexural Modulus	4.50 GPa
Hardness	70
mass density	1,225 Kg/m^3
tensile strength	28.0-96.0MPa

Source: Own results.

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Table 4. Equations used to calculate the size and shape attributes and analysis

Variables	Equations*	Literature
Elongation (E)	$E = \frac{L}{W}$	Fıratlıgil-Durmuş et al. (2010) [7]
Projected area(A)	$A = \frac{\pi}{4} \times (Dg)^2$	Afonso Junior et al. (2007)[10]
Roundness(R)	$R = \frac{(4 \times Area)}{\pi \times (L)^2}$	Sayinci et al. (2015)[18]
Flatness Index(FI)	$FI = \frac{(L+W)}{(2 \times TH)}$	Cervantes et al(2016)[3]
Shape Index(SI)	$SI = \frac{2 \times L}{W + TH}$	Ozkan and Koyuncu (2005) [16]
Geometric Mean Diameter (DG),mm	$Dg = (WLT)^{\frac{1}{3}}$	Ozkan and Koyuncu (2005) [16]
ESTREN	$ESTRN = 2[\frac{(\varepsilon 1 + \varepsilon 2)}{3}]^{\frac{1}{2}}$ $\varepsilon 1 = 0.5[(EPSX - \varepsilon^*)2 + (EPSY - \varepsilon^*)2 + (EPSZ - \varepsilon^*)2]$ $\varepsilon 2 = \frac{[(GMXY)2 + (GMXZ)2 + (GMYZ)2]}{4}$ $\varepsilon^* = \frac{(EPSX + EPSY + EPSZ)}{3}$	Segalman et al(2000)[19]
von Mises	$V.Mises = \{\frac{[(\sigma 1 - \sigma 2)^2 + (\sigma 2 - \sigma 3)^2 + (\sigma 1 - \sigma 3)^2]}{2}\}^{\frac{1}{2}}$	Segalman et al(2000)[19]
URES	$URES = \sqrt{X^2 + Y^2}$	Simo et al(1989)[22]

L= Length, mm, W= Width, mm, TH= Thickness, mm, Dg= Geometric Mean Diameter, mm, ε 1=Normal strain in the first principal direction. ε 2=Normal strain in the second principal direction. ε 3=Normal strain in the third principal direction. EPSX, EPSY, and EPSZ =Normal strain in the X, Y, and Z direction of the selected reference geometry.GMXY=Shear strain in the Y direction in the YZ-plane of the selected reference geometry. GMXZ=Shear strain in the Z direction in the YZ-plane of the selected reference geometry. GMYZ=Shear strain in the Z direction in the XZ-plane of the selected reference geometry.$\sigma 1 \backslash \sigma 2 \backslash \sigma 3$=principal stresses. X=is the first direction that the object is traveling. Y=s the second direction that the object is traveling
Source: Authors' determination.

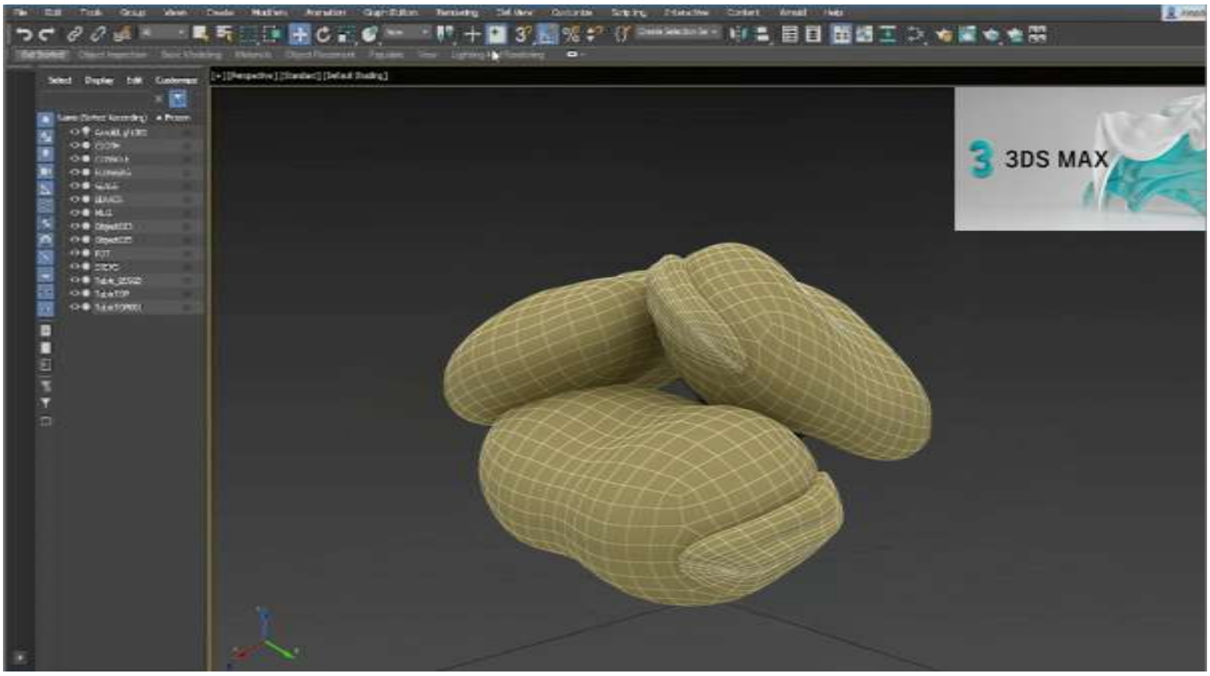

Fig. 1. Faba Bean Seeds with 3D max software
Source: Authors' determination.

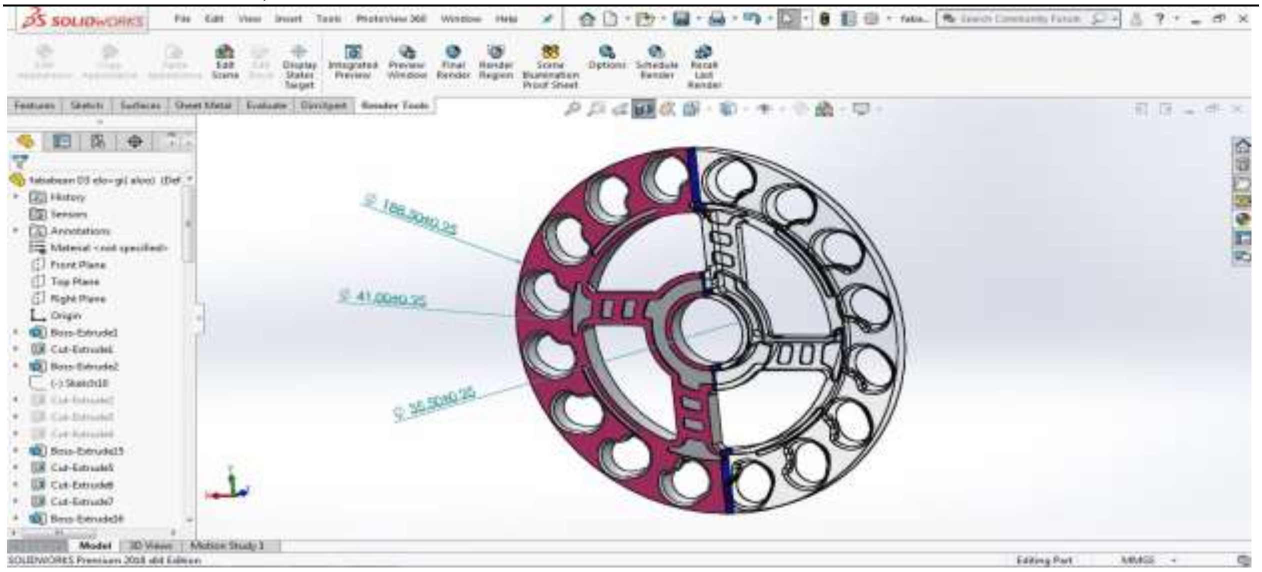

Fig. 2. Design of faba bean plate with Solidworks Software (V.2018)
Source: Authors' determination.

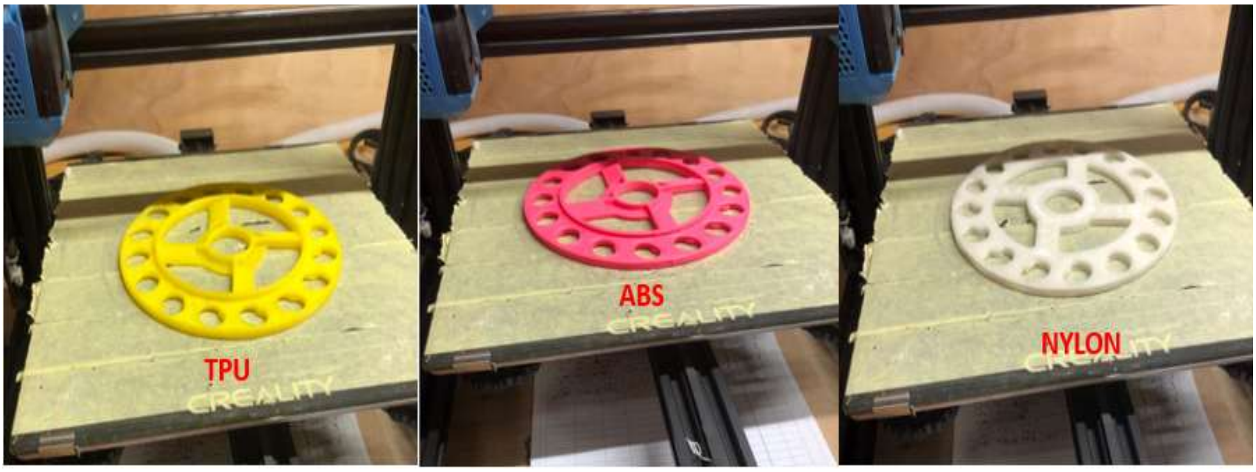

Fig. 3. Metering Plates of Faba Bean with 3D Printer in Final Stage for (TPU-ABS-NYLON) material
Source: Authors' determination.

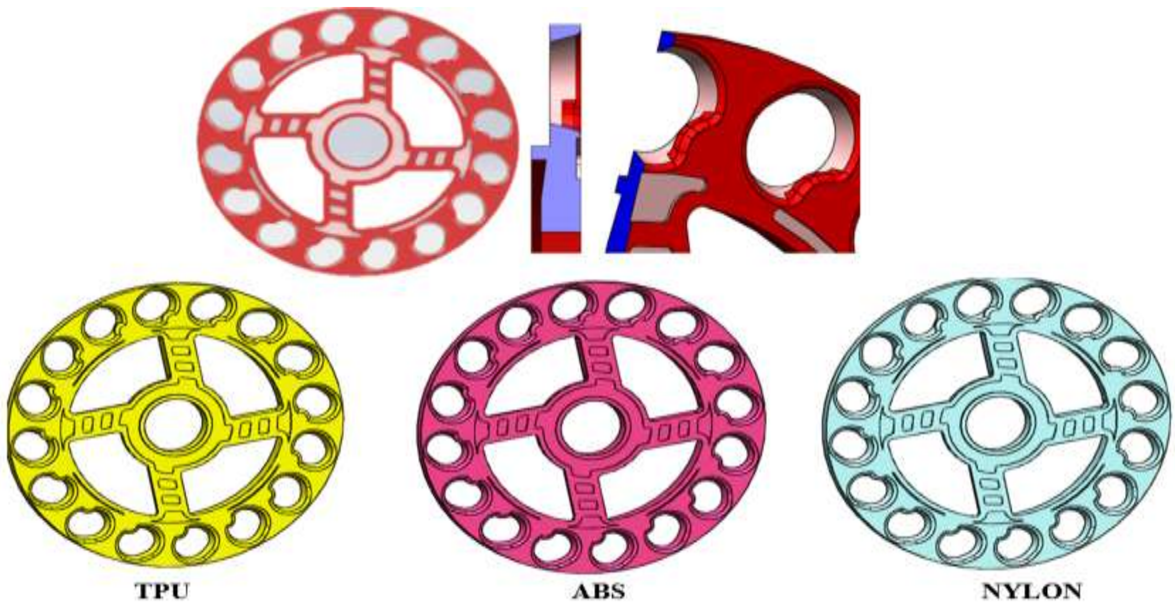

Fig. 4. The Plate 1 of metering discs of faba bean seeds with 3 materials
Source: Authors' determination.

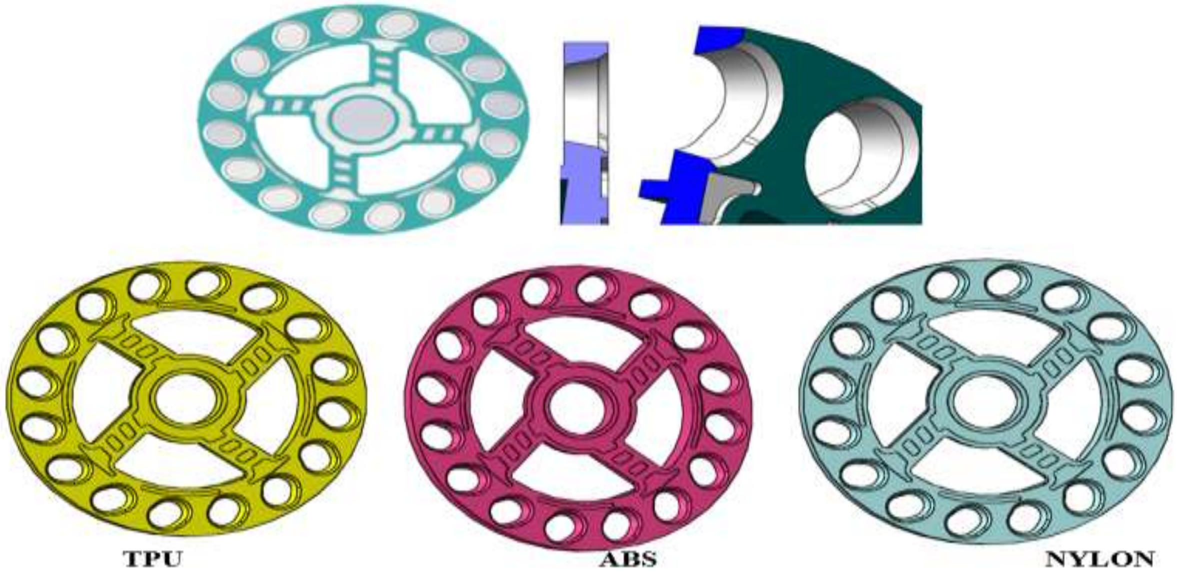

Fig. 5. The Plate 2 of metering discs of faba bean seeds with 3 materials
Source: Authors' determination.

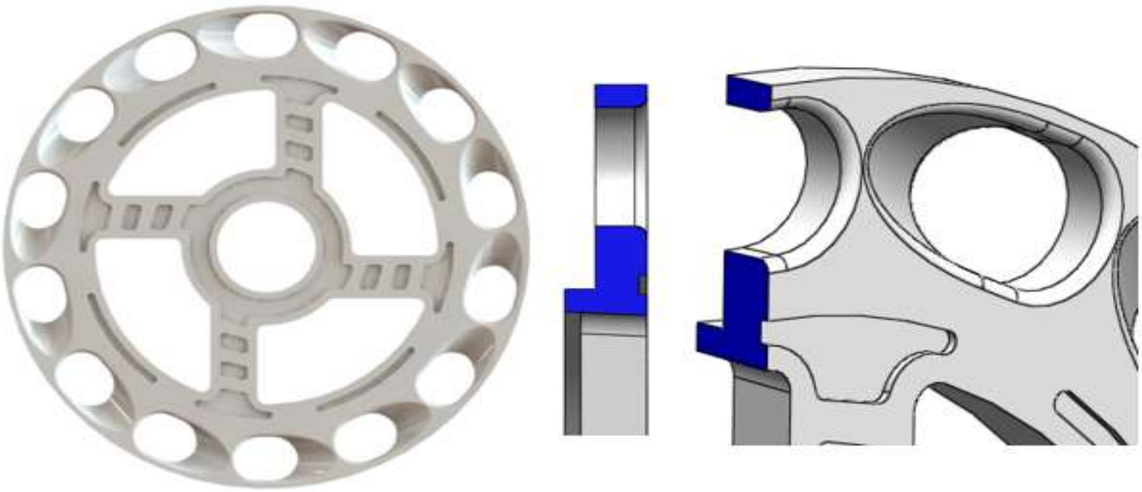

Fig. 6. The Plate 3 of metering discs of faba bean seeds with (PA) material
Source: Authors' determination.

RESULTS AND DISCUSSIONS

The Faba bean form index was evaluated and statistically examined.

Figures demonstrate the link between the shape index of seeds and the shape index of discs as investigated using Solidworks simulation (7- 39).

Shape Index of Faba Bean Seeds

The results showed the average elongation, projected area, flatness, and roundness and shape index, Geometric Mean Diameter of faba bean seeds were (1.356,107.54, 2.04, 0.743 and 1.705) respectively.

The results showed the average elongation, projected area, flatness, and roundness. shape index, Geometric Mean Diameter of the disc (plate 1) were (1.26, 117.81, 2.61, 0.789, 1.76, and 12.25) respectively.

The results showed the average elongation, projected area, flatness, and roundness. and shape index, Geometric Mean Diameter of the disc (plate 2) were (1.23, 136.88, 2.92, 0.809, 1.787, and 13.20) respectively.

The results showed the average elongation, projected area, flatness, and roundness. Shape index, Geometric Mean Diameter of the disc (plate 3) were (2.08, 194.06, 4.036, 0.479, 3.018, and 15.723) respectively.

Table 5. Plates Analysis Results

MATERIAL	PLATE	ANALYSIS	VALUE	
ABS	P1	Mesh	103,272	
		Stress	Max	1.919e+04 N/m^2
			Min	7.162e-03 N/m^2
		Displacement	4.202e-04 mm	
		Strain	Max	4.620e-06
			Min	5.710e-10
	P2	Mesh	31,137	
		Stress	Max	1.537e+03 N/m^2
			Min	1.738e-01 N/m^2
		Displacement	4.425e-05 mm	
		Strain	Max	3.778e-07
			Min	7.178e-11
TPU	P1	Mesh	103,272	
		Stress	Max	1.600e+04 N/m^2
			Min	1.572e-02 N/m^2
		Displacement	1.596e-01 mm	
		Strain	Max	1.929e-03
			Min	3.109e-07
		FOS	Max	5.874e+08
			Min	5.775e+02
	P2	Mesh	31,137	
		Stress	Max	1.436e+03 N/m^2
			Min	1.148e-01 N/m^2
		Displacement	1.643e-02 mm	
		Strain	Max	1.521e-04
			Min	5.397e-08
		FOS	Max	8.045e+07
			Min	6.432e+03
PA	P3	Mesh	31,993	
		Stress	Max	9.176e+02 N/m^2
			Min	1.385e-01 N/m^2
		Displacement	2.846e-05 mm	
		Strain	Max	2.380e-07
			Min	5.997e-11
		FOS	Max	7.482e+08
			Min	1.130e+05

Source: Authors' determination.

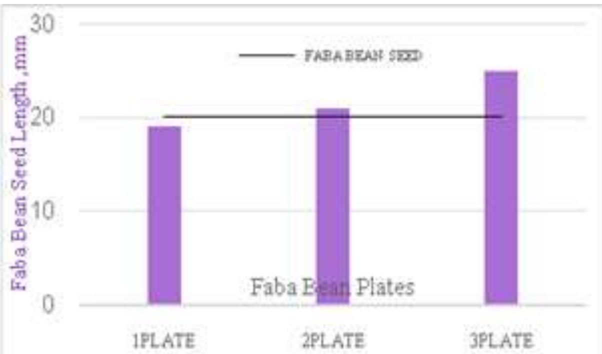

Fig. 7. The relationship between the length of faba bean seeds and the length of holes in various metering plates
Source: Authors' determination.

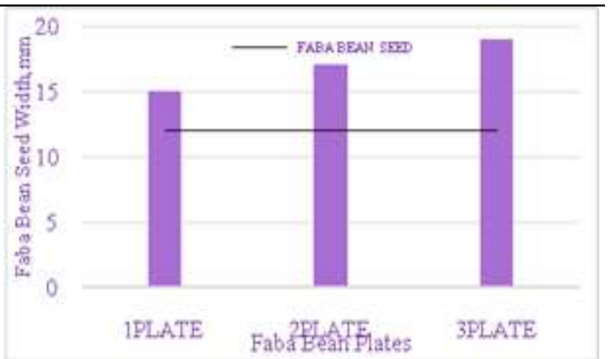

Fig. 8. The relation between faba bean seed width and hole width in various metering plates Source: Authors' determination.

Fig. 9. The thickness of faba bean seeds in proportion to the thickness of holes in various metering plates
Source: Authors' determination.

Fig. 10. The relationship between the elongation of faba bean seeds and the elongation of holes in various metering plates
Source: Authors' determination.

Fig. 11. The relation of flatness index of faba bean seeds and the holes in various metering plates
Source: Authors' determination.

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
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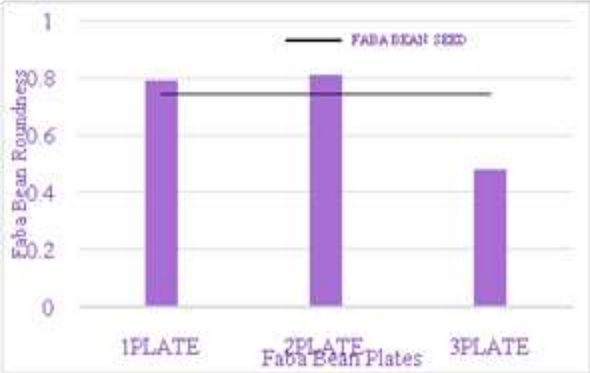


Fig. 12. The relationship between the roundness of holes in various metering plates , faba bean seeds
Source: Authors' determination.

Fig. 13. The relation between faba bean seeds and the holes in various metering plates of the projected area
Source: Authors' determination.

Fig. 14. The relationship between the Geometric Mean Diameter of faba bean seeds holes in various metering plates.
Source: Authors' determination.

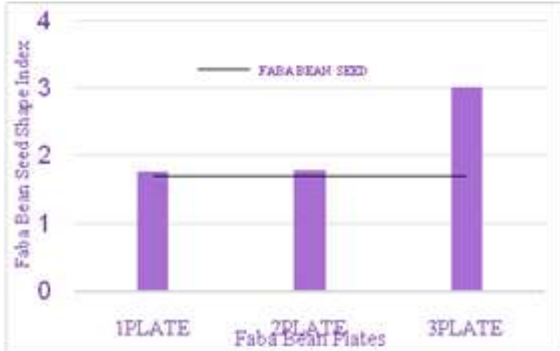
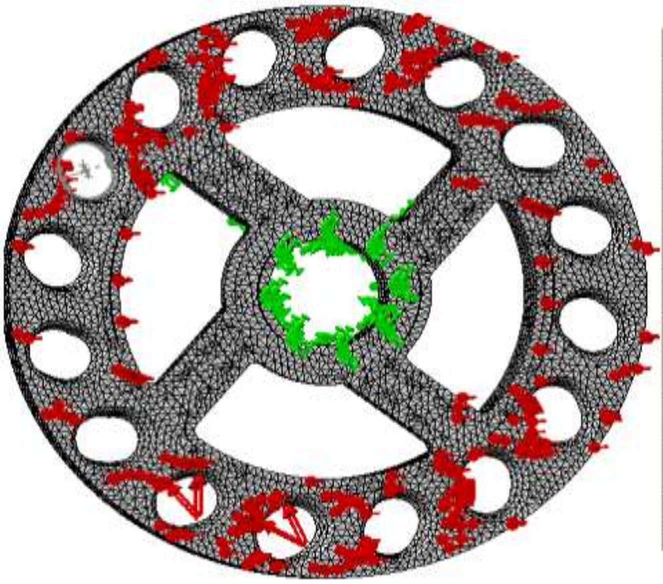


Fig. 15. The relation between the shape index of faba bean seeds and the holes in various metering plates
Source: Authors' determination.

❖ **Faba Bean plates (Plate 1)**



Study name	Static 2 (-Default-)
Mesh type	Solid Mesh
Mesher Used	Standard mesh
Automatic Transition	Off
Include Mesh Auto Loops	Off
Jacobian points	4 points
Element size	2.41547 mm
Tolerance	0.120773 mm
Mesh quality	High
Total nodes	103272
Total elements	61910
Maximum Aspect Ratio	17453
Percentage of elements with Aspect Ratio < 3	98
Percentage of elements with Aspect Ratio > 10	0.111
% of distorted elements (Jacobian)	0
Time to complete mesh(hh:mm:ss)	00:00:20
Computer name	DELL-PC

Fig. 16. Mesh generation of plate 1 (Total number of nodes103272).
Source: Authors' determination.

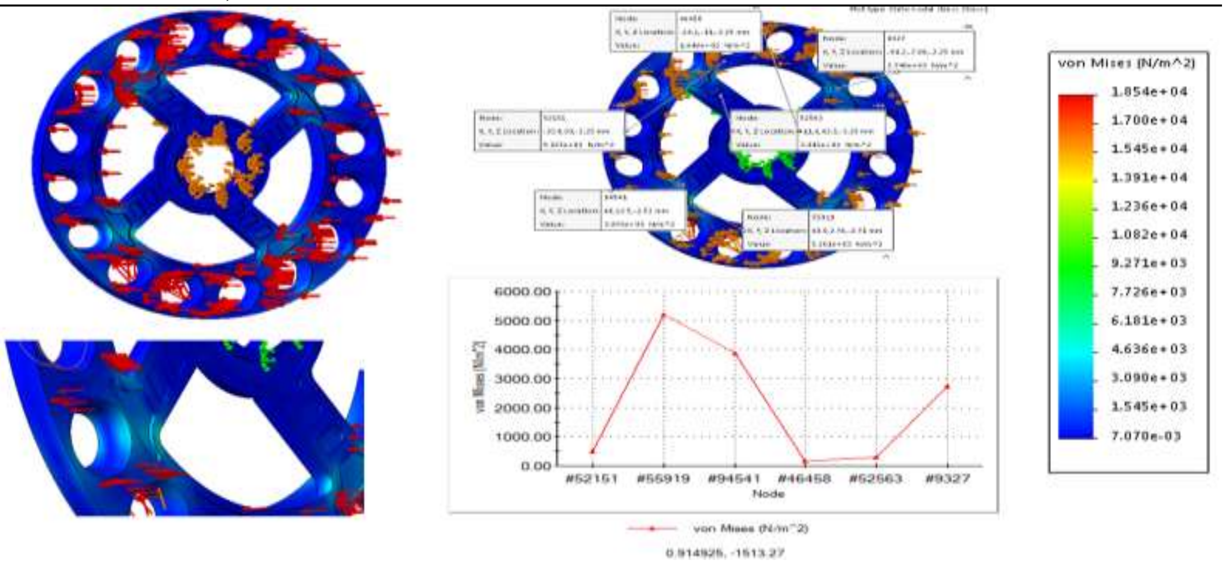


Fig. 17. Stress of the plate 1 of metering plates of faba bean seeds with (ABS) material.
Source: Authors' determination.

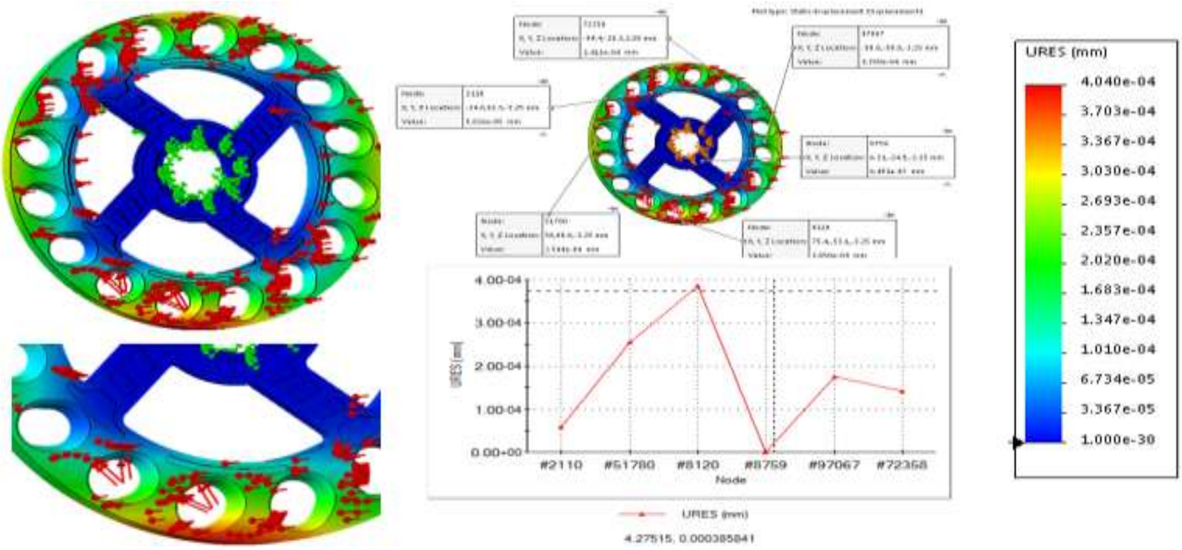


Fig. 18. Displacement of the plate 1 of metering plates of faba bean seeds with (ABS) material.
Source: Authors' determination.

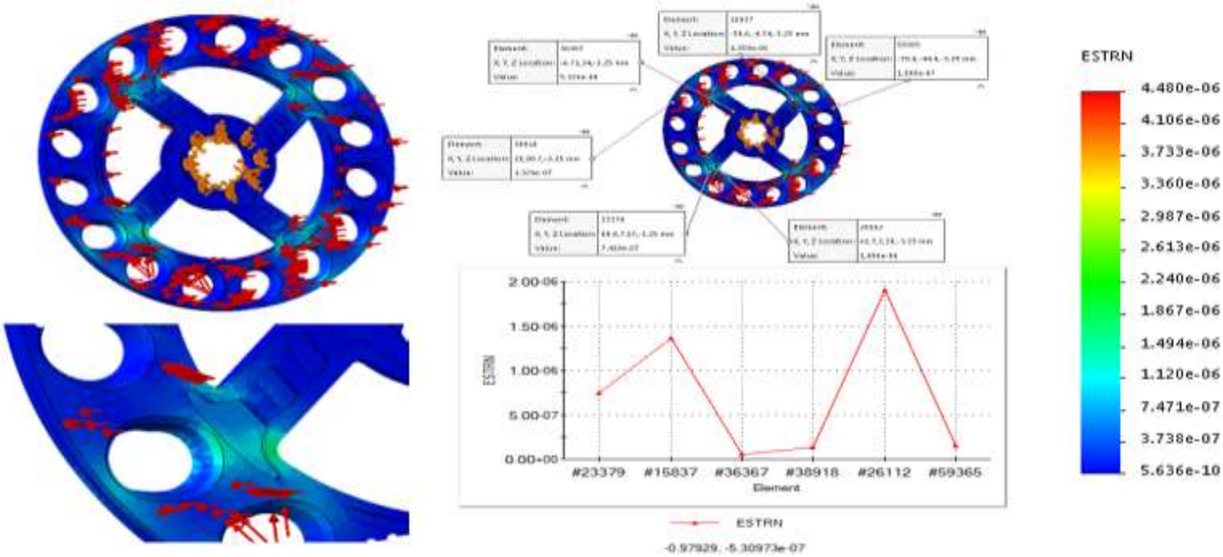


Fig. 19. Strain of the plate1 of meteringplates of faba bean seeds with (ABS) material.
Source: Authors' determination.

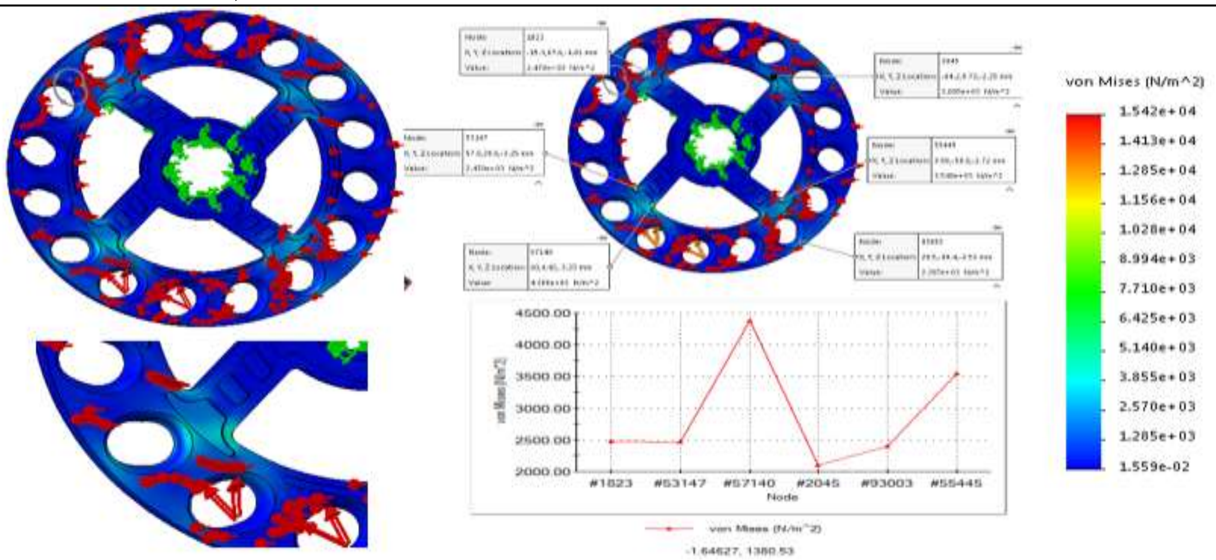


Fig. 20. Stress of the plate 1 of metering plates of faba bean seeds with (TPU) material.
Source: Authors' determination.

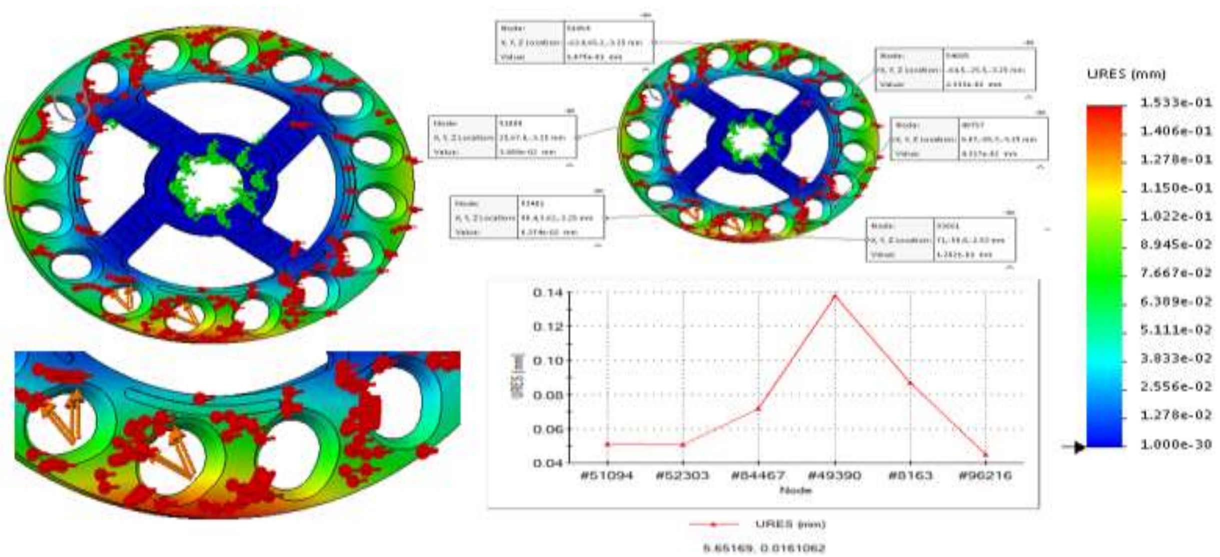


Fig. 21. Displacement of the plate 1 of metering plates of faba bean seeds with (TPU) material.
Source: Authors' determination.

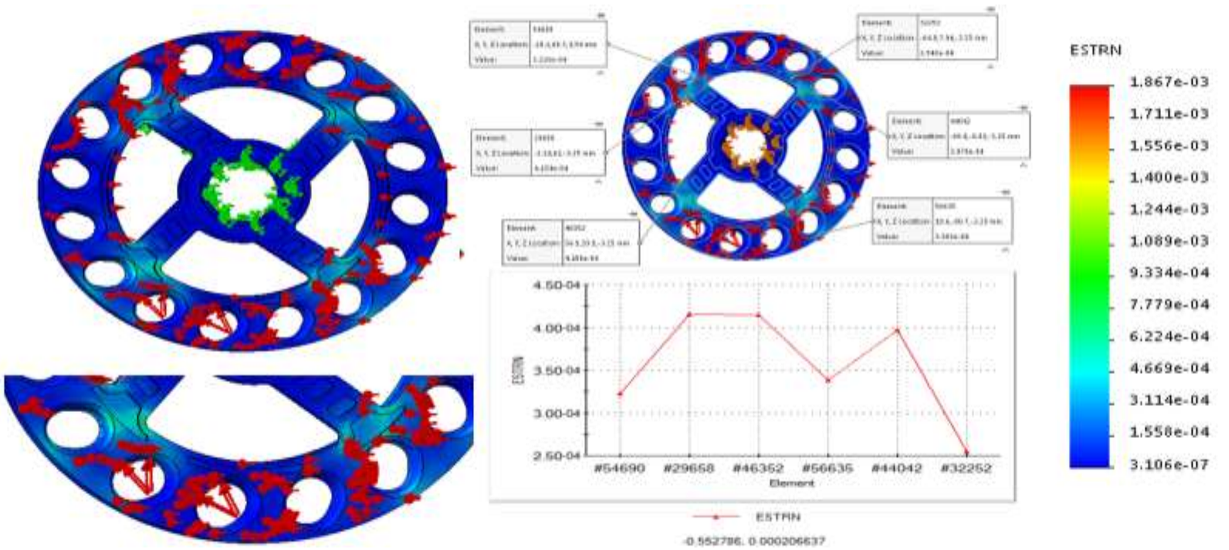


Fig. 22. Strain of the plate 1 of metering plates of faba bean seeds with (TPU) material
Source: Authors' determination.

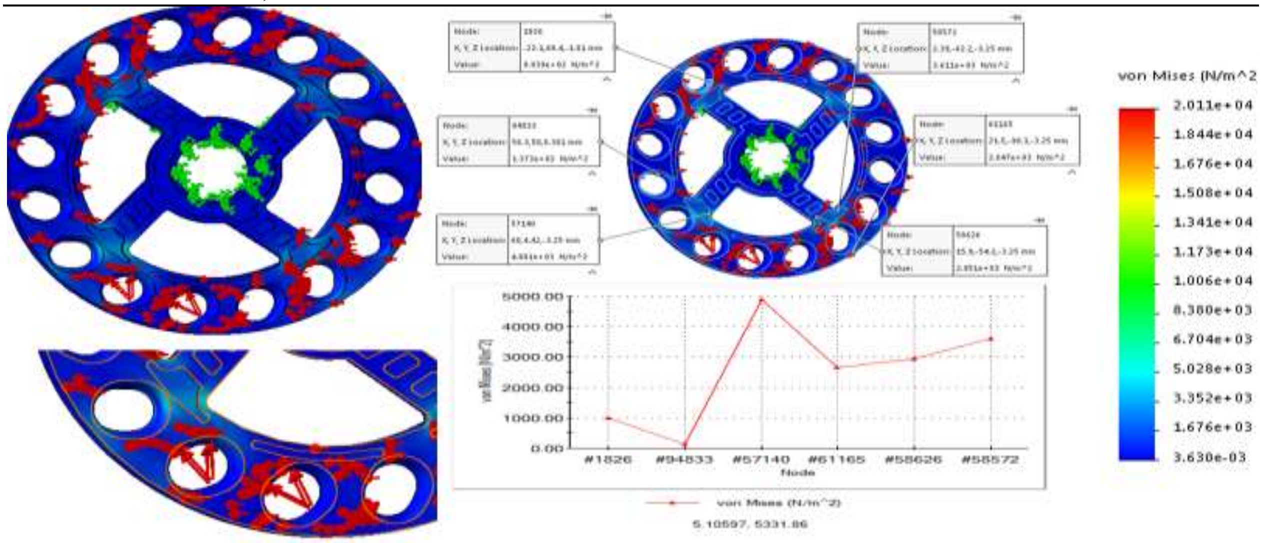


Fig. 23. Stress of the plate 1 of metering plates of faba bean seeds with (NYLON) material.
Source: Authors' determination.

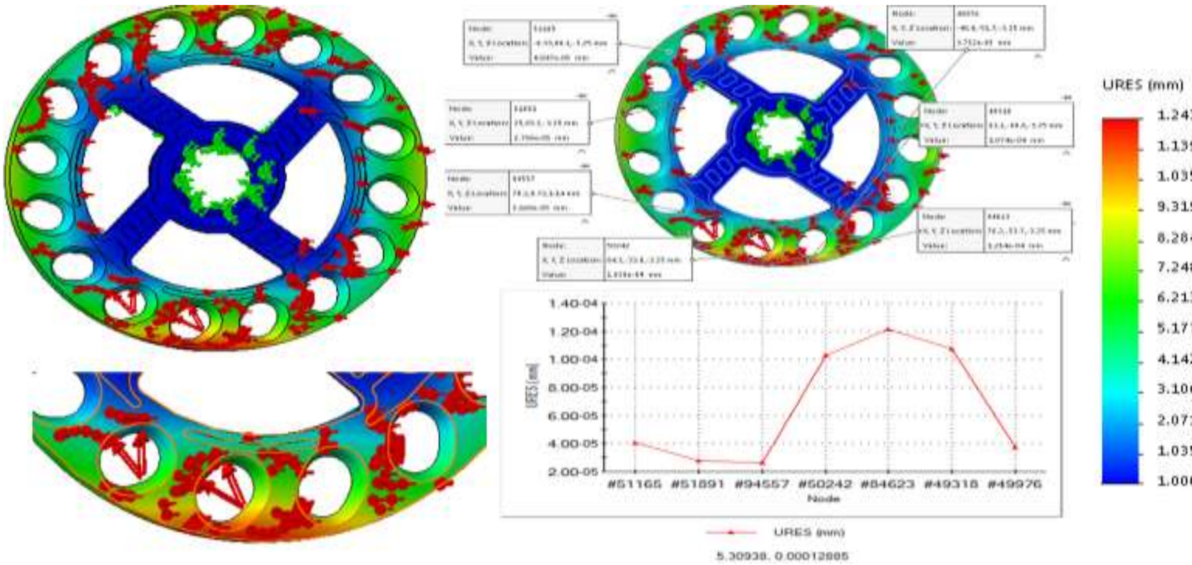


Fig. 24. Displacement of the plate 1 of metering discs of faba bean seeds with (NYLON) material
Source: Authors' determination.

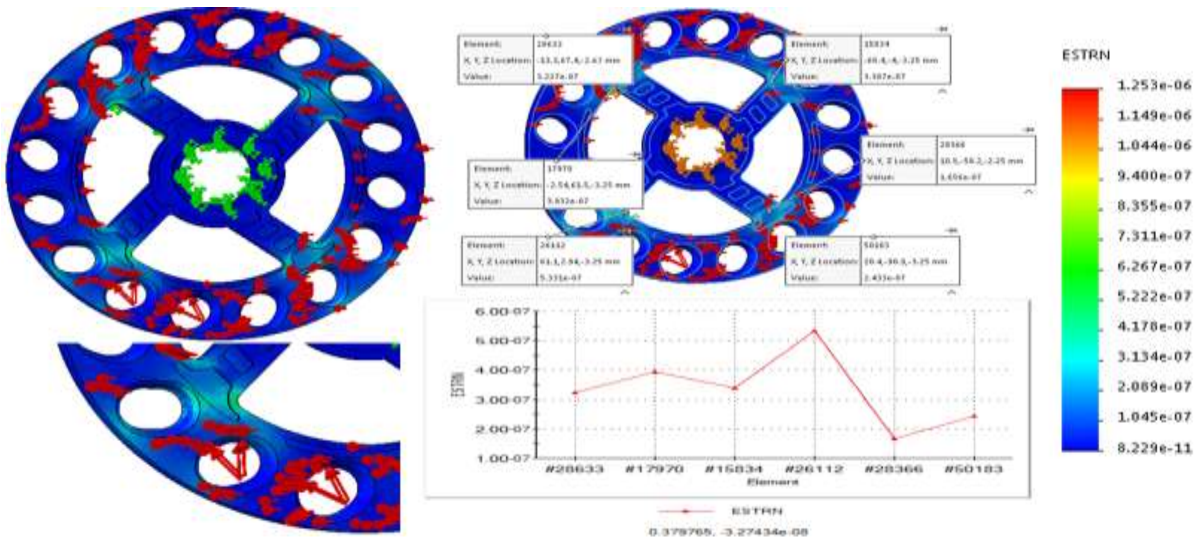


Fig. 25. Strain of the plate 1 of metering plates of faba bean seeds with (NYLON) material.
Source: Authors' determination.

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Vol. 23, Issue 1, 2023
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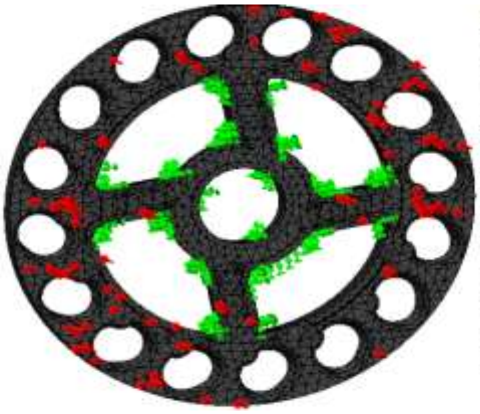
❖ **Faba Bean plates (Plate 2)**



Study name	Static (shape3) [-Default-]
Mesh type	Solid Mesh
Mesher Used	Standard mesh
Automatic Transition	Off
Include Mesh Auto Loops	Off
Jacobian points	4 points
Element size	4.51056 mm
Tolerance	0.225528 mm
Mesh quality	High
Total nodes	31137
Total elements	16910
Maximum Aspect Ratio	26.929
Percentage of elements with Aspect Ratio < 3	79.5
Percentage of elements with Aspect Ratio > 10	0.201
% of distorted elements (Jacobian)	0
Time to complete mesh(hh;mm;ss)	00:00:22
Computer name	DELL-PC

Fig. 26. Mesh generation of plate 2 (Total number of nodes 31137)
Source: Authors' determination.

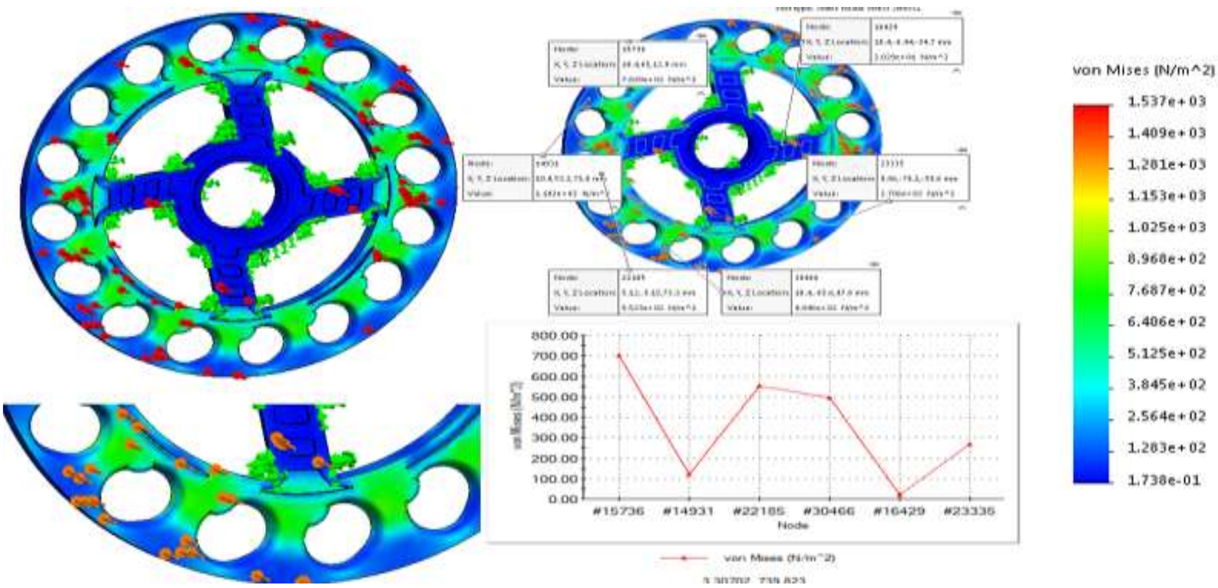


Fig. 27. Stress of the plate 2 of metering plates of faba bean seeds with (ABS) material
Source: Authors' determination.

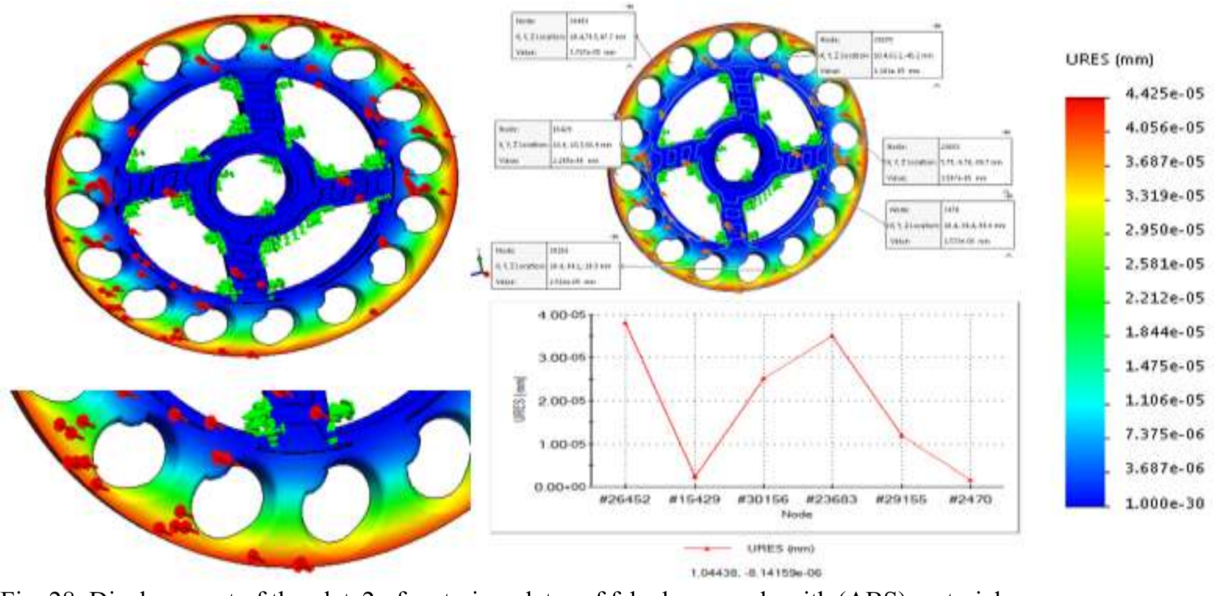


Fig. 28. Displacement of the plate2 of metering plates of faba bean seeds with (ABS) material
Source: Authors' determination.

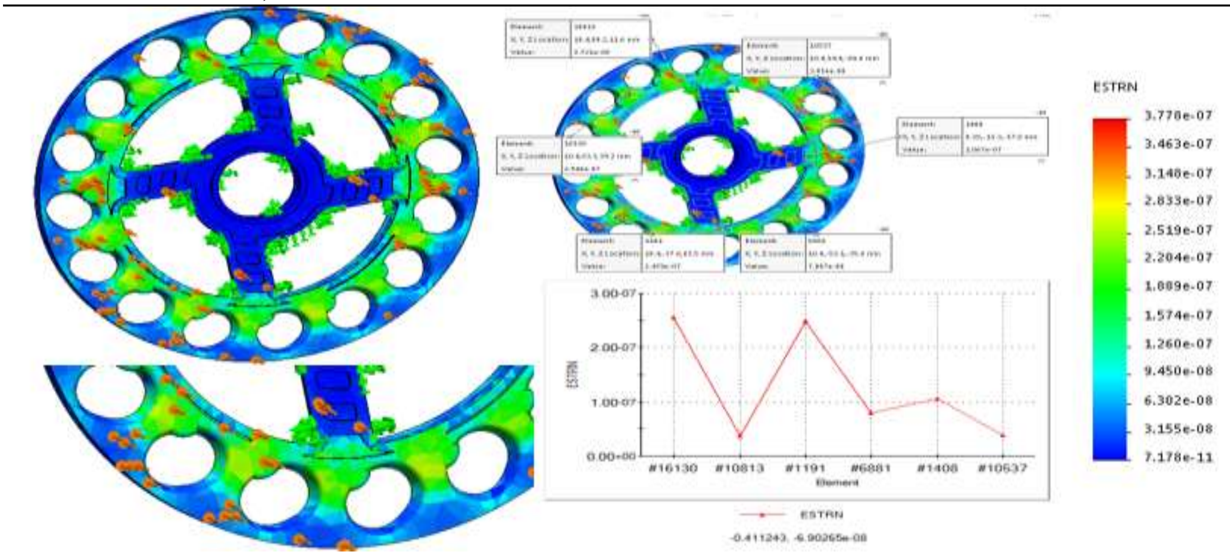


Fig. 29. Strain of the plate 2 of metering plates of faba bean seeds with (ABS) material
Source: Authors' determination.

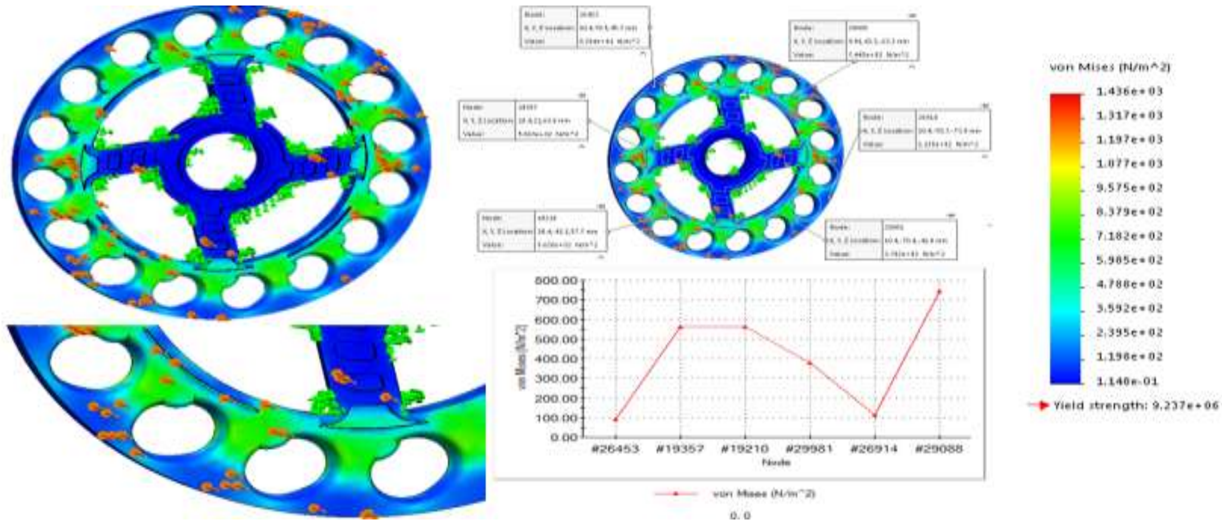


Fig. 30. Stress of the plate 2 of metering plates of faba bean seeds with (TPU) material
Source: Authors' determination.

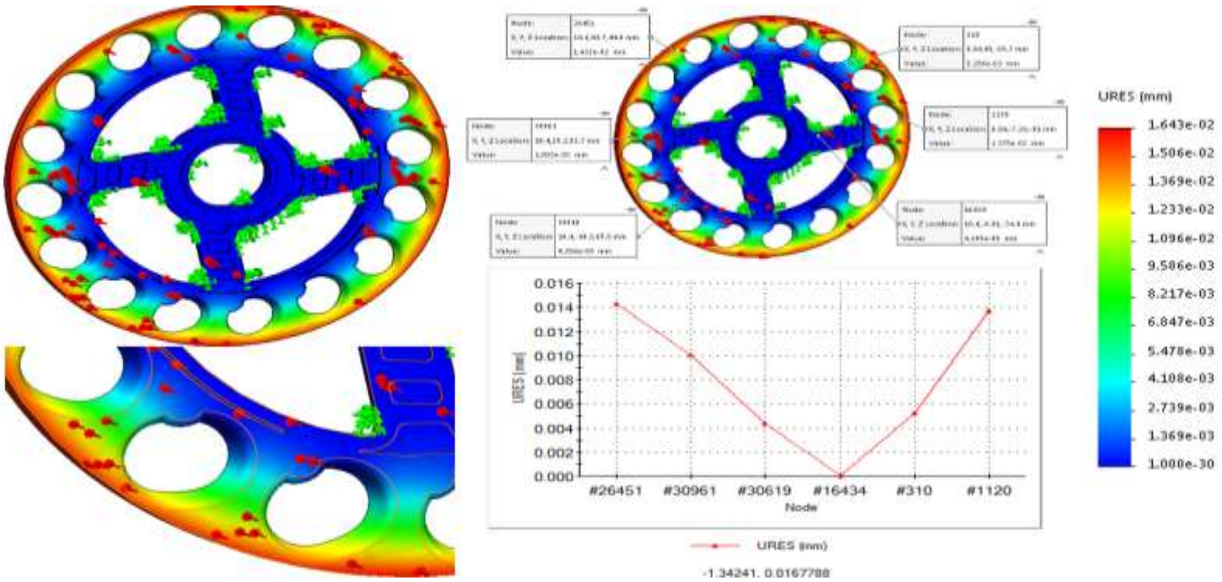


Fig. 31. Displacement of the plate 2 of metering plates of faba bean seeds with (TPU) material
Source: Authors' determination.

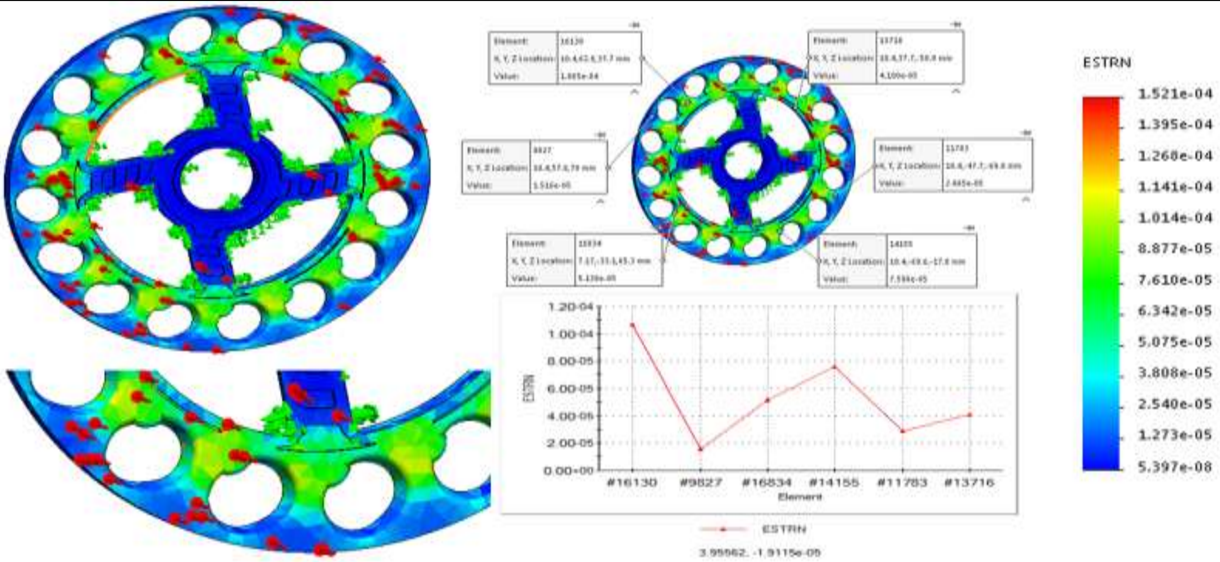


Fig. 32. Strain of the plate 2 of metering plates of faba bean seeds with (TPU) material
Source: Authors' determination.

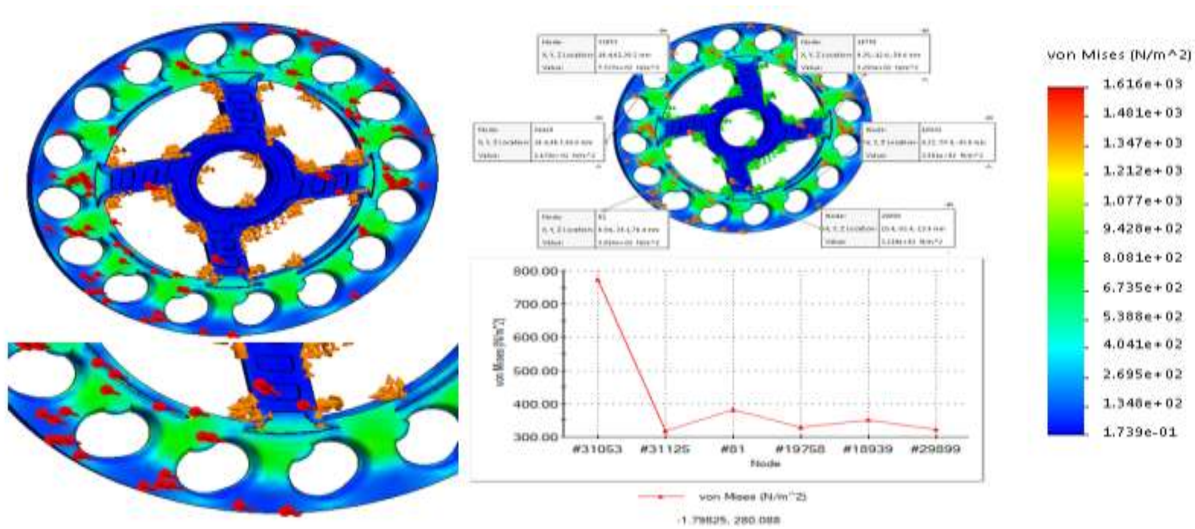


Fig. 33. Stress of the plate 2 of metering plates of faba bean seeds with (NYLON) material
Source: Authors' determination.

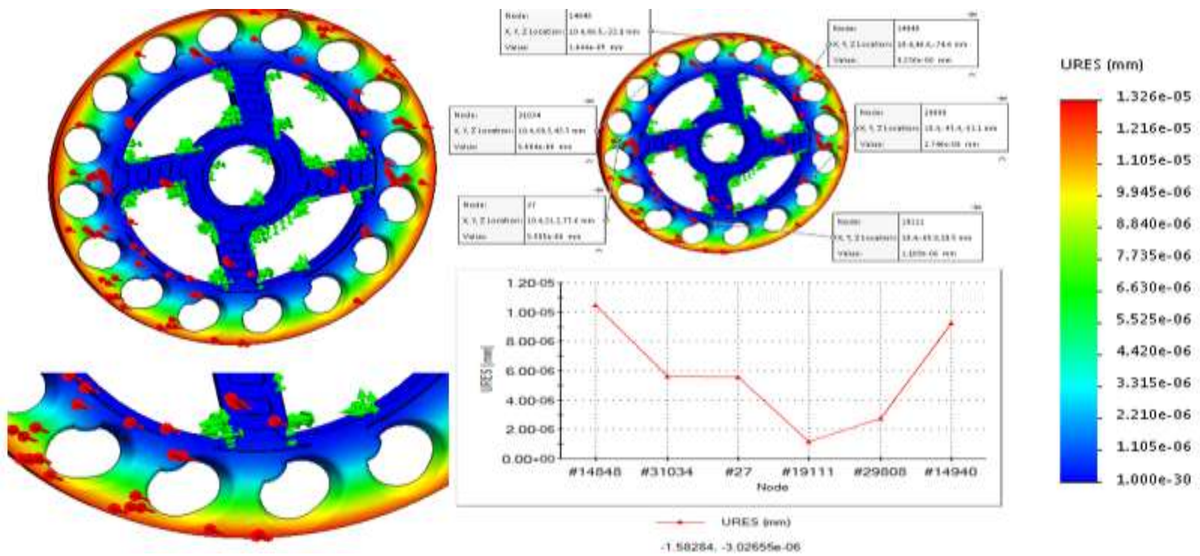


Fig. 34. Displacement of the plate 2 of metering plates of faba bean seeds with (NYLON) material
Source: Authors' determination.

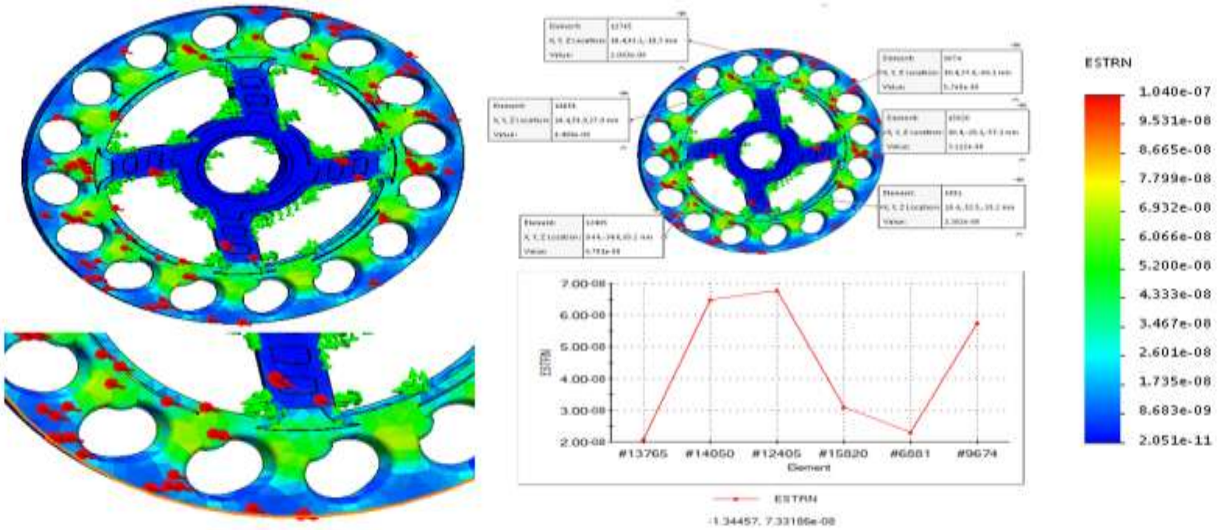
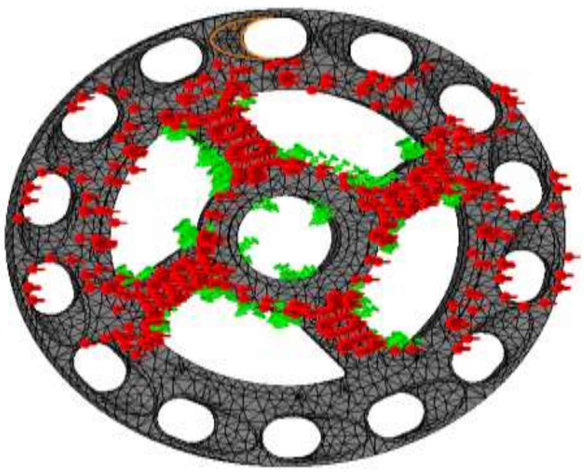


Fig. 35. Strain of the plate 2 of metering plates of faba bean seeds with (NYLON) material
Source: Authors' determination.

❖ Faba Bean plates (plate 3)



Study name	Static (shape3) (-Default-)
Mesh type	Solid Mesh
Mesher Used	Standard mesh
Automatic Transition	Off
Include Mesh Auto Loops	Off
Jacobian points	4 points
Element size	4.51056 mm
Tolerance	0.225528 mm
Mesh quality	High
Total nodes	31993
Total elements	17335
Maximum Aspect Ratio	16.308
Percentage of elements with Aspect Ratio < 3	76.8
Percentage of elements with Aspect Ratio > 10	0.496
% of distorted elements (Jacobian)	0
Time to complete mesh(hh:mm:ss)	00:00:22
Computer name	DELL-PC

Fig. 36. Mesh generation of plate 1 (Total number of nodes 31993)
Source: Authors' determination.

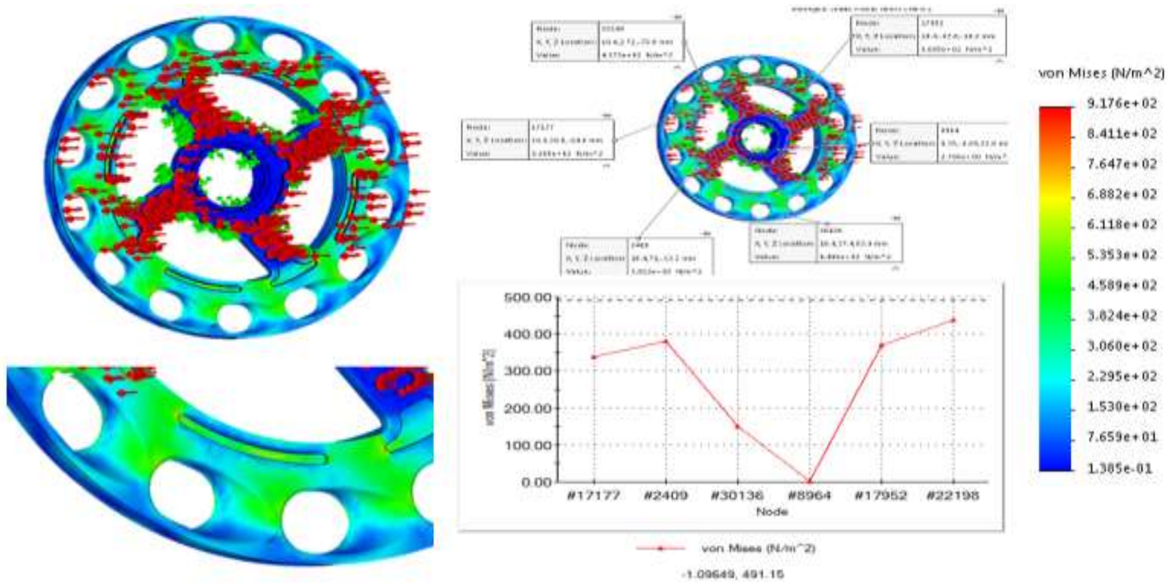


Fig. 37. Stress of the Plate 3 of metering plates of faba bean seeds with (PA) material
Source: Authors' determination.

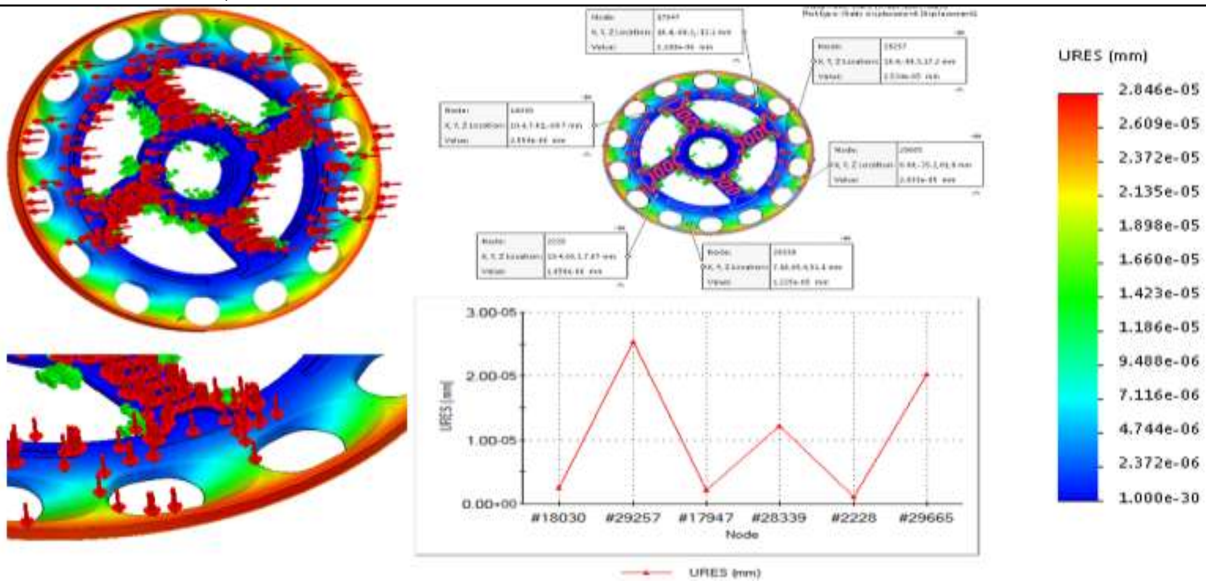


Fig. 38. Displacement of the Plate3 of metering plates of faba bean seeds with (PA) material
Source: Authors' determination.

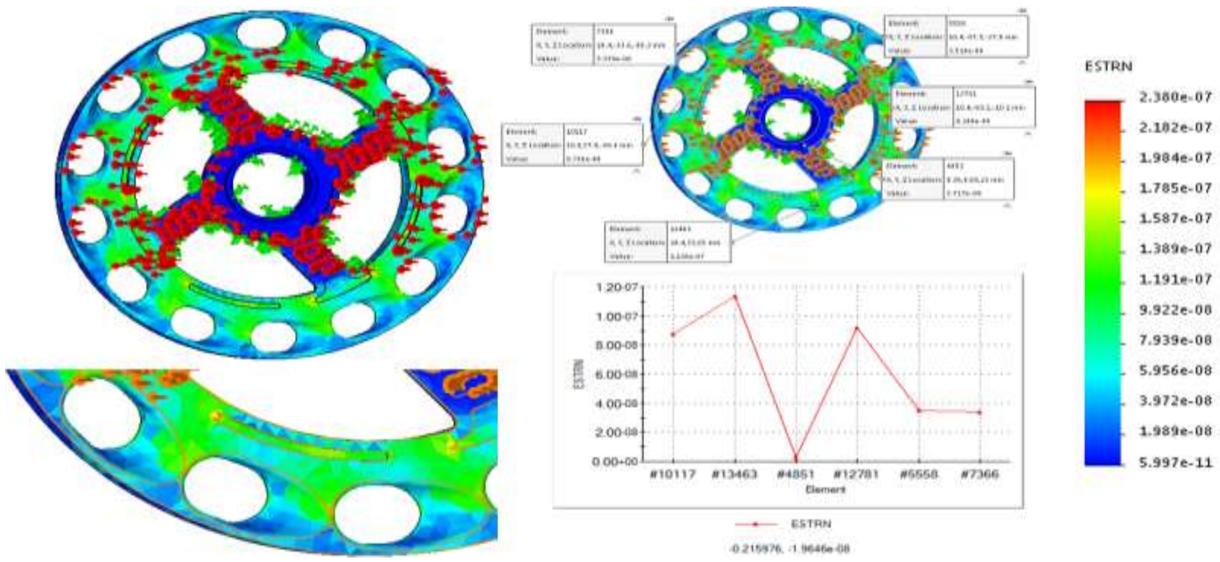


Fig. 39. Strain of the Plate 3 of metering plates of faba bean seeds with (PA) material
Source: Authors' determination.

CONCLUSIONS

Faba bean metering plates with dimensions of 18.5 cm and a thickness of 6.4 mm were developed and made using a 3D printer and the Solidworks software version 2018.

ABS, TPU, NYLON, and PA were used as fabrication materials for printing the metering plates and were then analyzed.

Plate 1 (TPU) had a maximum stress of 1.600e+04 N/m^2 and a minimum stress of 1.572e-02 N/m^2.

When the maximum strain and safety factor were 1.929e-03 and 5.874e+08, respectively, displacement was 1.596e-01 mm.

The minimum strain and safety factor were 3.109e-07 and 5.775e+02, respectively.

The average elongation, projected area, flatness, and roundness were all calculated. Geometric Mean Diameter of the Plate 1 was (1.26, 117.81, 2.61, 0.789, 1.76 and 12.25) correspondingly. In ideal situations, it is recommended to use Panel 1 made of TPU.

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THE EFFECT OF AERATION METHOD ON NILE TILAPIA BIOLOGICAL INDICATORS

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Abstract

This study examined the impact of applying the optimum operating condition for fine bubbles aeration of 0.554 $m^3.h^{-1}$ air flow rate, tube depths from the water surface of 0.7 m, tube inner diameter of 11 mm, and circular design shape at aquaculture greenhouse for rearing Nile Tilapia and compared with conventional water change system in three replicates for every treatment. For the classic water change method and fine bubbles, the corresponding water change ratios were 10 and 30, respectively. Before reaching commercial size, the experiment lasted for 8 weeks. Biological indicators estimated for blood, blood bio-chemical, digestive enzymes, anti-oxidant enzymes and serum bio-chemical parameters. Aeration method has a significant effect on red blood cells (Rbcs) where P value was 0.033. Also, a significant effect obtained on hemoglobin content (HB) where P value is 0.04. fine bubbles aeration has highest value of total protein by 4.93 g/dl compared with 4.46 g/dl for water change treatment. Amylas mean values were 21.047 and 12.307 U/L for fine bubbles aeration and water change treatment, respectively. mean values for SOD were 8.87 and 8.187 U/gm, CAT were 10.617 and 10.367 U/gm and MDA mean values were 12.93 and 18.367 nmol/g for fine bubbles aeration and water change treatment, respectively.

Key words: *aquaculture, biological indicators, dissolved oxygen, aeration diffusion by fine bubbles*

INTRODUCTION

The quantity of fish produced increased by 5.4% to 2.0 million tons in 2019 from 1.90 million tons in 2018. Lakes came in second with a production percentage of 7.97%, followed by marine waters with 4.9%, fresh water with 3.8% and rice fields with 0.8% of the total amount of fish produced. The revenue of fish production increased by 26.6% in 2019 to 61.1 billion LE from 48.3 billion LE in 2018. Also, the area of aquaculture farms decreased by 3.9% from 307.2 thousand feddan in 2018 to 295.2 thousand feddan in 2019 [6].

Between 1970 and 2000, the average annual cumulative growth rate of aquaculture production was 9%, compared to only 1.3% for catch fisheries. Global aquaculture increased steadily by 6.3% between 2000 and 2017, reaching 111.95 million metric tons (mmt). Finfish accounted for 53.40 mmt, or 47.7%, of the total fish production produced globally in 2017 and 83% of them originated from freshwater sources [11].

The most crucial period to introduce more aeration is shortly before dawn, when DO concentrations are often lowest because this is when they frequently drop below tolerable levels. Early morning DO for warmwater fish should stay above 3–4 mg/L and above 5–6 mg/L for cold-water fish. Warmwater and cold-water fish can survive with concentrations as low as 1.0-1.5 mg/L and 2.5-3.5 mg/L, respectively. However, these concentrations can raise stress, reduce appetite or aggression to eat and if low enough for a long length of time they can be deadly [5].

As well as serving as a sign of healthy liver function, variations in the activity of liver enzymes like lactate dehydrogenase (LDH), aspartate aminotransferase (AST), and alanine aminotransferase (ALT) can also be utilized as biomarkers for tissue injury [2].

The health of fish is undoubtedly impacted by the quality of the water because they are the largest and most diverse group of aquatic species that are closely tied to the aquatic environment. They are extremely sensitive to both immediate and subtle changes in the aquatic environment [4].

Hematological investigations are crucial for environmental monitoring because they shed light on how blood properties relate to habitat and how well a species can adapt to its surroundings [13].

Enzymes are sensitive indicators that can be used to identify stress in fish that have been exposed to different types of water contaminants [26].

It is crucial to completely take into account the habitat when doing research on the effect of habitat on fish health since physical and chemical changes in the aquatic environment frequently cause blood changes that lead to physiological abnormalities in fish.

An excellent approach for evaluating the health of aquatic habitat is the use of biochemical and enzymatic blood serum indicators in fish. Blood's biochemical and enzymatic properties have been shown to be a reliable way to assess an animal's state of health [17].

Natural water systems are susceptible to contamination from a variety of sources, including bacterial contamination, oil pollution, organic contamination, and inorganic contamination. All types of species are negatively impacted by water pollution. Additionally, fish health is impacted by the physicochemical characteristics of water, including temperature, pH, dissolved oxygen, nitrites, nitrates, and phosphates [22].

The main aims of the research were evaluating effect of aeration method on biological indicators.

MATERIALS AND METHODS

The aquatic fish of Nile tilapia *(Oreochromis niloticus*) was obtained from private farm at Damro village, Kafr El-Sheikh Governorate, Egypt. The experimental fish weight is of 140 grams with density of 5 fish/m^3 (90 fish/pond) for every treatment replicate of the experiment.

Fish feed were from extruded floating 25% CP, 3 mm diameter. The ingredients and the chemical composition of the used fish feed as shown in Table 1.

Aquaculture water used at aquaculture is mixture from lake Burullus water and agricultural drainage water. Secchi disk mean value before conducting experiments was 41 cm. The chemical analysis of aquaculture water at the begin of the experiment at kafr el-Sheikh university laboratories is shown at Table 2.

Table 1. The chemical composition of experimental fish feed

Composition	Value
Crude protein (%)	25
Crude fat (%)	4.5
NFE (%)	53.1
Ash (%)	5.1
Fibre (%)	4.3
P (%)	0.7
Gross energy (MJ)	17.5
Digestible energy (MJ)	7.5

Source: Feed datasheet.

Table 2. The chemical analysis of aquaculture water.

Test item	**Value**	**Unit**
pH	7.36	—
EC	3.22	ds/m
TDS	1.61	g/l
Na	35.63	meq/l
K	0.5	meq/l
Ca	10.0	meq/l
Mg	18.6	meq/l
CO_3	0.00	meq/l
HCO_3	10.0	meq/l
CL	50.0	meq/l
SO_4	4.73	meq/l
Fe	Nd	meq/l
Mn	Nd	meq/l

Source: Faculty of Agriculture laboratory.

The application of aeration by fine bubbles tubes and compare with traditional aquaculture system of water change occurred at green house in three replicates.

The greenhouse has design of quonset double span and covered with polyethylene (PE) plastic sheet.

It has 18 concrete ponds as shown at figure. Every pond has dimensions of 3 m width and 6 m length. Also, every pond filled with 18 m^3 of water.

An electric single phase compressor model APT (SGBM9037, China) of 1.5 hp, 25 L capacity, maximum pressure of 8 bar and maximum air delivery up to 130 $L.min^{-1}$ used as a source of air injection with regulator valve to control airflow rate.

Methods

The optimum operational conditions for oxygen productivity were applicated at aquaculture greenhouse and compared with traditional water change system in three replicates for every treatment. Water change ratios were 10 and 30% for fine bubbles and traditional water change method, respectively. The experiment period were 8 weeks until reach commercial size.

Operational conditions were: air flow rates of 0.554 $m^3.h^{-1}$, tube depth of 0.7 m from water surface for aeration tube and holder, tube wall inner diameter of 11 mm and circular design shape according to [16].

A statistical analysis of *t in pairs* attempted by using SPSS 25 program to conduct significant effect of treatments on biological characteristics in the study. The experiment divided into two treatments of water change (W.C.T.) and fine bubbles tube (F.B.T.) treatments in three replicates for every treatment.

Blood parameters

Blood sampling:

The blood samples were collected from the caudal vertebral vein [14].

Erythrocytic and leukocytic counts determination:

The erythrocytes and leukocytes were counted according to the method described [24]. using hemocytometer and Natt- Herrik solution.

Hemoglobin concentration determination:

Hemoglobin concentration was determined using the cyanomet hemoglobin method Drabkin's solution [24]. The cyanomet hemoglobin method converts all hemoglobin derivatives to methemoglobin using ferricyanide and cyanide ion. Methemoglobin is a stable red compound and can be measured color metrically.

Packed cell volume determination:

The micro hematocrit method was used for estimation of the PCV% [8].

Determination of differential leukocytic count (DLC):

A thin blood films were obtained, air dried, fixed with methanol for 3-5 min. and stained with Gimsa stain for 8-10 min., then rinsed with distilled water and left to dry. The white blood cells were counted among one hundred of blood smear [24].

The absolute DLC was calculated [25] according to the following formula:

Absolute DLC = no. of each white cell x no. of total leukocytic count/100.

Blood bio-chemical

Lysozyme concentrations assays:

The lysozyme activity of sera was assayed according to the method [9] based on the ability of lysozyme to lyses Gram positive lysozyme sensitive bacterium; Micrococcus lysodeikticus.

The lysozyme substrate was 75 mg/ml Micrococcus lysodeikticus lyophilized cells, suspended in 0.1M sodium phosphate/ citric acid buffer; pH 5.8.

A 25µl of the undiluted serum samples were placed into the 96- well micro plate, in triplicates.

A 175 µl of the substrate solution was then added to each micro titer plate well and kept at 25ºC; thereafter, rapidly mixed, the changes in turbidity was measured every 30 sec. for 5 min. at the wave length 450nm using the micro plate ELISA reader.

The unit of lysozyme present in serum (µg/ml) was obtained by matching with the standard curve made with lyophilized hen egg white lysozyme.

Serum total proteins (REF:310 001 Spectrum. Egyptian company for Biotechnology. Egypt) were determined colorimetrically at the wave length 546 nm [10].

Albumins (CAT. No. AB 10 10 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 630 nm [10].

Globulins content was calculated mathematically.

Serum bio-chemical

Activities of aspartate aminotransferase (AST), CAT. No. AS 10 61 (45) Biodiagnostic co. Egypt. were determined colorimetrically at the wave length 505 nm [20].

Alanine aminotransferase (ALT) CAT. No. AL 10 31 (45) Biodiagnostic co. Egypt. were determined colorimetrically at the wave length 505 nm [20].

Creatinine (CAT. No. CR 12 51 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 495 nm [3].

Urea (CAT. No. UR 21 10 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 550 nm [12].

Glucose (GOD-PAP) (REF. 1180 VitroScient co. Egypt.) were determined colorimetrically at the wave length 500 nm [7].

Triglycerides (CAT. No. TR 20 30 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 505 nm [15].

Cholesterol (CAT. No. CH 12 20 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 500 nm [21].

Antioxidants enzymes

Superoxide dismutase (SOD) (CAT. No. SD 25 21 Biodiagnostic co. Egypt) were determined colorimetrically at the wave length 560 nm [19].

Catalase (CAT. No. CA 25 17 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 510 nm [1].

Lipid peroxide (***Malondialdehyde***) (MDA) (CAT. No. MD 25 29 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 534 nm [23].

Digestive enzymes activity

Lipase (REF:281 001 Spectrum. Egyptian company for Biotechnology. Egypt) were determined colorimetrically at the wave length 580 nm [18].

Amylase (CAT. NO. AY 10 50 Biodiagnostic co. Egypt.) were determined colorimetrically at the wave length 660 nm [7].

A statistical analysis attempted by using SPSS 25 program to show significant effect of treatments on biological characteristics in the study.

The experiment divided into two treatments of water change (A) and fine bubbles tube (B) treatments in three replicates for every treatment.

RESULTS AND DISSCUSIONS

Blood parameters

Aeration method has a significant effect on red blood cells (Rbcs) where P value is 0.033, while fine bubbles aeration has highest value of 3.49X106/mm^3 compared with 2.96 X106/mm3 for water change treatment as shown in Tables 3 and 4. Also, a significant effect obtained on hemoglobin content (HB) where P value is 0.04, HB content mean value was 9.017 and 10.57 g/100ml in treatment of water change and fine bubbles tube, respectively as shown in Tables 3 and 4. In addition to that, Packed cell volume (PCV) has a significant different in favor of fine bubble tube aeration treatment with mean value of 33.33 and 28.33 % for fine bubble tube and water change aeration treatments, respectively at P value of 0.046 as shown in Tables 3 and 4. On the other hand, there is no significance between replicates mean values of fine bubbles aeration treatment and water change treatment for mean corpuscular volume (MCV), Mean corpuscular Hemoglobin (MCH) and mean corpuscular hemoglobin, concentration (MCHC) indicators as shown in Tables 3 and 4.

Blood bio-chemical parameters

The results showed that fine bubbles tube treatment and water change treatment has a significant effect on total protein and globulin with p value of 0.035 and 0.032, respectively. While fine bubbles tube treatment and water change treatment have no significant effect on albumin and lysozyme as shown in Tables 3 and 5.

While fine bubbles aeration has highest value of total protein by 4.93 g/dl compared with 4.46 g/dl for water change treatment as shown in Tables 3 and 5.

Also, fine bubbles aeration has highest value of globulin by 3.41 g/dl compared with 2.93 g/dl for water change treatment as shown in Tables 3 and 5.

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Table 3. Analysis of variance for blood test

Independent Samples Test					
		Trt	Mean	Std. Error Mean	Sig.
1	RBCS	A	2.96	0.05508	0.033
		B	3.49	0.30534	
2	HB	A	9.0167	0.19359	0.04
		B	10.5733	0.88939	
3	PCV	A	28.3333	0.66667	0.046
		B	33.3333	2.848	
4	MCV	A	95.71	0.98419	0.221
		B	95.5433	0.51596	
5	MCH	A	30.4567	0.11893	0.629
		B	30.31	0.09504	
6	MCHC	A	31.8333	0.40251	0.099
		B	31.7267	0.16128	
7	WBcs	A	9.0567	0.78065	0.084
		B	10.0467	0.17947	
8	basophil	A	0.0667	0.03383	0.024
		B	0.1	0	
9	esinophil	A	0.1267	0.04177	0.774
		B	0.1	0.05774	
10	monocyte	A	0.7267	0.08511	0.886
		B	0.7733	0.08667	
11	lymphocyt	A	6.7467	0.53261	0.112
		B	7.67	0.22898	
12	heterophil	A	1.39	0.18009	0.468
		B	1.41	0.1365	
13	Glucose	A	11.2133	0.59468	0.086
		B	11.5167	1.56263	
14	Protein	A	4.4633	0.40134	0.035
		B	4.93	0.06245	
15	Globulin	A	2.9333	0.42912	0.032
		B	3.41	0.07095	
16	Albumin	A	1.53	0.03786	0.284
		B	1.52	0.07371	
17	lysozyme	A	5.56	0.94495	0.713
		B	6.7633	0.78154	
18	Ast	A	30.3067	1.90398	0.669
		B	29.97	2.64195	
19	Alt	A	21.9267	1.71928	0.146
		B	19.9867	3.88684	
20	Urea	A	4.09	0.09866	0.175
		B	3.9133	0.19411	
21	creatinine	A	0.4467	0.0318	0.688
		B	0.4167	0.02333	
22	cholestrol	A	89.9433	5.01694	0.811
		B	90.3	6.23695	
23	triglyceride	A	99.0767	6.52827	0.467
		B	95.7333	3.52254	
24	Lipase	A	29.39	0.89034	0.049
		B	34.2633	3.49955	
25	Amylas	A	12.3067	0.92113	0.726
		B	21.0467	0.70516	
26	MDA	A	18.3667	0.84881	0.576
		B	12.9333	1.03577	
27	CAT	A	10.3667	0.33138	0.141
		B	10.6167	0.89841	

Source: Own results.

Table 4. Blood parameters values

Treatment	Rep.	RBCS ($x10^6$ /mm^3)	HB (g/100 ml)	PCV (%)	MCV	MCH	MCHC
Water change	1	2.86	8.69	27	94.41	30.38	**32.19**
	2	3.05	9.36	29	95.08	30.69	**32.28**
	3	2.97	9	29	97.64	30.3	**31.03**
	Mean	**2.96**	**9.02**	**28.33**	**95.71**	**30.46**	**31.83**
Fine bubble	1	3.21	9.76	31	96.57	30.4	**31.48**
	2	4.1	12.35	39	95.12	30.12	**31.67**
	3	3.16	9.61	30	94.94	30.41	**32.03**
	Mean	**3.49**	**10.57**	**33.33**	**95.54**	**30.31**	**31.73**

Source: Own results.

Digestive enzymes parameters

Aeration method has a significant effect on Lipase at P value of 0.049. While fine bubbles aeration has value of 34.26 U/L compared to 29.39 U/L for water change treatment as shown Tables 3 and 6. While fine bubbles tube treatment and water change treatment have no significant effect on Amylas. However, Amylas mean values were 21.047 and 12.307 U/L for fine bubbles aeration and water change treatment, respectively as shown in Tables 3 and 6.

Anti-oxidant enzymes parameters

The results showed that fine bubbles tube treatment and water change treatment haven't a significant effect on superoxide dismutase (SOD), catalase (CAT) and Malondialdehyde (MDA) as shown in Tables 3 and 7. Also, results showed that mean values for SOD were 8.87 and 8.187 U/gm for fine bubbles aeration and water change treatment, respectively as shown in Tables 3 and 7.

In addition to that mean values for CAT were 10.617 and 10.367 U/gm for fine bubbles aeration and water change treatment, respectively as shown in Tables 3 and 7.

While, MDA mean values were 18.367 and 12.93 nmol/g for fine bubbles aeration and water change treatment, respectively as shown in Tables 3 and 7.

Serum bio-chemical parameters

The results showed that fine bubbles tube treatment and water change treatment haven't a significant effect on white blood cells (WBcs), eosinophil, monocyte, lymphocyte, heterophil, glucose, Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), urea, creatinine, cholesterol and triglyceride.

Table 5. Blood bio-chemical parameters values

Treatment	Replicates	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)
Water change	1	3.98	1.52	**2.46**
	2	5.26	1.47	**3.79**
	3	4.15	1.6	**2.55**
	Mean	**4.46**	**1.53**	**2.93**
Fine bubble	1	4.96	1.41	**3.55**
	2	5.02	1.66	**3.36**
	3	4.81	1.49	**3.32**
	Mean	**4.93**	**1.52**	**3.41**

Source: Own results.

Table 6. Digestive enzymes parameters values

Treatment	Replicates	Amylase (U/L)	Lipase (U/L)
Water change	1	12.35	**29.98**
	2	10.69	**27.64**
	3	13.88	**30.55**
	Mean	**12.31**	**29.39**
Fine bubble	1	20.98	**41.24**
	2	19.86	**31.26**
	3	22.3	**30.29**
	Mean	**21.05**	**34.26**

Source: Own results.

Table 7. Anti-oxidant enzymes parameters values

Treatment	Replicates	SOD U/gm	CAT U/gm	MDA nmol/g
Water change	1	8.67	10.99	**19.85**
	2	6.94	9.86	**16.91**
	3	8.95	10.25	**18.34**
	Mean	**8.17**	**10.37**	**18.37**
Fine bubble	1	8.01	9.34	**14.25**
	2	10.65	10.16	**13.66**
	3	7.96	12.35	**10.89**
	Mean	**8.87**	**10.62**	**12.93**

Source: Own results.

Table 8. Serum bio-chemical parameters values, part (1).

Treatment	Rep.	WBcs ($x10^3$/ mm^3)	Heter-ophil%	Heter-ophil ($x10^3$/ mm^3)	Lymp-hocyt%	Lymp-hocyt ($x10^3$/ mm^3)
Water change	1	8.67	18	1.56	71	**6.16**
	2	7.94	13	1.03	79	**6.27**
	3	10.56	15	1.58	74	**7.81**
	Mean	**9.06**	**15.3**	**1.39**	**74.67**	**6.74**
Fine bubble	1	9.69	12	1.16	78	**7.56**
	2	10.26	14	1.44	79	**8.11**
	3	10.19	16	1.63	72	**7.34**
	Mean	**10.05**	**14**	**1.41**	**76.3**	**7.67**

Source: Own results.

Table 9. Serum bio-chemical parameters values, part (2)

Treatment	Rep.	Mon-ocyte%	Mon-ocyte	Esino-phil%	Esino-phil	Baso-phil%	Baso-phil
			($x10^3$/ mm^3)		($x10^3$/ mm^3)		($x10^3$/ mm^3)
Water change	1	9	0.78	1	0.09	1	**0.09**
	2	7	0.56	1	0.08	0	**0**
	3	8	0.84	2	0.21	1	**0.11**
	Mean	**8**	**0.73**	**1.3**	**0.13**	**0.67**	**0.07**
Fine bubble	1	8	0.78	1	0.1	1	**0.1**
	2	6	0.62	0	0	1	**0.1**
	3	9	0.92	2	0.2	1	**0.1**
	Mean	**7.7**	**0.77**	**1**	**0.1**	**1**	**0.1**

Source: Own results.

Table 10. Serum bio-chemical parameters values, part (3)

Treatment	Rep.	Urea	Alt	Ast	Trigly-ceride	Choles-terol	Glu-cose	Creat-inine
			(U/L)	(U/L)	(mg/dl)	(mg/dl)	(mg/dl)	(mg/dl)
Water change	1	4.25	25.34	30.15	99.34	80.64	10.32	**0.45**
	2	4.11	19.86	27.09	110.25	91.34	10.98	**0.39**
	3	3.91	20.58	33.68	87.64	97.85	12.34	**0.5**
	Mean	**4.09**	**21.93**	**30.3**	**99.01**	**89.9**	**11.21**	**0.45**
Fine bubble	1	4.3	27.64	29.86	94.66	101.24	9.86	**0.38**
	2	3.75	17.34	34.6	102.3	90.02	14.64	**0.41**
	3	3.69	14.98	25.45	90.24	79.64	10.05	**0.46**
	Mean	**3.91**	**19.99**	**29.97**	**95.7**	**90.3**	**11.52**	**0.42**

Source: Own results.

However, they have a significant effect on basophil at p of 0.024 as shown in Tables 3, 8, 9 and 10.

White blood cells (WBcs) mean values were 10.05 and 9.057 $x10^3/mm^3$ for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Eosinophil mean values were 0.1 and 0.127 $x10^3/mm^3$ for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Also, Monocyte mean values were 0.773 and 0.726 $x10^3/mm^3$ for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Eosinophil mean values were 0.1 and 0.127 $x10^3/mm^3$ for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Lymphocyte mean values were 7.67 and 6.647 $x10^3/mm^3$ for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Besides, Heterophil mean values were 1.41 and 1.39 $x10^3/mm^3$ for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Also, Glucose mean values were 11.5167 and 11.213 mg/dl for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Aspartate aminotransferase (AST) mean values were 29.97 and 30.30 U/l for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Alanine aminotransferase (ALT) mean values were 19.987 and 21.92 U/l for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10. Urea mean values were 3.91 and 4.09 mg/dl for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

Creatinine mean values were 0.4167 and 0.467 U/l for fine bubbles aeration and water change treatment, respectively as shown in tables VII.22. While, Cholesterol mean values were 0.4167 and 0.467 mg/dl for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

In addition to that, Triglyceride mean values were 95.73 and 99.07 mg/dl for fine bubbles aeration and water change treatment, respectively as shown in Tables 3, 8, 9 and 10.

CONCLUSIONS

There is no significance between replicates mean values of fine bubbles aeration treatment and water change treatment for mean corpuscular volume (MCV), Mean corpuscular Hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) indicators. Fine bubbles tube treatment and water change treatment have no significant effect on albumin and lysozyme. Aeration method has a significant effect on Lipase where P value is 0.049. While fine bubbles tube treatment and water change treatment have no significant effect on Amylas.

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THE EFFECT OF AERATION METHOD ON NILE TILAPIA GROWTH, WATER QUALITY INDICATORS AND ENVIRONMENTAL IMPACT

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Abstract

This study discussed the effect of application optimum operational conditions for fine bubbles aeration of 0.554 $m^3.h^{-1}$ air flow rate, tube depths from water surface of 0.7 m, tube inner diameter of 11 mm, circular design shape at aquaculture greenhouse for rearing Nile Tilapia and compared with traditional water change system in three replicates for every treatment. Water change ratios were 10 and 30% for fine bubbles and traditional water change method, respectively. The experiment period were 8 weeks until reach commercial size. The water quality indicators were: Dissolved oxygen (DO), Total ammonia nitrogen (TAN), Temperature, Total dissolved solids (TDS), pH. Also, the Fish growth indicators were: Weight gain, Feed conversion ratio (FCR) and survival rate, Specific growth rate (SGR). The best FCR value was 1.181 and obtained at the seventh week for fine bubbles aeration. The maximum SGR value was 1.96 which obtained at the seventh week for fine bubbles aeration, while the minimum value was 0.86 obtained at the fifth week for water change method. The maximum mean value for dissolved oxygen was 91% of saturation obtained at fine bubbles aeration method. Also, the minimum mean value for total ammonia nitrogen was 0.32 mg/l obtained at fine bubbles aeration method. The minimum and maximum mean values for total dissolved solids (TDS) in fine bubbles treatment were 1.610 and 1.7 mg/l, respectively.

Key words: *aquaculture, water quality indicators, fine bubbles aeration, fish growth indicators*

INTRODUCTION

The brackish water produced 855,789 t of tilapia in 2017, accounting for 70% of all tilapia produced in Africa. Egypt dominates the production of farmed tilapia in Africa. In 2017, the total amount of farmed tilapia produced in Africa was 967,301 t, with Egypt producing the majority of that amount. Africa's contribution to the world's tilapia output will drop from 21% in 2017 to only 4.3% if Egypt's share is discounted [7].

The quantity of fish produced increased by 5.4% to 2.0 million tons in 2019 from 1.90 million tons in 2018. Lakes came in second with a production percentage of 7.97%, followed by marine waters with 4.9%, fresh water with 3.8% and rice fields with 0.8% of the total amount of fish produced. The revenue of fish production increased by 26.6% in 2019 to 61.1 billion LE from 48.3 billion LE in 2018. Also, the area of aquaculture farms decreased by 3.9% from 307.2 thousand feddan in 2018 to 295.2 thousand feddan in 2019 [6].

The poor water quality decreased fish productivity, higher production costs for fish farmers and hatcheries and a higher risk of disease outbreaks. Additionally, poor water quality could harm the environment and people's health, including that of consumers and workers [11].

The quantity of free, non-compound oxygen contained in water or other liquids is referred to as dissolved oxygen. Due to its impact on the aquatic life present in a body of water, it is a crucial factor in determining the quality of the water. Dissolved oxygen is the second most important component in limnology, after water itself. Too much or too little dissolved oxygen in the water can harm aquatic life and change its quality [9].

The minimum dissolved oxygen ranges for *Oreochromis niloticus* were 0.1-0.5 mg/l while the optimum was between 6 and 6.5 mg/l [1].

The most crucial period to introduce more aeration is shortly before dawn, when DO concentrations are often lowest because this is when they frequently drop below tolerable levels. Early morning DO for warmwater fish should stay above 3-4 mg/L and above 5-6 mg/L for cold-water fish. Warmwater and cold-water fish can survive with concentrations as low as 1.0-1.5 mg/L and 2.5-3.5 mg/L, respectively. However, these concentrations can raise stress, reduce appetite or aggression to eat and if low enough for a long length of time they can be deadly [5].

Due to the local fish's higher metabolic rates while they are feeding, DO drops during feeding. Fish spend more energy to eat in a competitive manner which causes an increase in metabolic rate. A DO requirement is also produced by uneaten feed and feces. This excrement provides plant nutrients that encourage the growth of phytoplankton. When phytoplankton is more abundant, the amount of DO that they need to breathe at night can increase. To raise the need for DO, phytoplankton are also continuously perishing and decomposing. The use of fertilizer can encourage the growth of algae, which can improve oxygen production and remove potentially hazardous ammonia [14].

The performance of tilapia may be significantly impacted by the interplay between diet mix and DO concentration. These researchers fed Nile tilapia (35 g) two different diets at two different oxygen saturation levels: normoxia (100%, 6.9 $mg.L^{-1}$) and hypoxia (50%, 3.5 $mg.L^{-1}$). The control diet was based on fishmeal (FM), while the other diet was based on soybean meal (SBM). Under normoxia, the FM "control" diet resulted in the highest growth rates [13].

An experiment in three nations of Nepal, Cambodia, and Kenya low-cost tilapia production with fertilization and supplemental feeding. Nile tilapia fingerlings (6.2 g) were raised in each of the three countries by feeding only with 25-30% crude protein (cp) diets at a daily feeding rate of 3% of fish body weight [10].

The daily rate of partial water exchange in clay ponds is relatively low. In fact, early in the season, when the number of fish is minimal and well below the pond's carrying capacity, it might not even be necessary. However, as fish get bigger and bigger, there is a greater need for freshwater. Based on the stocking density, fish size and species, it may reach 20% or more every day by the end of the season [12].

The total water use in aquaculture according to culture intensity and species. Water requirements for intensive aquaculture were 40-80, 10-15 and 12 m^3/kg for shrimp (20% daily water change), intensive tilapia and carp polyculture, respectively. While for semi-intensive it was 5 and 3-6 m^3/kg for carp polyculture, warmwater fish (nighttime aeration), respectively [7].

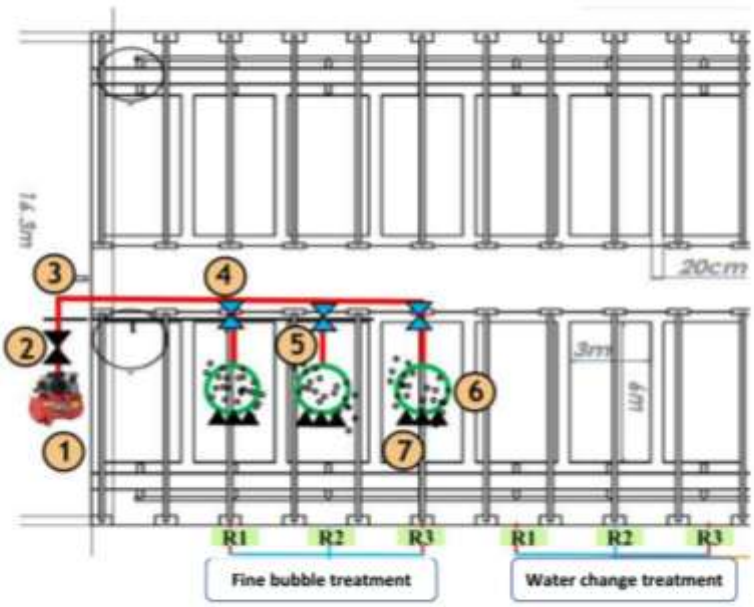
The main aims of the research were to:

- Reduce water, energy consumption and aquaculture gases emissions.
- Determine the effect of fine bubbles aeration method on water quality and fish indicators compared with water change method.

MATERIALS AND METHODS

Experiments were carried out over winter season 2021-2022 (25th Nov 2021 – 19th Jan 2022) at a private earthen aquaculture pond and greenhouse, Damro city, Kafr El-Sheikh governorate, with co-ordinates of 31°22'41.3"N and 30°47'32.4"E. The experiment was under taken to applicate the optimum operational conditions for oxygen production at aquaculture greenhouse for a rearing season in comparison with traditional water change system with three replicates for each system.

The Nile tilapia *(Oreochromis niloticus*) as aquatic fish was obtained from a private farm located in Damro city, Kafr El-Sheikh governorate, Egypt. The experimental fish start weight was 140 grams with a density of 5 fishes/m^3 for every replicate. Aquaculture water used is a mixture from lake Burullus water and agricultural drainage water. The secchi disk mean values before conducting experiments were 44 and 41 cm for water source and pond, respectively. As shown in Figures 1 and 2 the greenhouse has a design of quonset double span and covered with polyethylene (PE) plastic sheet.



Aeration system components

No.	Item
1	Air compressor
2	Main valve
3	Main air line
4	Secondary valve
5	Secondary air line
6	Aeration tube
7	Tube holder

Fig. 1. Schematic diagram for aeration system components at aquaculture greenhouse
Source: Drawn by the researchers.

It consists of 18 concrete ponds. Every pond has dimensions of 3 m width, 6 m length and 1.5 m depth. Also, every pond filled up with 18 m^3 of water. Also, three meters of diffusion tube for every greenhouse pond with 6 aeration periods/day and 30 minutes of working for period. The aeration system components consist of: an electric single-phase compressor and diffusion tube of D25-7 which made from recycled porous rubber for airmmax company, China. Fish feed were from extruded floating 25% CP, 3 mm die holes diameter. Table III.4 shows fish feed chemical composition which presented twice times daily [4].

Methods

The optimum operational conditions for oxygen productivity were applicated at aquaculture greenhouse and compared with traditional water change system in three replicates for every treatment. Water change ratios were 10 and 30% for fine bubbles and traditional water change method, respectively. The experiment period were 8 weeks until reach commercial size.

The **water quality indicators** were aquaculture water dissolved oxygen (DO), aquaculture water total ammonia nitrogen (TAN), aquaculture water temperature, aquaculture water total dissolved solids (TDS) and aquaculture water pH.

Also, the **Fish growth indicators** were fish weight gain, feed conversion ratio (FCR and survival rate) and specific growth rate (SGR).

Weight gain was determined by measuring body weight at specific time. Also, for each sampling, feed conversion ratio (FCR) [3] and Specific Growth Rate (SGR (%)) [2] were calculated by the following equations:

$$FCR = \frac{dry\ feed\ consumption}{live\ weight\ gain}$$

$$SGR\ (\%) = \frac{[\ln(final\ weight) - \ln(initial\ weight)]}{Number\ of\ feeding\ days}$$

Operational conditions were: air flow rates of 0.554 $m^3.h^{-1}$, tube depth of 0.7 m from water surface for aeration tube and holder, tube wall inner diameter of 11 mm and circular design shape according to [8].

RESULTS AND DISSCUSIONS

The main experiment results include **water quality indicators** (Water dissolved oxygen, water total ammonia nitrogen (TAN), water total dissolved solids (TDS), water pH and water and air temperature) and **fish growth indictors** (Fish weight gain, Specific growth rate (SGR), Feed conversion ratio (FCR) and survival rate).

Water quality indicators

Water indicators could be conducted as follow:

Effect of fine bubbles aeration and water change treatments on dissolved oxygen values

The results showed that fine bubbles aeration method give highest values for dissolved oxygen compared to traditional method at all experimental replicates as shown in Figure 2.

The maximum mean value for dissolved oxygen was 91% of saturation obtained at fine bubbles method. Also, the minimum mean value for dissolved oxygen was 15% of saturation obtained at traditional method.

All day long, the dissolved oxygen mean value increases from 3 a.m. to reach the maximum mean value at 3 p.m., then decreases to reach minimum value at 3 a.m. this happens in all replicates and the two aeration systems. This may be due to plant photosynthesis as plants take oxygen at night and produce it at the day. Also, DO consumption at biological processes.

Over the experiment period with determining a time on the day, the highest dissolved oxygen concentration values were at fine bubbles aeration method. For example, at 3 am along all the experiment days dissolved oxygen mean values ranged between 40-52, 15-25 and 23-30% of saturation for fine bubbles method, traditional water change method and water source, respectively.

Effect of fine bubbles aeration and water change treatments on total ammonia nitrogen (TAN) values

The results declared that fine bubbles aeration method gives low values for total ammonia nitrogen compared with traditional aeration method at all experimental replicates as shown in Figures 3 and 4. The maximum mean value for total ammonia nitrogen was 4.89 mg/l obtained at traditional aeration method. Also, the minimum mean value for total ammonia nitrogen was 0.32 mg/l obtained at fine bubbles aeration method.

All day long, the total ammonia nitrogen mean value decreases from 3 am to reach the minimum mean value at 11 am, then increases to reach maximum value at 3 am this happens in all replicates and the two aeration systems.

This may be related to plant photosynthesis, feeding time and feed wastes. The results showed that at 3 am along all the experiment days, the total ammonia nitrogen mean values ranged between 2.2-3.02, 4.3-4.89 and 4.21-5.74 mg/l for fine bubbles method, traditional water change method and water source, respectively.

Unionized ammonia (NH_3) minimum mean value was 0.0018 mg/l for fine bubbles method and maximum mean value was 0.0557 mg/l for traditional water change method and all values were at permissible limits.

Effect of fine bubbles aeration and water change treatments on air and water temperature values

The obtained results showed that air temperature values in greenhouse were higher than those out the greenhouse at all days and times on the day of the experiment.

The air temperature reached the maximum value at 3 p.m. and minimum value at 3 a.m. for in and out green house, respectively at all days. The maximum and minimum mean values for air temperature in greenhouse were 39.9 and 7.3 °C, respectively.

The maximum and minimum mean values for air temperature out greenhouse were 33.8 and 6.2 °C, respectively.

The obtained results showed that water temperature values in fine bubbles treatment were higher than those at traditional water change treatment at all days and times on the day of the experiment as shown in Figures IV.20 and IV.21. The water temperature reached maximum value at 3 p.m. and minimum value at 3 a.m.

The maximum and minimum mean values for water temperature in fine bubbles treatment replicates were 31.4 and 5 °C, respectively. The maximum and minimum mean values for water temperature in traditional water change treatment replicates were 30.9 and 5°C, respectively.

This result may be due to high water change ratio in traditional water change treatment compared with fine bubbles treatment ratio, as the water in the source is colder than in greenhouse.

Effect of fine bubbles and water change values treatments on total dissolved solids (TDS)

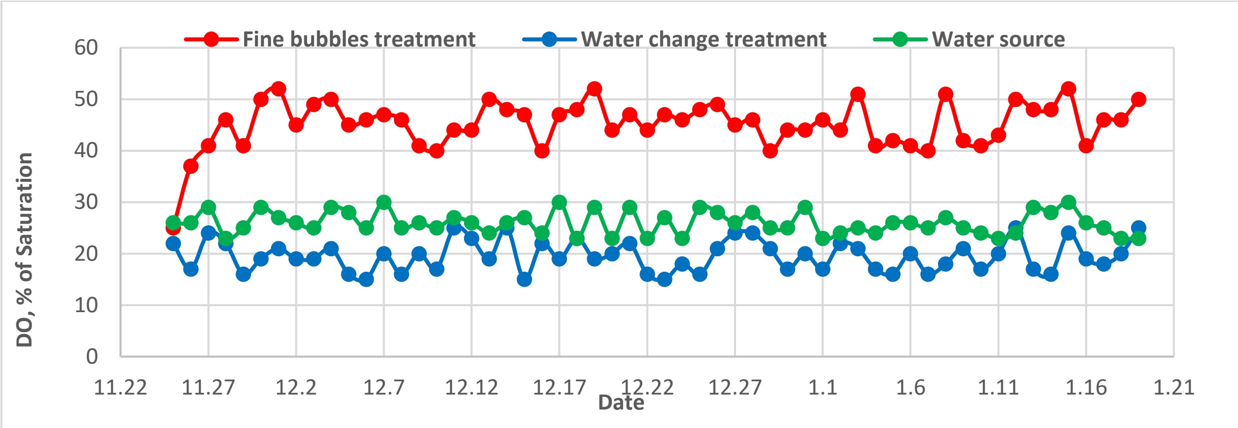


Fig. 2. Dissolved oxygen mean values for aeration by fine bubbles, water change treatments and water source at 3 a.m.
Source: Own results.

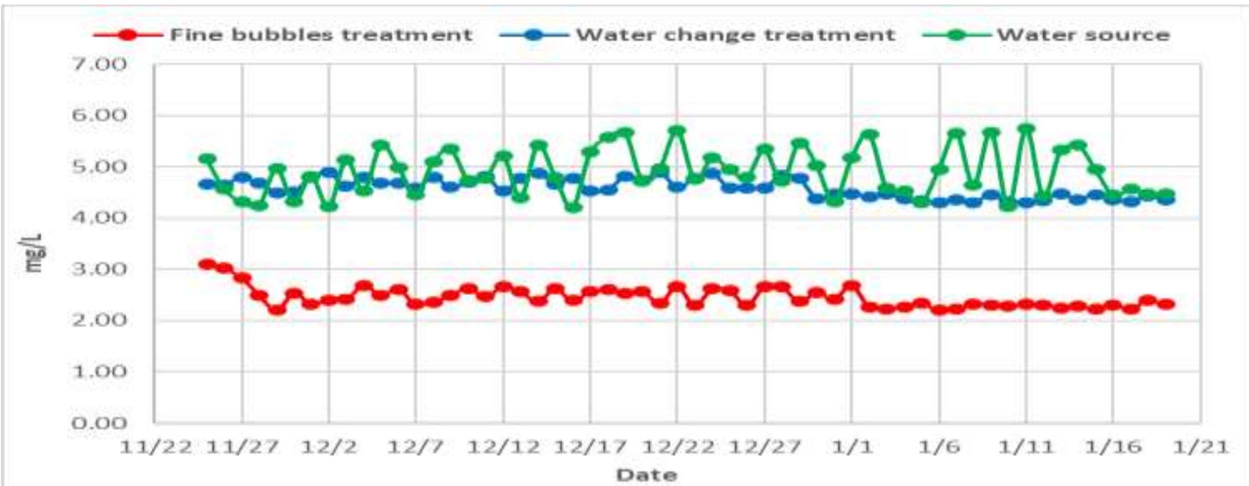


Fig. 3. Dissolved oxygen mean values for aeration by fine bubbles, water change treatments and water source at 3 a.m.
Source: Own results.

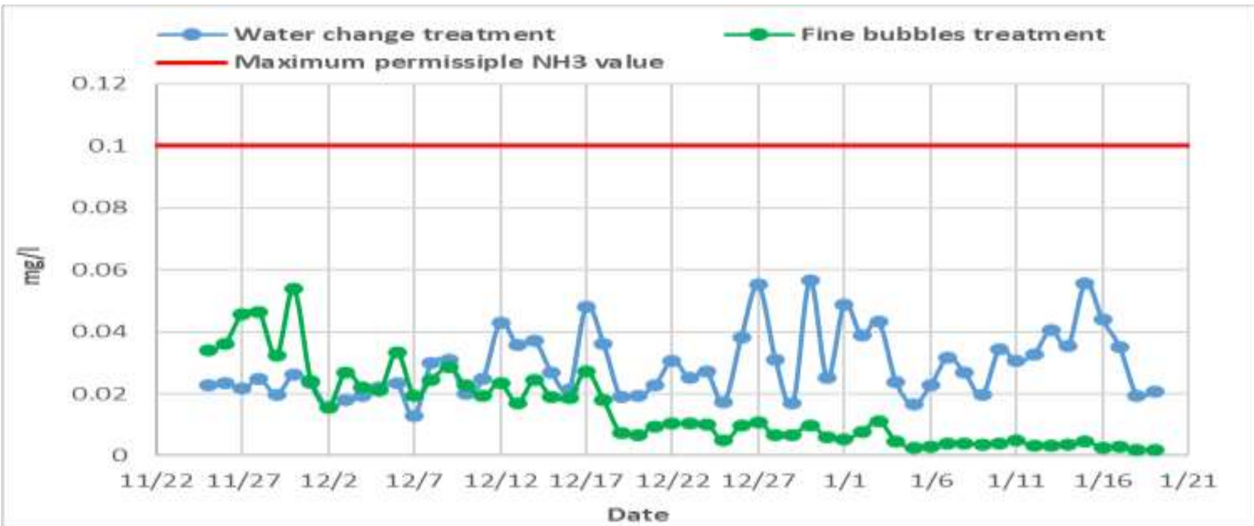


Fig. 4. Ammonia mean values for aeration by fine bubbles and water change treatments at 3 a.m.
Source: Own results.

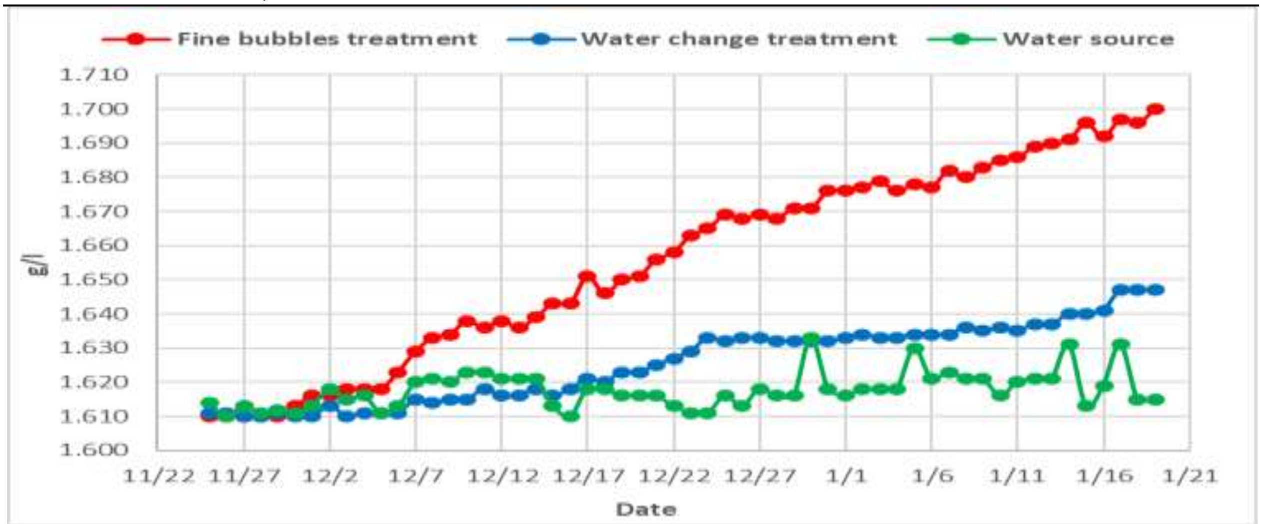


Fig. 5. TDS values for fine bubbles treatment, water change treatment and water source at 3 a.m.
Source: Own results.

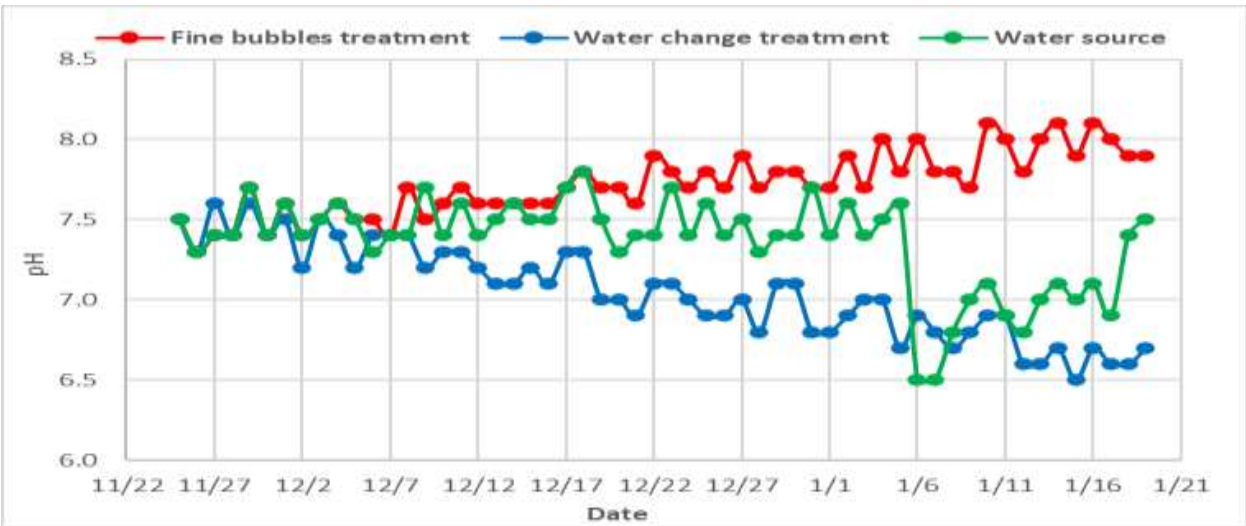


Fig. 6. pH values for fine bubbles, water change treatments and water source at 3 a.m
Source: Own results.

The obtained results showed that TDS mean values in fine bubbles treatment were higher than those at traditional water change treatment at all days and times on the day of the experiment as shown in Figures 5.

Also, the measurement time hasn't a significant effect on TDS values. The minimum and maximum mean values for TDS in fine bubbles treatment were 1.610 and 1.7 g/l, respectively.

The minimum and maximum mean values for TDS in traditional water change treatment were 1.610 and 1.647 g/l, respectively.

This result may be due to high water change ratio in traditional water change treatment compared with fine bubbles treatment ratio which removes them continuously.

Effect of fine bubbles and water change treatments on water pH values

The results showed that pH mean values in fine bubbles treatment were higher than those at traditional water change treatment at all days and times on the day of the experiment as shown in Figures 6.

The measurement time has a little significant effect on pH values, so it has low increase at 3 p.m. The minimum and maximum mean values for pH in fine bubbles treatment were 7.3 and 8.1, respectively. The minimum and maximum mean values for pH in traditional water change treatment were 6.5 and 7.6, respectively.

Fish growth indicators

Fish growth indicators classified into three partitions as follow:

Fish Weight gain

Average body weight of Nile Tilapia is affected by aeration method during the experimental periods as shown in Figure 7. Also, it declared that there an increase in weight gain for the two treatments along the experiment. However, its ratio in F.B.T more than W.C.T. along the experiment. It's conducted that the maximum weight gain for F.B.T. was 346.4 gram, while it was 308.1 g for W.C.T.

Fish feed conversion ratio (FCR) and survival rate

Results indicated that FCR values decreases with F.B.T. compared with W.C.T. at all experiment period as shown in Figure 8.

The best FCR value was 1.181 and obtained at the seventh week for F.B.T, while the maximum value for W.C.T was 1.58 and obtained at the fifth week. Also, the survival rate values were 98.89 and 91.11 % for F.B.T. and W.C.T., respectively. Whereas, the mean values of the feed conversion ratios were 1.251 and 1.46 for the treatments of fine bubble aeration and aeration by traditional method of changing water, respectively.

Specific growth rate (SGR)

Results showed that SGR values were high at F.B.T. compared with W.C.T. as shown in Figure 9. The maximum SGR value was 1.96 which obtained at the seventh week for F.B.T, while the minimum value was 0.86 obtained at the fifth week for W.C.T. SGR value influence with other conditions as temperature.

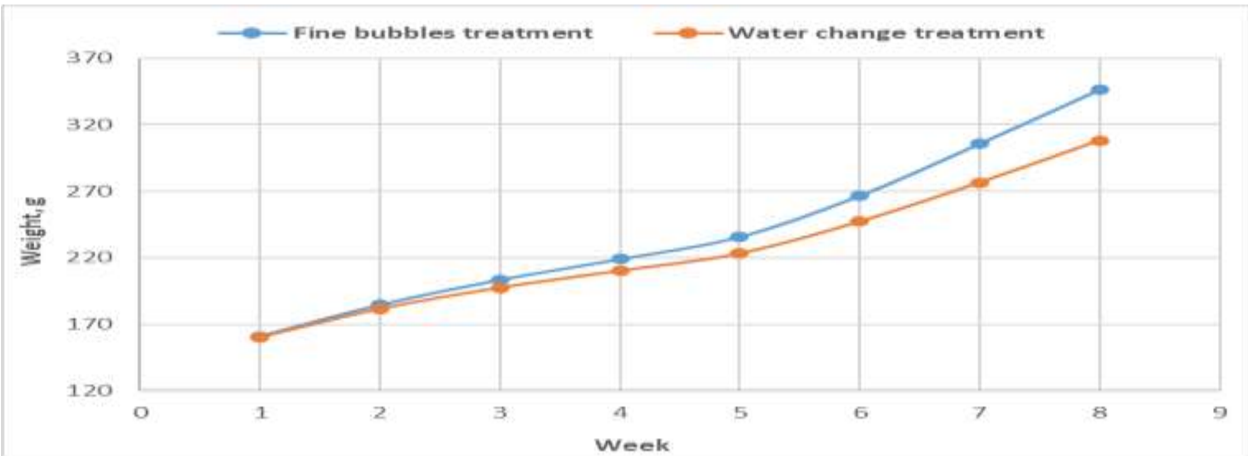


Fig. 7. Fish weight gain for aeration by fine bubbles treatment and water change treatment over the experimental period

Source: Own results.

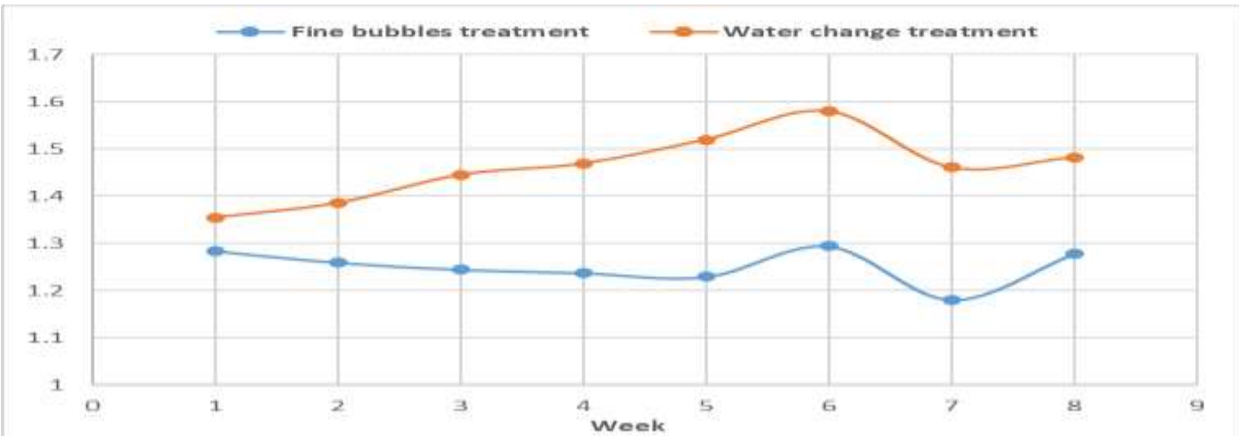


Fig. 8. FCR mean values for aeration by fine bubbles treatment and water change treatment a long experimental period.

Source: Own results.

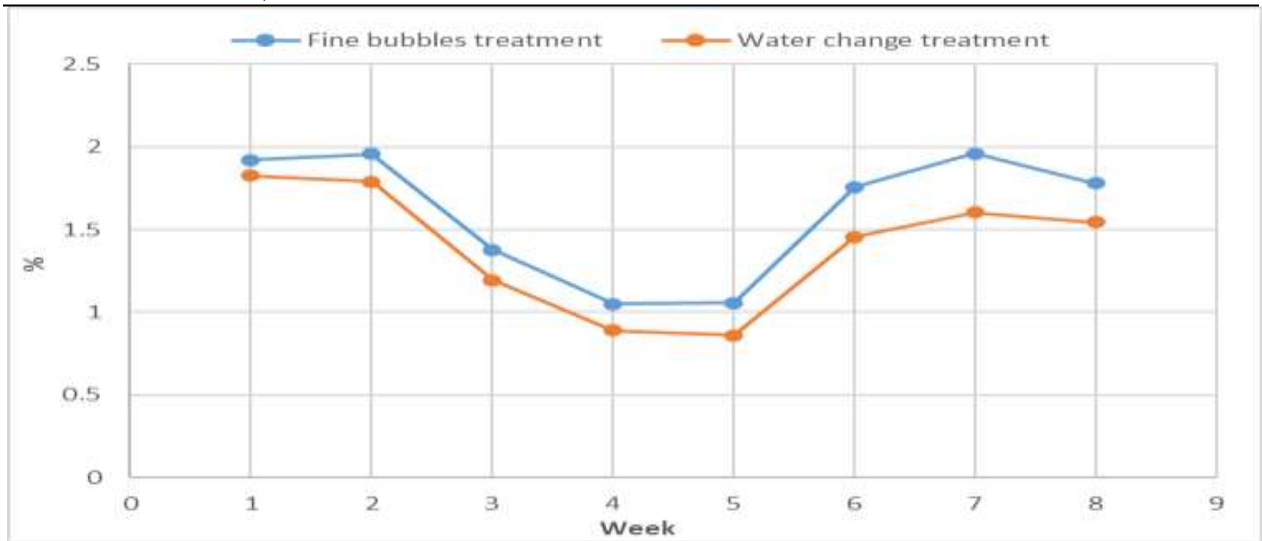


Fig. 9. SGR mean values for aeration by fine bubbles treatment and water change treatment over the experimental period.
Source: Own results.

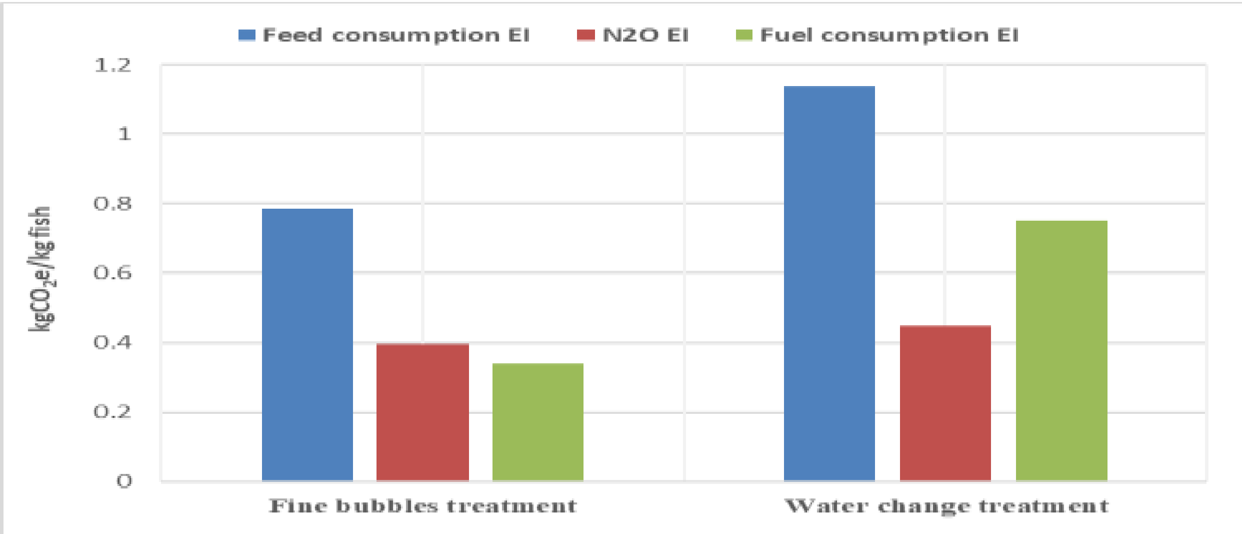


Fig. 10. Emission intensities for fine bubbles treatment and water change treatment
Source: Own results.

Effect of developed aeration system on aquaculture greenhouse emissions

The results showed that there is a reduction in GHGs emissions by using fine bubbles tube aeration method with 0.8058 kg.CO_2e/kg. fish due to reduction in feed consumed, N_2O emissions and fuel consumption. This reduction details values were 0.3529, 0.0529 and 0.4 kg.CO_2e/kg. fish for feed, N_2O emissions and fuel consumption, respectively as shown in Figure 10.

Water footprint estimation

The results showed that 1m^3 of water can produce 153.97 g of fish at F.B.T., while 42.765 g at W.C.T at experimental period (equivalent 6.498 m^3/kg. fish for F.B.T and 23.386 m^3/kg. fish for W.C.T.). These results due to the aeration efficiency of F.B.T rather than W.C.T. Also, survival rate is higher in F.B.T. than W.C.T.

CONCLUSIONS

The maximum mean value for dissolved oxygen was 91% of saturation obtained at fine bubbles aeration method.

Also, the minimum mean value for total ammonia nitrogen was 0.32 mg/l obtained at fine bubbles aeration method. The best FCR value was 1.181 and obtained at the seventh week for F.B.T, while the best value for W.C.T was 1.58 and obtained at the fifth week. Also, the survival rate values were 98.89 and 91.11 % for F.B.T. and W.C.T., respectively.

The permissible variables limits were (0.1, 0.18 and 0.23 $m^3.h^{-1}$) for air flow rate, (4, 6 and 7 mm) for tube wall thickness, (0.3, 0.50 and 0.70 mm) for tube depth from water surface and both of (circular and Longitudinal) design shapes.

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ANALYSIS OF THE DEMOGRAPHIC SITUATION AND DEMOGRAPHIC SAFETY OF THE RURAL POPULATION: A CASE STUDY OF UKRAINE

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Abstract

The main task of the research is to clarify the main trends of demographic processes in the rural areas of Ukraine and to formulate proposals for the development and improvement of the demographic policy of Ukraine in the future. In the process of preparing the article, we used abstract-logical, mathematical-statistical, visualization and econometric methods of scientific research. According to the results of the grouping of the regions of Ukraine by the level of demographic safety, we found that most regions of Ukraine form a group of so-called "demographic danger". And if in 2009 there was a third of the regions in this group, then in 2021, about 50% showed demographic problems related to rural population caused by the decline of the population, including also the rural one and migration process with reduce the labor potential of rural areas, etc. In the article we substantiated that Ukraine, as a future member of the European Union, should move to the priority goals of the common agricultural policy (CAP), which include improving the quality of life in rural areas, diversifying the rural economy, improving the state of the environment and rural areas, and increasing the level of competitiveness of the agricultural industry.

Key words: *rural population, rural areas, demographic safety, demographic crisis, labor potential of rural areas, demographic policy*

INTRODUCTION

The demographic crisis, the reduction in the birth rate, and the need to form an effective demographic policy are among the most urgent problems in the formation of approaches to regulating the demographic situation of the rural population of Ukraine. The development of crisis phenomena in the population, and the need to find new ways to alleviate the situation is an objective necessity to ensure the sustainable development of rural areas and ensure the efficiency of the agricultural sector, which needs an adequate level of labour resources. At the same time, one of the main problems of the demographic situation is the decline in the birth rate, but from the point of view of the demographic transition, it is a universal process characteristic of all developed countries. After all, in general, currently in the world, about a third of all countries have a value of the total fertility rate, which is below the level of simple reproduction. A significant deterioration of the demographic situation in the rural areas of Ukraine is also caused by the actual Russian hostilities.

Therefore, the development of an effective demographic policy for the rural population of Ukraine is an extremely important task, which requires the study of the socio-economic reasons for the deterioration of the situation.

The study of the issues of forming an effective demographic policy for the population is not new for modern economic science, and currently, there is enough work on methods of regulating social and economic policy aimed at eliminating deformation in the demographic sphere of rural areas. In this aspect, it is especially worth highlighting the works of such researchers as I. Balaniuk [1], O. Binert [2], I. Britchenko [3-11], Y. Chaliuk [12],

M. Dziamulych [13-21], S. Koshova [23-24], T. Kravchenko [25], M. Mašľan [26], A. Popescu [27-38], T. Shmatkovska [40-42], R. Sodoma [43-48], O. Staschuk [49-51], I. Tofan [54], I. Tsymbaliuk [55], I. Yakoviyuk [57], V. Yakubiv [58], O. Yatsukh [59], and many others. At the same time, the significant acceleration of negative processes taking place in the demographic sphere of the rural population of Ukraine requires a more thorough assessment of the situation in order to find ways to solve existing problems.

MATERIALS AND METHODS

Under the demographic policy of the rural population, we understand the system of parameters of natural and mechanical movement and structure of the population, which allows us to effectively respond to internal and external threats to ensure the sustainable development of society and the life of an individual.
A demographical policy will allow to establish objectives and corresponding measures to develop effective mechanisms for solving the demographic crisis both at the national level and in the rural areas.

$$P_e = \frac{P_a}{P_{90}} \times 100$$

where:
P_e – the population percentage at present in the population existing in the year 1990;
P_a – the number of the available population in the analyzed period (thousands of people);
P_{90} – the number of the total population in 1990, (thousands of people)

$$D_b = \frac{P_a}{P_w} \times 100$$

where:
D_b – the demographic burden of the disabled population on the able-bodied population (%);
P_a – the number of the population younger and older than the working age (persons);
P_{90} – the number of the population at the working age, (persons)

Table 1. Weighting coefficients for calculating the integral indicator of the demographic policy of the rural population

Name of the indicator, unit of measurement	The value of the weighting factor
The size of the existing population, percentages to the level of 1990	0.1265
Life expectancy at birth, years	0.1265
Infant mortality rate (children under one year of age died) per 1,000 live births	0.1431
Coefficient of natural growth, per 1,000 people of the existing population	0.1874
Share of the elderly population in the total population (as of the end of the reporting period), percentages (aging ratio)	0.1625
The demographic burden of the disabled population on the able-bodied population, the percent	0.1265
The total coefficient of migration growth, reduction (-) (per 10,000 people)	0.1274

Source: systematized based on [52].

RESULTS AND DISCUSSIONS

The main task of the research is to clarify the main trends of demographic processes in the rural areas of Ukraine and to formulate proposals for the development and improvement of the demographic policy of Ukraine in the future.
The demographic situation in rural areas is characterized by a number of degradation processes, including depopulation (primarily due to a decrease in the birth rate and an increase in mortality), internal and external migration of the economically active rural population, reduction of the average life expectancy, etc. In this regard, the number of rural residents in Ukraine decreases by 1.1% every year, which is on average equal to 340 villages or 2 administrative districts and causes the reduction of the rural settlement network [53]. In addition to the demographic situation, the trends of socio-economic processes in rural areas, as well as the agroecological condition of agricultural lands, are also negative.
The depopulation process changes the location of the population on the territory, and ethnic proportions, and affects the dynamics of the population structure by gender, which, in turn, affects the intensity of natural and

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migration processes. The social consequences of depopulation are quite diverse, and some of them are also related to the aging of the population.

In view of this, structural changes in the management of rural areas are a particularly urgent task. We note that the reform process is caused primarily by the process of decentralization of power, which is designed to increase the level of management powers of local self-government and, in particular, of rural territorial communities.

It is appropriate to note that since independence, Ukraine has observed a negative trend of deterioration of the demographic situation (Fig. 1) and a reduction in the number of rural settlements (Fig. 2).

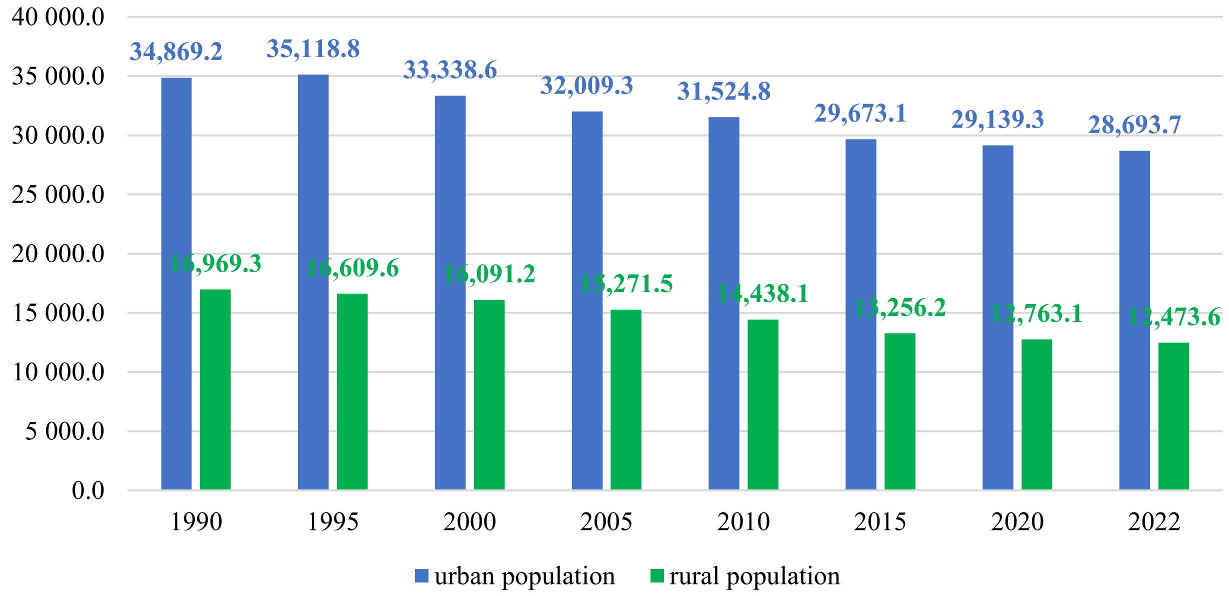

Fig. 1. Dynamics of the rural and urban population of Ukraine for 1990-2022, thousands of people.
*Data for 2015-2022 are given without taking into account the territories occupied by Russia.
Source: built based on [52].

According to the information of the State Statistics Committee of Ukraine, there is a decrease in the specific weight of both the urban and rural populations of Ukraine. Fig. 1 shows that both the urban and rural population has a tendency to decrease because compared to 1990, the number of rural residents has decreased significantly.

Regionally, the largest number of the rural population is registered in the western part of Ukraine, namely in the Vinnytsia, Zakarpattia, Ivano-Frankivsk, Rivne, Ternopil, and Chernivtsi regions, where compared to urgan population, the rural population accounts for 50%, and lower shares are in the eastern parts of the country: Dnipropetrovsk, Donetsk, Luhansk, and Kharkiv regions with a share of the rural population of less than 20%.

It should be emphasized that there is an uneven regional distribution of rural settlements in Ukraine, which may be due to geographical conditions, and therefore natural and climatic conditions, historical and cultural features, etc. (Fig. 2).

At the same time, the cause and effect of depopulation is the sex-age structure of the population, which exerted and continues to exert a decisive influence on the stability of the demographic system, because they (in particular, the ratio of men and women) are the main factors in the development of both the entire population and its regional components. For the rural population of Ukraine, «aging from below» is observed, which is caused by a gradual decrease in the number of children due to a decline in the birth rate.

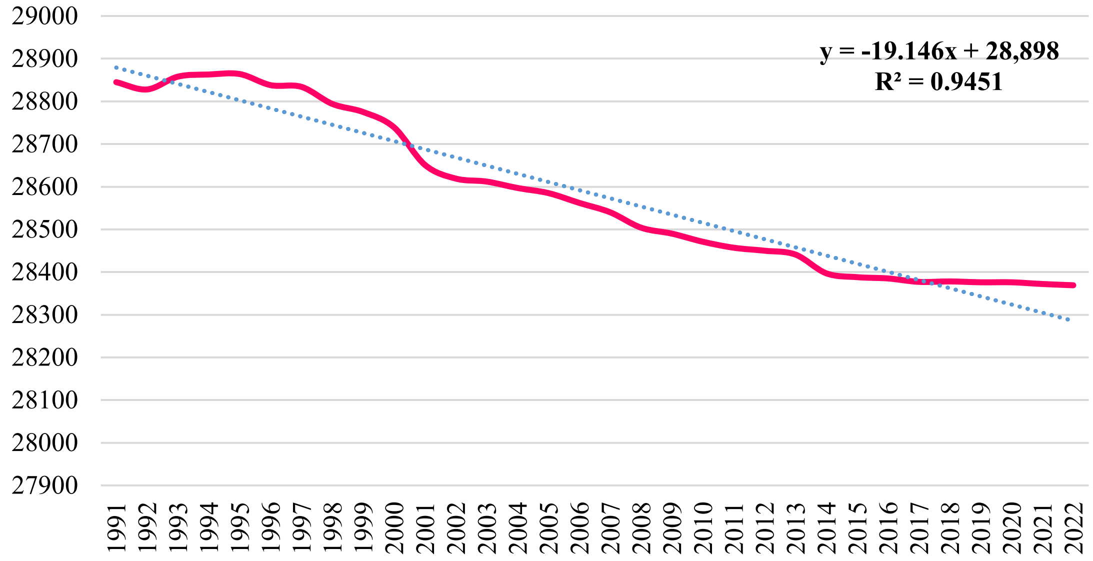

Fig. 2. Dynamics of the number of rural settlements in Ukraine by year
Source: built based on [52].

There is a gradual transition from a «stationary» type of age structure to a «regressive» one. Another disappointing conclusion can be made by predicting a significant aging of the population when the large generation of 49-54-year-olds ages. It is expected as in the future, about 33% of the rural population in Ukraine to be older than 60, even though at the current level of mortality, the increase in the aging rate slows down.

According to the age scale proposed by the UN, a population in which the proportion of people aged 65 and over is more than 7% is considered «old». The population of Ukraine crossed this limit in 1970, and today the share of people over 65 in Ukraine is about 15.5%. The rate of aging of the rural population of Ukraine, that is, the specific weight of people aged 60 years and older in today`s realities is 23%, while men have 17%, and women – have 28%, which is connected with the high mortality of men. At the same time, the threshold value for simple reproduction of the rural population of Ukraine is 12%, and for extended – 8%.

The problem of the qualitative and quantitative composition of the labour potential of rural areas remains unresolved. The gender imbalance in the structure of the population`s economic activity in rural areas is obvious, as there is a tendency to decrease the specific weight of men and vice versa, to increase the specific weight of women in the gender structure. Note that the researcher of problems of development of rural areas H. I. Sabluk [39] draws attention to such a problem as the role of a peasant woman, a working woman. As of January 1, 2022, the ratio of men and women living in rural areas of Ukraine was 47% and 53%, respectively. According to H. I. Sabluk, in each rural territorial community, it is expedient to create a so-called women`s centre, where all socio-economic aspects of the life of a peasant woman as the guardian of a rural family would be concentrated.

By demographic policy, we understand the system of parameters of natural and mechanical movement and population structure, which allows us to effectively respond to internal and external threats to ensure the sustainable development of society and human life. In our opinion, based on open statistical data, it is appropriate to use the following indicators to determine the level of demographic policy of the rural population: total population growth, birth rate, mortality rate, natural increase rate, infant mortality rate, migration balance, demographic burden, general population aging rate.

The calculation of the indicator of demographic policy of the rural population of the regions of Ukraine was carried out by analogy with the integrated indicator of the level of demographic security proposed by I. Hudzeliak and N. Verchyn [56]. As a result of the determination, the final indicator varies between 0 and 1.0. Note that the indicator of demographic policy makes it possible to analyze the current situation, identify prevailing trends, and conduct a retrospective analysis of the demographic indicators of the region and to determine the possible state of the demographic situation in the future. To compare the regions of Ukraine by the level of territorial differentiation of the demographic situation of the rural population, a ranking method was chosen, where the indicator used is the indicator of demographic statement.

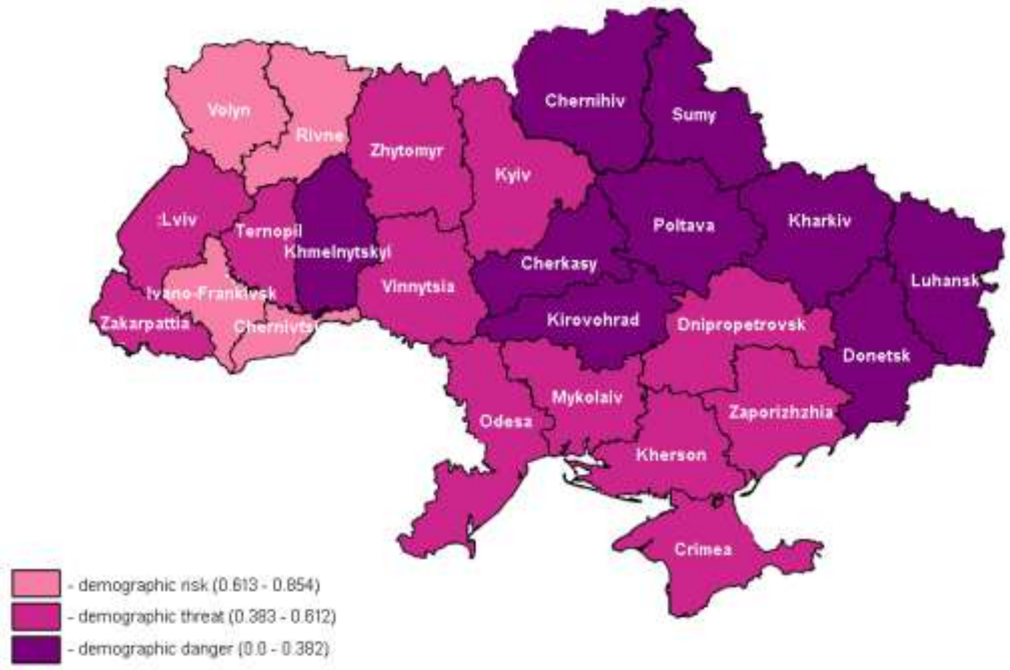

Fig. 3. Cartogram of the results of the grouping of the regions of Ukraine according to the level of demographic safety of the rural population in 2009
Source: built based on [52].

Based on the results of the calculations, it was established that in 2009 (Fig. 3) according to the indicator of demographic safety of the rural population, Volyn, Rivne, Ivano-Frankivsk, and Chernivtsi regions belonged to the regions of demographic risk. The regions with a demographic threat included Zakarpattia, Lviv, Ternopil, Zhytomyr, Vinnytsia, Kyiv, Odesa, Mykolaiv, Kherson, Dnipropetrovsk, and Zaporizhia and Crimea regions.
Khmelnitskyi, Cherkasy, Kirovohrad, Chernihiv, Sumy, Poltava, Kharkiv, Luhansk, Donetsk regions were regions with a demographic danger.
In 2015 (Fig. 4), Volyn, Rivne, and Zakarpattia regions were among the demographic risk regions. Khmelnitskyi, Vinnytsia, Cherkasy, Kirovohrad, Chernivstiv, Sumy, Poltava, Dnipropetrovsk, Zaporizhzhia, Luhansk, and Donetsk regions were among the regions with demographic danger.
In 2021 (Fig. 5), Volyn, Rivne, and Kyiv regions were among the demographic risk regions. Vinnytsia, Cherkasy, Kirovohrad, Kherson, Mykolaiv, Chernihiv, Sumy, Poltava, Kharkiv, Dnipropetrovsk, Zaporizhzhya, Luhansk, and Donetsk regions belonged to regions with demographic danger.
It was established that during the research period, Volyn and Rivne regions demonstrated the highest indicator of demographic safety of the rural population and belonged to the so-called «demographic risk» group. Zakarpattia, Ivano-Frankivsk, and Chernivtsi regions «dropped out» of this group, but in 2021, the Kyiv region entered it. Lviv, Ternopil, Zhytomyr, and Odesa regions, were constantly included in the so-called «demographic threat» group.

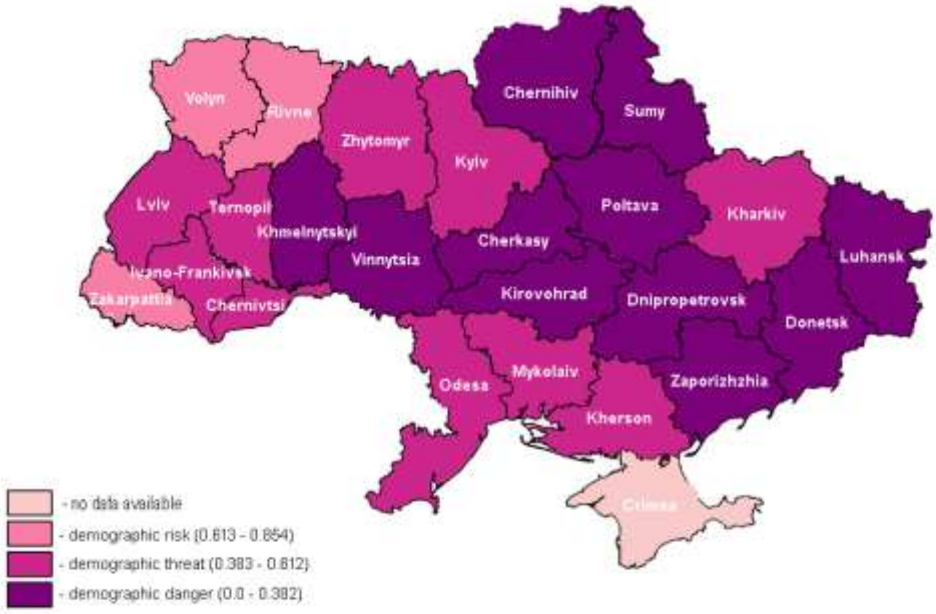

Fig. 4. Cartogram of the results of the grouping of the regions of Ukraine by the level of demographic safety in 2015
Source: built based on [52].

Fig. 5. Cartogram of the results of the grouping of the regions of Ukraine by the level of demographic safety in 2021
Source: built based on [52].

In 2015, the Kharkiv region was included in the same group. Most regions of Ukraine form a group of so-called «demographic danger». And if in 2009 there was a third of the regions in this group, then in 2021 – half of them, which indicates the aggravation of demographic problems regarding the rural population of Ukraine. We also note that in the context of European integration processes, the experience of solving current problems of the development of rural areas in the European Union is important for Ukraine. Moreover, in the Association Agreement with the EU on issues of political association and economic integration, Chapter V «Economic and sectoral cooperation» stipulates that expanded cooperation in the field of agriculture and rural development is envisaged. As about 51% of the world`s population lives in rural areas, which cover 75% of the total area, and on which is achieved 32% of the global GDP, the problem of sustainable development of rural areas is relevant not only for Ukraine but also for other countries [22].

Thus, the relevance of the European integration processes in Ukraine necessitated the adaptation of the European practice of transition to the principles of sustainable development of rural areas. It is interesting that the European Statistical Committee classifies European countries according to the specific weight of the rural population into "urban (the specific weight of the rural population is less than 20%), transitional (the specific weight of the rural population ranges from 20 to 50%) and rural (the specific weight of the rural population is more than 50%)".

Table 2. Statistical characteristics of the distribution of the specific weight of the rural population of the countries of the European Union (by country) and Ukraine (by region)

Statistical parameters	The European Union by country	Ukraine by regions
Arithmetic mean	31	34
Standard deviation	18	17
Median	336	278
Coefficient of variation, %	30	30
Dispersion	58	49

Source: systematized based on [52].

In view of this, the necessary mathematical measurements were carried out and it was established that the main statistical parameters of the distribution of the specific weight of the rural population in the countries of the European Union in the cross-section of countries and Ukraine in the cross-section of regions are very similar, namely, the arithmetic means, standard deviation, median, coefficient of variation and dispersion (Table 2). To visualize the results of the study, a polygon of the statistical distribution of the specific weight of the rural population of the countries of the European Union and Ukraine was built (Fig. 6). Thus, it was established that in solving the issues of Ukraine`s transition to the principles of sustainable development of rural areas, it is necessary to take into account the experience of the European Union, since the features of demographic processes have similar trends and patterns of development.

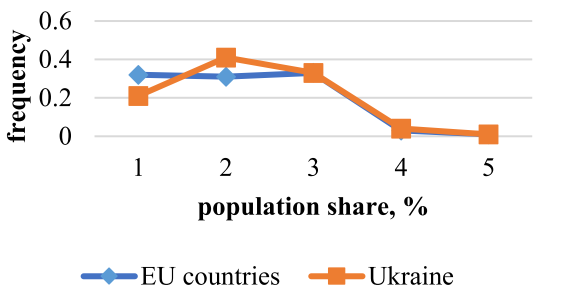

Fig. 6. Polygon of the statistical distribution of the share of the EU countries and Ukraine rural population
Source: built based on [52].

That is why, the effective implementation of the rural development policy for optimizing both the development of the agricultural sector and of the rural areas, which are two interrelated and interdependent processes, we believe that it is important for Ukraine to adopt the experience and be guided by the main provisions of the common agricultural policy (CAP) of the European Union. For more than half a century, the main priorities of the SAP (prescribed in Article 39 of the Treaty of Rome) are primarily aimed at strengthening the position of the agricultural sector and the production of agricultural products thanks to rapid scientific and technical progress, as well as aimed at improving social welfare and the standard of living for those who work in the agricultural sector - primarily for the population of rural areas.

CONCLUSIONS

Based on the results of the research, it can be stated that the development of rural areas in Ukraine is characterized by a complex imbalance. The consequence of such a situation is the aggravation of the demographic crisis in connection with the constant decrease in the number of the population (including the rural population), migration processes, reduction of the labor potential of rural areas, etc.

Research by scientists confirms that in modern conditions it is impossible to fundamentally improve the age structure of the rural population by an increase in birth rates. Therefore, considerable attention must be paid to improving the quality of life of the rural population, and its health, which can be reflected in the increase in life expectancy; creating opportunities for improving its quality, increasing the efficiency of using the labor potential of both the working population and the socio-cultural and labour potential of the rural population of older age groups.

In connection with the relevance of Ukraine`s integration processes into the European Community, in our opinion, it is appropriate to borrow the experience of the European Union countries regarding issues of sustainable development of rural areas. We believe that Ukraine, as a future member of the European Union, should move to the priority goals of the common agricultural policy (CAP), which include improving the quality of life in rural areas, diversifying the rural economy, improving the state of the environment and rural areas, and increasing the level of competitiveness of the agricultural industry. In addition, it is advisable to direct state support and financial resources separately to the development of rural areas and rural production, which are interdependent and mutually determined processes, but not identical.

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INPUT USE AND FACTORS AFFECTING IN POTATO FARMING IN TÜRKİYE

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Abstract

The study aimed to analyse the technical applications of the farmers in the production of potatoes in Türkiye and to reveal the information sources that were affected. In this framework, the provinces of Niğde, Nevşehir, İzmir, Afyonkarahisar, Konya, Adana, Aksaray and Kayseri, which constitute more than half of Türkiye's potato production, were included in the scope of the research. Data were obtained from 533 farmers by face-to-face survey technique. The average of the interviewed farms was 14.07 hectares of potato cultivation area, 62.07% of which was for rent, 35.96% was property and 2.77% was lands held in partnership. As the scale of the farms' increases, the rate of rental land for potato cultivation increases. In the region average, almost half of the potato cultivation area was grown on rented land. In addition, the average parcel size of 2.72 hectares and the number of pieces of potato planted land cause an increase in pre- and post-production costs. 71.63% of the potatoes produced on the farms were table, 23.57% industrial type and 4.80% seed. Although 44 different kinds of potatoes were grown in the region, it was determined that the farmers gave weight to Melody, Madeleine, Jelly, Marabel, and Agria varieties. Seed diversity varies according to the characteristics of the regions. Seed use per hectare in the research area was determined as 4,076.6 kg in the average of the enterprises and 3,950.0 kg in the weighted average of the region. In the average of the farms interviewed, the labour force used per hectare was 1,419.4 hours, and the average of the region was 1,940.4 hours. In potato production, machinery was used for 37.7 hours on average and 56.5 hours on average for the region. The amount of nitrogen given per hectare in the potato cultivation areas was 416.6 kg, the weighted average of the region was 497.2 kg, the phosphorus 89.7 kg, the regional weighted average 108.2 kg, the potassium 75.2 kg, the regional weighted average 86.1 kg. The irrigation system was mainly in the form of sprinkler irrigation. Farmers in the selection of seeds; expressed the factors of yield level, price, ease of sale, germination power, and resistance to diseases and pests as very important criteria. The farmers were using traditional information sources in the selection of seeds. It was determined that modern information sources and traditional information sources were equally effective in agricultural control. The farms interviewed received high scores on the level of cultural practices in an agricultural struggle. It was determined that producers were more affected by modern information sources in potato cultivation in the region. The potato was a product that uses a high level of input. In this respect, more conscious use of inputs and policies that guide farmers to modern information sources were considered important in terms of sustainability.

Key words: *input use, potato farming, technical applications, information sources, Türkiye*

INTRODUCTION

The potato is a plant whose homeland is South America and belongs to the genus *Solanum* [28]. It is stated that potato farming was brought to Türkiye via Russia and the Caucasus, and it was first produced in the Eastern Anatolia Region and the Black Sea Region in areas where the highland climate is dominant [15].

Potato production in the world ranks sixth after sugarcane, corn, wheat, rice and oil palm fruit. It is in sixteenth place in terms of agricultural cultivation areas. The most important potato-producing country in the world in terms of production is China with a production of 91,818,950 tons and a share of 24.79%. China is followed by India with a share of 13.55 percent and Russia with a share of 5.96%.

Potato production in Türkiye ranks sixth after wheat, sugar beet, tomato, barley and corn production. Türkiye takes a 1.34% share of the world's total potato production. The share of Türkiye in world potato production generally shows an increasing trend between 1961 and 2019, and it is in the 1.10-1.50% band in the 2005-2019 period.

When the potato yield per hectare in the world and Türkiye between 1961-2019 was examined; Potato yield in Türkiye increased to more than 15,000 kg per hectare in 1980, 20,410 kg in 1986, 25,889 kg in 1998, and over 30,000 kg in 2009 and later. Especially in yield, an upward trend has been experienced after the above-mentioned dates. When the annual increase rate of potato per hectare yield in Türkiye was calculated for the 1961-2019 period, it can be stated that there was a positive development of 2.22%. The annual increase rate of potato per hectare yield was 2.70% in the 1961-1980 period, 2.37% in the 1980-1999 period and 1.47% in the 2000-2019 period. In the world, while the potato yield per hectare was 12,216 kg in 1961, it was around 15,000 kg in the 1980s, followed a stable course until the 2000s, exceeded 16,000 kg in the 2000s and increased to 20,000 kg in 2014 and after watched over. Potato yield per hectare in Türkiye in 2019 was 35,377 kg. Potato yield per hectare in Türkiye increased 3.7 times in 2019 compared to 1961. In 2019, the potato yield per hectare in the world was 21,362 kg. When the annual increase rate of potato per hectare yield was calculated for the 1961-2019 period in the world, it has been determined that there was a positive development in the form of an increase of 0.95%. It has been determined that the annual rate of increase in the yield of potato per hectare in the world in the 1961-1980 period was at a very low level, such as 0.23%. It was determined that there was an increase of 0.83% in the period 1980-1999, and an increase of 1.38%, which was close to the average growth rate of Türkiye, in the period 2000-2019.

According to the data obtained, potato yield per unit area showed a great increase in Türkiye, it caught the world yield in 1975 and remained above it after this year. Despite the decrease in the total potato production area in Türkiye, the increase in the amount of production resulted from the increase in yield.

The potato cultivation area in Türkiye followed a fluctuating course in the 1961-2019 period. In 2019, Türkiye's potato cultivation area was 140,776 ha. Compared to 1961, the potato cultivation area in Türkiye decreased by 4.24%. When the annual increase rate of potato cultivation area in Türkiye was calculated for the 1961-2019 period, it can be stated that it exhibits a decrease of seven per ten thousand. The annual rate of increase in potato cultivation areas increased by 1.10% in the 1961-1980 period, increased by 1.31% in the 1980-1999 period and decreased by 1.85% in the 2000-2019 period. In the world, potato cultivation areas decreased by 0.69% annually in the 2000-2019 period.

Potato production in Türkiye was close to 5 million tons according to 2019 data. Between 1961 and 1999, a continuous increase trend was dominant in potato production in Türkiye, after the 2000s, it entered a decreasing trend and remained in the band of 4-5 million. Compared to 1961, potato production in Türkiye increased by 254.44%. It has been calculated that the annual rate of increase in potato production in Türkiye has increased by 2.14% for the 1961-2019 period. The annual rate of increase in potato production was 3.79% in the 1961-1980 period, and 3.69% in the 1980-1999 period. On the other hand, it was calculated that there was a decrease of thirty-eight per ten thousand in the 2000-2019 period. In the world, there was an annual increase of 0.69% in potato production in the 2000-2019 period.

Although the potato cultivation area in Türkiye followed a fluctuating course during the 1961-2019 period, it showed an increasing trend until 1999, and after this year, it showed a fluctuating but decreasing trend. In the same period, an increase was observed in potato production. Until 1999, the increase in cultivation area and the unit area was effective. After this year, the increase in yield has been effective. Especially since 2005, it has been following a fluctuating course in the band of 4.00-4.95 million tons.

The provinces of Niğde, Nevşehir, İzmir, Afyonkarahisar, Konya, Adana, Aksaray and Kayseri, which constitute more than half of Türkiye's production, were included in the scope of the research.

This study aimed to analyse the affecting factors and input use of potato producers in the Türkiye.

MATERIALS AND METHODS

The main material was obtained by the survey method from the producers in the villages producing potatoes in the provinces of Adana, Afyonkarahisar, Aksaray, Kayseri, Konya, İzmir, Nevşehir, and Niğde. The data belonged to the 2019 production period.

The sample size was calculated as 533 potato producers according to the Stratified Sampling Method [27]. The distribution of sample enterprises according to groups was made using the “Neyman Method” [6]. The farms were divided into three groups, considering the frequency distribution of the potatoes land they owned. Accordingly, farms with less than 5 hectares of potatoes cultivation area was I. group (248 farms), farms with 5.01-10.00 hectares of potatoes cultivation area were II. group (91 farms), and farms with a potatoes cultivation area of more than 10.01 hectares were also included in III. group (194 farms) formed. The “Neyman Method” we used for sampling takes more samples from the layer with high variance. For this reason, we determined the regional weighted average using the method specified by [11] and [12]. In the study, the technical applications of potato producers in potato farming in the provinces in the research area were determined and their judgment, attitude and current knowledge levels about potato farming practices, and information channel selection were measured. According to the Likert scale, the statements in the attitude scale were evaluated according to a 5-point scale. The severity of the attitude increases or decreases towards the extremes [3].The research area was given in Map 1.

Map 1. Location map of the study areas
Source: Own calculation.

RESULTS AND DISCUSSIONS

When the soil characteristics of the potato production areas were examined, the average of the farms was sandy-loamy soil with a rate of 55.72%, sandy soil with a rate of 26.83%, sandy-stony soil with a rate of 4.69%, clay soil with a rate of 4.50%, and humus soil with a rate of 3.56%. It was stated that stony soil with a rate of 2.81% and a calcareous soil type with a rate of 1.88%. Sandy-loam soil, in particular, potato cultivation was dominant on the farms. The potato planting area was 14.07 hectares on the average of the enterprises interviewed in the research area. The number of pieces of potato planted land was 6.17 and the average parcel width was 2.28 hectares. The potato area, which was 5.52 hectares in the region on average, was grown in 3.58 parcels and an average parcel size of 1.33 hectares. The potato area of the first group of enterprises was 2.95 hectares, the average parcel size was 0.99 hectares and the number of potato planted land was 2.98. The potato area of the second group enterprises was 7.97 hectares, the average parcel size was 2.22 hectares and the number of potato planted land was 3.59. The potato area of the third group enterprises was 31.15 hectares, the average parcel size was 2.72 hectares, and the number of potatoes planted plots was 11.46 (Table 1). The increase in the number of land plots in potato farming causes an increase in pre- and post-production costs. When the ownership, tenant and shareholder status of the total potato lands of the farms in the research area were examined, the property land amount of the first group of farms was 1.97 hectares and the ratio of this figure to the total land amount was 66.92%. The amount of land leased for potatoes in the first group of farms was 0.95 hectares and constitutes 32.15% of the total area. The potato property land amount of the second group of farms was 4.25 hectares and the ratio of this figure to the total potato land amount was 53.32%. The amount of land leased by the second group of farms for potatoes was 3.72 hectares and constitutes 46.68% of the total area. The amount of land owned by the third group of farms for potato cultivation was 9.39 hectares and the ratio of this figure to the total potato land was 30.13%. The amount of land leased for potato cultivation in the third group farms was 21.04 hectares, and the ratio of this figure to the total potato land amount was determined to be 67.54%. On the average of the farms interviewed, 62.07% of the 14.07 hectares of potato planting area was for rent, 35.96% was property and 2.77% was lands held in partnership. As the scale of the farms' increases, the rate of rental land for potato cultivation increases. On average in the region, 51.34% of the potato planting was grown on the property and 47.54% on leased land. It was determined that 44 different kinds of potatoes were grown in the farms considered within the scope of the research.

The varieties that were mainly grown on the farms' were Melody with 17.19%, Madeleine with 16.07%, Jelly with 14.99%, Marabel with 11.71%, Agria with 10.34%, Florice with 4.06%, Arizona with 3.91%, Lady Amarilla with 3.10%, 2.57 of them were Universal potato variety. The rate of other potato varieties was around 2%. Melody type was mostly in the first and second group enterprises proportionally. In the first group of enterprises, Melody in 31.58%, Marabel in 21.71%, Madeleine in 15.03%, Agria in 8.77% and Jelly in 3.19% of the total area.

In the second group of businesses, 27.17% of the total area was Melody, 18.76% Madeleine, 17.52% Marabel, 13.42% Agria, 3.45% Belmondo, 3.32% Lady Amarilla, 2.96% Jelly, Hermes variety was planted in 2.48.

In the third group of businesses, 17.86% of the total area was Jelly, 17.86% Madeleine, 14.25% Melody, 10.16% Agria, 9.80% Marabel, 4.69% Arizona, 4.66% Florice, 3.24%, Lady Amarilla in 2.95%, Universal in 2.95%, Hermes in 1.80% and Lady Olympia in 1.38%. According to the statements of the business owners, it has been determined that the businesses take into account factors such as yield, durability and earliness in the selection of varieties. The change in potato cultivation areas of the examined enterprises in the period of 2010-2020 was examined.

Accordingly, based on 2019, it was estimated that there will be a 15.30% decrease in the potato cultivation areas of the examined enterprises in 2020. It has been estimated that there will be a contraction in the cultivation area, especially in large-scale enterprises.

It was determined that small-scale enterprises planted 7.83-55.73% more potatoes in 2010-2018 compared to the potato planting area in 2019. On the other hand, it was determined that large-scale enterprises planted 12.33-34.72% fewer potatoes from 2010-2018 compared to the 2019 planting area (Table 2).

On the other hand, potato cultivation areas increased by 4.94% in the research region in 2020. The reason for this can be explained by the perception that fewer producers will turn to potato planting with the decrease in prices at the end of 2019.

Table 1. Potato average parcel width and number of pieces in farms

Farm groups	Number of potato pieces	Average parcel size (ha)	Potato planting area (ha)
I	2.98	0.99	2.95
II	3.59	2.22	7.97
III	11.46	2.72	31.15
FA*	6.17	2.28	14.07
WA**	3.58	1.33	5.52

*FA: Farms Average; **WA: Research Region Weighted Average
Source: Own calculation.

Table 2. Change in potato cultivation areas of farms

Years	Farm groups			FA	WA
	I	II	III		
	Index (2019=100)				
2010	155.73	101.01	65.28	81.83	118.17
2015	128.90	100.23	68.99	80.78	106.01
2016	115.19	83.90	80.24	85.32	97.99
2017	108.12	84.44	84.31	87.79	95.78
2018	107.83	94.45	87.67	91.37	99.15
2019	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
2020	101.56	83.29	81.80	84.70	91.68

Source: Own calculation.

Farmers' potato production period (planting to harvest, days) in the study area averaged 137.82 days on farms and 137.36 days on the regional average. The second group farms had the highest number of days with 138.80 days, and the first group farms had the lowest number of days with 136.90 days. The third group farms were 138.46 days.

When the potato production process (sowing-harvest months) in the research area was examined, it was determined that the potato producers of Adana province carried out potato sowing in November-December-January, and the potato harvest was in April-May-June (Table 3 and Table 4).

It was determined that potato producers in İzmir province planted early potatoes in January-February, harvested potatoes in May-June, planted potatoes as the second or third product in August and harvested in November-December (Table 3 and Table 4).

It was determined that the potato planting period of the producers in Konya was from March-April-May, and the harvesting period was from July-August-September (Table 3 and Table 4).

It was determined that the producers interviewed in Nevşehir and Aksaray provinces planted potatoes in April-May, and harvested their products in August-September-October (Table 3 and Table 4).

In Niğde, the province where the most potatoes are grown in Türkiye, it was determined that the interviewed producers planted potatoes in April-May-June and harvested their products in September-October-November (Table 3 and Table 4).

In the province of Kayseri, the period in which potato producers plant their crops was March-April-May. The producers were also harvested in the months of August-September-October-November (Table 3 and Table 4).

In Afyonkarahisar, on the other hand, the periods in which the potato producers interviewed carried out planting were determined as March-April-May. It was determined that the harvest periods were in the months of August-September-October-November (Table 3 and Table 4).

The ratio of the enterprises in the research area that had soil analysis was 43.15%. This rate was the highest in the third group of enterprises with 55.67%. 34.68% of the first group enterprises and 39.56% of the second group enterprises had soil analysis. With the increase in the scale of the enterprise, the level of soil analysis was increased. The rate of farms that had leaf analysis was 14.63%. In the third group of enterprises, the rate of leaf analysis was the highest at 20.10%. 9.68% of the first group enterprises and 16.48% of the second group enterprises had leaf analysis. With the increase in business scale, the level of leaf analysis was increasing.

It was stated that 74.30% of the enterprises in the research area did not use consultants in potato production, 23.64% received firm support and 2.06% received paid consultant support. The ratio of paid consultants and firms was higher in the third group of enterprises.

When the importance levels of the information sources used by the enterprises in potato cultivation are examined; It was determined that the most important source was other growers (neighbours) (4.03), fertiliser dealers (3.91), drug dealers (3.90), seed dealers (3.72), product buyers (industry) (3.72), product buyers (trader) (3.70) (Table 5). Therefore, it was determined that farms preferred modern information sources more than traditional information sources.

Table 3. Potato planting period in the research area

Provinces	January	February	March	April	May	June	July	August	September	October	November	December
Adana												
Konya												
Aksaray												
Nevşehir												
Niğde												
Kayseri												
Afyon												
İzmir												

Source: Own calculation.

Table 4. Potato harvest period in the research area

Provinces	January	February	March	April	May	June	July	August	September	October	November	December
Adana												
Konya												
Aksaray												
Nevşehir												
Niğde												
Kayseri												
Afyon												
İzmir												

Source: Own calculation.

Table 5. The importance level of some information sources in potato cultivation

Information source	Farm groups			FA	WA
	I	II	III		
Other farmers (neighbours)	4.00	4.14	4.03	4.04	4.03
Fertiliser dealer	3.93	3.79	4.09	3.97	3.91
Agrochemical dealer	3.91	3.82	4.06	3.95	3.90
Seed dealer	3.72	3.73	3.76	3.73	3.72
Product buyers (industry)	3.69	3.87	3.64	3.70	3.72
Product buyers (trader/merchant)	3.68	3.82	3.58	3.67	3.70
Producer association-Cooperative	3.49	3.49	3.80	3.60	3.51
Mukhtar (village mayor) etc. notables of the village	3.25	3.49	3.13	3.25	3.29
Technical personnel of the Provincial/District Directorate of Agriculture and Forestry	2.82	2.89	2.89	2.86	2.84
Fairs	2.69	2.60	2.62	2.65	2.67
Internet	2.47	2.74	2.80	2.63	2.54
University	2.50	2.46	2.50	2.49	2.49
TV	2.29	2.69	2.31	2.37	2.37

(1=Not at all important 2=Not important 3=Partly 4=Important 5=Very important)
Source: Own calculation.

Farmers interviewed in the research area were evaluated according to the 5-point Likert scale for the factors affecting the selection of seeds. In the farm general average, while yield level, price factor, ease of sale, germination power, resistance to diseases and pests were considered very important by the farmer, earliness, physical characteristics of the product (size, shape, etc.), flesh-shell colour, ease of payment, firm, period, cold resistance and variety factor were considered important (Table 6).

It was determined that potato planting distance was 70.09 cm between rows and 21.57 cm in-row planting distance on farms' average.

Farmers interviewed in the research area were evaluated according to a 5-point Likert scale, which was effective in choosing seeds. In the farms' general average, their own knowledge and experience, suggestions from other producers, product buyers (trader), and product buyers (industry) were important resources by the operator (Table 7). Therefore, although the effect of modern information sources was important in the selection of seeds, it was determined that the producers attach more importance to the traditional sources of information.

When the people-institutions-organizations that were effective in the agricultural struggle in farmers' potato farming were examined, it was determined that the most important factor was their own experience (4.49), agrochemical dealers (4.20), and suggestions of other producers (4.02). The explanations on the packaging and the technical staff of the Ministry of Agriculture and Forestry

Provincial/District Directorate were also close to significant levels (Table 8). At this point, it was determined that the producers preferred modern information sources and traditional information sources together equally.

Table 6. The importance level of some factors in the selection of seed potatoes

Factors	Farm groups			FA	WA
	I	II	III		
Yield ability (level)	4.70	4.75	4.79	4.74	4.71
Price	4.59	4.56	4.60	4.59	4.58
Ease of sale	4.60	4.55	4.57	4.58	4.59
Germination power	4.52	4.60	4.50	4.53	4.53
Disease and pest resistance	4.49	4.60	4.53	4.53	4.51
Earliness	4.49	4.37	4.49	4.47	4.47
Physical characteristics of the product (size, shape, etc.)	4.49	4.43	4.46	4.47	4.48
Flesh colour	4.46	4.41	4.45	4.45	4.45
Shell colour	4.44	4.42	4.38	4.41	4.43
Ease of payment	4.42	4.41	4.39	4.41	4.42
Manufacturer	4.33	4.41	4.37	4.36	4.35
Production period	4.38	4.37	4.33	4.36	4.38
Cold resistance	4.34	4.40	4.25	4.32	4.35
Sort	4.25	4.29	4.18	4.23	4.25

(1=Not at all important 2=Not important 3=Partly 4=Important 5=Very important)
Source: Own calculation.

Table 7. The significance level of some information sources about seeds

Information source	Farm groups			FA	WA
	I	II	III		
Own knowledge and experience	4.34	4.44	4.41	4.38	4.36
Recommendations from other farmers	4.00	4.20	3.89	3.99	4.03
Product buyers (merchant)	3.87	3.73	4.05	3.91	3.85
Product buyers (industry)	3.68	3.65	3.87	3.74	3.68
Producer organisation (Coop. or Union)	3.43	3.35	3.52	3.45	3.42
Research Institute	3.29	3.53	3.32	3.34	3.34
Suggestions for the staff of the Provincial/District Directorate of Agriculture	3.21	3.22	3.18	3.20	3.21
Fair	2.83	2.90	2.80	2.83	2.84
Counsellor	2.61	2.85	2.44	2.59	2.65
Written tariffs (books, brochures, etc.)	2.40	2.52	2.37	2.41	2.42
TV	1.96	2.14	2.24	2.09	2.01

(1=Not at all important 2=Not important 3=Partly 4=Important 5=Very important)
Source: Own calculation.

Table 8. The significance level of some information sources related to agricultural protection

Information source	Farm groups			FA	WA
	I	II	III		
Own knowledge and experience	4.46	4.59	4.52	4.51	4.49
Agrochemical dealer's recommendations	4.18	4.25	4.37	4.26	4.20
Recommendations from other farmers	4.02	4.03	3.97	4.01	4.02
Descriptions on the packaging	3.71	3.85	3.68	3.72	3.74
Suggestions of the staff of the Provincial/District Directorate of Agriculture	3.65	3.45	3.78	3.66	3.62
Producer organisation (Coop. or Union)	3.42	3.09	3.47	3.38	3.36
Counsellor	2.84	2.97	2.74	2.82	2.86
Written tariffs (books, brochures, etc.)	2.52	2.64	2.58	2.56	2.55
TV	2.19	2.21	2.53	2.32	2.21

(1=Not at all important 2=Not important 3=Partly 4=Important 5=Very important)
Source: Own calculation.

When the integrated control knowledge status of the enterprises in potato farming was examined, 37.15% of the farms have no knowledge at all, 33.21% have low integrated knowledge levels, 16.14% have medium levels of integrated knowledge, 8.82% have high integrated knowledge levels and They stated that 4.69% of them had a very high level of integrated knowledge. There was a direct relationship between the scale of the enterprise and the level of integrated combat knowledge.

When the status of integrated pest control in potato farming was investigated, 80.11% of the farms did not apply, 5.44% of them applied integrated control less, 3.19% of them were medium, 8.26% of them were more and 3% of them were at the integrated farming application level was found to be excessive. In general, the level of implementation of IPM methods by the enterprises was low. There was a direct relationship between the scale of the enterprise and the level of IPM.

When the good agricultural practice knowledge levels of the enterprises in the research area were examined, 24.95% of the farms stated that they did not know at all. On the other hand, 32.27% of them reported that they had little knowledge, 22.70% of them had moderate knowledge, 14.82% of them had a lot of knowledge of good agricultural practices, and 5.25% of them had a very high level of knowledge of good agricultural practices. In general, the knowledge level of good agricultural practices of enterprises was low. There was a direct relationship between the scale of the enterprise and the knowledge level of good agricultural practices.

When the good agricultural practice levels of the interviewed enterprises were examined, 70.36% of the farms reported that they did not apply at all and 7.88% of them applied less. It was determined that 19.14% of them applied moderately, 1.50% of them applied good agricultural practices at a high level, and 1.13% of them applied good agricultural practices at a very high level. The level of application of good agricultural practices in the surveyed enterprises was low. As the scale of the enterprise increased, the level of application of good agricultural practices increased.

In the average organic agriculture knowledge level in the research area, 28.71% of the producers have no organic farming knowledge, 27.95% have little knowledge, 31.33% have medium organic farming knowledge, and 7.32% have organic farming knowledge. It was determined that 4.69% of them had too much organic farming knowledge. The organic farming knowledge level of the surveyed enterprises was low. However, as the scale of farms increased, the knowledge level of organic farming was increasing.

It was determined that 87.66% of the enterprises examined did not practice organic agriculture at all, 5.07% of them had little organic farming practices, and 6.94% of them had moderate organic farming practices. The level of organic farming practices of the enterprises studied was low.

It was stated that the knowledge levels of biological control in potato production of the enterprises in the research area, with a ratio of 54.22% on the farm average, did not know at all, and 24.58% of them had little knowledge. It was determined that 16.14% of the enterprises had a medium level of knowledge, 2.44% had a high level of knowledge and 2.63% had a very high level of knowledge. The level of biological control knowledge and biological control application level of the enterprises interviewed were low. However, biological control knowledge levels were increasing with the farms' scale.

In potato production, it was of great importance to combat diseases, pests and weeds to obtain more quality products from the unit area. The emergence of the side effects of the intensive use of chemical drugs in the fight against these factors brought the issues of human health, the protection of the environment and biological diversity to the fore. Therefore, in addition to reducing the consumption of chemical drugs, to combat the agroecosystem and sustainability criteria was needed. Emphasis was placed on methods that are alternatives to chemical control and integrated control. To make an economical and ecological struggle against potato diseases, pests and weeds in Türkiye, the "Potato Integrated Control Research, Application and Training Project" was put into practice in 1995 [10].

IPM is a sustainable struggle system that takes into account human health, environment and natural balance. In Türkiye, basic research on integrated combat began in 1970. Research-integrated projects were carried out in important crops such as cotton, apples, hazelnuts, wheat, citrus fruits, corn, potatoes, vegetables grown under cover, olives, cherries, pistachios and vineyards until 1994. "Integrated Combat Research, Implementation, Education and Promotion Policy, Strategy and Priorities" were revised and "Integrated Struggle Research, Application and Education Projects" were put into practice in potato, which is one of the 16 important products [10].

In Türkiye, the Ministry of Agriculture and Forestry issued the potato integrated technical manual in 1998, where potato definition, diseases and pests, control methods and periods of pests were specified. At this point, the cultural, biological and biotechnical control methods specified in the technical instructions were also included in the questionnaire of potato growers and the producer was evaluated.

The level of cultural practice in the enterprises interviewed received high scores. In general, their cultural practices were close to my "practices". Within cultural practices; "I clean the weeds of *Solanum* species at the edge of the field, I prevent weeds from developing and giving seeds", "I clear the soil as much as possible while the tuber is stored", "I do hoeing, throat filling and maintenance carefully and regularly", "The tubers obtained from the dished field are definitely seed-proof. , I do not use it as table and animal feed", "I do seed checks after harvest or before planting, I make weeding", "I use clean-resistant potato varieties", "I avoid deep planting - I adjust the planting depth well", "potatoes in the fields determined to be contaminated" production and all kinds of production materials and sugar beet, onion, etc.

Table 9. The level of application of some methods against diseases and pests in potato cultivation

Implemented activity	Farm groups I	II	III	FA	WA
I clean the weeds of the *Solanum* species on the edge of the field, I prevent the weeds from developing and giving seeds on the edge of the field	4.64	4.63	4.72	4.67	4.64
I remove as much soil as possible while the tuber is being stored	4.58	4.65	4.62	4.61	4.60
I do hoeing, throat filling and maintenance operations carefully and regularly	4.56	4.52	4.56	4.55	4.55
I definitely do not use the tubers obtained from the contaminated field as seed, table and animal feed	4.50	4.56	4.61	4.55	4.52
I check the seeds after harvest or before planting, I make weeding	4.54	4.51	4.57	4.54	4.54
I use disease-resistant potato varieties	4.49	4.48	4.57	4.52	4.49
I avoid deep planting - I adjust planting depth well	4.48	4.41	4.53	4.49	4.47
I do not produce potatoes in the fields determined to be contaminated, and I do not grow crops such as sugar beet, onions, etc., whose soil can carry all kinds of production materials	4.42	4.43	4.48	4.44	4.43
I fight weeds	4.37	4.43	4.40	4.39	4.38
I collect and destroy potatoes in the field before planting potatoes, I do not leave any tubers in the field after the potato harvest	4.38	4.37	4.36	4.37	4.38
I take care not to injure the tuber during harvest	4.39	4.37	4.30	4.36	4.38
I do not harvest in humid and rainy weather	4.26	4.46	4.41	4.35	4.31
I clean soil tillage tools used in dishes	4.35	4.20	4.35	4.32	4.32
I do not fertilise excessive nitrogen	4.14	4.05	4.07	4.10	4.12
In the hot and dry months of the year, I make deep tillage in the soil with an interval of 15 days	4.04	3.96	4.14	4.06	4.03
I grow potatoes in the dew-free, south-facing fields morning and evening	3.98	3.73	4.11	3.98	3.94
I practice rotation	3.87	4.19	3.85	3.91	3.93
I provide good soil drainage	3.92	3.67	3.83	3.84	3.87
I do not plant the seed tubers by cutting, as it facilitates the entry of the disease agent	3.79	3.81	3.89	3.83	3.80
I keep it in storage below 10°C	3.76	4.02	3.65	3.77	3.80
I do seed spraying	3.83	3.76	3.68	3.76	3.81
I provide ventilation and air circulation in warehouses	3.73	3.95	3.61	3.72	3.77
I weed out sick tubers, with their storage checked frequently	3.71	3.88	3.63	3.71	3.74
I do warehouse spraying	3.35	3.68	3.34	3.40	3.41
I apply sulphur according to soil analysis	3.17	3.38	3.36	3.28	3.22
I use certified seeds	2.92	3.09	3.65	3.22	2.99
I use burnt farm manure	2.67	2.88	2.74	2.73	2.71
Using a predator (beneficial insect)	1.36	1.40	1.39	1.38	1.37
Using parasitoids	1.34	1.38	1.38	1.36	1.35

(1=I definitely do not apply 2=I do not apply 3=Sometimes 4=I do 5=I definitely do)

Source: Own calculation.

I do not grow plants that can carry contaminated soil, such as "I do not collect and destroy potatoes in the field before planting potatoes", "I do not leave a tuber in the field after the potato harvest", "I pay attention not to injure the tuber during harvest", "I do not harvest in humid and rainy weather" "Tillage used in dishwashing areas" It can be stated that practices such as "I clean their tools" are made consciously by the farmers (Table 9).

Seed is the most important input item in potato cultivation. In some countries, seed production started with real seed production. However, tubers, which are vegetative organs, are used as seeds in many countries [18].

In plants whose vegetative organs such as potatoes are used as seeds, the effect of seeds on yield is very high. If a good seed is not used in production, there will be problems in the yield and quality of potatoes, even if the best cultivation techniques are applied [2]. In general, if potato growers use the potato tuber they produce as seeds, there may be serious yield losses. If the yield obtained from potatoes is 100% under the condition of using 0 seeds (free from viruses and diseases), if their seeds are used in the second year, the yield decreases to 80%, and 50% in the third year. However, there may be serious losses in the marketable properties of potato tubers [18].

In addition to the low number of varieties that have been bred and registered in Türkiye, the scarcity of commercial production of these varieties, the supply of potato varieties in production from countries such as the Netherlands, Germany, France and the USA [23] and as a result, the seed is the most important cost factor in potato production [5].

Seed used in the research area was determined as 4,076.6 kg per hectare on farms average and 3,950.0 kg on the regional weighted average. While the amount of seed usage per hectare in the first group enterprises was 3,903.0 kg, it was 4,022.0 kg in the second group enterprises and 4,076.6 kg in the third group enterprises.

Kızıloğlu [18] determined the use of seeds per hectare in the province of Erzurum as 2000 kg in potato production. Engiz [8] calculated the use of seeds per hectare in farms groups in the production of seed potatoes in Nevşehir province as 3,262.5-3,722.5 kg, and enterprises producing edible-industrial potatoes as 3,989.6-3,990.9 kg per hectare. Kadakoğlu [16] determined the use of seeds per hectare in potato production as 3,377.8 kg in Afyonkarahisar province.

Although it is the best way to determine the amount of fertiliser to be applied in potato planting areas by soil and leaf analysis, reasons such as lack of technical facilities and lack of producer information especially in the region prevent this.

Potato comes first among the plants that make the best use of farm manure. With the application of 20-40 tons of farm manure per hectare in the cultivation area, significant increases in tuber yield and quality can be achieved. It is known that the use ratio of nitrogen, phosphorus and potassium, which are the basic nutrients in potatoes, is 1:0.5:2. However, in Türkiye, composite fertilisers such as 20-20-0, 15-15-15, 18-46-0 are widely used [1]. Half of the nitrogen needed by the plant is recommended to be given with potato planting, and the remaining half in two parts during the period of throat filling and tuber swelling [18].

The amount of nitrogen given per hectare was 416.6 kg in the farm averages considered in the potato cultivation areas, and 497.2 kg in the regional weighted average. The lowest amount was in the third group farms with 402.0 kg application per hectare and the highest amount was in the first group farms with 521.0 kg application. In the interviewed farms average application amount of phosphorus, one of the plant nutrients, was 89.7 kg per hectare, and the weighted average of the region was 108.2 kg. While the first group farms had the highest use of phosphorus with 113.7 kg per hectare, the third group farms had the lowest application amount with 86.3 kg. Potassium, one of the other main nutrients, was 75.2 kg per hectare in the farms interviewed, and the regional weighted average was 86.1 kg. The farms' group that applied the least potassium per hectare was the second group farms with 71.4 kg, while the farms in the first group with the most 90.8 kg.

Engiz [8] determined that 402.9-456.6 kg nitrogen (N), 132.1-230.5 kg phosphorus (P_2O_5) and 44.3-50.7 kg potassium (K) per hectare were used as plant nutrients in farm groups in seed potato production in Nevşehir province. The author calculated that 678.1-739.1 kg nitrogen (N), 206.8-402.7 kg phosphorus (P_2O_5) and 69.3-88.2 kg potassium (K) are used per hectare in enterprises producing edible-industrial potatoes. Kadakoğlu [16] determined that 488.5 kg nitrogen (N), 146.4 kg phosphorus (P_2O_5) and 172.9 kg potassium (K) per hectare are used as plant nutrients in the farm average in potato production in Afyonkarahisar province. Er et al. [9] found that irrigation was done 10-15 times in potato farming in the Nevşehir-Niğde region and the use of nitrogen fertiliser increased up to 700-900 kg per hectare. They report that this amount is excessive and 500 kg of nitrogen per hectare will be sufficient. Gunel et al. [13] reported that excessive washing in the region inevitably increases the use of nitrogen in the region.

In the farms considered within the scope of the research, the farms' average labour force usage per hectare in potato production was 22.0 hours in tillage plough, 4.57 hours in sowing, 5.97 hours in cover, 10.98 hours in irrigation, 90.8 hours in fertiliser and pesticides, 37.9 hours in hoeing, and harvesting. It was calculated that 445.1 hours, 151.1 hours in the classification packaging process, 421.6 hours in the transport process, 11.7 hours in the storage process, and 24.0 hours in the marketing process. In total, the workforce used per hectare was 1,419.4 hours. It was calculated that the most labour use per hectare in the average of the examined farms was in the harvesting process with 445.1 hours. The use of labour per hectare in potato farming was the highest in the first group with 2,093.0 hours. In the second group of farms, 1,531.8 hours of labour per hectare and 1,324.4 hours in the third group of farms were used. It was determined that the use of labour per hectare decreased as the scale of the enterprise increased.

When the proportional distribution of labour use, which was used as 1,419.4 hours per hectare, was examined; 1.55% in tillage-ploughing, 3.22% in sowing, 4.21% in cover, 7.74% in irrigation, 6.40% in fertilisation-spraying, 2.67% in hoeing, 31.36% in harvesting. 10.64% in the sorting-packaging process, 29.70% in the transport process, 0.83% in the warehouse process and 1.69% in the marketing process (Table 10).

Yalçın [26], in the Central Sakarya Basin, calculated 552.0 hours of labour and 21.7 hours of machine power per hectare of potato production. Dernek [7], in Ankara, determined that there were 626.0 hours of labour and 42.3 hours of machine drawing power in one hectare of potato production. Güney [14], and Yalçın [26], in the province of Tokat, calculated 718.4 hours of labour and 12.6 hours of machine drawing power per hectare of potato production. Kolçak [21], in Erzurum, determined the use of 913.4 hours of labour and 14.6 hours of the machine drawing power in one hectare of potato production. Kızıloğlu [19] calculated the labour demand as 705.8 hours and the machine drawing power requirement as 48.7 hours in potato production in Erzurum province. Ozcelik et al. [25] found that the labour demand of agricultural enterprises producing contracted potatoes in Nevşehir province was 978.1 hours and the demand for machine drawing power was 55.5 hours. In the same study, they calculated the share of field rent as 11.42%, machine wages as 32.56%, labour force as 24.83% and material costs as 31.19% in total cost elements. Koral and Altun [22] calculated the labour demand per hectare as 723.6 hours, machine draft power demand as 55.6 hours in the enterprises producing potatoes in irrigated conditions in the Aegean region, and as 668.3 hours and 42.3 hours in the Ankara region, respectively. Birinci and Küçük [4] calculated the labour demand of potato enterprises as 782.0 hours and the demand for machine drawing power as 44.0 hours in the province of Erzurum for the 2003 production season. Engiz [8], in Nevşehir province for the 2002-2003 production season, found the farm labour force to be 768.0 hours and the machine drawing power to be 78.8 hours in the production of seed potatoes. He reported that labour demand was mostly used in maintenance works. It has been determined that 796.2 hours of labour and 77.8 hours of machine drawing power are used per hectare for the production of edible and industrial potatoes.

When the farmers within the scope of the research had a spraying schedule for potato production, it was determined that 87.05% of the farms had a spraying schedule. In general, it was determined that there was a spraying schedule for potato cultivation in all farm groups.

The rate of those who mechanically struggle with weeds in potato farming was 94.93%. In general, all farm groups preferred mechanical methods for weed control in potato farming.

In the farm potato production in the research area, it was determined that 85.74% of the chemical drug dose application amount applications were applied as specified, 12.38% applied by increasing the chemical drug dose amount, and 1.88% reduced the chemical drug dose.

It was determined that 74.30% of them took protection measures in chemical drug dose application in farm potato production within the scope of the research. With the increase in the scale of the enterprise, the situation of taking protective measures in the application of chemical pesticides was increasing.

Potato, which is an important industrial plant, has many diseases, harmful and weed species that cause product loss. The most important of these are potato beetle, potato moth, potato downy mildew, potato wart disease, weeds, nematodes, and bacterial and viral diseases [9].

The alteration, or rotation, refers to planting different plants in the same field sequentially. Alternation is important in potato production. 79.5% of the interviewed farmers were in alternation. The producers of the second farms' group drew attention as the group that alternated the most. This was followed by the third farms' group and the first farms' group, respectively.

The use of machinery in potato production was 104.01 hours in tillage-ploughing, 77.07 hours in sowing works, 0.10 hours in cover operations, 125.59 hours in irrigation works, 39.20 hours in fertilisation, 60.71 hours in pesticide works, 13.62 hours in hoeing operations, and 95.73 hours in harvesting works, 5.37 hours were used in transport operations.

The use of machinery in potato production of the examined enterprises was 37.7 hours per hectare. This value was the highest with 59.1 hours in the first group enterprises. While the use of machine power was 53.0 hours per hectare in the second group enterprises, it was 33.3 hours in the third group enterprises. When the proportional distribution of machine usage was examined, it was 19.58% in tillage-ploughing, 14.51 in sowing, 0.02% in cover, 23.65% in irrigation, 7.38% in fertilisation, 11.43% in spraying, 2.56% in hoeing, 18.03% were at harvest and 1.01% were at the transport (Table 11).

Table 10. Use of labour in potato production

Implemented activity	Farm groups			FA	WA
	I	II	III		
	Ratio (%)				
Tillage	2.36	2.26	1.30	1.55	2.31
Sowing	2.82	3.55	3.25	3.22	2.95
Covering	15.79	5.18	1.86	4.21	13.62
Irrigation	6.33	7.58	8.03	7.74	6.59
Fertilisation-Spraying	8.64	9.40	5.55	6.40	8.63
Hoeing	6.60	4.69	1.64	2.67	6.12
Harvest	23.45	28.44	33.28	31.36	24.59
Classification packaging	7.72	9.33	11.38	10.64	8.11
Transport	22.95	26.14	31.49	29.70	23.77
Warehouse	2.08	0.75	0.60	0.83	1.82
Marketing	1.25	2.66	1.64	1.69	1.49
Total	100.00	100.00	100.00	100.00	100.00

Source: Own calculation

When the production types were examined according to the farms' potato cultivation area in the research area, 71.63% were a table, 23.57% were industrial type and 4.80% were a seed. It was determined that 66.52% of the potatoes planted on large-scale farms were table, 27.77% industrial type and 5.71% seed (Table 12).

When the production types of the interviewed enterprises were examined according to potato production, 70.64% were a table, 24.41% were industrial and 4.95% were a seed. Considering the calculations as the research region average, it was determined that 84.05% of the potatoes were used for table production, 13.33% for industrial production and 2.62% for seed production. It was calculated that 65.49% of the potatoes produced in large-scale farms were a table, 28.63% industrial and 5.88% seed. Therefore, small-scale farms were more concentrated on table production.

When the irrigation system used in the farms' potato production in the research area was examined, it was determined that 99.67% of them used the sprinkler irrigation system on average. Since the potato plant growth period was 120-150 days, the water requirement of the plant is between 500-700 mm depending on the climatic conditions. In general, it is reported that there is no need for irrigation to ensure good development of the roots until the budding period. The most sensitive period for irrigation is expressed as the beginning of tuber growth with the beginning of stolon formation (between budding and 75% flowering). Especially for this period, the useful moisture in the soil should not be reduced below 75%. Between the end of flowering and the harvest, 50% of the useful moisture should be kept in the soil, and it is recommended to stop irrigation 20 days before the harvest starts [24].

Potatoes with a root depth of around 30 cm are usually grown in coarse-textured, permeable soils. Due to the highly permeable nature of the soils in Niğde-Nevşehir and similar provinces where potato cultivation was intense in Türkiye, the irrigation interval in potato cultivation narrows. The number of irrigation was also increasing [20]. It was reported that the best irrigation system was a sprinkler, as the plant surface was partially cooled by sprinkling during the development period [17] [18]. Almost all of the farms in the region were using the sprinkler system.

While the number of irrigation was 11.87 on the farms' average, it was 12.15 on the weighted regional average.

The third group was determined as the farm width group with the lowest number of irrigations with 11.34 farms. While the first group farms were irrigated 12.29, the second group farms had 11.85 irrigations.

Table 11. Use of machine power in potato production

Implemented activity	Farm groups (da)			FA	WA
	I	II	III		
	Ratio (%)				
Tillage	22.88	19.93	18.81	19.58	22.19
Sowing	16.21	12.86	14.47	14.51	15.56
Covering	0.02	0.00	0.02	0.02	0.00
Irrigation	15.97	24.53	25.13	23.65	17.79
Fertlisiation	5.40	5.49	8.17	7.38	5.52
Spraying	11.30	8.97	11.93	11.43	10.94
Hoeing	2.15	2.06	2.75	2.56	2.19
Harvest	22.79	18.31	16.95	18.03	21.81
Transport	0.96	3.56	0.54	1.01	1.47
Total	100.00	100.00	100.00	100.00	100.00

Source: Own calculation.

Table 12. Potato production type

Farm groups	Seed potato	Table potato	Industrial potato	Total
	Ratio (%)			
I	1.97	92.99	5.04	100.00
II	0.06	92.70	7.25	100.00
III	5.71	66.52	27.77	100.00
FA	4.80	71.63	23.57	100.00
WA	2.63	84.44	12.92	100.00

Source: Own calculation.

CONCLUSIONS

In the study, the technical practices of farmers in “Türkiye” potato production and the information sources they are affected by were analysed. In the region average, almost half of the potato cultivation area was grown on rented land. With the increase in the scale of the enterprise, the rate of rental land for potato cultivation was also increasing. In potato farming, the average parcel size was small, and the number of pieces of potato planted land was high. Therefore, this situation creates an increasing situation in the use of technical inputs and causes an increase in costs. It was determined that 44 different potato cultivars were grown in the region and the variety of seeds varied according to the characteristics of the regions. Farmers used traditional information sources in the selection of seeds and preferred modern information sources and traditional sources of information equally in the agricultural struggle. In the agricultural struggle, the level of making cultural practices was high. Although producers were more affected by modern information sources in potato cultivation, traditional information sources were still important. Since potato farming uses a high level of inputs, it is important for sustainability to ensure that farmers use more conscious inputs with policies that guide them to modern information sources.

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BULGARIAN FARMER'S PERCEPTION TOWARDS RISK

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Abstract

The characteristics that influence farmer's behavior and attitude toward risk should be identified in order to explain inconsistencies between the farmer's perception of risk and the accurate measurement of the probability of the occurrence of a risk event. The article investigates the various types of responses of farmers to risk-related decision-making. The paper's goal is to highlight various types of farm characteristics in terms of risk and on this basis to be prepared general conclusions. The following tasks were assigned to achieve the goal: 1) a literature review is associated with the risk perception; 2) application of methodology for research the farmer's behavior regarding their perceptions of risk taking; 3) determining and evaluating farm types; and 4) main conclusions and statements.

Key words*: *risk appetite, agrarian risk, risk management, Bulgaria

INTRODUCTION

For better understanding the farmer's risk behavior and perception, it is necessary first to understand their strategy and management approaches. Farmer's risk attitudes can be influenced by their market orientation, family involvement (a person with family commitments and responsibilities may be more willing to take the risk than one who does not), and age. Farmers who are older and more experienced would be more willing to take the risk than inexperienced farmers [11]. On the other hand, [15] note that knowing the farmer's attitude toward risk is of significant importance for: 1) agricultural producers to manage their farms better; 2) national advisory services for better support and for more targeted assistance to farmers; 3) industry by providing the necessary inputs for agricultural production and 4) policy makers to increase the efficiency of the use of public funds. [13] identified two key elements of farmer's risk perception. The first one is the individual's assessment of the probability of the occurrence of risk event. The second is the farmer's perception of the seriousness of this risk event. [16] expresses a different point of view, that the perception of risk is influenced by socio-cultural factors that predetermine the values, thinking, behavior of the farmer. [1] also define the individual characteristics of the farmer and his family as important factors for the farmer's behavior towards risk, such as education, experience, family size, income, but also the author adds land status and land size as a factors that influence on farmer's risk perception.

Concerning specialization, some researchers investigate the link between farm investment and production, and it can be discovered that the more the technology of an operation is known, the less risk can be gained [10].

[3] categorize risk attitudes into four categories:

1. Risk aversion: people who see risk as a threat and are hesitant to take risks. These people frequently try to avoid or mitigate potential threats. According to the literature, this attitude is typical for small farms because of their inability to withstand financial losses associated with risk [11]. Farmers who are risk averse are neutral towards all proposed agricultural risk-reduction strategies [2].

2. Risk takers: These individuals are at ease with risk and see it as an opportunity. Even if the outcome is uncertain, they will feel good. According to [17] risk-taking farmers are willing to maximize their production factors regardless the risk of not obtaining optimal production results.

3. Risk resistant-individuals who believe that risk is neither an opportunity nor a threat, but

nevertheless engage in risky activities when exposed to them.

4. Risk-neutral: These are those who do not find long-term risk to be comfortable and are prepared to take immediate actions to reduce it. According other authors [6] the absence or presence of risk don't affect the neutral farmers, when they managed their farm. They neither seek the risk nor avoid it.

Variances between the farmer's perception of risk and the correct measurement of the probability of occurrence of a risk event suggest that these discrepancies should be resolved by identifying the factors that influence the farmer's behavior and attitude toward risk. The following are the factors that influence risk perception:

- Collective actions. The general consensus is that engaging in voluntary activities is considered less "risky" than dealing with an incurred risk by the farmer. The new risks are perceived differently than the old ones. In his article, [4] consider that market or collective management has advantages related on one hand to the prevention of risk and on the other to bearing its negative consequences. The author adds that despite the great opportunities for risk minimization that arise from collective action, the creation of collective organizations is difficult process, and small farms are reluctant to join them. Another research pointed out that the sharing of experience, knowledge, technique and other material assets among a group of farmers is one of the main benefits of collective action, but at the same time, the results of the study show the low degree of collective action that is implemented in Bulgaria [14].
- Historical perception of risk. This response is based on the historical approach, with the assumption that farmers would cope better if they could see how others or themselves have dealt with a risk in the past. If there is no data on previous similar events and how the owners have dealt with them, the opposite reaction occurs.
- Conservative risk perception. Statements in the literature frequently classify the agricultural sector as traditional, and farm owners are slower to adopt risk-reduction innovations. The main barriers faced by farmers is the high cost of innovation. In the literature, many authors provide solutions for overcoming this main constrain, through the purposeful use of European and national financial resources [5] and lending for improving the investment potential and modernization of agricultural holdings [12].
- Risk as obligations and responsibilities. Improved communication among stakeholder's aids in adoption and proper management. [7] considers that it is extremely important to determine the right sources of information, which can be scientists, advisory services, media such as family, neighbors etc.
- Incorrect focus. Farmers frequently focus on studying a risk that would have significant consequences for the sector (or the economy), but the probability for the occurrence of such an event is low. Also, the desire to avoid a certain type of risk and the incurred costs for risk mitigation lead in a number of cases to diverting the focus from the most effective solution to deal with the risk [8].

MATERIALS AND METHODS

The purpose of the paper is to generate various types of farm characteristics in terms of risk attitude. Figure 1 displays the primary elements determining "risk appetite". To accomplish the purpose, we suppose that the elements are broadly classified as external and internal. Internal factors will be divided into two primary divisions for the purposes of the research, namely, internal directed to social features of the farmer and internal directed to farm activity. The intersection of these two internal groups can also explain which types of farmers, based on size and activity, are most willing to take risks.

At this point, no extensive research has been conducted in Bulgaria on farmer's risk-taking proclivity. For this reason, literature review is used to introduce differences in risk response among different types of farmers to a theoretical level. As a result, in order to select relevant questions, a literature study is suggested to aid in the design of appropriate questions.

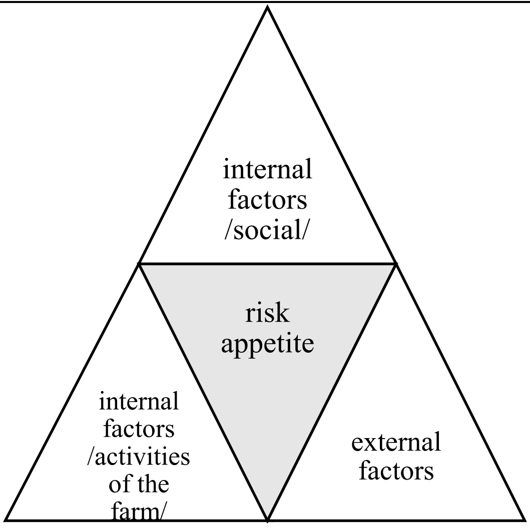

Fig. 1. Risk appetite explanation
Source: Own conception.

A study was conducted using a questionnaire developed in order to determine and evaluate the different types of farms based on their attitude to risk. The survey was conducted in 2021, and the respondents were chosen using the following criteria:

1. Crop production and livestock breeding are the agrarian sectors in Bulgaria. The major types of holdings are divided into 11 major sub-sectors. Three farms were chosen from each sub-sector, with production volumes ranging from 1 to 8,000, 8,001-20,000, and over 20,000, respectively. According to previous research (MAF, 2018), this classification corresponds to small, medium, and large farms.
2. There are two groups of prepared questions. The first group of questions relates to the manager's and the farm's characteristics in terms of age, education, gender, and so on, while the second group refers to their /farm managers / attitude toward the occurrence of risks.
3. A relation between social characteristics of the farmer, size, and specialization of holdings in terms of risk management will be pursued based on survey data.
4. The information is summarized, and the main conclusions are obtained.

According to the methodology used, the sample consists of 50 respondents, based on the determined holding's relation to economic size and specialization. The study doesn't claim to be comprehensive, but it might generate some recommendations for further in-depth analyses.

RESULTS AND DISCUSSIONS

According to the results of the study, the average age of the owners of the small farms is 62.5 years, of the middle 48 years, and of the large farms 53 year (Table 1). The age of the farmers also explains the fact that small farm owners are less willing to take risks. The share of owners with higher education is the largest in medium-sized farms, and the owners of small and large farms with higher education are respectively 36%. The majority of farm owners are men. With female sex are 9 % of the owners in small farms, 6% in meddle-sized farms and only 3% in large farms. 91% of the owners of large farms take decisions independently, followed by 82% of small farm owners and 45% of middle farms. It can be concluded that the most risk-oriented farmers (large farm’s owners) have an average age of 53 years, one-third have higher education, take their decisions alone and are male.

Table 1. Distribution of farmers by farm size and characteristics of the manager

Characteristics	small farms	middle farms	large farms
Age	62,5	48	53
Education- higher %	36%	55%	36%
sex- woman %	9%	6%	3%
self-decision taking	82%	45%	91%

Source: Own calculation by data of [9].

In order of time spent in agricultural activities, large farms have full employment in agricultural activities (Table 2). 70 % from them diversify in agricultural activities, only 15 % are vertical diversified and 100% applies market diversification. 38 % from the large farms use insurances and also 38 % of them use monitoring and control system. 36 % of small farms are full employed in agricultural activities. 65 % of them diversify in agricultural activities, as 8 % practice vertical diversification and 15 % market diversification. Only 8 % from the small agricultural producer use insurances and no

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one practice monitoring and control system. 70 % from the middle farms are full employed in agricultural activities. 60 % of them diversify their activity, 66 % practice vertical diversification, 60 % - market diversification. Middle farms use insurances the most (45%).

Table 2. Distribution of farmers by farm size and time spent in agricultural activities, %

Characteristics	small farms	middle farms	large farms
Full employment in agricultural activities	36	70	100
Diversification of agricultural activities	65	60	70
Vertical diversification	8	66	15
Market diversification	15	60	100
Insurances	8	45	38
Monitoring and control systems	0	18	38

Source: Own calculation by data of [9].

According to the results of the study, which are summarized in Figure 2 for the entire sample, most Bulgarian farmers underestimate risk by neglecting to pay attention to it (45%).

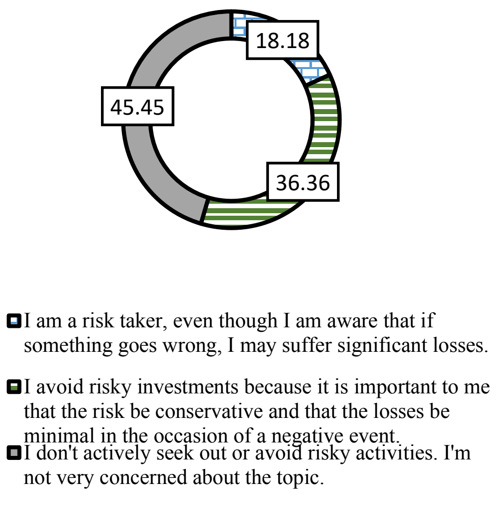

Fig. 2. Self-evaluation of Bulgarian's farmer
Source: Own calculation by data of [9].

This part of the respondents doesn't actively seek out or avoid risky activities. 36% of the respondents make every effort to stay away from situations that could put their activity at risk. They avoid risk, because it is important for them to minimize the losses if negative event occurred. About 18% from the farmers indicate they are willing to take chances in the hopes of increasing their revenue from farming. They are risk taker regardless of the negative consequences that may occur in case of risky event.

Figure 3 displays the average score of the responses of 50 farms in order to assess personal perception of risk taking and risk avoidance. For this purpose, a scale of 1 to 10 was used, and respondents had to rate how they define themselves in terms of risk taking. The score of 1 means that they are not at all willing to take risks to 10, which means that the farmer is very risk-oriented. The average rating from the investigated holdings reveals a comparative balance in terms of personal perception and preparation for taking and avoiding risks.

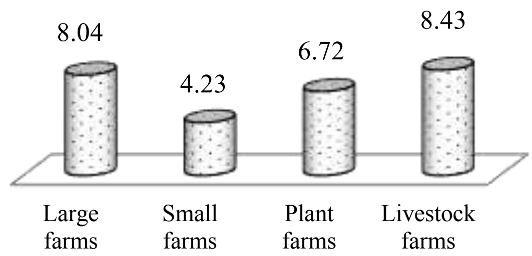

Fig. 3. Average score to determine personal perception regarding preparedness to take and avoid risks.
Source: Own calculation by data of [9].

An intriguing relationship is discovered as large farms tend to take risks. Their average score is 8.04, which is much higher than the average in the examined sample. This is largely explained by the ability of large farms to diversify their activities and compensate for risky events. Farmers who manage large farms have more resources to prepare for probable risk events and reduce losses. On the other hand, the diversity of activities and orientation of large farms allows riskier behavior and the ability to overcome the repercussions.

Small farms receive an average score of 4.23, which is close to the respondent's average score of 5.04. Small farms are risk-averse and adopt a more conservative approach. In large part, the reason is related to alternatives for avoiding harmful situations in addition to a lack of adequate chances and resource allocation.

From the perspective of the question (YES/NO), it is clear from the table that small farms are not likely to take risks (Table 3).

Table 3. Self-assessment of the risk perception, %

Self-assessment	small farms		middle farms		large farms	
	YES	NO	YES	NO	YES	NO
I am a risk taker, even though I am aware that if something goes wrong, I may suffer significant losses.	17	83	33	67	50	50
I avoid risky investments because it is important to me that the risk be conservative and that the losses be minimal in the occasion of a negative event.	8	92	42	58	50	50
I don't actively seek out or avoid risky activities. I'm not very concerned about the topic.	60	40	27	73	13	87

Source: Own calculation by data of [9].

However, the majority of these farms (60%) do not understand the risk and are not overly interested in the topic. Medium-sized farms are often conservative, but they also frequently take risks in order to make profit. Except for the fact that they are knowledgeable about the subject of risk, large farms do not have a fixed weight for their answers (50 to 50%) when it comes to these issues.

100 % from the farmers meet risk event last 5 years (Table 4).

Table 4. Distribution of farmer's opinion about the occurred risk, its effect and the received government support

Characteristics	small farms	middle farms	large farms
Occurred risk event last 5 years	100%	100%	100%
Effect /1 low effect to 10 catastrophic/	3	4	5
Received government support	0%	35%	64%

Source: Own calculation by data of [9].

Owners with small farms evaluate the effect with score 3, for the middle farmers the effect is 4 and the strongest effect occurred in large farms. According to government support, small farmers didn't receive such kind of support, 35 % from the middle farmers and 64 % from the large farms were supported by the government.

CONCLUSIONS

The analysis shows that there are differences across various farm types in terms of their tendency to take risks. The key findings may be summarized as follows:

✓ According to the study's findings, the majority of Bulgarian farmers' underestimate risk by failing to pay attention to it.

✓ Around 18% of farmers consider they are prepared to take risks in the expectation of boosting their farming profitability. They are risk takers regardless of the potential negative effects of a dangerous occurrence.

✓ Small farms avoid risks, and the ratio decreases as farm size grows. Large farms, on the other hand, are more likely to take chances; nevertheless, medium-sized farms are seen to be adequately adaptable, with around one-third prepared to take risks.

✓ The average age of small farm owners is 62.5 years, 48 years for middle farm owners, and 53 years for large farm owners. The small farm owners are less inclined to take risks. The proportion of owners with a higher education is highest in medium-sized farms, with 36% of small and large farm owners having a higher education.

✓ Men make up the vast majority of farm owners. Females hold 9% of small farms, 6% of medium-sized farms, and only 3% of large farms. 91% of large farm owners make their own choices, followed by 82% of small farm owners and 45 % of small farms. It may be inferred that the most risk-averse farmers (large farm owners) are 53 years old on average, have a higher education, make their own decisions, and are male.

✓ Large farms have full employment in agricultural activities in terms of time spent on agricultural operations. 70% of them diversify in agricultural operations, 15%

vertically, and 100% use market diversification. 38% of large farms have insurance, and 38% have a monitoring and control system. 36% of small farms are entirely devoted to agricultural activity. Agricultural operations account for 65% of their diversification, whereas vertical diversification accounts for 8% and market diversification accounts for 15%.

✓ Insurers are only used by 8% of small farmers, and no one uses a monitoring and control system. 70 % of the medium farms' workforce is fully devoted to farming. Sixty-six percent of them engage in vertical diversification, sixty percent in market diversification. 45% of middle-sized farms use insurance.

✓ In the previous five years, 100% of farmers experienced danger.

✓ According to government assistance, small farmers didn't get this sort of help; instead, the government sponsored 64% of large farms and 35% of middle-sized farms.

✓ These shows that large and middle sized farms have better access to government financial support.

Although many authors have proposed an analysis of farmers' risk behavior on a theoretical level, there is not enough empirical evidence to support their claims.

Despite the fact that there is similarity between the study's findings and those from the literature, some of the factors relating to Bulgarian traditions in agriculture that are concealed in the particulars of the country's agriculture cannot be explained.

Future research will have the option to observe how farmers behave in terms of their attitude toward risk.

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CRITICAL ANALYSIS OF MINI UNMANNED AERIAL VEHICLES (UAV) DEVELOPMENT CAPABILITIES AND PERSPECTIVES OF EFFECTIVE INTEGRATION IN HORTICULTURAL AGROECOSYSTEMS IN ROMANIA

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Abstract

The present attests to the development of autonomous unmanned aircraft systems and their widespread use in various fields. The article presents the level of development of mini UAVs, the rapid growth of their use in various fields and challenges for various civil applications. At the same time, current research trends are highlighted and future perspectives for use in precision horticulture are identified. For this, the research methodology used included both quantitative and qualitative methods of the type of secondary analysis of statistical data and specialized literature, respectively the SWOT analysis model, supplemented with the observation method. The realization of the study allowed to obtain an overview of the level of development of mini UAV and the possibilities of increasing the degree of use in various fields.

Key words*: *research, horticulture, precision, mini Unmanned Aerial Vehicles (UAV), perspectives

INTRODUCTION

The development of unmanned aircraft systems is a certainty of the present in which society shows increased interest. If at the time of their appearance they were intended and used in various military applications, we have gradually witnessed their adoption by civil society where there is a rapid increase in interest regarding the use in various civilian applications. At the same time, the interest of researchers in the development and implementation of unmanned aircraft systems is also increasing, indicated by the numerous topics addressed in SCOPUS publications, for example, whose numerical evolution registers a spectacular increase between the years 2000 and 2015, from 539 to 23,502 topics [31].

Unmanned aircraft systems comprise different components (unmanned aerial vehicle, launch and recovery station, data network, technical support systems, control station, human interface, etc.) whose complexity configures different classes among which the mini UAS is considered the fastest growing class [43]. The growth is due to recognized features such as: low costs [40], implementability directly from the field, accessibility of technologies [43], flexibility etc., which give it advantages and ensure a dominant presence in applications civilians from all fields of activity [6, 7, 27, 12, 28, 55, 9, 42]. Missions and applications dedicated to precision horticulture are relatively new, emerging and fruiting capabilities to provide a unique recognizable image of agricultural/horticultural land and even precision detailing solutions starting from broad spectrum sensors (EO-optical, infrared IR , NIR quasi-infrared TR thermal sensors). These details were almost impossible a few years ago even for conventional UAV systems. Starting from the success of these applications, attention was also directed to the area of precision agriculture/ horticulture. The first type of missions for agriculture/

horticulture applications refers to the rapid integration of crop images, a comparison with the classic method performed with conventional tractors for areas of 5-10 x 5-10km is provided [23]. In this case it is suggested that multiple drone systems [11]. connected to ground robots may be used in the future (the problem of communication between these types of robotic vehicles will benefit from disruptive technological progress). The new missions specific to precision agriculture/horticulture [39]. are moving towards analyzing and comparing soils, evaluating the effects of specific procedures, evaluating specific performances [23,17].

The current state of research in the field

Yamaha Motor Company (Japan, 1987) [60] proposed the RMAX-R50 concept dedicated to spraying rice crops with pesticides. Cisneros (2013) [13] proposed the low-cost concept for use in emerging South American countries (especially Peru). Subsequently, Glen (2015) [22] anticipated the downsizing effect and showed a possible market entry of medium and small UAV robotic systems that take advantage of the downsizing of specific multispectral sensor systems [2].

Gogarty and Robinson (2012) [23] proposed a classification of modern drones based on endurance and flight altitude: HALE (high-altitude long endurance), such as Global Hawk and Predator, or MALE (medium-altitude long endurance). For applications for precision agriculture/horticulture, there is no question of special performances, the endurance not being over 30-60 minutes of flight [24, 20]. The correlation between types, missions and specific performances starts from the following reference elements [5]:

a) Maximum take-off mass
- -giant drones: Global Hawk
- -heavy drones: m=200-2,000kg (e.g. Fire Scout)
- -medium drones: m=50-200 kg
- -light drones: m=5-50 kg (RMAX, Yintong, Autocopter)
- -micro-drones: mass under 5 kg (Raven, Lancaster, eBee, Swinglet, CropCam)

b) Endurance and range
- -long endurance (24h) and range (over 1,500km): Global Hawk
- -medium endurance (3-24h) and 100 km range
- - drones for agricultural missions typically achieve an endurance of 30-60 minutes and a range of 20-25 km

c) Maximum flight altitude
- - high altitude
- - medium altitude (500-5,000m) - rarely used in agriculture (NIR, TS)
- -low altitude (100-500m)

d) Alar loading - for agriculture/horticulture applications, reduced loads are preferred to ensure transport capabilities

e) Propulsion system: classic (RMAX, Autocopter) or electric

f) Power source.

Regarding drones for precision agriculture/horticulture (plane or multicopter type), there are very few bibliographic references [32]. In this case, the elements of interest (performance, flight qualities, specific transport aspects) refer to the semi-autonomous flight capabilities, the initial acquisition cost, the level of complexity of the possible missions, maintenance costs (including periodic corrections specific to drones small).

In this context, the purpose of the study is to know the level of development of mini UAVs and to identify future prospects for their use in precision agriculture/horticulture. Achieving the goal was possible by fulfilling the following objectives: knowing the current state of research in the field; benchmarking analysis with the main achievements worldwide; identifying the main uses of mini UAVs in precision agriculture/horticulture; future prospects for the use of mini UAVs in precision agriculture/horticulture.

MATERIALS AND METHODS

Achieving what was proposed was possible by carrying out research from a double perspective: descriptive to ensure the understanding of the evolution of mini UAVs and the need for their adoption in precision horticulture, as well as explanatory to identify the variables and the relationships between them for their widespread adoption in precision horticulture.

From a methodological point of view, quantitative and qualitative methods belonging to strategic management were used because they allow obtaining an overview of the level of development of mini UAVs and the possibilities of increasing the degree of use in various fields.

The research was organized in two stages. In the first stage, the secondary analysis of statistical data and specialized literature was carried out, identifying critical factors and successful initiatives. The second stage included the application of the SWOT analysis model where, based on the combination of information from the four quadrants, the current research trends were highlighted and the future prospects for the use of mini UAVs in precision horticulture were identified (Fig. 1).

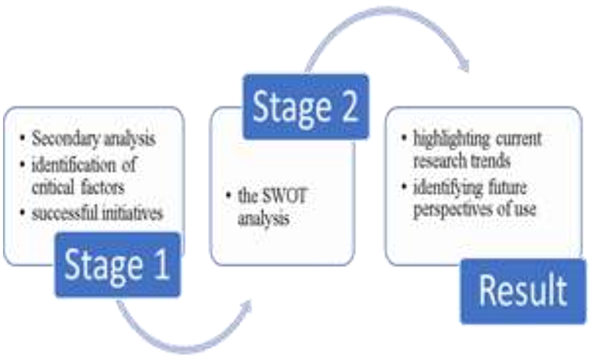

Fig. 1. Schematic structure of the research Source: Own conception.

RESULTS AND DISCUSSIONS

The present study was carried out according to the schematic structure of the research presented in Figure 1. The secondary analysis of the statistical data and the relevant specialized literature allowed both the highlighting of the achievements and the level of development of UAVs and the scenarios of their application in horticultural ecosystems from the perspective of the following directions: monitoring the state of vegetation and identifying possible vulnerabilities in horticultural ecosystems, applying the necessary treatments with precision and with a reduced volume of solution; soil texture mapping, irrigation scheduling, production maturity mapping.

The main achievements worldwide have been highlighted with the help of the benchmarking analysis and highlight the following types of UAVs (Table 1).

Table 1. Benchmarking analysis with the main achievements worldwide

Airplane type drones	Rotary wing/multicopter drone	Parachute/aerostat flexible surface drones
Precision Hawk Lancaster	RMAX	SUSI-62
Swinglet Cam	Yintong	-
eBee	Venture Outrider/ Nenture Surveyor	-
Wave Sight	EnsoMOSAIC	-
CropCam	-	-
Trimble UX5	-	-
Agribotix Horne	-	-

Source: prepared by the authors based on the secondary analysis of the specialized literature.

The rapid evolution of mini UAV technology leads us not to detail the types of drones further and to bring to attention those mentioned by Dalamagkids (2015) and Stark et al., (2013) [15, 46].

Mini UAVs have the ability to collect a large volume of high-resolution spatial images, their processing leads to obtaining useful information for the identification, quantification and classification of vulnerabilities within agro-ecosystems determining a quick reaction from the management to correct the vulnerabilities.

The collection of information takes place with the help of sensors mounted on the mini UAV. There are four types of sensors that cover almost all UAV remote sensing research applications in precision agriculture: RGB, multispectral, hyperspectral and thermal sensors. The first three categories compete in the creation of georeferenced reflectance maps, and the last category in the creation of temperature maps [35].

The SWOT analysis

SWOT analysis is used in numerous studies to evaluate the capabilities and shortcomings of the analyzed subject [33]. The results obtained proved relevant for increasing the level of development of mini UAVs and highlighting the types of missions applied in precision horticulture. The SWOT analysis model was applied to evaluate current research trends and identify future perspectives of use. It allowed the development of strategic options for boosting the use of mini UAVs in precision horticulture.

Strong points

Mini UAVs are emerging technology elements increasingly used in agriculture. Their adoption in specific technologies in horticulture is based on the ability to collect, store and analyze large volumes of digital data related to the crops of interest, with reference to the identification of possible disease and pest attacks and implicitly to the development of solutions regarding the optimization of resources. This results in a number of benefits:

- economic benefits based on cost reduction (especially those associated with labor, energy and water resources)
- speed/agility and precision in action
- ensuring the sustainability of the soil
- non-destructive analysis capabilities, solutions and strategies.

Weaknesses

Like all activities and the use of mini UAVs, they present a series of weaknesses: operating under strictly regulated conditions, which often do not keep up with the evolution of technology and slow down the expansion of these applications; short flight time and the need to purchase several batteries; the existence of restrictive environmental factors (wind) and restrictions for certain areas imposed by the aeronautical authority; the timidity of integrated educational initiatives regarding training in the operation of mini UAVs and monitoring of horticultural fields; few partnerships between horticultural and IT specialists to analyze, interpret and develop solutions to regulate agroecosystem vulnerabilities.

Oportunities

The analysis carried out led to the highlighting of the following opportunities regarding the adoption of mini UAVs in horticulture: the manifestation of a flexibility on the part of the authorities manifested with the change of regulations regarding UAV management in 2001 and implicitly of a continuous availability to adapt the regulations to the evolution of technologies and market requirements; imprinting agriculture with the character of high-tech industry with decisions based on the collection and real-time processing of data for the automation and optimization of the management of the agricultural enterprise; the opening of new directions of research and development; the attraction of young people to drone technology and the need for their entrepreneurial education for the development of service enterprises to operate in the rural area; the creation of new jobs; improving production and profitability of horticultural enterprises.

Threats

The following threats to the increase in the adoption of mini UAVs in horticultural fields have been identified: the shyness of actions to promote among farmers the need to adopt aerial monitoring of horticultural fields even at the level of access as a third-party service; the lack of partnerships at the level of small farmers for the joint purchase of aerial monitoring services for horticultural crops; lack of educational partnerships between farmers and public institutions (universities and central/local authority) regarding drone technology education.

Missions to monitor the state of vegetation and identify possible vulnerabilities in horticultural ecosystems

Aerial monitoring of horticultural ecosystems involves the development of work processes based on the use of space technologies with a very low impact on the environment, for monitoring resources to increase production and the state of vegetation of crops using UAV (unmanned aerial vehicle) type equipment to capture of aerial images and an information system for the processing of aerial photographs, the creation and georeferencing of orthophoto planes. The implementation of aerial monitoring takes place by carrying out flight missions at certain heights (heights for example 100 m), according to a flight plan made by selecting a terrain area on a Google Earth or Map support. It follows obtaining approvals from the Aeronautical Authority and the Ministry of National Defense for flying over a land surface at this height with the specification of the take-off and landing points; the realization of the flight plan aiming primarily at the coverage of the area of interest, then the generation of the flight trajectories that the drone must cover, so that the photos taken have an overlap of 70% and the flight times are supported by the power of the batteries (approx. 25 min for a battery); preparation for the takeoff of the drone (favorable weather conditions - clear sky and wind below 7m/s, coverage of the telephone network necessary for data transmissions, adequate GPS signal); carefully following the trajectories traveled [29]. The images obtained during the aerial monitoring of horticultural ecosystems are processed with the help of dedicated software leading to the early detection of diseases and pests in the crop; accurate weed mapping; accuracy in forecasting; the application of pesticides with precision and in a small volume of solution; optimizing nutrient administration; monitoring plant growth [4]. Thorp et Tian (2011) [48] identified spectral differentiation solutions and proposed spectral response testing solutions. Thus, remote detection is possible, fruiting the ability to provide the aerial image and location precision specific to drone-based technologies [50]. In this sense, the following phases are identified [49]: mission planning; flight for image acquisition (EO and NIR sensors); spectral image processing.

The SWOT analysis of aerial monitoring missions of horticultural ecosystems highlights the existence of some strong points for their adoption represented by the short time required for flying over the surfaces and the ability of the sensors mounted on the drone to capture images that contain information about the presence of stressors and the recording of GPS coordinates. Large-scale adoption of aerial monitoring is hampered by operating under strict regulatory conditions and a lack of action to train farmers in the operation of mini UAVs. Added to this is the shyness of actions to promote aerial monitoring services offered by different companies. However, the flexibility and willingness of the authorities to adapt operating regulations to the evolution of technologies and market requirements represent an opportunity that favors the orientation of farmers towards aerial monitoring of horticultural ecosystems in order to identify possible vulnerabilities early.

Missions of application with precision and in a small volume of solution of phytosanitary treatments

The use of mini UAVs in agriculture was not limited to the aerial monitoring of crops and the research of the state of vegetation through captured images, but continued with the application of imputations, respectively of pesticides [47]. Thus, mini UAVs for disease and pest control manage to maintain their control in identified areas, by applying variable doses of pesticides [30]. The positive impact of the activity on the environment and human health is evident [16] as a result of spraying small volumes of pesticides and only in identified areas compared to the classical administration of treatments uniformly and over the entire surface. However, the risk of spraying deviation from the target area as a result of the negative influence exerted by technical and environmental factors is not excluded, which attests to the development of research to improve the technique [3, 34] in the conditions of finding a real potential for the use of mini UAVs in the precision application of pesticides [18, 19, 10]. In Japan, the use of UAVs has a history and remarkable achievements since the 80s with the creation in 1987 of the first unmanned helicopter for pesticide application with a payload of 20 kg [58] and subsequently numerous improved variants. As a result of the success recorded in rice fields in Japan, UAVs for pesticide spraying have been extended to numerous agricultural crops: wheat, oats, soybeans [59] including horticultural ecosystems in California vineyards [21]. This attests to the utility of these practices and the development of spray platforms compatible with numerous commercial UAVs in numerous states [58, 45, 25, 37]. Moreover, there are studies that highlight the use of drones in the biological control of pests [54] and in the elimination of stress factors by ensuring conditions at the level of requirements and thus maintaining the state of health and implicitly resistance to diseases and pests [41, 57].

The SWOT analysis of the precision application missions in a small volume of phytosanitary treatment solutions highlights their favoring of the possibility of application in a variable rate and implicitly of the positive impact on the environment and human health, of the speed and low cost, respectively of the quick access in conditions where other machines cannot operate. Weaknesses are also indicated, such as the negative influence of some technical and environmental factors, but also opportunities offered especially by the real potential for the use of mini UAVs in the precise application of plant protection products.

Soil texture mapping missions

The importance of the soil for the manifestation of the productive characters of the plants is known, and obtaining fast and precise information about its characteristics is very useful. Because soil texture is a relatively stable natural property of soil that influences a number of physical and chemical properties (structure, porosity, hydraulic properties, and nutrient retention capacity), research is oriented toward rapidly obtaining information about it (Wang et al. . 2015) [56]. Numerous studies attest to different methods of soil mapping: quantitative methods based on the theory of the soil-landscape relationship [26], respectively on geo-statistical factors [38]; method based on artificial neural network operating on remote sensing data [61]; establishing regression models between the reflected spectrum and the percentage content of sand or clay [36]; using microwave remote sensing of soil moisture [44]; methods for evaluating soil texture by studying the relationships between the content and size of different soil particle fractions and its surface temperature (daytime, nighttime, diurnal temperature range) using predictive linear regression models [56].

The SWOT analysis of the soil texture mapping missions brings to the fore the ability to obtain information in a short time about the physical and chemical properties of the soil which, along with the development of different categories of sensors and remote sensing, favors their adoption. The lack of solid partnerships between horticultural, pedological, IT and public institutions to analyze, interpret and develop sustainable solutions to improve soil characteristics and ensure their maintenance is delaying the large-scale adoption of these missions. The high-tech industry character imprinted on horticulture by these technologies capable of real-time collection and processing, automation and optimization of business management, creation of new jobs for young people are opportunities for their adoption.

Irrigation monitoring missions in agricultural/horticultural lands

The objective refers to the selection of sensors for obtaining relevant images. The first test [53] refers to an airplane-type drone with a wingspan of 2.5m and an endurance of 40 minutes with capabilities to retrieve digital data and images (in real time) of soil quality variation, salinity and crop development. Research has focused on the ability to create temperature maps through thermal imaging [8, 14]. Turner (2011) [52] equipped a multicopter with electric motors for vineyard mapping missions; sensors used were EO and IR. Tsouvaltsidis et al. (2015) [51] proposed the use of a low-endurance multicopter (10-15 minutes) equipped with IR sensors (QE, Ocean Optics) in synergy with EO in a way that allows the identification of drought effects on crop productivity. Real-time data allows identifying the need for irrigation in a remarkable timing [62]. Drones have been used in 3D surveying missions and are excellent robots for farms, providing capabilities for monitoring irrigation equipment and its operation mode, highlighting the need for maintenance. Another related mission concerns the surveillance of water resources for irrigation [1].

The SWOT analysis of horticultural field irrigation monitoring missions highlights numerous assets for their widespread adoption: the ability to collect real-time information on soil quality variation, soil salinity and crop development; the ability to create temperature gradients; identifying the

need for irrigation, monitoring water resources, etc.
The analysis of the four elements of the SWOT analysis leads to the elaboration of the following strategic options for increasing the degree of adoption of mini UAVs in horticultural fields:
Dynamic adaptation of UAV management regulations to technological evolution and market requirements;
• Promotion of educational partnerships regarding the utility of aerial monitoring of horticultural crops and the application of variable rate imputations;
• automation and optimization of agricultural enterprise management;
• promoting an entrepreneurial education for the development of aerial monitoring service companies of horticultural fields to operate in the rural area;
• encouraging partnerships between farmers and their joint access to aerial monitoring services;
• the attraction of young people to drone technology and the need for their entrepreneurial education for the development of service enterprises to operate in the rural area;

CONCLUSIONS

There is a particular interest in expanding the applications of UAV systems in the conditions of the fruition of the aspects of modularity, scalability and the reduction of operating costs through the downsizing conferred by the developments at the level of materials, sensors, and propulsion systems. Starting from the analysis of the current state of the miniUAV, new capabilities and possible developments in the field of precision agriculture and horticulture were demonstrated. The realization of this study leads to the development of recommendations with a positive impact in the process of dynamizing the effective implementation of mini UAV applications in the horticultural field.
This article promotes specific research and accelerates capabilities regarding the adaptation of mini UAV systems to specific horticultural technologies. By studying the numerous applications of mini UAV systems in the agricultural field, new research and development directions and new implementation perspectives result. Capitalizing on the high potential to develop mini UAV systems dedicated to precision agriculture and horticulture applications involves not only the development of materials to reduce the mass of the pods, the improvement of electric propulsion systems, with a focus on batteries, C2 capable systems, but also the development of sensors suitable for the applications and the missions analyzed, respectively ensuring efficiency and adequate implementation at the level of users. These mini UAV systems can thus contribute to increasing yields and productivity by automating and optimizing the management of agricultural enterprises in a scalable way. In this way, superior results can be obtained at the level of the capabilities to ensure the food needs, under the conditions of awareness of the fact that resources are limited and in a way that also integrates the active management of the negative impact of climate change on the agricultural/horticultural field.
Technological progress in mini UAV systems equipment cannot be fruitful without the support of entrepreneurial educational partnerships for understanding and training in the process of aerial monitoring of horticultural fields. In this way, new directions for the development of service enterprises are opened and new jobs are created in the field of precision horticulture. The field of mini UAV technologies is emerging and attracts young people, and its adoption can help keep them in rural areas where they can capitalize on the employment opportunities created through this entrepreneurial educational partnership.

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THE IMPACT OF REDUCING THE AMOUNT OF FERTILIZERS AND PESTICIDES ON THE YIELD OF THE SOYBEAN CROP

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Abstract

The study aims to analyze the main effects of the reduction in the use of agricultural inputs in the soybean culture, according to the Farm to Fork Strategy: decrease in agricultural production, increase in price, decrease in producers income, affecting the purchasing power of consumers. We analyzed soybean cultivation in Romania and compared to seven other EU countries (Germany, Spain, France, Italy, Hungary, Poland and United Kingdom) and showed that the use of pesticides and fertilizers in Romania is below the average of the quantities used in the countries included in the study. The areas cultivated with soybeans are significant and Romania occupied the 2nd place in the top of multi-year average for the total production of soybeans compared to the other analyzed countries.

Key words*: consumption of fertilizers and pesticides, soybean crop, Romania*

INTRODUCTION

Soya is used in human nutrition, in animal feed and as a row material for various industries [12].

The biggest soybean producers are Brazil, USA and Argentina. The EU' s soybean production does not cover its needs, therefore it is necessary to capitalize on the community's agricultural potential [5][6].

In our country, there are 5 favorable zones for soybean cultivation, depending on the thermal potential, namely:

- *Zone I* – includes the South of the Romanian Plain and Dobrogea. In this area, it is recommended to cultivate late and semi-late soybean varieties, under irrigation conditions.

-*Zone II* – includes the Western Plain (the Plain of Banat and Crisana). In this area, it is recommended to cultivate semi-late and semi-early soybean varieties, under irrigation conditions, but also under non-irrigation conditions.

Zone III – includes the Northern part of the Romanian Plain. In this area, it is it is recommended to cultivate semi-late, semi-early and early soybean varieties in the more northern areas.

Zone IV includes the Eastern part of Moldova and North-Western Plain of the Country. In this area, it is it is recommended to cultivate semi-early, early and very early soybean varieties.

Zone V includes the Western and South-Western parts of Transylvania (the meadows of Mures, Tarnave and Somes) and North-Eastern part of Moldova. In this area, it is it is recommended to cultivate early and very early soybean varieties [9].

In the context of the transition to a sustainable agriculture, soybean culture has an important role both from the perspective of environmental quality, as well as its use in population nutrition and animal rations. Soy is a valuable crop due to the fact that it is combines in its composition a very high amount of protein on average 40% and oil 20% [3].

The specific consumption of nutrients for the formation of 100 kg of seeds and related secondary biomass is: 7.1-11 kg Nitrogen, 1.6-4.0 kg P_20_5 and 1.8-4.0kg K_20. Soybean consumes large amounts of nitrogen, due to the high content of the whole plant in this element (in protein) [9].

The Farm to Fork Strategy proposes that each country establish precise targets regarding the reduction of pesticides, fertilizers and antimicrobial substances used [2][1]. The effects generated by the reduction in the use of agricultural inputs will be evident on the one hand, through the reduction of agricultural production in the soybean crop, on the other band, through the reduction of competitiveness for export [3][4]. All these will lead to higher soybean prices, which will have a negative impact on consumers [11].

In this context, the goal of the paper was to analyze the soybean cultivation in Romania and compared to seven other EU countries: Germany, Spain, France, Italy, Hungary, Poland and United Kingdom to show if the amount of pesticides and fertilizers used in Romania is below the average quantities utilized in other EU countries selected in the study.

MATERIALS AND METHODS

In this study, the data provided by Eurostat, FAOStat and National Institute of Statistics were the basis of the processing and establishment of the impact of the use of the quantities of fertilizers and pesticides on the production of the soybean crop, in the period 2010-2019 [10].

In the article we analyzed the following indicators: cultivated area, total production, average production per hectare, multi-year average for total cultivated area, multi-year average for total production, multi-year average for average production/ha, in Romania and Germany, Spain, France, Italy, Hungary, Poland and the United Kingdom.

We used the multi-year average (2010-2019) of the amounts of chemical fertilizers and pesticides used per cultivated hectare(nitrogen fertilizers(N), potassium fertilizers(K_20), phosphorus fertilizers (P_20_5), pesticides-total), in the countries included in the analysis and the average productions per hectare(tons) made to calculate the amount (kg) of chemical fertilizers and pesticides used to obtain one ton of soybeans.

At the macroeconomic level, in the conditions where it is a high demand for soybeans worldwide, an increase in the demand for soybeans is estimated, due to lower productions, even an uncertainty in ensuring global food security. In this sense, an accelerated increase in soy process is expected, which may become unsustainable for users of soy products [7].

RESULTS AND DISCUSSIONS

The largest area cultivated with soybean can be found in Italy, in 2018, with a value of 326.59 thousand hectares and in Romania with a value of 169.45 thousand hectares [7].

In the period 2010-2018, Romania had the second largest area of land cultivated with soybean among the analyzed countries. Since 2019, the cultivated area has decreased, thus Romania occupies the third place with an area of 158.15 thousand hectares, while France has the second largest cultivated area with 163.80 thousand hectares (Fig. 1).

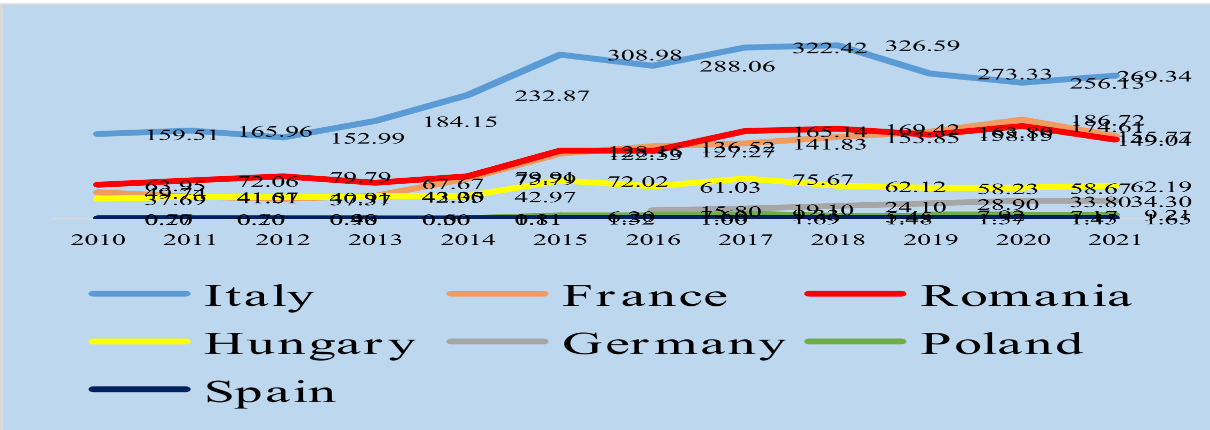


Fig. 1. The total area cultivated with soybeans (thousand ha), in the main growing states of the E.U.
Source: Created by authors based on the data from EUROSTAT, 08.11.2021 [7].

The multi-year average for the total area cultivated with soybean for the countries studied varied between 241.49 thousand ha and 1.03 thousand ha.

The multi-annual average for the total area cultivated with soybean in the analyzed period was 111.15 thousand ha for Romania.

Romania took the 2nd place in the top of multi-year average for the total area cultivated with soybeans compared to the countries studied.

Romania held 46.02% of the multi-annual average recorded by Italy, depending on the total area cultivated with soybeans (Fig. 2).

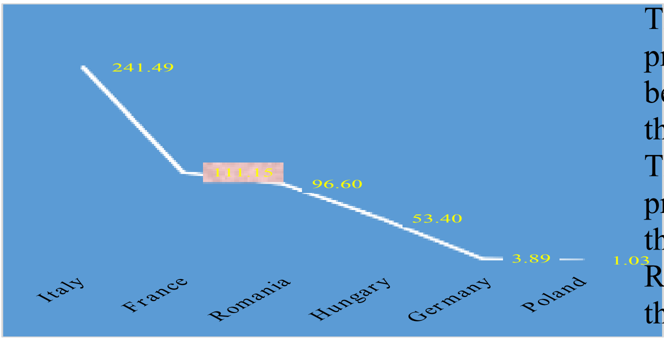


Fig. 2. Multi-annual average 2010-2019 for the total area cultivated with soybean (thousand ha) in the main growing countries in the E.U.
Source: Created by authors based on the data from Eurostat, 08.11.2021 [7].

Italy had the largest total soybean production, with a maximum of 1,186.35 thousand tons in 2018.

In 2017, the total soybean production in Romania registered an increase of 149% compared to 2016 at a value of 416.37 thousand tons. The highest total production in Romania was 492.68 thousand tons in 2018.

Between 2010-2013 and 2017-2019, Romania ranked the 2nd in total production among the analyzed countries.

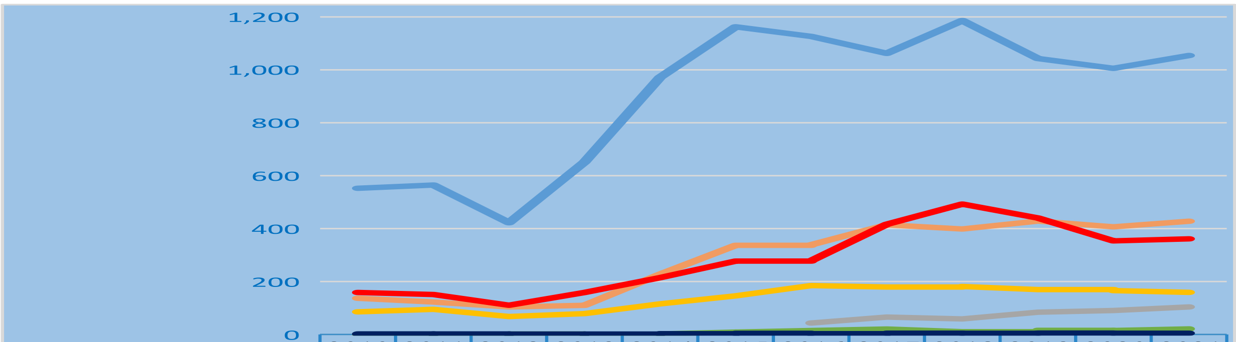
With a production of 406.67 thousand tons in 2020, France has the second largest total soybean production among the analyzed countries (Fig. 3).

The multi-year average for the total soybean production in the countries studied varied between 874.30 thousand tons- 3.08 thousand tons.

The multi-year average for total soybean production in the analyzed period was 269.85 thousand tons for Romania.

Romania came on the 2nd place in the top of the multi-year average for the total soybean production compared to the countries studied.

Romania held 30.86% of the multi-year average recorded by Italy, according to total soybean production (Fig. 4).



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Italy	552.4	564.6	422.1	651.5	971.7	1,162	1,126	1,062	1,186	1,042	1,005	1,054
France	136.7	122.5	103.9	110.0	227.2	336.8	338.9	414.3	398.4	428.5	406.6	427.9
Romania	158.6	150.9	110.4	158.6	214.6	277.3	278.6	416.3	492.6	440.1	353.6	361.3
Hungary	85.44	94.96	67.73	78.76	115.5	145.8	184.7	179.2	181.2	169.5	165.7	159.0
Germany							43.20	65.70	58.70	84.10	90.50	104.0
Poland	0.20	0.30	1.47	0.00	2.02	8.90	14.87	20.54	10.39	15.54	14.94	21.00
Spain	1.92	1.84	1.41	1.47	2.80	4.20	2.94	4.71	4.35	5.17	4.62	4.96

Fig. 3. Total production of soybean obtained in the main growing states in the E. U. (thousands of tons)
Source: Created by authors based on the data from Eurostat, 08.11.2021 [7].

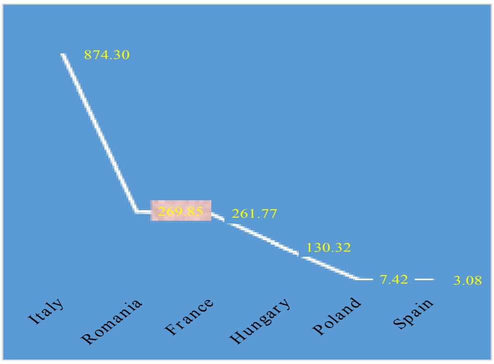
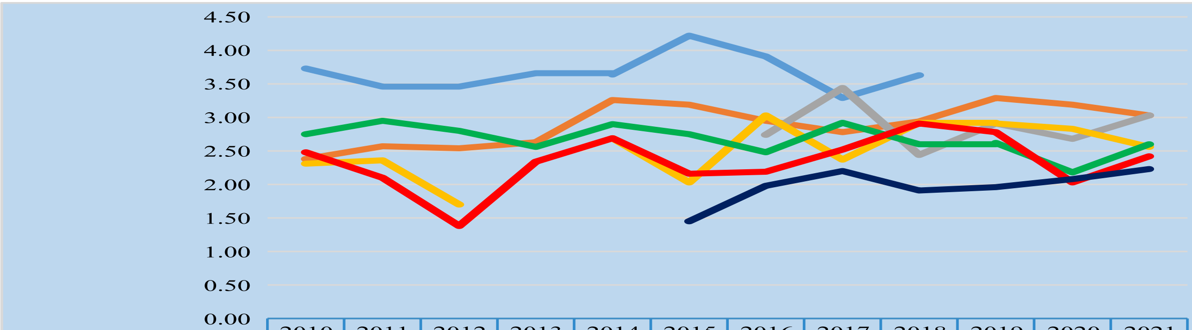


Fig. 4. Multi-annual average 2010-2019 for the total soybean production obtained in the main growing states in the E.U. (thousand tonnes)
Source: Created by authors based on the data from Eurostat, 08.11.2021 [7].

The average production per hectare was the highest in Italy, with a maximum of 4.22 tons per hectare in 2015. High productions were also recorded in Spain with 3.19 tons per hectare, France with 2.75 tons per hectare and Romania with 2.16 tons per hectare (Fig. 5).
The multi-year average for average soybean production/ha in the countries studied varied between 2.85 tons/ha and 2.36 tons/ha.
The multi-year average for average soybean production/ha in the analyzed period was 2.36 tons for Romania.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Italy	3.73	3.46	3.46	3.66	3.64	4.22	3.91	3.29	3.63		3.93	
France	2.38	2.57	2.54	2.63	3.26	3.19	2.95	2.78	2.94	3.29	3.19	3.03
Romania							2.74	3.44	2.44	2.91	2.68	3.03
Hungary	2.31	2.36	1.70		2.69	2.03	3.03	2.37	2.92	2.91	2.83	2.56
Germany	2.75	2.95	2.80	2.56	2.90	2.75	2.48	2.92	2.60	2.62	2.18	2.60
Poland	2.48	2.10	1.38	2.34	2.69	2.16	2.19	2.52	2.91	2.78	2.03	2.42
Spain	1.44					1.45	1.98	2.20	1.91	1.96	2.08	2.23

Fig. 5. Average production/ha of soybeans obtained in the main growing states in the E. U. (tons/ha)
Source: Created by authors based on the data from Eurostat, 08.11.2021 [7].

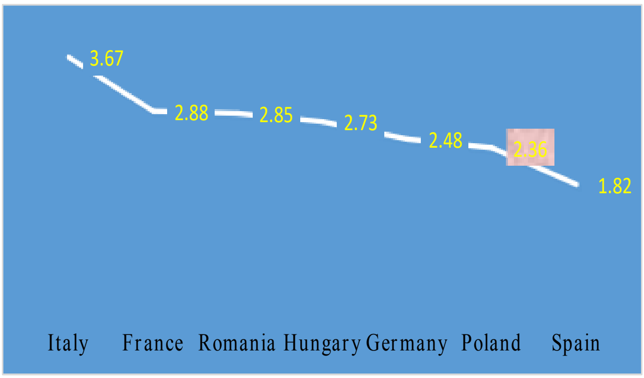


Fig. 6. Multi-year average for average production/ha of soybeans obtained in the main growing countries in the E. U. (tonnes/ha)
Source: Created by authors based on the data from Eurostat, 08.11.2021 [7].

Romania, according to the multi-year average achieved for the average soybean production/ha, ranked the 6th (2.36 tons/ha) after Italy (3.67 tons/ha), Germany (2.88 tons/ha), Spain (2.85 tons/ha) and Hungary (2.48 tons/ha) (Fig. 6).
Romania achieved 64.30% of the multi-year average recorded by Italy for the average soybean production/ha.
In 2019, the average soybean production per hectare in the studied countries varied between 3.60 tons/ha and 1.7 tons/ha.
Romania, according to the average production per hectare ranked the 8th (2.78 tons/ha) after Greece (3.60 tons/ha), Spain (3.29 tons/ha), Croatia (3.15 tons/ha), Austria (3.15 tons/ha), Slovenia (2.96 tons/ha), Hungary (2.91 tons/ha), Germany (2.91 tons/ha) (Fig. 7).

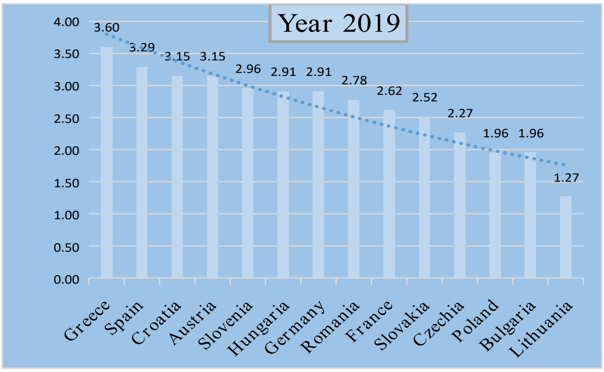


Fig. 7. Average soybean production/ha (tonnes/ha), obtained in E. U. member states, 2019
Source: Created by authors based on the data from Eurostat, 08.11.2021 [7].

The multi-year average (2010-2019) of the amounts of chemical fertilizers and pesticides used per cultivated hectare, in the countries included in the analysis, and the average productions per hectare (tons) achieved, highlighting the quantity (kg) of chemical fertilizers and pesticides used to obtain one ton of soybean is presented below [8].

Regarding to **Nitrogen** (N) fertilizers, in soybean cultivation, Romania is positioned last in terms of Nitrogen (N) consumption with an amount of 16.36 kg of Nitrogen (N) used to obtain one ton of soybean, with a negative deviation of 36.73 kg compared to Poland, which is the largest consumer of Nitrogen (N) fertilizers among the countries studied, in the soybean crop (Fig. 8).

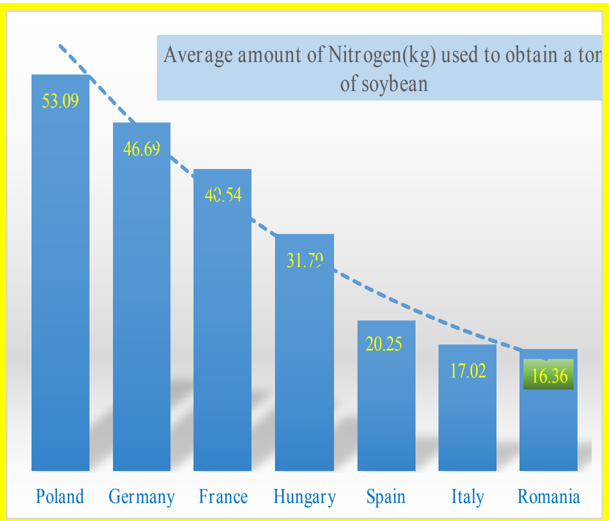


Fig. 8. Soybean crop - the average amount of Nitrogen(kg) used to obtain one ton of product
Source: Created by authors based on the data from FAO (United Kingdom– no data) [8].

Regarding phosphorus fertilizers (P_20_5) for soybean cultivation, Romania is ranked the 6th in terms of phosphorus consumption (P_20_5), with a quantity of 6.37 kg of phosphorus (P_20_5) used to obtain one ton of soybeans, with a negative deviation of 10.62 kg compared to Poland, which is the largest consumer of phosphorus fertilizers (P_20_5) among the countries under the study, in soybean cultivation (Fig. 9).

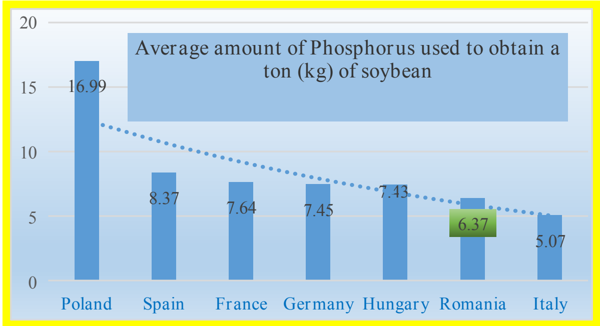


Fig. 9. Soybean crop - the average amount of Phospho rus used to obtain one ton of product (kg)
Source: Created by authors based on the data from FAO (United Kingdom– no data) [8].

Regarding Potassium fertilizers (K_20), in soybean cultivation, Romania is positioned last in terms of Potassium (K_20) consumption, with an amount of 2.28 kg of Potassium (K_20) used to obtain one ton of soybeans, with a negative deviation of 22.13 kg compared to Poland, which is the largest consumer of Potassium fertilizers (K_20) among the countries studied, in the soybean crop (Fig. 10).

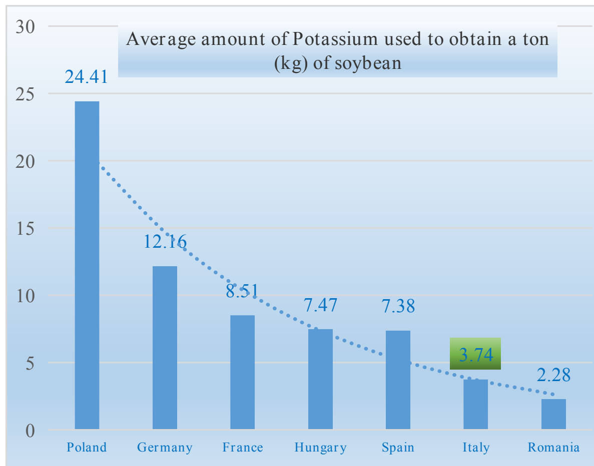


Fig. 10. Soybean crop-the average amount of Potassiu m used to obtain one ton of product (kg)
Source: Created by authors based on the data from FAO (United Kingdom– no data) [8].

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Regarding pesticides-total, in the soybean crop, Romania is positioned on the last position in terms of pesticide consumption-total, with a quantity of 0.3 kg of pesticides-total used to obtain one ton of soybeans, with a negative deviation of 1.47 kg compared to Italy, which is the largest consumer of pesticides-total among the countries studied, in the soy crop (Fig. 11).

The multi-annual average amount of N used in France, 30.8 kg in Hungary, 19.07kg in Spain, 15.95 kg in Romania (Fig. 12).

to obtain a ton of soybeans in 2021 is 44.38 kg in Germany, 43.33 kg in Poland, 42.62 kg

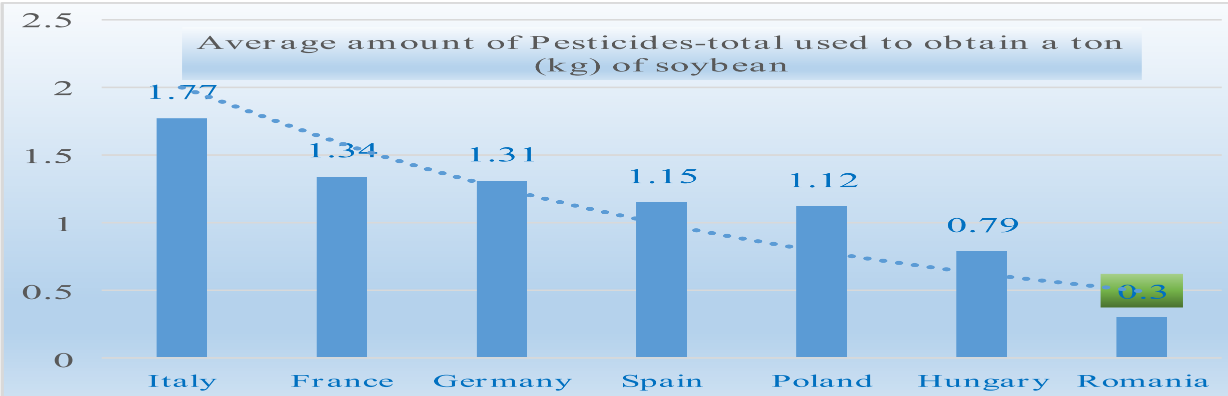

Fig. 11. Soybean crop - the average amount of Pesticides-total used to obtain one ton of product (kg)
Source: Created by authors based on the data from FAO (United Kingdom– no data) [8].

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Germany	0	0	0	0	0	0	49.08	39.09	55.11	46.11	50.18	44.38
Spain	24.28	22.48	22.75	21.97	17.72	18.11	19.59	20.78	19.65	17.56	18.11	19.07
France	40.29	37.56	39.57	43.28	38.21	40.29	44.68	37.95	42.62	42.29	50.83	42.62
Italy	16.75	18.05	18.05	17.07	17.16	14.8	15.98	18.99	17.21	0	15.9	0
Hungary	34.13	33.41	46.38	0	29.31	38.84	26.02	33.27	27	27.1	27.86	30.8
Poland	67.10	0	0	0	0	66.64	48.80	43.92	50.59	49.3	46.46	43.33
Romania	15.56	18.38	27.97	16.5	14.35	17.87	17.63	15.32	13.26	13.88	19.01	15.95

Fig. 12. Multi-annual average quantity of N fertilizers to obtain one ton of soybeans
Source: Created by authors based on the data from FAO (United Kingdom– no data) [8].

CONCLUSIONS

The European soybean growing countries are so different in terms of climate, irrigation rate, level of technological progress, consumption of inputs.

Among the analyzed countries, Romania had the second largest area of land cultivated with soybeans and occupied the second place in terms of total production.

Romania, according to the multi-year average, achieved for the average soybean production/ha ranked 6th(2.36tons/ha) after: Italy(3.67tons/ha), Germany(2.88 tons/ha); Spain (2.85 tons/ha) and Hungary(2.48 tons/ha).

In this context, it is necessary to reduce the consumption of chemical fertilizers and pesticides depending on the real situation, existing in each individual country.

To obtain a ton of soybeans in Romania:

- it is ranked last in terms of nitrogen(N) consumption, with an amount of 16.36 kg of nitrogen(N);
- it is ranked sixth in terms of phosphorus(P205) consumption, with an amount of 6.37 kg of phosphorus(P205);

- it is ranked last in terms of potassium(K20) consumption, with an amount of 2.28 kg of potassium(K20);
- it is positioned last in terms of pesticide consumption-total , with a quantity of 0.3 kg of pesticides-total.

The technical data that can be taken into account are the reporting on the reduction of the quantities of fertilizers and pesticides to the European average, the level of access/use of the elements of technological progress in the targeted country ant to take into account the impact on the average productions and respectively the total productions for soybean culture

Therefore, we consider it necessary to estimate the effects of applying the Farm to Fork Strategy on the on the beneficiaries of soy products, in the context of forecasting the increase in demand for soy products.

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CARBON FOOTPRINT ESTIMATION IN CLOSED BREEDERS' FARMS

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Abstract

The study was conducted to determine the carbon footprint of poultry farms. Breeder farms were included in the study. The fuel and electricity bills from farm, house size and age, flock size and number of flocks per year, and manure management were all collected. The methane, nitrous oxide, and carbon dioxide equivalent emissions were calculated, as well as the effect of these gases on breeder farms productivity, as well as determining the carbon footprint of breeder farms to reduce the negative effects of greenhouse gas emissions. In addition to providing necessary information on breeder's chicken performance and advising poultry farmers on the relative merits of different climatic conditions to help set standards for different production traits. The experiments were conducted of closed farms in the city of Mansoura during the period from May 2019 to December 2021 and the capacity of the farm was 43,300 breeders' chickens. The results showed that the amount of methane gas produced from the farm was 1.76 ton ch_4 yr^{-1} and nitrous oxide gas was 0.13 ton n_2o yr^{-1} for manure management. Thus, the total emissions of manure management are estimated at 81.65 tons of co_2-eq. The amount of greenhouse gas emissions for diesel is 5.23 tons of co_2-eq. The amount of greenhouse gas emissions (GHG) for the electricity used in the farm is 0.15 tons of co_2-eq. In the end, the total amount of emissions produced from the farm is 87.04 tons of co_2-eq. In the end, the total amount of carbon dioxide equivalent emissions generated from Egypt's farms is 271.8 (kiloton co_2-eq).

Key words: *breeder chicken, nitrous oxide, methane, carbon footprint, carbon dioxide equivalent*

INTRODUCTION

The poultry industry is one of Egypt's most important agricultural industries, with an estimated investment of 90 billion LE. The labor force consists of approximately 3.5 million permanent workers and approximately two million temporary workers. The industry provides a significant portion of the country's animal protein supply (white meats and eggs). Local meat production averaged 1,454.856 kt in 2019, while egg production averaged 617.521 kt in the same period [4].

Broiler meat production has increased exponentially in order to meet global demand and increase business profits. Low production costs and rapid economic progress are critical to its growth. Broiler chickens are raised specifically for meat production due to their characteristic soft, tender meat, low fat content, and short production period. Broilers take the place of valuable food animals around the world, significantly contributing to food security, protein supply, and job creation [8].

The poultry industry has grown rapidly as a result of the effective implementation of high-yielding strains of meat-type chickens and the availability of nutritionally balanced feed. Broiler farming is critical to increasing income, improving food safety, and alleviating scarcity in developing countries' rural and semi-urban communities. For several decades, the poultry industry has played an important role in the country's economic development by providing job opportunities, food security, and high-quality protein. By modifying animal protein sources such as beef and mutton, the poultry industry has helped to change people's eating and living habits [6].

Poultry meat is an essential source of animal protein in human growth and development, so it is in high demand worldwide. Poultry meat has several advantages, including adequate nutrition, a delicious taste, a relatively low price, ease of availability, and acceptance at all levels of society from diverse backgrounds [11].

Carbon footprint is a calculation of a person's contribution to global warming in terms of greenhouse gas emissions, expressed in carbon dioxide equivalent units. It consists of two parts in total. The direct or primary footprint is a calculation of our direct carbon dioxide (CO_2) equivalent emissions from fossil fuel combustion, which includes home energy use, transportation (e.g., automobiles and aircraft), and other activities. The indirect or secondary footprint measures the indirect carbon dioxide (CO_2) equivalent emissions caused by the entire life cycle of the products and services we use, including those associated with their manufacture and final decomposition [7].

The fundamental cause of climate change is greenhouse gases produced into the atmosphere by human activities and other sources. Livestock production contributes significantly to air pollution, especially carbon dioxide (CO_2), methane (CH_4), and nitrogen oxides (NOx) [10].

The Middle East's poultry industry expanded significantly in the final two decades of the twentieth century. Construction of environmentally controlled chicken houses with evaporative cooling systems has cost a lot of money. The Arab world produces over 22 billion table eggs per year, accounting for more than 2.5 percent of total global output (the top producers being Morocco, Algeria, Egypt, and Syria) [2].

When compared to ruminant N2O emissions, the non-ruminant sector contributes only a small amount. The poultry industry is the non-ruminant animal industry's largest direct N2O generator, accounting for 92.8 percent of total non-ruminant N2O emissions [3].

The term "carbon dioxide equivalent" or "CO_2-eq" is used to describe the various greenhouse gases in a single unit. CO_2-eq is the amount of CO_2 that has the same greenhouse effect as any other amount and type of greenhouse gas. The amount of greenhouse gases can be represented as CO_2-eq by multiplying the amount of greenhouse gases by the global warming potential. For example, one kilogram of methane released equals 25 kilograms of carbon dioxide (1 kg CH_4 * 25 = 25 kg CO_2 equivalent). "CO_2-eq" is a very useful term for several reasons: it allows a "package" of greenhouse gases to be stated as a single quantity; it allows for simple comparison of various packages of greenhouse gases; and it allows for simple comparison of various packages of greenhouse gases (in terms of the overall effect of global warming) [1].

A substance's carbon dioxide equivalent is calculated over a specified time period and must be provided whenever a global warming potential (GWP) is mentioned. It is expected to have an impact on global warming. Nitrous oxide, for example, has a GWP of 298 over a 100-year period. This means that emitting 1 million ton of N_2O is equivalent to emitting 298 million ton of CO_2-eq over a 100-year period. Methane has a global warming potential of 25 over the next 100 years [9].

The total CO_2-equivalent emissions from manure management from laying hens housing are estimated to be 50.365 tons. Diesel produces 434.59 tons of CO_2-equivalent greenhouse gas emissions. The greenhouse gas emissions from the farm's electricity use are 8 ton of CO_2-eq. In the end, the farm's total emissions are 492.96 tons of CO_2-equivalent [5].

The increase in CO_2 and NH_3 concentrations inside broiler chicken housing was the research problem. Carbon emissions have a negative impact on chicken growth rates due to increased mortality rates, resulting in a decrease in the amount of meat produced.

The study's aim was to calculate the nitrous oxide, methane, and carbon dioxide equivalents produced by breeder over the course of a year, as well as the carbon footprint of poultry production.

MATERIALS AND METHODS

The experiment was carried out in a farm in Dakahlia Governorate, Mansoura, Egypt, from May 2019 to December 2021. To calculate the carbon footprint and other greenhouse gas emissions. A cup 500 chicken was used, and the farm had a capacity of 43,300 hens.

Work was done on a farm with a closed system for breeder hens. consists of 8 floors, each floor has one house without side dimensions (12 m wide x 90 m long), house dimensions (80 m x 10.5 m x 3 m) with a nominal capacity of 7,200 hens during the production period, house system is dark for breeding.

The drinking system was used on three lines, each with 17 pieces. Each piece is 3 meters long and has 12 nipples, one of which is enough for ten birds. An air-driven heater's heating system consists of (stainless steel furnace, counter flow heat exchanger, axial fan) and an electronic control box. And a ventilation system with 5 hoods, each 140 cm long and 140 cm wide, circulating air for 44,000 m^3/h with 6 brushes. A stainless steel, 3-phase electrically operated, evaporative cooling system was used, and a closed floor chain feeding system was used.

A set of mathematical equations and program was used to estimate greenhouse gas emissions from poultry farms such as methane gas, nitrous oxide, carbon dioxide and carbon dioxide equivalent, as presented below.

Input data:

Enter number of hens (N), emission factor for layers (EF), default N secretion rate (Nrate), standard layers mass (TAM), emission factor for direct N_2O emissions (ES_3), part of total annual nitrogen secretion for layers (MS), percent of manure nitrogen for hens that volatilises as NH_3 and NO_x ($Frac_{GasMS}$), emission factor for N_2O emissions (EF_4), quantity of fuel combustion (Q), the energy content factor of the fuel (EC), emission factor for the fuel (EF), quantity of electricity purchased from the electricity grid (Q_e), emission factor for the electricity in the farm (EF_e).

Calculate data

- $CH_{4manure} = (EF \times N)/10^6$
- $Nex = (N_{rate} \times (TAM \times 1{,}000)/365)$
- $N_2O_D = ((N \times Nex \times MS) \times ES_3)/(44/28))$
- $N_{volatilization\text{-}MMS} = ((N \times Nex \times MS) \times (Frac_{GasMS/100}))$
- $N_2O_G = (N_{volatilization\text{-}MMS} \times EF_4 \times (44/28))$
- $Kg\ CO_2e = Kg\ CH_4 \times 25 + Kg\ N_2O \times 298 + E_{generator} + E_{electricity}$
- $E_{generator} = ((Q \times EC \times EF)/1{,}000)$
- $E_{electricity} = ((Q \times EF)/1{,}000))$

Output data

Methane emissions ($CH_{4manure}$), direct and indirect nitrous oxide emissions (N_2O), Carbon dioxide equivalent)CO_2-eq), GHG emissions from generator ($E_{generator}$), GHG emissions from purchased main electricity grid ($E_{electricity}$).

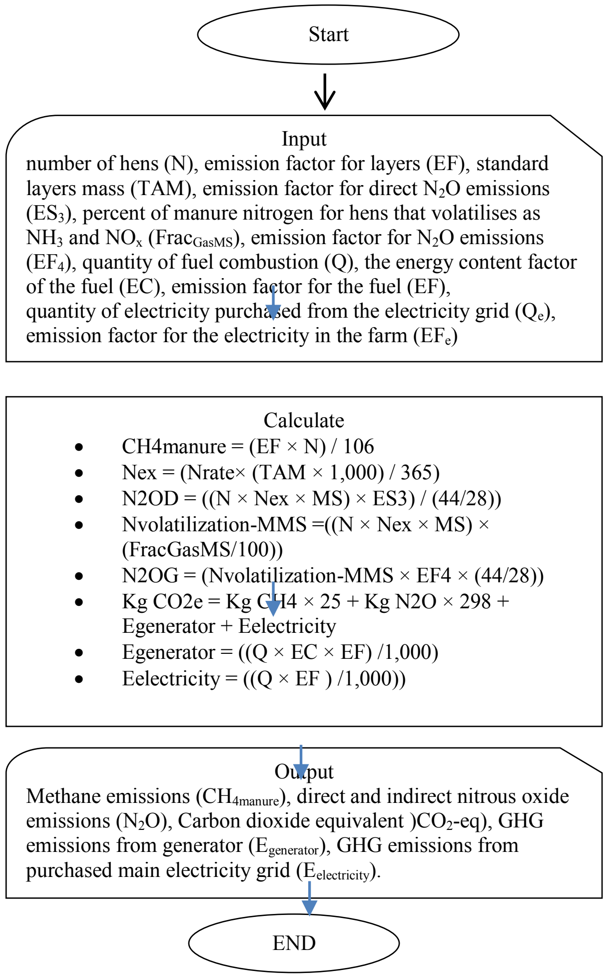

Fig. 1. Showing the inputs and outputs
Source: Authors' drawing.

Carbon Footprint Estimation Toolkit For Poultry On-Farm Emissions

Data is entered such as the number of poultry in the farm, the amount of fuel used in the heating meter (KL), and the amount of electricity, (kw/hr). Then the program starts calculating and updating the results for the current year. Also, **several** recommendations designed to reduce energy consumption on the farm are selected, and the implementation of these recommendations will affect the next year's figures. The numbers below the "expected year" reflect energy savings.

Calculating Direct GHG emissions from Primary Aluminum Production Calculation worksheets.

(a)Introduction Page

The spreadsheet has an introductory page or tab as showing in Fig 2, which informs the user of the capability and it uses it. It provides specific directions on how to enter the information into the spreadsheet. This page also gives the growers options that can be used to reduce their energy use and subsequently to reduce their carbon footprint.

Definitions:

CO_2: Carbon dioxide.
CH_4: Methane.
N_2O: Nitrous Oxide.
LPG use: emissions from stationary sources such heaters and incinerators.
Purchased electricity: emissions from electricity due to usage on farm.
Diesel use: emissions from sources such as equipment used in the operation (tractors, generators etc.).
CO_2-eq Tones: metric tons of carbon dioxide equivalent.
AAP: Annual average population.
NAPA: number of animals produced annually.
NEX: Annual average nitrogen excretion.
NEMMS: Nitrogen excretion from manure management system.
N_{vol}.MMS: Nitrogen losses due to vitalization from manure management.
TAM: Typical animal mass.
Global Warming Potential (IPCC 2006):
CO_2: 1 CH_4: 25 N_2O: 298

Fig. 2 The introductory page can be viewed by selecting the "Introduction" tab on the bottom left of the spreadsheet.
Source: www.ghgprotocol.org for other GHG calculation tools.

(b)Interface Page

Farm Information and Energy Consumption the "Interface" tab is the only page where the user can enter data into the tool. The user will need to select from the first drop-down box Fig 3 the type of poultry (laying, pullet, or breeder) they have. Based on the type of bird, appropriate boxes for that operation will be available for the user to input data. This information will determine the non-mechanical emissions. The non-mechanical emissions are those GHG emissions that occur from manure management and will depend on the type of poultry, the number of birds/flocks grown per year, and the type of manure management system that is used on the farm. The user will next enter energy consumption information. Users have the option of entering LP gas, diesel, and/or natural gas. This will determine the mechanical emissions from the farm. These emissions occur from heating, incineration, diesel for tractors, generators, and other equipment on the farm. Users will also need to enter the amount of electricity used in kilowatt-hours. Electricity is used for ventilation, lighting, feed motors, and water pumps, as well as other electrical equipment for daily bird management and house maintenance.

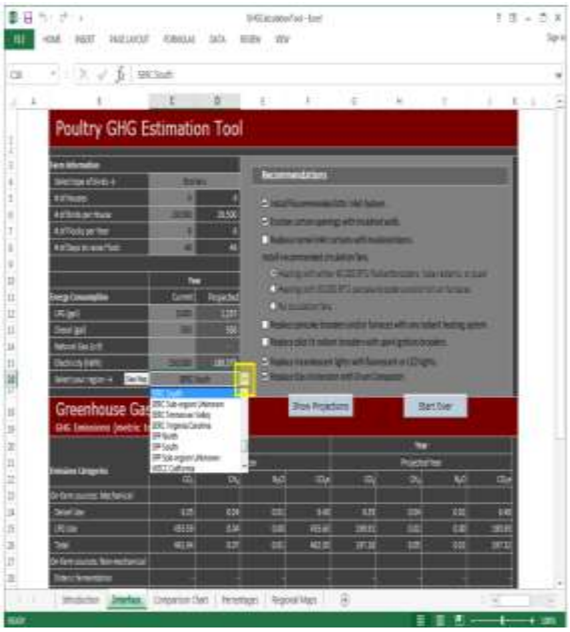

Fig. 3. The data input section of the "Interface" tab. The drop-down box for selecting the user's region is indicated.
Source: www.ghgprotocol.org for other GHG calculation tools.

After the user selects options from the "Recommendations" section, he or she should click the "Show Projections" button. The projected year fields of the "GHG Inventory" section will be populated with the estimated emissions (Figure 5).

(c)Recommendations

The calculation tool also allows the user to choose house adjustments or renovations (Figure 4) that will result in reductions in energy use and GHGs. This can be done by selecting recommendation options to reduce energy use in the "Interface" tab. The tool will show the user what the emissions would be if these adjustments were made on the farm. The recommendations selected will affect the electricity, LPG, and/or natural gas use projections. Therefore, changes in the GHG emissions will be reflected in the mechanical and off-farm emissions inventory.

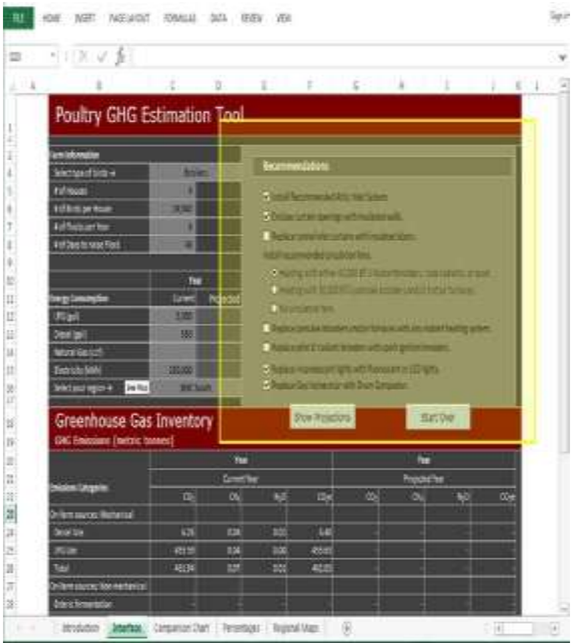

Fig. 4. Recommendations can be selected to see how emissions would be reduced
Source: www.ghgprotocol.org for other GHG calculation tools.

After the user selects options from the "Recommendations" section, he or she should click the "Show Projections" button. The projected year fields of the "GHG Inventory" section will be populated with the estimated emissions Figure 5.

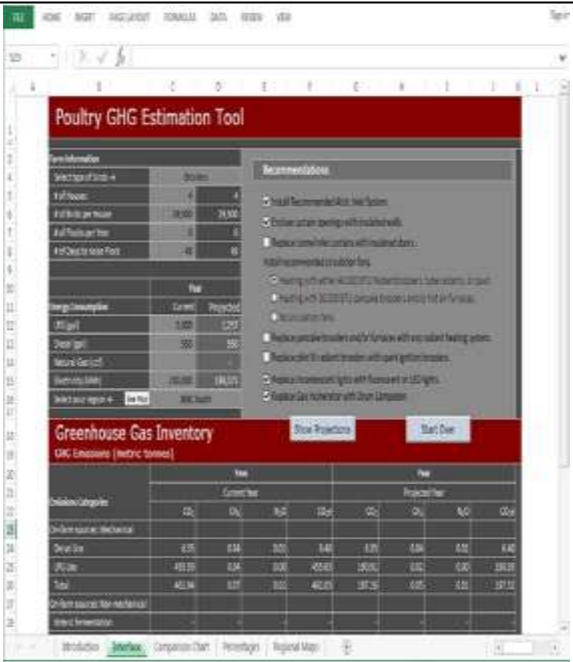

Fig. 5. The projected fields are calculated based on the selected recommendations.
Source: www.ghgprotocol.org for other GHG calculation tools.

(d)Greenhouse Gas Inventory

The "GHG Inventory" section Figure 6 and Figure 7 on the "Interface" page shows users the sources of the emission and also the amount of each GHG emitted.

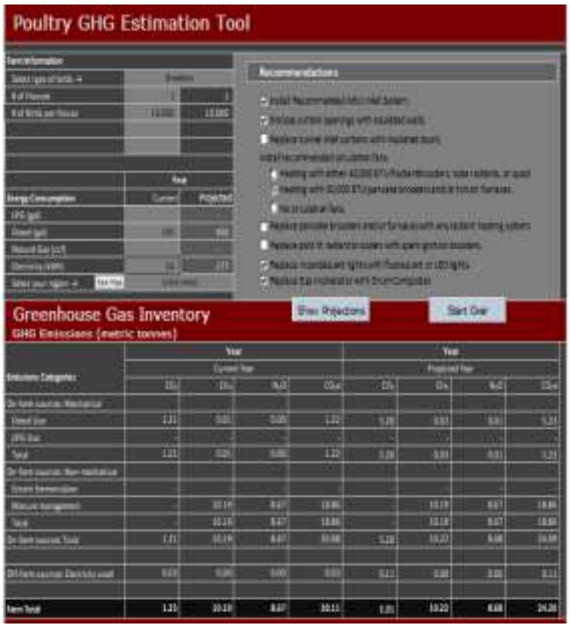

Fig. 6. The Greenhouse Gas Inventory on the Interface page shows current and projected emissions
Source: www.ghgprotocol.org for other GHG calculation tools.

The inventory separates the emissions based on their source (mechanical, non-mechanical, and electricity use) and also on-farm and off-farm sources. It gives the total of each source and the total farm emissions. The inventory is divided into two sections, "Current Year" (the actual farm emissions) and "Projected Year" (the emissions based on the energy reduction options selected). All the emissions are represented as metric tons of CO_2-eq.

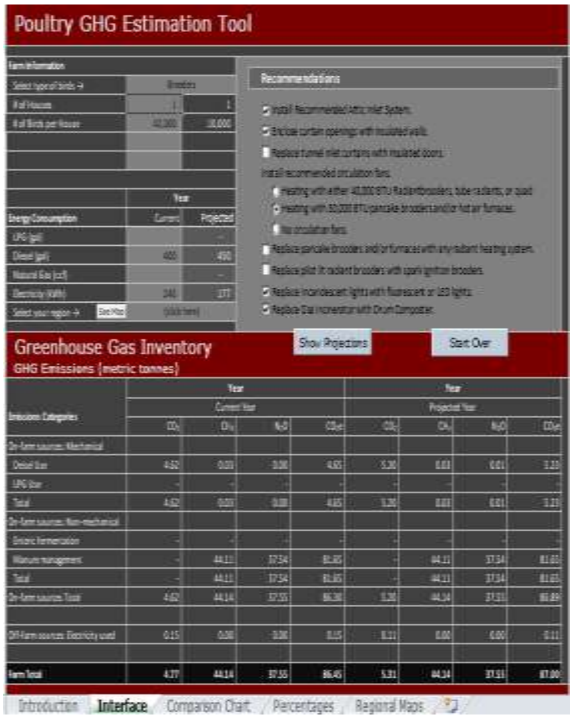

Fig. 7. Interface for breeder farm.
Source: www.ghgprotocol.org for other GHG calculation tools.

RESULTS AND DISCUSSIONS

Emissions of CH4 for layers from manure management by (ton CO_2-eq)

Figure 8 depicts CH4 emissions for breeder hens, which were estimated to be 0.41 ton of methane per year for 10,000 chickens, which is equal to 10.19 ton of CO_2-eq per year. While the annual emissions from 100,000 chickens were 4.1 ton CH4 yr^{-1}, which is equal to 101.87 ton CO_2-eq per year.

Nitrous oxide emissions (ton CO_2-eq) for breeder hen from manure management

Figure 9 depicts N_2O emissions for breeder hens, which were estimated to be 0.03 ton of Nitrous oxide per year for 10,000 chickens, which is equal to 8.67 ton of CO_2-eq per year. While the annual emissions from 100,000 chickens were 0.3 ton N_2O yr^{-1}, which is equal to 86.71 ton CO_2-eq per year.

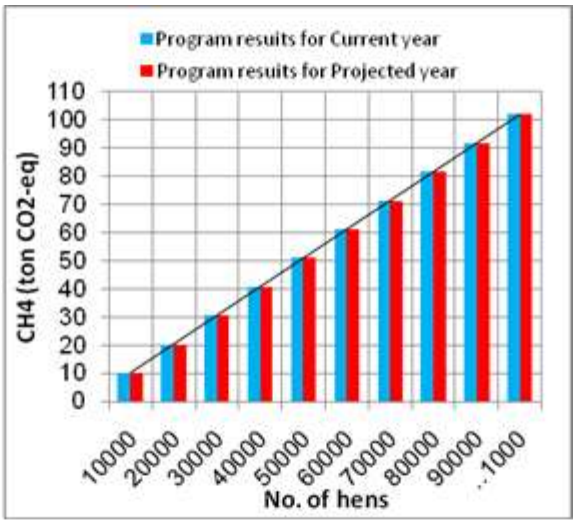

Fig. 8. Methane emissions (ton CO_2-eq) for breeder hen
Source: Authors' determination.

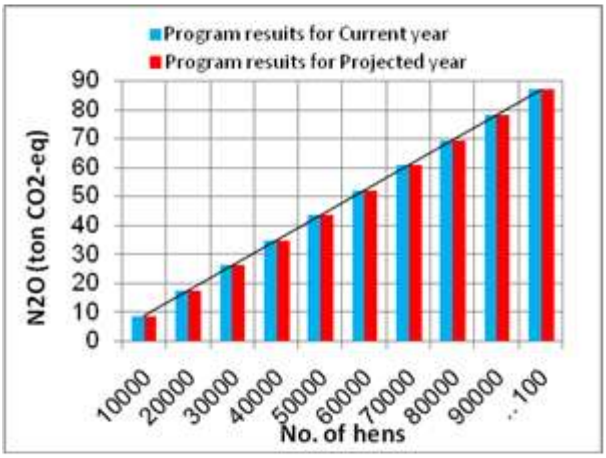

Fig. 9. Nitrous oxide emissions (ton CO_2-eq) for breeder hen.
Source: Authors' determination.

Fuel emissions from laying hens farms

Figure 10 depicts the diesel emissions from the farm's heating heaters and generators, which were calculated for breeder hens and were estimated to be 1.22 ton CO_2-eq for 10,000 chickens. While the annual emissions from 100,000 chickens were 12.2 ton CO_2-eq.

Emissions from electricity from laying hens farms

Figure 11 depicts the farm's electricity use emissions, which were calculated for breeder hens and were estimated to be 0.03 ton CO_2-eq for 10,000 chickens. While the annual emissions from 100,000 chickens were 0.35 ton CO_2-eq.

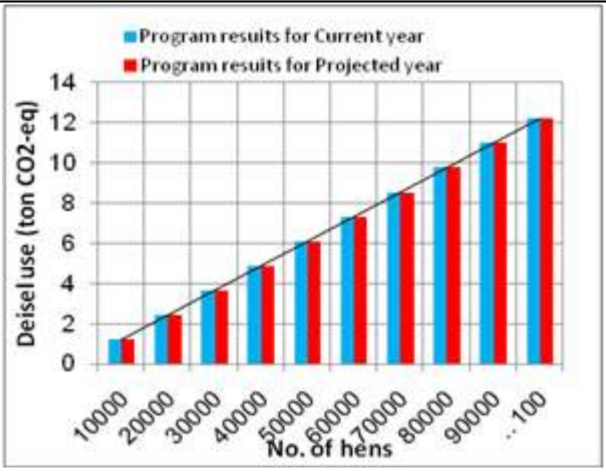

Fig. 10. The fuel emissions used (ton CO_2-eq) for breeder hen.
Source: Authors' determination.

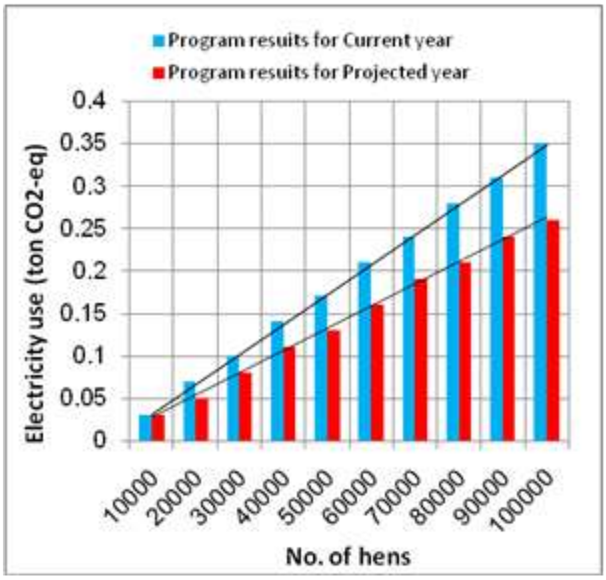

Fig. 11. The electricity emissions used (ton CO_2-eq) for breeder hen.
Source: Authors' determination.

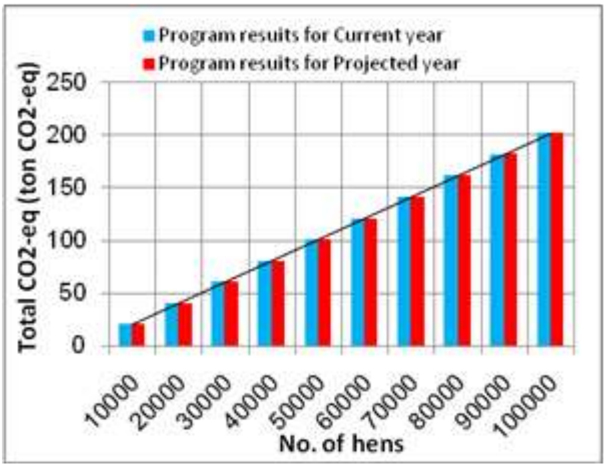

Fig. 12. Total CO_2-eq Emissions (ton CO_2-eq) for breeder hen
Source: Authors' determination.

Total CO_2-eq Emissions from Poultry Farms

Figure 12 shows Total CO_2-eq emissions from poultry farms were calculated and estimated to be 20.11 ton CO_2-eq for 10,000 chickens. While the annual emissions from 100,000 chickens were 201.14 ton CO_2-eq.

CONCLUSIONS

For manure management, the farm produced 1.76 ton CH_4 yr-1 of methane gas and 0.13 ton N_2O yr-1 of nitrous oxide gas. Thus, the total CO_2-equivalent emissions from manure management are estimated to be 81.65 ton. Diesel produces 5.23 ton of CO_2-equivalent greenhouse gas emissions. The greenhouse gas emissions (GHG) from the farm's electricity use are 0.15 ton of CO_2-eq. Finally, the farm produces 87.04 ton of CO_2-equivalent emissions. Finally, the total amount of CO_2 equivalent emissions generated by Egypt's farms is 271.8. (Kiloton CO_2-eq).

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MEASUREMENTS OF THE UDDER OF COWS-FIRSTBORN OF BLACK-AND-WHITE CATTLE OF THE UKRAINIAN BREEDING, THE LEVEL OF THEIR HERITABILITY AND CORRELATIVE VARIABILITY WITH MILK YIELD

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Abstract

The udder of first-born Holstein (n = 86) and Ukrainian Black-and-White dairy (UBWD) breed (n = 112) in the Burynske herd of Sumy region of the Ukraine was evaluated. The following morphological udder traits were measured, cm: girth, length, width, depth of the front part, and distance from bottom to floor, front quarter length, conditional volume, length, diameter and shape of teats, distance between teats. Heritability coefficients of udder measurements cows of Holstein (h^2 = 0.125-0.488) and UBWD (h^2 = 0.113-0.464) breed testified that most udder traits are controlled by heredity. Correlation between udder measurements and milk yield for 305 lactation days cows of both breeds was -0.054… 0.568 in Holstein and -0.075… 0.493 in UBWD breed. A negative relationship was found between distance from udder bottom to floor and milk yield, -0.295 and -0.258, respectively. Heritability level and correlations of measurements with milk yield will allow obtaining genetic progress of udder improvement because of indirect selection.

Key words: *Holstein, measurements, udder, heritability, correlation*

INTRODUCTION

The study of the dairy cattle udder according to measurements that characterize its structure has never lost its relevance from the point of view of breeding and production technology. Intrabreed comparisons indicated about significant variability of measurements and the udder and teats forms of cows of different breeds [1, 4, 9], the malformation of which caused deep economic losses and had a significant influence on the welfare and productivity of cows dairy [14, 18, 24].
Other researchers have found that cows with malformation of the udder and teats were more susceptible to infection by pathogens that cause mastitis [5, 31].
Due to the established positive correlations between measurements and forms of the udder with traits of milk productivity [23, 27, 30], there is a possibility of indirect breeding of cows, which will be effective for improving these traits.
It should also be noted that the traits of the udder and teats structure were characterized by a high degree of heritability [8, 15, 19, 20, 34]therefore, they can serve as an additional selection marker for their improvement in dairy cattle [10].
The aim of the study was to assess the udder structure by measurements and form in a comparative analysis of two breeds: Ukrainian Black-and-White dairy (UBWD) with Holstein heredity of 75.0-87.5% and Holstein domestic selection, with the determination of heritability and correlative variability with milk productivity.

MATERIALS AND METHODS

The material for this research were first-born cows of Holstein (86 heads) and Ukrainian Black-and-White dairy breeds (112 heads) in the controlled herd of PE "Burynske", Sumy region of Ukraine. Measurements and visual assessment of the udder were carried out in

1.0-1.5 hours before morning milking, 30-40 days after calving. The measures of the udder and teats were performed at the points shown in Fig. 1 using a measuring tape, compass, caliper and ruler, expressed in centimeters (cm).

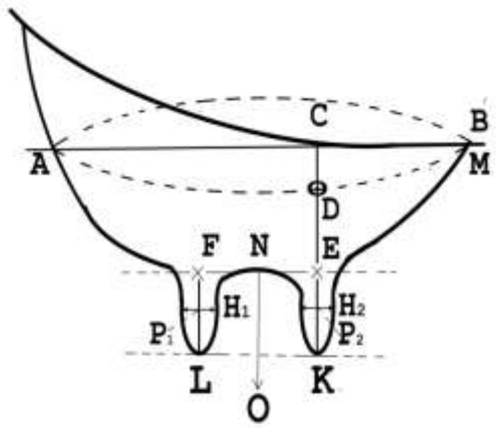

Fig. 1. Points of udder and teats measurements
Legend:
AB – udder girth along a horizontal line at the level of front edge (by tape);
AM –udder length from the back bulge to its front edge (by compass);
CM – front quarter length;
D–maximum udder width above teats of front parts (by compass);
CE – front part depth - vertically from the abdominal wall to the upper teat part (by tape);
EK, FL – front and rear teats length (by ruler);
H_1, H_2– front and rear teats diameter (by caliper);
P_1P_2– distance between front and rear teats (by ruler);
NO – distance from the udder bottom to the floor (by tape).
Source: Own design.

The nominal udder volume (cm^3) was determined as the sum of udder girth multiplied by its front part depth.
Basic statistical data of the udder measurements include the average value (x) and the standard error ($S.E.$).
From statistical indicators, the average value of measurements(x) and standard error ($S.E.$) were studied.

$$S.E. = \frac{\sigma}{\sqrt{n}} \quad \text{...(1)}$$

where:
σ – standard deviation;
n – number of variants.

The coefficient of linear phenotypic correlation was determined by the Pearson formula:

$$r_{xy} = \frac{\sum(x_i - \bar{x})\times(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \times \sum(y_i - \bar{y})^2}} \text{..........(2)}$$

where:
x_i – value for variable x;
y_i – value for variable y;
$\bar{x}$ – average value for x;
$\bar{y}$ – average value for y.
The heritability (h^2) of udder measurements assessed as calculating the father's influence force indicator (η_x^2) in a one-factor variance complex [28] according to the formula:

$$h^2 = \eta_x^2 = \frac{C_x}{C_y} \text{...(3)}$$

where:
C_x – factorial variance;
C_y – total variance.
The reliability of obtained data was evaluated by calculating the errors of statistical values (S.E.) and Student's reliability criteria (td) for correlation analysis and Fisher (F) for variance analysis. The probability level was classified by comparison with standard criteria values. The results were considered statistically significant for the first – P<0.05 (^{1}), the second – P<0.01 (^{2}), and the third – P<0.001 (^{3}) probability thresholds. Statistical processing of experimental studies was performed by the methods of mathematical statistics using formulas given by Merkur'eva [22] in Microsoft Excel.

RESULTS AND DISCUSSIONS

The Ukrainian Black-and-White dairy breed in the Sumy region of Ukraine was created by crossing method of aboriginal Lebedinsky breed of the combined type with Holstein sires of foreign selection. The obtained crossbred genotypes of animals with Holstein's conditional blood 62.5-67.5% were bred "in itself" (Burkat, 2003) [7]. The Holstein breed was created by absorbing crossing of hybrid UBWD genotypes with Holstein breeders of foreign selection. It was the task of these studies to determine how much the morphological udder traits of cows-firstborn of UBWD breed improved as a result of its absorption by Holsteins.

Table 1 shows the results of assessing the morphological udder traits by measurements in comparison of two experimental breeds.

Table 1. Characteristics of cows-firstborn in dairy cattle by udder morphological traits (x ± S.E.)

Measurement name of udder traits, cm		Breed: Holstein	Breed: Ukrainian Black-and-White dairy
udder girth		144.7 ± 0.52***	141.5 ± 0.48
front part depth		24.8 ± 0.33**	23.4 ± 0.29
distance from bottom to floor		62.4 ± 0.42	61.6 ± 0.33
front quarter length		15.3 ± 0.29	14.8 ± 0.25
udder length		44.5 ± 0.26***	42.3 ± 0.23
udder width		35.2 ± 0.28***	33.1 ± 0.24
conditional udder volume, cm^3		3,589 ± 49.3***	3,309 ± 45.4
teats length	front	5.0 ± 0.10	5.5 ± 0.08***
	rear	4.2 ± 0.08	4.5 ± 0.06**
teats diameter	front	2.3 ± 0.03	2.4 ± 0.02
	rear	2.3 ± 0.03	2.3 ± 0.02
distance between teats	front	17.2 ± 0.29**	16.1 ± 0.25
	rear	8.5 ± 0.19	8.2 ± 0.15
	front and rear	12.6 ± 0.15***	10.9 ± 0.12
shape, %	bath-like	86	81
	cupped	14	19
teats shape, %	cylindrical	92	86
	conical	8	14
stepped udder, %		3	7

Source: Own calculations.

Udder measurement indices showed the superiority of cows-firstborn of the Holstein breed over their peers of the UBWD in terms of udder girth by 3.2 cm (P<0.001), front part depth – 1.4 (P<0.01), distance from bottom to ground – 0.8, front quarter length – 0.5, udder length – 2.2 (P<0.001), udder width – 2.1 (P<0.001), conditional udder volume 280 cm^3 (P<0.001).

According to important technological udder traits, cows-firstborn of the Holstein breed turned out to be the best. The length of the front teats in first-calf Holstein cows was significantly shorter by 0.5 cm (P <0.001), and the rear teats by 0.3 cm (P <0.01). Between the location of the front teats, the distance was greater in cows-firstborn of Holstein breed by 1.1 cm (P <0.01), the rear teats – 0.3, and between the front and rear – 1.7 cm (P <0.001). The diameter of the front and rear teats in Holstein cows decreased by 0.1 cm (P <0.01).

Among the estimated total number of Holstein cattle, 86% of cows-firstborn had the desired bath-like udder form and 92% – cylindrical teats shape, which was 5% and 6% more than the UBWD, respectively. Only 3% of cows were found with stepped udders among Holsteins, or 4% less than among UBWD cows.

So, a comparative analysis of cows of both breeds has shown the best indicators of udder development in Holstein cows. About the improving effect of Holsteins when crossed with other breeds has been reported in other studies [6, 9, 12, 17, 26, 32]. At the same time, the results of assessment cows-firstborn of the Ukrainian Black-and-White dairy breed according to udder measurements testified to its good development by most of the traits, both in terms of shape and manufacturability. According to such important traits that characterize the udder size – length and width, they meet the target parameters of measurements of the desired type (42 and 33 cm) for cows-firstborn of the UBWD breed [13, 16].

From population-genetic parameters, the most important for selection by quantitative traits is heritability and the correlation between them. High coefficient indicators of heritability and correlation variability of breeding traits make it possible effectively select to them and improve more quickly in animals [11]. Heredity is a key parameter in quantitative genetics because it determines the response to selection. Since the quantitative traits of milk production of cows were characterized by polymer inheritance, the efficiency of selection for them was significantly determined by heritability [29]. Breeding based on the trait with a high degree of heritability will be effective even through mass selection.

The values of heritability of most udder morphological traits of cows-firstborn of experimental breeds, estimated by measurements, indicate about the possibility of effective mass selection by them (Table 2).

Table 2. Heritability of udder measurements of cows-firstborn Black-and-White cattle and correlation variability with milk yield

Measurement name of udder traits, cm		Breed			
		Holstein (n=86)		Ukrainian Black-and-White dairy (n=112)	
		$r \pm m_r$	h^2	$r \pm m_r$	h^2
udder girth		0.406 ± 0.091^3	0.488^3	0.349 ± 0.083^3	0.464^3
front quarter depth		0.364 ± 0.096^3	0.395^3	0.261 ± 0.092^2	0.374^3
distance from bottom to floor		-0.295 ± 0.089^3	0.275^3	-0.258 ± 0.088^2	0.264^3
front quarter length		0.259 ± 0.097^2	0.312^3	0.212 ± 0.090^1	0.268^2
udder length		0.453 ± 0.086^3	0.474^3	0.348 ± 0.083^3	0.456^3
conditional udder volume, cm^3		0.433 ± 0.88^3	0.468^3	0.376 ± 0.091^3	0.475^3
udder width		0.452 ± 0.086^3	0.482^3	0.336 ± 0.084^3	0.383^3
teats length	front	0.017 ± 0.108	0.125^1	0.045 ± 0.107	0.113^1
	rear	0.022 ± 0.106	0.128^1	0.039 ± 0.109	0.116^1
teats diameter	front	-0.054 ± 0.092	0.144^1	-0.083 ± 0.094	0.126^1
	rear	-0.066 ± 0.091	0.137^1	-0.075 ± 0.093	0.131^1
distance between teats	front	0.036 ± 0.101	0.085	0.029 ± 0.097	0.094
	rear	-0.056 ± 0.103	0.092	-0.063 ± 0.105	0.089
	front and rear	-0.086 ± 0.104	0.081	-0.074 ± 0.104	0.088
shape	udder	0.568 ± 0.082^3	0.474	0.493 ± 0.081	0.379
	teats	0.284 ± 0.095^2	0.232	0.321 ± 0.083	0.267

$^1 - P < 0,05$; $^2 - P < 0,01$; $^3 - P < 0,001$
Source: Own calculations.

The heritability degree of udder measurements of cows-firstborn in the conditions of one herd did not differ by significant variability between breeds. The values of heritability coefficients of measurements at the level of reliability (P <0.05-0.001) testified that most of the udder morphological traits of Holstein cows were controlled according to heredity by 12.5-48.8%. These indicators for UBWD cows were 11.3-46.4%.It's important to note that the level of heritability coefficients for such traits as girth, length and width of the udder, front quarter depth, distance from udder bottom to floor, front quarter length, conditional volume, shape of the udder and teats in cows of Holstein (h^2 = 0.232-0.488) and UBWD (h^2 = 0.264-0.434) breeds – sufficient for effective selection to improve the udder structure of cows.

Since it will be almost impossible effectively select animals for one trait, it is important to know how a change in one trait will affect the development of other biological and economically useful animal traits associated with it.Therefore, the next from the parameters of population genetics, characterizing the possibility of effective selection, may be a correlation between traits. Scientific studies with cattle have repeatedly proved that there is a correlation between udder conformation traits and milk productivity of different focus and strength [23, 26, 27].

The correlation between udder measurements and milk yield for 305 days of first lactation in cows of both breeds was differed by significant variability with coefficients in the range of -0.054 ... 0.568 for Holstein and -0.075 ... 0.493 for UBWD breed. The traits that characterize the udder development in size and the udder form were closely correlated with milk yield.

A negative reliable relationship was found between the distance from the udder bottom to the floor and milk yield, -0.295 and -0.258, respectively, which was consistent with other studies [2, 3, 21, 25, 33], who also received negative correlations (r=-0.129… -0.310). As for the correlations between milk yield and diameter, length and location of teats, they were insignificant and unreliable, so the selection will be ineffective.

CONCLUSIONS

Comparative analysis of cows-firstborn of the Holstein and UBWD breeds by measurements of udder morphological traits revealed the advantage of Holstein cows. This indicates about positive breeding effect for the further absorption of crossbred cows by Holstein sires, which will lead to improved udder development in their offspring. Due to the moderate heritability of the udder qualitative traits, genetic progress will be ensured, and their improvement in cows of Holstein and UBWD breeds. A close and moderate level of correlations of measurements with milk yield will ensure the effectiveness of indirect selection to improve these traits.

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THE FOOD AND THE FUTURE: CONSUMERS WILLIGNESS TO PAY FOR MORE MEAT AND ITS DETERMINANTS IN TIRANA, ALBANIA

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Abstract

The developments of the last year in the consumer economy have been a tangible reality throughout Europe. These dynamics, and economic features have increased research interest on the sustainability of food consumption in Albania. Given the context and predictions the research within consumer behavior and willingness to pay (WTP) may be of interest theoretically and practically. The study objective is to provide a multidisciplinary observation through a qualitative–quantitative approach of three groups of variables, such as (a) socio–economic; (b) psychological–social; and (c) motivational and their possible effect to WTP for meat product in the markets of Tirana. Results of the used Ordered Logit model show that variables age, income, consumption, food safety and education levels are factors that impact WTP for more meat. Living labs should consider the effectiveness of multidisciplinary theories within the segment and beyond.

Key words: *WTP, income, consumption, Albania*

INTRODUCTION

The last few years and especially the year 2022 have been characterized by unprecedented effects of the lockdowns, Covid–19 pandemic and global shocks to energy markets and especially food prices. These developments have also been unpredictable for the food markets in Albania. The broad socio–economic consequences of these dynamics and especially the high inflation during the last year have raised concerns over the consumption economy. Within the segment of consumer choice, willingness to pay (WTP) represents a very important part of consumer behavior. While consumption economy is an underutilized resource of the Albanian economy, consumer behavior from a theoretical point of view represents a subject of continuous research interest. Moreover, studies on consumer behavior and WTP can contribute for the increase of predictability in an unpredictable world, where borders, national factors and efficiency of resources use have suddenly become very important.

WTP varies between products or attribute differences, socio–economic context and demographics, etc., among consumer groups [3], and over the time it may change [7]. WTP is affected by tastes, preferences, attitudes or subjective norms etc., and new approaches such as post–consumption behavior [21], have been developed with focus the segment and marketing. The determinants of WTP can be understood in a multidisciplinary way within the social dilemma (i.e. within socio–economic picture) including materialism, self–interest or ex–collectivism, facts, opinions, beliefs, etc., and their evaluations, and the degree of self–understanding about the importance of the consumption economy not merely statistically but as an potential for creating economic positives and socially a new and progressives environment where professionals can focus on solving problems for overcoming poverty by creating a developed–professional society as part of the European standard of living.

WTP may be related to groups of factors such as region/location (eg Mediterranean vs. continental), socio–economic or institutional ones, and/or psychological–social such as religiousness, etc. A core–interdisciplinary work argue the link between religiousness and sustainable behavior [32], while value–belief–norm theory explain the importance of religiousness and its absolutist standard which indicate values, beliefs or decisions [24]. In 'The theory of price' [25], as it is presented the impact of theories on consumer choice — including zero–predictability tautological statements, it is clearly emphasized that the society may not rely exclusively on the free preferences of consumers, because institutions may impose restrictions on the consumer choice and the productive system responds to their choices to the extent that they are free to choose goods, underlining the importance of the socio–economic factors and the latter is broadly supported [17], [4].

Considering the challenging dynamics and the implications in the consumption segment the study by covering the justified need for more research on these effects aims to verify the impact of several groups of factors such as (1) socio–economic, (2) psychological–social and (3) motivational ones to WTP for food products in the markets of Tirana. Research on WTP in the light of main and newer theories can be valuable for professionals and responsible institutions by helping to understand even the micro–macroeconomic implications. Given the specific context of developments in energy markets and the consequences on employment, income and consumption, the paper may be useful in several ways: (1) for the consumption economics and potential considerations and predictabilities in consumers activities within the segment; (2) for the market actors, consumer associations, agencies; and (3) for the data enrichment and expanding of instruments that can provide potentially optimal effects to the sustainable consumption or social policy schemes and wider.

The literature is characterized by diversity and contradictions over the set of factors that influence or have synergistic effects across products or within the segment, between or beyond regions or countries, etc., regarding the key socio–economic factors or their impact to the willingness to pay more for food products. Among the demographic factors, the age of consumers represents an important variable to willingness to pay more for food animal products [6], and the youngest consumers are willing to pay a higher price for food products [8]. Family size (starting from singles) affects the willingness to pay more for meat products [19], and since it is based on the family model of meat consumption, WTP more is highly related to the family unit [5]. The increase of employees in several sectors across Europe has had a positive effect on the willingness to pay for products [27]. The employment status affects the willingness to pay for food products [20]. The income represents a very important variable to the willingness to pay for the meat product [26], and individuals with higher income levels are willing to pay the largest premiums for meat product [18]. Willingness to pay more may increase as the consumption of food products increases [9]. WTP is highly related to food quality and standards, and food safety affects the willingness to pay more for food products [16]. Moreover, decisions about WTP a higher price are closely related to consumers' confidence in the food safety of products [29]. Willingness to pay for a food product is heterogeneous within the segment and varies especially with the consumers education level [23]. Consumers with lower education level are willing to pay more a premium for food product compared with those with higher education levels [10]. There is also a positive and statistically significant effect of gender (female) on WTP more for food products [30], [28]. The studies support that Muslim religiousness has a significant impact on willingness to pay more for specific food products [2], and especially at the butcher shops [31]. Notably, based on the philosophical–ethical foundations, affiliations and established behavioural norms on the value traditional cooking of Christianity, Christian religiousness has a significant impact on WTP more for food products [12].

Objectives and hypotheses

The objective of the study is to provide a multidisciplinary observation through theories and new approaches in consumer behavior, verifying the influence of a number of variables such as gender, age, family size, employees, income, consumption and education levels, religiousness and food safety to WTP for more meat—according to consumer's perception in the markets of Tirana, Albania.

The study hypotheses are:

H_1 — with age willingness to pay more for meat product increases;
H_2 — increase of family size affects the increase of WTP more for the meat product;
H_3 — increase of family employees affects the increase of WTP more for the meat product;
H_4 — increase of family income affects the increase of WTP more for the meat product;
H_5 — increase of consumption affects the increase of WTP more for the meat product;
H_6 — increase of food safety affects the increase of WTP more for the meat product;
H_7 — increase of primary education affects the increase of WTP more for the meat product;
H_8 — increase of secondary education affects the increase of WTP more for the meat product;
H_9 — increase of female gender affects the increase of WTP more for the meat product;
H_{10} — increase of Muslim religiousness affects the increase of WTP more for the meat product;
H_{11} — increase of Christian religiousness affects the increase of WTP more for the meat product.

MATERIALS AND METHODS

Measurement procedure

In the measurement procedure variables are adjusted (Table 1) according to group–categories.
The interview was conducted face to face after an improvement of the questionnaire in a focus group.

Table 1. Concepts and variables in the measurement procedure.

Concept	Variables
	Dependent variable
Willingness to pay	*WTP*
Socio–economic factors	Independent variables
Age	*Age*
Family size	*FamSize*
Family employees	*FamEmp*
Income	*Income*
Consumption	*Consump*
Education 1	*Edu_1*
Education 2	*Edu_2*
Gender	*Gend_0*
Motivational factors	
Food safety	*FoodSaf*
Psychological–social factors	
Religion 1	*Relig_1*
Religion 2	*Relig_2*

Source: Data processed by authors.

Empirical data have been obtained through interviewing consumers in 4 administrative units of the municipality of Tirana (Figure 1), considering the composition of the regions and respectively in mini–municipalities no. 3, 5, 8 and 11.

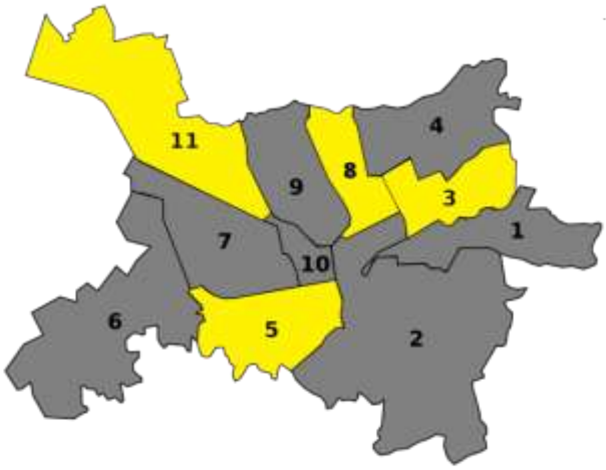

Fig. 1. Mini–municipalities no. 3, 5, 8 and 11 in the municipality of Tirana.
Source: Data processed by authors.

Each interview lasted an average of 22 minutes and given the resources, time and location limitations and difficulties encountered in practice, the simple size (220) used with a precision rate of 7% and a confidence level of 95% was considered valid [13], [14].

The questionnaire designed into 4 main parts was used with the aim of providing a large number of data in the city markets by considering the heterogeneity of the sample and the composition of consumers within the aforementioned administrative units. In the first *demographic* section, standard data on the gender, age, religious belief, education, employment status, (monthly) income, etc. of the interviewees were provided. In the second section, *the market, preferences and consumer education* were included questions on the preference of buying in supermarkets, butcheries or farms, the preference of cooking, the origin of product, the method of meat production, knowledge on food safety, knowledge about risk, etc. In the third section, *reliability, protection and consumer behavior*, were included questions on the perception of effects from meat consumption, the perceived trust towards actors within the segment, main institutions and information sources, etc. In the fourth section *the perspective of safety and consumer readiness,* were included questions on the perception of risks from meat consumption (last 5 years), the perceived impact on consumption, the willingness to increase future (5 years) consumption, and the WTP more for a (future) safer product.

The interview was based on the standard procedure in which each sample has equal probability of being selected(random choice),and the above variables are verified according to scaling in the respective sections. So, variable education and religiousness was measured using 3 scales (elementary school; secondary school; university; and Muslim; Christian; other). The size of family, family employees and consumption was measured using 4 scales (1 member; 2–3 members; 4–5members;> 5 members; and up to 1 kg; 1–2kg; 2–5kg; over 5 kg).The age using 5 scales(≤ 24years; 25–34; 35–49; 50–64; ≥ 65years), and the variables income and food safety using 6 scales. The variables under review are multinomial, and they are expressed with a nominal or ordinal scale (Likert), therefore the variants for each variable are not numbers but are categories.

Based on data provided the statistical model Ordered Logit was used and the significance of variables is presented in Table 2.

Table 2. The significance of variables by Ordered Logit model.
Model 2: Ordered Logit, observations 1–220 (n=219)
Missing or incomplete observations dropped: 1
Dependent variable: *Willingness to pay*
Standard errors based on Hessian

	Coefficient	*Std. Error*	*Z*	*p–value*	
Age	0.370516	0.156721	2.364	0.0181	**
FamSize	−0.192851	0.174089	−1.108	0.2680	
FamEmp	0.204182	0.190836	1.070	0.2846	
Income	0.00582632	0.00216948	2.686	0.0072	***
Consump	0.248304	0.0916400	2.710	0.0067	***
FoodSaf	0.870073	0.187901	4.630	<0.0001	***
Edu_1	−0.984865	0.442227	−2.227	0.0259	**
Edu_2	−1.12150	0.350511	−3.200	0.0014	***
Gend_0	0.330996	0.274830	1.204	0.2284	
Relig_1	−0.0137361	0.527591	−0.02604	0.9792	
Relig_2	−0.0452052	0.550858	−0.08206	0.9346	
cut1	−0.330406	0.953312	−0.3466	0.7289	
cut2	2.45459	0.920384	2.667	0.0077	***
cut3	5.26459	0.982703	5.357	<0.0001	***

Mean dependent var	2.940639	S.D. dependent var	0.778814
Log–likelihood	−212.7326	Akaike criterion	453.4651
Schwarz criterion	500.9121	Hannan-Quinn	472.6276

Number of cases 'correctly predicted' = 115 (52.5%)
Likelihood ratio test: Chi–square (11) = 124.837 [0.0000]

Model:

WTP = + 0.371*Age - 0.193*FamSize + 0.204*FamEmp + 0.00583*Income + 0.248*Consump.
(0.157) (0.174) (0.191) (0.00217) (0.0916)

+ 0.870*FoodSaf - 0.985*Edu_1 - 1.12*Edu_2 + 0.331*Gend_0 - 0.0137*Relig_1
(0.188) (0.442) (0.351) (0.275) (0.528)

- 0.0452*Relig_2 - 0.330*cut1 + 2.45*cut2 + 5.26*cut3
(0.551) (0.953) (0.920) (0.983)

Source: Data processed by authors.

RESULTS AND DISCUSSIONS

Based on the data provided, a socio–economic picture of the main characteristics of the individuals included in the study can be created. Among other family members, women are the main buyers (Figure 2) of meat, and this evidence supported by other previous studies of food consumption in the city of Tirana. This can be explained by their caring and managerial role in terms of cooking and preparing food in the family, or their employment status, culture, the traditional family, etc.

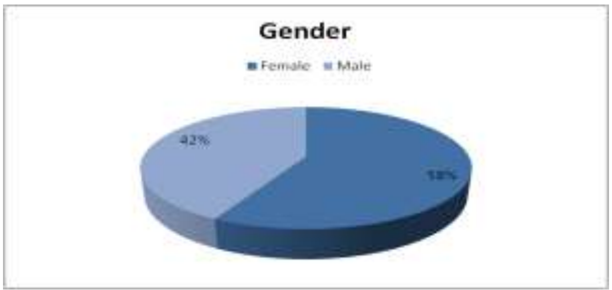

Fig. 2. The gender of the interviewees.
Source: Data processed by authors.

Most of the respondents (Figure 2) belong to the age group 35–49 years (35%), the age groups 25–34 years and 50-64 years are the same (respectively from 25%), followed by the age group ≥ 65 years (8%) and≤ 24 years (7%).The adult's group–category is majority and this is important for market policies and consumption. However, this may be a justifiable evidence during the post–pandemic period, either due to the influence of the family model on the consumption of food and especially meat, or perhaps due to the importance of the age group of the most employed for consumption, etc. (Figure 3).

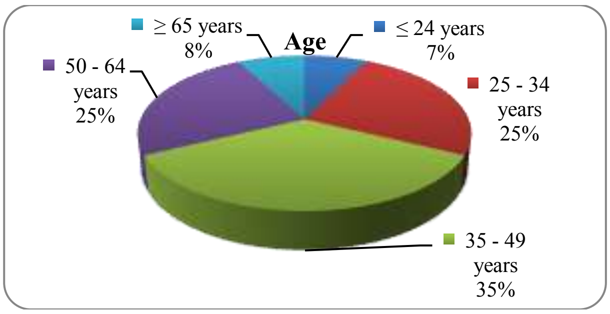

Fig. 3. The age of the interviewees.
Source: Data processed by authors.

As expected most of the interviewees belong to the Muslim religiousness (Figure 4), and 31% of them belong to the Christian religiousness. Remaining part (14%) represent other beliefs.

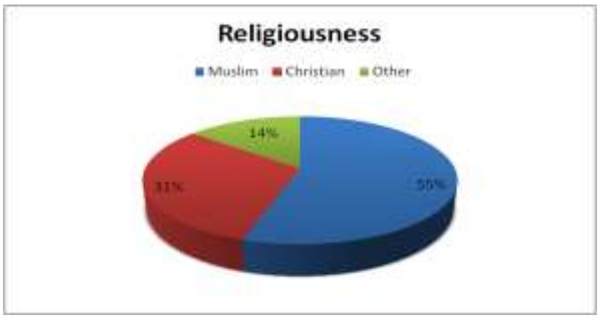

Fig. 4. Religiousness of the interviewees
Source: Data processed by authors.

The structure of the Albanian family, despite the economic and social developments, continues to be dominated by the multi–member–family (Figure 5), where 48% consist of families of 4–5 members and 29% of families with more than 6 members. This can be an influential factor for important variables within the consumption segment as they are WTP, food preferences, consumption patterns, etc. Institutions considering demographic predictability can design more efficient instruments.

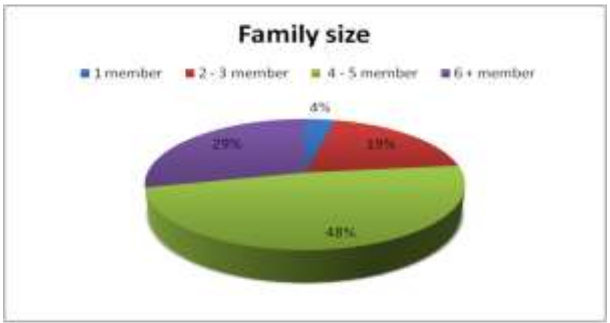

Fig. 5. Family structure of the interviewees
Source: Data processed by authors.

The quantity of consumption (Figure 6) shows that the 2 main groups consume 1–2 kg and 2–5 kg of meat/week (35% each). Fewer consume up to 1 kg of meat (20%) and the rest consume more than 5 kg per week (10%). Based on the dominant family structure, and the employment status and income level beyond a moderate approach are very important within the segment, and we emphasize that the meat among other products meat represent one of the main products of the food diet for families.

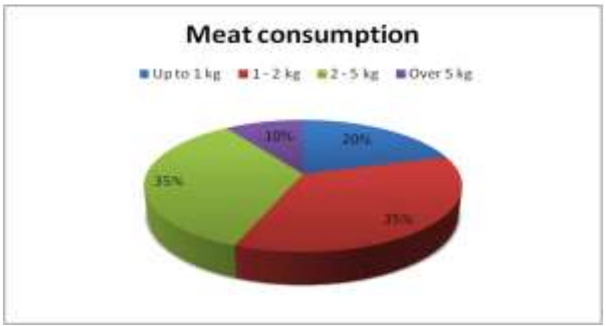

Fig. 6. Meat consumption quantity (weekly).
Source: Data processed by authors.

Among the meat types consumed (Figure 7), the main part is chicken meat (40%), followed by beef/cow meat and lamb (20% each), and then pork meat (16%).A small part of the respondents (4%) consume other types of meat or have replaced it for other food products (eg fish).

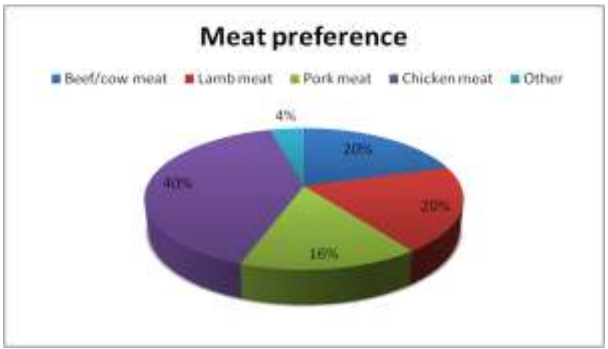

Fig. 7. Preference for meat types
Source: Data processed by authors.

The WTP for the price of meat (Figure 8) is headed from the category that pays 601–900 ALL (or about 5.2–7.77 Euro).
Thus, about 21% of the interviewees are willing to pay a price of 900–1600 ALL, about 19% a price of 301–600 ALL, and 20% of them up to 300 ALL.
Despite the limitations (eg materials), the interviewees express their concern for the food safety of meat. Regarding the question of how much they are willing to pay more in the future for a safer meat (Figure 9), about 46% answer that they are willing to pay more than 20% of the price, 35% answer that they are ready to pay 10%–20% more, and 19% answer up to 10% more. Meanwhile, consider that the average price of meat this year (2022) increased from 900 ALL/kg to 1,200 ALL/kg.

Fig. 8. WTP for the price of meat product.
[1 Albanian Lekë (ALL) = 0.0086 Euro]
Considering the fluctuations in exchange rates, 300 ALL = 2.6 Euro.
Approximately 600 ALL = 5.2 Euro, 900 ALL = 7.77 Euro, and 1,600 ALL = 13.8 Euro.
Source: Data processed by authors.

Fig. 9. (Future) WTP more than the price for a safer meat (in %).
Source: Data processed by authors.

From the measurement of the variables under consideration through the Ordered Logit Model (Table 2), unlike to how it was hypothesized, family size, family employees, gender, and religion (Muslim, Christian) have no influence to WTP for more meat product. Variables age, income, consumption, food safety and education (1, 2) have influence on the probabilities for WTP for more meat. The research is characterized by limitations during the measurement procedure, and especially related to the self–perception of the interviewees. Further complementary studies can avoid possible subjectivism regarding the self–assessment of knowledge about the issue of food safety or consumer behavior, etc.

CONCLUSIONS

The paper in accordance with the objective provides a measurement of above variables and the outcome of the regression Ordered Logit Model(table 2) show the levels of significance; which mean that with increasing age, income, consumption, and food safety has a very high probability to pay more for meat product underlining the importance of key socio–economic and motivational factors. Education levels (1, 2) have a very significant impact and are negatively related to WTP. This finding deserves further specific research. As we pointed out education levels vary widely and that there are contradictions on the impact of education. The literature also supports the link between the higher education factor and the willingness to pay more for food products which may be explained by the higher level of consciousness on food nutrients and energy level or motivational factors (healthy foods, food safety, etc). There is a positive association of respondents with education level (Bachelor's degree) or higher to WTP for food products [11].Findings are consistent with other studies focusing on WTP in Albania and specifics of post–pandemic within food consumption [22], [15],highlighting the impact of motivational and socio–economic variables and extrinsic differences. Especially to the main determinants (income, consumption) should be paid attention because they may affect at all times and in many ways both the consumer behavior and the post–consumption behavior. It is supported that emotions mediate to the cognitive appraisals, and the ego, or anger and shame effects to post–consumption behavior [21]. Perhaps under the pressure of rising risks from poverty or deprivations, the above variables may have multiple effects on post–consumption behavior and the impact of emotions on satisfaction and the relationship to behavior is well–documented.

Given the size of the interview (small number), or subjectivism level among the interviewees (eg perceptions between WTP, purchase, eating, consumption, etc.) and especially specific context (eg post–pandemic, psychological effects, inflation, price increases, etc.)or casual links, but also referred to the trust to retailers versus certifications in Albania a measurement between buyers of a category (eg butcher shops) could have been more efficient. The study highlights the specifications within WTP for products but nevertheless some limitations may affect the level of generalizations. However, through a broad observation, it is evident that there is a theoretical gap and the research in consumer behavior can be viewed in the light of basic theories, such as the theory of planned behavior [1], and value–belief–norm theory [24], and lastly post–consumption behavior [21] where emphasized that cognitive appreceals as antecedents of emotions determines behavior; by explaining 'why–s' of beliefs within segments and beyond in marketing (eg polls, their predictability, etc), perceptions, truths or experiences or positive and negative emotions and their impact for improving or deteriorating of the interviewees' skills. Deprivations and socio–economic consequences in post–consumption appraisals or beliefs can be both causes and consequences for the functioning of a system that is self–feeding within the zero–minimum interval, promoting opportunistic or ego–defensive behaviors and characteristics such as hypocrisy, ambiguity, misunderstanding or distrust. The recommendation for the research extension within the new theories and approaches is valid. We pointed out that WTP varies according to factors, or between products, and over time — but over time researcher's competencies on the same subject can be enriched. Economics is a way of seeing, and a good theoretical focus can enrich the corpus of competencies by making interventions simpler, and this could be a second valuable outcome.

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MEAT PRODUCTIVITY OF KHARKIV INBRED LAMBS OF THE PREKOS BREED BORN AS SINGLES AND AS TWINS

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Abstract

Studies of meat productivity and meat quality of lambs, taking into account the type of their birth, are relevant for the theoretical justification of the young lamb production issue. The aim of the work was to investigate the meat productivity of lambs taking into account their type of birth. The work was carried out following the Program of Research of the National Academy of Agrarian Sciences 32, "Selection and technological system of transformation of sheep breeding production directions in Ukraine". Kharkiv inbred lambs of the Prekos breed were the object of the study. The lambs were born as singles and as twins. Meat productivity was studied by conducting a control slaughter of 9-month-old lambs, three animals from each group. It has been established that the type of birth of single lambs ensured a reliable increase in pre-slaughter live weight by 13.4 and 19.4%, fresh carcass weight by 11.8 and 19.8%, slaughter weight by 14.0 and 22.2%, with a simultaneous increase in the absolute content of the first class pieces - by 13.1 and 23.5%, the content of pulp - by 24.8 and 30.8%, compared to lambs born among identical and different-sex twins. On the other hand, the muscle tissue of same-sex twins, compared to yearlings born as singles and among twins of different sexes, in terms of the amount of food components accumulated in the dry matter, is characterized by a higher mass fraction of fat - by 8.5 and 10.4%, and ash - by 0.63 and 0.83% and has a higher caloric value - by 38.2 and 43.3%.

Key words: *lambs, breed, type of birth, meat productivity, grade composition of half-carcasses, internal organs, chemical composition of lamb*

INTRODUCTION

Sheep breeding is one of the leading branches of animal husbandry, which is a source of food products - meat and milk, as well as sheepskin, lambskin, wool fat and other products [14].
A characteristic feature of modern sheep breeding is the growing importance of lamb compared to wool, and therefore the leading attention of specialists is devoted to the development of sheep breeding in the meat direction of productivity. In this area, increasing the meat productivity of sheep and improving the quality of lamb determine the main directions of breeding work with animals of any direction of productivity. Meat obtained from a young lamb in the year of its birth is considered the most valuable. At the same time, meat productivity is characterized

by qualitative and quantitative indicators of carcasses of slaughtered animals. It is caused by breed differences [2, 6, 29]. Crossbreeding is the most expedient method of increasing the meat qualities of sheep [1, 3, 5, 7, 25]. In addition, factors such as age of animals [9], breed [30], conditions of keeping, etc. influence the formation of meat productivity of young sheep. [4, 12]. Feeding is a key factor that affects not only the intensity of growth of young animals at an early age, but is also a determining criterion for animal development, which further contributes to the formation of carcass composition [10, 20]. In the case of unsustainable feeding, those organs and tissues that have the highest intensity of growth in the early period of ontogenesis are underdeveloped in young animals. With the improvement of feeding conditions, growth retardation can be compensated only partially. It is worth noting that extensive systems of sheep farming in the summer can also lead to both a decrease and an increase in sheep productivity [11, 15, 21]. And since pasture grass, as the only source of fodder, does not always provide the optimal level of feeding and production of sheep farming products, there is a need to feed sheep using concentrated fodder [8, 22, 26, 32]. Compared to animals of the specialized wool and wool-meat sectors, sheep of the meat-wool productivity direction are characterized by better development of muscle tissue, higher indicators of meat output, meatiness coefficient, growth energy, especially at a young age, as well as paying for feed with products at relatively low rates of skeleton development [31].

Kharkiv inbred sheep of the Prekos breed are typical representatives of sheep of the meat-wool direction of productivity, which are characterized by high precocity of young, good breeding, productive and meat qualities [27]. At the same time, the practice of sheep breeding development in many countries of the world shows that it is possible to overcome the problem of providing the population with mutton by increasing the fertility of ewes. However, the opinion of experts regarding the effectiveness of raising young animals among singles or multiple offspring is quite contradictory.

In the context of the above, some authors report that the body mass indices of triplets are lower than those of lambs born as twins and as singles [23]. Whereas, in the same publication, it is claimed that triplets, on the contrary, differ from singles and twins in a better formed physiological status. According to other experts, the type of birth also affects the live weight of lambs at different age periods: twin and triplet lambs are inferior in this indicator to lambs born as singles [13, 19]. Currently, as [28] emphasize that the survival rate of twins is higher than that of singles.

Therefore, the determination of the influence of the type of birth (singles, twins) on the manifestation of signs that characterize the meat productivity of sheep of the meat-wool direction of productivity, in particular, the Kharkivintrabreed type of the fine-wool breed Prekos, has scientific and practical significance and determines the relevance of the conducted research.

MATERIALS AND METHODS

The work aimed to investigate the meat productivity of lambs taking into account their type of birth.

The tasks of research include: the study of indicators characterizing slaughtering qualities, the morphological composition of lamb carcasses and the development of internal organs; assessment of the chemical composition and individual physical and technological properties of lamb.

The scientific and economic experiment was carried out on the lambs of the breeding plant for breeding Kharkiv inbred sheep of the fine wool breed Prekos of the State Enterprise Experimental Farm "Gontarivka" Institute of Animal Science of the NAAS, Chuhuiv District of the Kharkiv Region, and the experimental work was carried out in the Department of Selection and Technological Research in Small Animal Breeding and Horse Breeding. Housing - stable, feeding conditions - identical for all experimental groups, using feed of own production and feed additives.

To study meat productivity, a control slaughter of 9-month-old lambs was carried out, 3 heads from each group, following the methodical principles given in the manual edited by I. I. Ibatullina and O. M. Zhukorskyi [16]. In the process of work, the quality composition of half-carcasses meat was studied - on the basis of their cutting, followed by weighing of separate parts following the requirements of GOST 7596-81. Morphological composition of half-carcasses - by carcass deboning and weighing meat and bones. Absolute mass and development of internal organs - by weighing and calculating their relative values to the pre-slaughter live weight of lambs. The assessment of the chemical composition and some physical and technological properties of meat was performed on samples that were studied in the Laboratory for Assessing the Quality of Feed and Animal Products of the Animal Husbandry Institute NAAS, which is accredited in accordance with the international requirements of DSTU ISO / IEC 17025:2006 as a basic organization of the metrological service of the Ministry of Agrarian Policy of Ukraine. The average meat sample was taken from the spine-costal part from the 9th to the 11th rib inclusively, deboned, tendons and cartilage were removed. Then the lamb was ground in a meat grinder and, after mixing, minced meat was taken in the amount of 0.3 kg to evaluate the content of mass fractions of moisture (according to the methodical recommendations of VASKhNIL, Moscow 1990), protein (according to GOST 25011-85), fat (according to GOST 23042-80), ash (according to the methodical recommendations of VASKhNIL, Moscow 1990 item 4.1.5).

The ratio of some components of the chemical composition of lamb was determined by calculation. Samples were examined 48 hours after slaughter.

Based on the results of the chemical analysis of the average sample, the caloric value of lamb was calculated, taking into account that one gram of protein contains 4.1 kcal, and one gram of fat - 9.3 kcal according to the formula of V. M. Oleksandrov:

$$C = (D - (F + A)) \times 4.1 + F \times 9.3,$$

where C: - caloric content 100 g of lamb, kcal; D - content of the mass fraction of dry matter, %; F - content of the mass fraction of fat, %; A - content of the mass fraction of ash, %.

The moisture-retaining capacity was investigated by the Grau and Gamm press method, improved by Volovynska and Merkulova; the active reaction of the medium - potentiometrically in a water-salt extraction with a pH meter; the area of stains (general, meat, wet) - by the press method according to DSTU ISO 2917:2001 [18].

During manipulations with animals, the bioethical requirements of the Law of Ukraine "On the Protection of Animals from Cruelty Treatment" were observed [17]. The research program is approved by the Bioethics Committee Institute of Animal Science of the NAAS.

The digital material of the experimental studies was processed biometrically according to V. P. Kovalenko et al. [24], using a personal computer and the MS Excel 2003 application package. The difference between groups was considered significant at $p<0.05$.

RESULTS AND DISCUSSIONS

Summarizing the obtained materials, it should be noted that by the most of the indicators characterizing the slaughter qualities, single lambs reliably exceeded coevals, born among identical and different-sex twins, while there was no significant and reliable difference between the latter in terms of the studied parameters. At the same time, lambs born in same-sex twins, under the same conditions of maintenance and feeding during the rearing period, grew more intensively and were able not only to compensate for their lag in development, obtained at the end of the weaning period, but also to slightly surpass coevals born as part of different-sex twins for the slaughter time. It is likely that the established fact of compensatory growth is due to more intensive individual features of the metabolic process that took place in their bodies and were caused by a better assimilation of the nutrients of the rations and the conversion of feed into muscle tissue.

It has been established that lambs born as singles exceeded the same-sex twins in terms of pre-slaughter live weight by 5.56 kg or 13.4% ($p<0.05$) and by 7.67 kg or 19.4% ($p<0.05$) - different-sex twins. While in the weight of the fresh carcass meat, the advantage in favor of singles decreased to 2.06 kg or 11.8% ($p<0.05$) against same-sex twins and to 3.23 kg or 19.8% compared to different-sex twins (Table 1).

Table 1. Indicators of control slaughter of lambs, ($X \pm S_X$, n=3)

Indicator	Type of birth		
	Singles	twins	
		same-sex	different-sex
Pre-slaughter live weight, kg	$47.17 \pm 0.83^{0/\#}$	41.61±1.80	39.50±2.64
Weight of the fresh carcass, kg	$19.53 \pm 0.35^{\#}$	17.47±0.84	16.30±1.01
Output of fresh carcass, %	41.4	42.0	41.3
Mass of chilled carcass, kg	$18.93 \pm 0.31^{\#}$	16.95±0.83	15.80±0.99
Output of chilled carcass, %	40.1	40.7	40.0
Mass of internal fat, kg	$1.42 \pm 0.08^{0/\#}$	0.90±0.14	0.85±0.19
Output of internal fat, %	3.0	2.2	2.2
Slaughter weight, kg	$20.95 \pm 0.42^{0/\#}$	18.37±0.76	17.15±1.06
Slaughter output, %	44.4±0.12	44.2±0.34	43.5±1.25
Weight of fresh skin, kg	$5.93 \pm 0.15^{0/\#\#}$	4.97±0.18	4.40±0.25
Output of fresh skin, %	12.6	11.9	11.1
Weight of the head, kg	$2.63 \pm 0.02^{00/\#}$	2.24±0.07	2.27±0.09
Weight of limbs, kg			
including: front ones	$0.54 \pm 0.01^{000/\#\#}$	0.44±0.01	0.45±0.02
hind legs	$0.53 \pm 0.01^{00/\#}$	0.47±0.01	0.42±0.02

Note: $^{0}p<0.05$; $^{00}p<0.01$; $^{000}p<0.01$ - reliability of the same-sex difference and $^{\#}p<0.05$; $^{\#\#}p<0.01$ - different-sex twins
Source: own calculations.

Single lambs are characterized by a more intensive deposition of internal fat by 0.52 and 0.57 kg or 57.8 and 67.1%, compared to a similar indicator in both identical and different-sex twins, with $p<0.05$ in both cases of comparison. And as a result of this and heavier fresh carcasses, there was registered a proportional increase in slaughter weight by 2.58 kg ($p<0.05$) and 3.80 kg ($p<0.05$) or 14.0 and 22.2%, respectively.

Identified differences in these parameters did not have a significant impact on the level of slaughter yield, which ranged from 43.5% to 44.4%. However, despite the reliably greater mass ($p<0.05$ in both cases of comparison) of accumulated internal fat in the carcasses of single lambs, only a tendency to increase its relative value was followed, compared to coevals of the other groups.

Single lambs had a significantly higher mass of fresh skin, by 0.96 kg or 19.3% ($p<0.05$) compared to the same-sex by birth type coevals and by 1.53 kg or 34.8% ($p<0.01$) - compared to different-sex twins. However, the relative indicators of the mass of fresh skins to the pre-slaughter live weight of lambs did not differ significantly between the compared groups.

According to other parameters of the control slaughter (weight of the head and limbs), although the twins did not completely reach the level of singles, they approached it with a statistically significant difference between the groups in favor of singles ($p<0.05$-0.001). However, the proportional nature of the development of this trait is indicated by the fact that the relative weight as a percentage of the pre-slaughter live weight turned out to be almost the same.

The relative indicators of fresh, chilled carcasses, internal fat and fresh skin to the pre-slaughter live weight of the experimental lambs did not differ much from each other, with the exception of the yield of fresh skin, for which the difference between the groups was slightly larger by 0.7-1.5% with an advantage of singles compared both groups of twins.

However, the differences within both groups of twins in terms of indicators characterizing slaughter qualities varied from 5.3% to 13.0% and were slightly better in lambs born as part of the same-sex offspring, but no statistical significance was found between their values.

Due to the higher pre-slaughter live weight and weight of fresh carcasses, single lambs had an advantage over coevals born as twins in terms of the weight of chilled half carcasses and the content of cuts of the first and second grades (Table 2).

Table 2. Grade composition of the left half carcass, ($X \pm S_X$, n=3)

Indicator	Type of birth		
	singles	singles	
		same-sex	different-sex
Mass of chilled half -carcass, kg	9.60±0.16#	8.50±0.42	7.97±0.46
Weight of parts by grade, kg			
including: I	8.03±0.02⁰/#	7.10±0.26	6.50±0.48
II	1.57±0.15	1.40±0.15	1.47±0.03
Specific share of some parts in the half-carcass, %			
including: I	83.6	83.5	81.6
II	16.4	16.5	18.4

Note: ^{0}p<0,05 - reliability of a difference with respect to same-sex twins and $^{\#}$p<0.05 - different-sex twins
Source: own calculations.

Analyzing the data of the grade composition, it was noted that single lambs by weight of chilled half-carcasses reliably exceeded coevals born among same-sex twins by 1.1 kg or 12.9% (p<0.05) and for different-sex twins - by 1.63 kg or 20.5% (p<0.05).

At the same time, by comparing the influence of the type of birth on the results of graded cutting of half-carcasses, it was found that the main increase in their mass in single lambs was due to an increase in the absolute content of the first grade parts, namely by 0.93 and 1.53 kg or 13.1 and 23.5% than in coevals-twins, which ensured statically significant difference between them (p<0.05) in both cases of comparison. The excess of the absolute content of second-grade parts in singles over twins was 0.17 kg (12.1%) and 0.10 kg (6.8%), respectively, over the indicators of the same-sex and different-sex by birth type coevals.

The specific share of parts of the first grade in half carcasses ranged from 81.6% to 83.6% with an increase in favor of singles.

The morphological composition of the three-rib cut confirmed the results obtained in the process of graded cutting of half-carcasses (Table 3).

Table 3. Morphological composition of a three-rib cut, ($X \pm S_X$, n=3)

Indicator	Type of birth		
	singles	twins	
		same-sex	different-sex
Weight of three-rib cut, kg	0.417±0.01⁰⁰/##	0.342±0.01	0.330±0.01
including: flesh, kg	0.327±0.01⁰⁰/##	0.262±0.00	0.250±0.01
%	78.4	76.6	75.8
bones and cartilage, kg	0.09±0.01	0.08±0.01	0.08±0.01
%	21.6	23.4	24.2
Coefficient of fleshiness	3.63±0.14	3.28±0.22	3.13±0.22

Note: ^{00}p<0.01 - the reliability of a difference with respect to same-sex twins and $^{\#\#}$p<0.01 - different-sex twins
Source: own calculations.

It was found that single lambs in terms of absolute mass of the carcass cut outweighed twins from same-sex offspring by 21.9% and twins from different-sex offspring by 26.4%, with a statistically significant difference between them p<0.01 in both cases of comparison. According to the studies of the main indicator that characterizes the nutritional value of carcasses - flesh content, a reliable advantage of single lambs was established by 24.8% (p<0.01) and 30.8% (p<0.01), respectively.

Intergroup differences in the absolute parameters of bone and cartilage mass in the three-rib cut were leveled out and were at the level of 0.08-0.09 kg, while their relative indicators in the composition of the cuts were higher in both groups of twins.

In general, by the meatiness coefficients, single lambs were characterized by a greater availability of edible components in the carcasses, which also indicates their better meat productivity. Due to the more massive muscle tissue and almost the same content of bones and cartilage in the cuts, they had 3.65 kg of flesh per kilogram of bones and cartilage, which is 0.35 and 0.50 kg or 10.7 and 16.0% more than in coevals born as twins.

The birth of lambs as singles contributed to the better development of almost all internal organs that make up the category of offal (Table 4).

Table 4. Absolute and relative weight of internal organs of lambs, ($X \pm S_X$, n=3)

Indicator	**Type of birth**		
	singles	**twins**	
		same-sex	**different-sex**
Absolute mass of internal organs, kg	2.08±0.15	1.95±0.13	1.70±0.08
including: liver	0.84±0.05	0.71±0.06	0.68±0.05
spleen	0.09±0.02	0.08±0.01	0.05±0.01
heart	0.27±0.01	0.24±0.02	0.21±0.02
lungs without trachea	0.62±0.06	0.67±0.04	0.61±0.05
kidneys	0.26±0.03	0.25±0.02	0.15±0.01
Relative weight of internal organs to pre-slaughter live weight, %			
including: liver	1.78	1.71	1.70
spleen	0.19	0.19	0.10
heart	0.57	0.58	0.50
lungs without trachea	1.30	1.60	1.54
kidneys	0.55	0.60	0.38

Source: own calculations.

According to the results of weighing, it was established that the total mass of internal organs in single lambs in absolute terms was 2.08 kg, which is 0.13 and 0.38 kg or 6.7 and 22.4% more than in twins of the same age. Whereas in terms of the weight development of the rest of the internal organs, the differences in their favor were greater: the liver by 18.3 and 23.5%; spleens - by 12.5 and 80.0%; heart - by 12.5 and 28.6% and kidneys - by 4.0 and 73.3%.

The revealed peculiarities of the development of internal organs in single lambs were caused by a higher pre-slaughter live weight. The only exception is the lungs, the absolute weight of which was 7.5% lower in single lambs than in same-sex twins and close to that of different-sex twins (0.62 kg versus 0.61 kg).

Considering this sign in a relative sense, it can be seen that the mass of internal organs of lambs, regardless of the type of their birth, almost did not differ. In particular, the specific share of the liver in them was from 1.70% to 1.78%; spleen - from 0.10% to 0.19%; heart - from 0.50% to 0.58%; lungs without trachea - from 1.30% to 1.60%; kidneys - from 0.38% to 0.60% of pre-slaughter live weight. Which is quite natural from the standpoint of the proportionality of the development of live mass and internal organs in animals.

It should be noted that lamb obtained from same-sex lambs was characterized by a 7.2 and 6.6% higher mass fraction of dry matter, due to more intensive deposition of a mass fraction of fat in their muscle tissue - by 8.5 and 10.4 % with a statistically significant difference ($p<0.05$ in both cases of comparison) and ash - by 0.63 and 0.83% ($p<0.05$) against coevals born as singles and among different-sex twins. This gave it better taste qualities and marbling (Table 5).

Table 5. Chemical composition, caloric content and biological value of lamb, ($X \pm S_X$, n=3)

Indicator	Type of birth		
	Singles	twins	
		same-sex	different-sex
Mass fraction of moisture, %	70.20 ± 1.25^{0}	63.01 ± 1.71	69.64 ± 1.34^{0}
Mass fraction of dry matter, %	29.80 ± 1.25	$36.99 \pm 1.71^{*\#}$	30.36 ± 1.34
including: mass fraction of protein	14.93 ± 1.48	12.95 ± 0.30	17.56 ± 0.42^{000}
mass fraction of fat	13.47 ± 1.95	$22.01 \pm 2.22^{*\#}$	11.60 ± 1.04
mass fraction of ash	1.40 ± 0.57	$2.03 \pm 0.22^{\#}$	1.20 ± 0.13
Correlation:			
mass fraction of protein/fat	1.11 : 1	0.59 : 1	1.51 : 1
mass fraction of dry matter/moisture	0.43 : 1	0.59 : 1	0.44 : 1
mass fraction of fat/moisture	0.19 : 1	0.35 : 1	0.17 : 1
Caloric content of 1 kg of meat, kcal	1864.8±156.26	2577.9±264.12	1798.8±103.11

Note: $^{*}p<0.05$ - the reliability of a difference with respect to singles; $^{0}p<0.05$ and $^{000}p<0.001$ - same-sex and $^{\#}p<0.05$ - different-sex twins
Source: own calculations.

At the same time, an inversely proportional trend with regard to the content of the mass fraction of fat was noted in the distribution of the mass fraction of protein, in which lamb obtained from different-sex twins was richer in its content, which is 2.6 and 4.6% (p<0.001) more than in single and same-sex lambs.

The highest content of the mass fraction of fat in the lamb of same-sex lambs provided an increase in the caloric content of one kilogram of minced meat by 713.1 and 779.1 kcal or 38.2 and 43.3%, compared to singles and twin-born lambs, but statistically significant difference between the groups for this indicator was not detected.

At the same time, the higher energy value of 1 kg of lamb obtained from lambs born among identical twins was complemented by a better ratio of mass fractions of dry matter to moisture, which was at the level of 0.59: 1 against 0.43 and 0.44 in coevals respectively, born among identical and different-sex twins. That is, the higher this ratio is, the higher the nutritional value of lamb and the precocity of animals. The most mature (according to the ratio of fat/moisture) is also the lamb obtained from same-sex twins 0.35 : 1 against 0.19 and 0.17 : 1 - in singles and different-sex twins.

In the process of laboratory experiments, it was established that in terms of the area of the total spot formed when the lamb samples were pressed, single lambs take the first place, those born as different-sex twins take the intermediate place, and the last is characteristic of lamb samples that were selected from half-carcasses of the same-sex twins (Table 6).

Table 6. Physico-technological indicators of lamb, ($X \pm S_X$, n=3)

Indicator	Type of birth		
	Singles	twins	
		same-sex	different-sex
Area of the total spot, cm^2	7.70 ± 0.12	6.83 ± 0.80	6.70 ± 0.50
including: meat	2.30 ± 0.21	2.57 ± 0.17	2.97 ± 0.45
moisture	$5.40 \pm 0.16^{\#\#}$	4.26 ± 0.78	3.73 ± 0.32
Moisture retention capacity, %	55.08 ± 1.60	51.06 ± 1.01	59.18 ± 1.35^{00}
Active reaction of the medium, pH	5.87 ± 0.03	5.84 ± 0.03	5.88 ± 0.18

Note: $^{00}p<0.01$ - the reliability of a difference for the same-sex and $^{\#\#}p<0.05$ - different-sex twins
Source: own calculations.

However, according to the size of the meat spot, it can be stated that the lamb of rams born in different-sex twins is more tender, as it has a larger area (Table 6).

The values of moisture retention capacity and active acidity did not go beyond the optimal parameters. However, with a better ability to retain moisture, lamb obtained from identical and different-sex twin lambs was characterized by greater juiciness and less loss of nutrients during heating. Almost close values of active acidity indicate a normal course of post-slaughter autolysis and an intensive maturation process of meat obtained from lambs of all groups.

CONCLUSIONS

Single lambs were characterized by the highest slaughter rates, which prevailed over coevals born among identical and different-sex twins in terms of pre-slaughter live weight by 13.4 and 19.4%, fresh carcass weight by 11.8 and 19.8%, slaughter weight - 14.0 and 22.2%, the absolute content of the first grade parts - by 13.1 and 23.5%, the flesh content - by 24.8 and 30.8%.

The slightly better development of internal organs in single lambs indicates a higher viability of their organism compared to coevals from same-sex and different-sex twins. Whereas, according to the results of the determination of the chemical composition, higher taste qualities are characteristic of lamb obtained from animals born among identical twins due to higher mass fractions of dry matter by 7.2 and 6.6%, including fat - by 8.5 and 10.4% and ash - by 0.63 and 0.83%, as well as caloric value - by 38.2 and 43.3%, compared to singles and coevals born among different-sex twins.

This indicates a relatively higher precociousness of these animals. The obtained results are the basis for the further detailed determination of the influence of the factors of differentiated feeding on the realization of the productive potential of lambs when reared for meat, taking into account the type of their birth, while simultaneously studying the heritability and repeatability of the investigated trait and assessing the share of the influence of fathers and mothers on the type of birth of the young animals.

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INFLUENCE OF GENOTYPE AND PARATYPE FACTORS ON THE REPRODUCTIVE QUALITIES OF MOTHER BREEDS OF PIGS

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Abstract

The object of the research was the study of the influence of the breed of pigs and methods of their breeding on the reproductive functions of sows. Manifestation of various forms of the effect of hybrid power during direct and reverse crossing of animals of these breeds, as well as the tightness and directionality of correlative relationships were studied. No significant difference was found in most parameters of reproductive capacity between Large White and Landrace sows of Irish origin for purebred breeding and crossing, except for individual piglet weight at weaning. The weight of one piglet at weaning was probably higher in purebred litters of the Landrace breed compared to other investigated genotypes. We found that the heterosis caused the advantages of crossbred litters over purebred litters in most traits of reproductive performance. But despite this, the mass of weaned piglets had an intermediate form of inheritance. It was established that there was a strong positive correlation between fertility indicators and litter weight of piglets at birth, as well as between the number of piglets in the nest at weaning and the weight of the litter of piglets at weaning, similarly as between the weight of the litter of piglets at birth and the number of piglets in the nest at weaning and the weight of the litter of piglets at weaning. A strong positive correlation was found between indicators of the number of piglets in the nest at weaning and their weight during this period, as well as between the individual weight of the piglet at weaning and the weight of the nest of piglets at the time of weaning. Between multifertility and the average weight of one piglet at weaning, an inverse moderate relationship was found, as well as between the indicator of survival of piglets before weaning and survival of piglets at the time of weaning. As a result of the research, it can be asserted that there is a medium-strength correlation between the weight of the litter of piglets at birth and their weight at weaning.

Key words: *pigs, Irish breeding, reproductive capacity, breeding methods, heterosis effect, industrial production pork production*

INTRODUCTION

Breeding of pigs in recent years has been carried out in the direction of creating specialized breeds or types, which, when combined, should provide the effect of heterosis for a number of traits. However, productivity traits in pigs have different degrees of heritability and different genetic conditioning, and therefore their improvement depends on a number of geno- and paratypic factors [9].

The pig breeding industry allows to produce a large amount of meat in a relatively short time due to the introduction of intensive technologies and rational use of the pig gene pool in purebred breeding and hybridization systems [11]. Inheritance of reproductive traits mainly occurs in a non-additive type, which makes it difficult to assess the breeding value of animals, but indicates the possibility of increasing fertility, improving the maternal qualities of sows through controlled heterozygosity and creating appropriate environmental conditions for animals [29].

The results of numerous studies indicate the effectiveness of interbreed crossings [12], breed-line hybridization, which leads primarily to an increase in fertility, the weight of piglets and the litter as a whole compared to purebred breeding [23]. To improve reproductive qualities in industrial pig breeding, two-breed F_1 crossbreeds from direct and backcrossing of animals of Large White and Landrace breeds are usually used, which allows to additionally use the effect of hybrid strength in terms of reproductive performance characteristics [18]. It has long been established that the degree of inheritance of reproductive qualities is noticeably low and selection for them does not differ in efficiency. Pigs of new specialized lines have high productivity, which was genetically determined [10]. However, increased productivity is the reason for their high dependence on negative environmental factors. The authors reported [14] that reproductive indicators of sows, such as multifertility, the proportion of piglets born dead, depended on the factors of their breeding method and the breed of pigs, the influence of which was higher.

The selection of the last 30 years, being aimed at a larger size of offspring in sows, led to its steady increase, which continues to this day [24, 34]. Piglet live weight at birth has a huge influence on the subsequent productivity of pigs [22]. Piglets with a low body weight at birth have a negative effect on the efficiency of pig farming. These piglets have lower organ development and lower productivity later on [15]. Scientists also reported [7] that heavier newborn piglets have better viability, which positively affects the growth of fattening and slaughter indicators compared to counterparts born lighter. According to the results of recent experiments [8, 17], the influence of piglet weight at birth on the reproductive qualities of pigs was determined. In particular, they [8, 17] showed that for every 0.1 kg decrease in the birth weight of piglets, pre-weaning mortality increased by 3%, post-weaning mortality increased by 2%, and market weight decreased by 1.63 kg [3]. Most studies show that if a live-born piglet is 0.45 kg heavier, then at weaning its weight will be 0.9 kg heavier than the average piglet weight. And at the end of the rearing period, heavier piglets at weaning gain from 1.8 kg to 3.6 kg in the same number of days of rearing compared to normal or lighter piglets. The weight of piglets is inversely dependent on the number of piglets born to a sow per farrowing [13]. According to the reports of other authors [33], there was a high statistically reliable correlation between indicators of fertility and nest weight at the time of weaning r = 0.64–0.89 and milk yield and fertility of sows under different breeding methods r = 0.65–0.81.

In order to intensify the use of brood stock, various technological methods are used, one of which is the reduction of the length of the suckling period [2, 5, 16]. The timing of weaning piglets also has an impact on the reproductive qualities of pigs. According to scientists [26], the development of pig farming is moving towards increasing the weaning age of piglets. This allows for higher pig weights and higher average daily gains, better survival and a higher number of piglets at birth, and especially ensures more efficient use of production facilities and, as a result, increases profits. According to scientists [28], early weaning of piglets has a positive effect on the further reproductive capacity of sows and promotes the development of genital organs and improves the reproductive qualities of their daughters. Piglets that were weaned at 35 days had better developed internal organs and a secretory system, which allowed them to be significantly ahead of their counterparts that were weaned at 60 days in terms of average daily gains and feed efficiency [28]. Early weaning of piglets can provide certain advantages of higher growth intensity only if appropriate conditions are created, without which this measure will not be effective [4]. The main conditions for successful rearing of early-weaned piglets are good health and development of piglets at weaning, provision of piglets with sufficient and complete feeding, warm and dry premises. In addition, it should be taken into account that if piglets are weaned too early, the involution of the sow's reproductive system is delayed [6, 21], and the length of the service period increases [1]. It was reported that the time of weaning reliably influenced the time of onset of heat in sows. In particular, sows from which piglets were weaned at 60 days old came to the farrowing house 5-7 days after weaning on average. Their counterparts, whose piglets were weaned at 45 days after the end of the suckling period, gave birth in 13-17 days. In this way, the reduction of the suckling period led to an increase in the period of arrival of sows in heat by 7-10 days [30].

Since it was found that there are ambiguous views of scientists on the strength of the relationship between the reproductive qualities of sows and the method of their breeding taking into account the length of the suckling period, we consider it urgent to continue researching this problem.

The purpose of our experiment was to establish the influence of the breed, pig breeding technology, litter size and piglet weaning period on their growth intensity and on the reproductive qualities of the sow.

MATERIALS AND METHODS

Four groups of sows were selected to study the influence of the breed and breeding method, the number of piglets in the nest at birth and the length of the suckling period on the productive qualities of sows of the Large White and Landrace breeds of the Irish selection of the genetic company Hermitage Genetics and their combining ability (according to the main indicators of reproductive ability). Each group included 10 sows (Table 1).

The first and third groups were made up of purebred sows of the Large White breed. The second and fourth groups included their purebred Landrace counterparts.

Table 1. Scheme of the experiment on the study of the influence of genotypic and paratypic factors on the reproductive qualities of pigs of maternal breeds

Group	Sows		Boars	
	Breed	Number	Breed	Number
I	Large White (GW)	10	Large White (GW)	3
II	Landrace (L)	10	Landrace (L)	3
III	Large White (GW)	10	Landrace (L)	3
IV	Landrace (L)	10	Large White (GW)	3

Source: Own calculation.

Sows of groups I and IV were inseminated with the sperm of boars of the Large White breed of the Irish company Hermitage Genetics. Their peers from II and III groups were inseminated with the sperm of Landrace boars of the same selection. Maintenance of sows in all periods of the reproductive cycle was identical according to the norms of the PIC company. The feed was also identical, full-rational and balanced, compound feed of our own production. The study evaluated the total number of piglets born, fertility, litter weight of piglets and their individual weight at birth, number, individual weight and nest weight of piglets at weaning, duration of suckling period of sows, survival of piglets until weaning.

Reproductive characteristics of pigs were calculated using the evaluation index of reproductive qualities (I) [25]:

$$I = B + 2W + 35G \quad ....(1)$$

where:

B is the number of piglets at birth, head;

W is number of weaned piglets, head;

G is average daily growth of piglets before weaning, kg.

The selection index of reproductive qualities of sows (SIRQS) was determined according to the methodology [31]:

$$(SIRQS) = 6X_1 + 9.34\left(\frac{X_2}{X_3}\right) \text{..........(2)}$$

where:
SIRQS is the selection index of reproductive qualities of sows;
X_1 is multifertility, goal;
X_2 is weight of the nest at weaning, kg;
X_3 is weaning period, days;
6 and *9.34* are coefficients.
Heterosis indices were determined according to the formulas proposed by the methodology [32]:

$$Ht = \left(\frac{Hs}{Sb} \times 100\right) - 100 \text{ ....(3)}$$

where:
Ht is heterosis true;
Hs is hybrid sign;
Sb is sign of better parental form;

$$Hh = \left(\frac{2 \times Hs}{Sp + Sm} \times 100\right) - 100 \text{ ....(4)}$$

where:
Hh is heterosis hypothetical;
Hs is hybrid sign;
Sp is sign of the parent form;
Sm is sign of the mother form;

$$Hg = \left(\frac{Hs}{Sm} \times 100\right) - 100 \text{ ....(5)}$$

where:
Hg is heterosis general;
Hs is hybrid sign;
Sm is a sign of the mother form;

$$Hsp = \left(\frac{Hs}{Sp} \times 100\right) - 100 \text{ ....(6)}$$

where:
Hsp is heterosis specific;
Hs is hybrid sign;
Sp is sign of the parent form.

Statistical processing of data from experimental studies was carried out by biometric methods using Microsoft Excel software. The results were considered statistically significant at the first – P<0.05, the second – P<0.01, and the third – P<0.001 thresholds. To assess the closeness of the relationship between indicators of the reproductive capacity of sows, a correlation analysis was conducted using Statistica 10.
The methodological part of the experiment was approved by the Bioethical Commissions of Animal Care and Use during scientific (experimental) research of Sumy National Agrarian University (ethical approval number BT-22-110822-01).

RESULTS AND DISCUSSIONS

The analysis of the data showed that when using direct and reciprocal crossing, there was a tendency to increase the multifertility rate of sows by 0.2–0.6 piglets compared to counterparts that were bred by the purebred method. Landrace sows had a higher rate of multifertility compared to peers of the Great White breed at purebred breeding by 0.2 piglets.
We did not find any statistically significant discrepancies in the reproductive performance of sows of the experimental groups in terms of high fertility, although a tendency to its decrease with increasing multifertility was observed.
Number of weaned piglets turned out to be 0.9–1.4 more in crossbreed nests compared to purebred nests, but due to the small size of the sample, it turned out to be improbable.
The average weight of 1 piglet at weaning turned out to be the highest in sows of the Landrace breed when purebred breeding them. The piglets of this group were probably (p<0.01) heavier by 0.4 kg compared to the analogues of the control group and by 0.3 kg (p<0.05) heavier compared to peers of the III experimental group, and by 0.6 kg (p<0.001) heavier in comparison with the animals of the IV experimental group.

Table 2. Reproductive qualities of sows

Indicators	Group I (♀LW × ♂LW)	Group I (♀L × ♂L)	Group III (♀LW × ♂L)	Group IV (♀L ×♂LW)
Multifertility, heads	15.8±0.62	16.0±0.36	16.4±0.72	16.2±0.56
Weight of piglets at birth, kg	1.29±0.02	1.28±0.03	1.25±0.01	1.24±0.02
The nest weight of piglets at birth, kg	20.4±0.78	20.5±0.57	20.5±0.96	20.1±0.85
Number of weaned piglets, heads	13.9±0.43	13.5±0.34	14.4±0.51	14.8±0.49
The average weight of piglets at weaning, kg	7.5±0.15	8.1±0.10**	7.8±0.09*2	7.5±0.08***2
The weight of the nest of piglets at weaning, kg	104.3±4.62	108.4±4.78	111.5±4.72	110.7±3.96
Preservation of piglets,%	88.1±1.59	84.2±2.06	87.6±1.69	91.6±1.73
Index of reproductive qualities (I)	51.4	51.4	53.3	53.7
Selection index of reproductive qualities of sows(SIRQS)	129.6	132.2	135.6	134.1

* – P <0.05; ** – P <0.01; *** – P <0.001.
Source: own calculations.

We did not establish statistically confirmed differences in the weight index of weaned piglets, although a tendency to increase it by 3.3–7.2 kg was found in crossbred litters compared to purebred litters.

The preservation of piglets was lower in nests with high multiple fertility, and there was no probable difference between the groups.

The index of reproductive qualities of pigs (*I*) in the group where piglets were obtained by purebred breeding method was equivalent. In groups of piglets obtained from direct crossing, the Index of reproductive qualities of sows (*I*) was higher by 1.9 points compared to counterparts obtained using purebred breeding. The specified index (*I*) in pigs obtained from reciprocal crossing was 2.3 points higher compared to piglets obtained from purebred breeding. The Selection index of reproductive qualities of sows (SIRQS) was also higher by 2.0–6.0 points in crossbred animals compared to purebred breeding. For the latter, it turned out to be 2.6 points higher in sows of the Landrace breed compared to their Large White counterparts (Table 2).

We did not find statistically confirmed differences in most reproductive indicators of Great White and Landrace sows obtained using purebred breeding. The only exception was the piglet mass index at weaning, which was higher in Landraces. It was also noted that the use of the crossbreeding method compared to purebred breeding had a positive effect on the tendency towards growth of most reproductive indicators of pigs. However, the weight of piglets at weaning was outside the boundaries of the influential breeding method and did not differ when using different breeding methods. The weight of one piglet at weaning was probably higher in purebred litters of the Landrace breed compared to other investigated genotypes.

We conducted a study of the influence of various types of heterosis effect on increasing the productive qualities of sows when crossing maternal breeds. As can be seen from Table 3 when crossing sows of the Large White breed with boars of the Landrace breed, the total and true effect of heterosis was at the level of 12.33%, the hypothetical heterosis was 7.19%, and the specific heterosis was 7.19%.

In the reverse variant of the combination of these breeds, the manifestation of the effect of heterosis in any of its forms has not been established.

According to the indicator of the weight of piglets at birth, the manifestation of the effect of hybrid strength was not established either in the direct or in the reciprocal variants of the combination of these breeds.

At weaning, the manifestation of the heterosis effect was established for almost all signs (Table 4). Thus, in terms of the survival of piglets, the manifestation of general heterosis was the highest (8.79%) when sows of the Landras breed were combined with boars of the Large White breed. At the same time, the hypothetical heterosis was 6.33%, and the specific and real heterosis were 3.97% each.

In the reverse variant of the combination of these breeds, the manifestation of the general and true forms of heterosis was not established, while the specific and hypothetical forms were found at the level of 4.04 and 1.68%.

Table 3. Effect of heterosis on indicators of reproductive quality of sows during farrowing

Breeds combination	Indicators	Heterosis hypothetical, %	Heterosis general, %	Heterosis true, %	Heterosis specific, %
Multifertility, heads					
♀LW × ♂LW	15.8				
♀L × ♂L	16.0				
♀LW × ♂L	16.4	7.19	12.33	12.33	2.50
♀L ×♂LW	16.2	-7.19	-11.25	-2.74	-2.74
Weight of piglets at birth, kg					
♀LW × ♂LW	1.29				
♀L × ♂L	1.28				
♀LW × ♂L	1.25	-2.72	-3.10	-2.34	-2.34
♀L ×♂LW	1.24	-3.50	-3.13	-3.13	-3.88

Source: own calculations.

Table 4. Effect of heterosis on indicators of reproductive quality of sows during weaning

Breeds combination	Indicators	Heterosis hypothetical, %	Heterosis general, %	Heterosis true, %	Heterosis specific, %
Preservation of piglets,%					
♀LW × ♂LW	88.1				
♀L × ♂L	84.2				
♀LW × ♂L	87.6	1.68	-0.57	-0.57	4.04
♀L ×♂LW	91.6	6.33	8.79	3.97	3.97
Number of weaned piglets, heads					
♀LW × ♂LW	13.9				
♀L × ♂L	13.5				
♀LW × ♂L	14.4	5.11	3.60	3.60	6.67
♀L ×♂LW	14.8	8.03	9.63	6.47	6.47
The average weight of piglets at weaning, kg					
♀LW × ♂LW	7.5				
♀L × ♂L	8.1				
♀LW × ♂L	7.8	0	4.0	-3.70	-3.70
♀L ×♂LW	7.5	-3.85	-7.41	-7.41	0
The weight of the nest of piglets at weaning, kg					
♀LW × ♂LW	104.3				
♀L × ♂L	108.4				
♀LW × ♂L	111.5	4.84	6.90	6.90	2.86
♀L ×♂LW	110.7	4.09	2.12	6.14	6.14

Source: own calculations.

In terms of the number of piglets at weaning, the nests of sows of the Landrace breed differed by their combination with boars of the Large White breed, and their true and specific forms of heterosis were at the level of 6.47%. The general and hypothetical heterosis wereat the levels of 9.63 and 8.03% respectively.

In the reverse variant of the combination of these breeds, lower rates of heterosis were established in all its forms.

According to the average weight of one piglet at weaning, it was found that there was no manifestation of the effect of hybrid power when crossing Landrace sows with boars of the Large White breed, while in the case of backcrossing, only its general form was established.

According to nest weight of weaned piglets, the manifestation of the effect of hybrid power was established both in direct and backcrossing. Somewhat higher values of hypothetical, general and true forms of heterosis were obtained for the combination of Large White breed sowsand Landrace boars. The specific heterosis turned out to be higher during the reverse combination.

Manifestation of different forms of the heterosis effect according to a set of traits was compared using the comparison of two indices (Table 5).

Table 5. The effect of heterosis on a set of indicators of reproductive quality

Breeds combination	Indicators	Heterosis hypothetical, %	Heterosis general, %	Heterosis true, %	Heterosis specific, %
Selection index of reproductive qualities of sows(SIRQS)					
♀LW × ♂LW	129.6				
♀L × ♂L	132.2				
♀LW × ♂L	135.6	3.59	4.63	4.63	2.57
♀L ×♂LW	134.1	2.44	1.44	3.47	3.47
Index of reproductive qualities (I)					
♀LW × ♂LW	51.4				
♀L × ♂L	51.4				
♀LW × ♂L	53.3	3.70	3.70	3.70	3.70
♀L ×♂LW	53.7	4.47	4.47	4.47	4.47

Source: own calculations.

Thus, according to the selection index of reproductive qualities, higher levels of hypothetical, general and true forms of heterosis were noted in sows of the Large White breed when they were combined with boars of the Landrace breed, while specific heterosis was 0.90% higher than in the reciprocal variant of the combination of these breeds.

Thus, the advantages of crossbred nests over purebred litters in most characteristics were due to the manifestation of the heterosis effect, while the average weight of piglets at weaning, in our opinion, had an intermediate form of inheritance.

The relationship between individual indicators of reproductive characteristics of sows was evaluated using correlation analysis. Correlations were found between the multifertility indicator and the weight of newborn piglets, r = 0.92 (p<0.001). Correlation analysis also showed a relationship between multiple fertility and the number of weaned piglets r = 0.89 (p<0.001). Also, multifertility was correlated with the mass of weaned piglets r = 0.81 (p<0.001). The correlation between multifertility and the weight of weaned piglets was of medium strength r = -0.45 (p<0.01), Multifertility and piglet survival were connected by an inverse relationship of medium strength r = -0.44 (p<0.05).

The weight of newborn piglets was correlated only with the weight of weaned piglets.

The weight of the nest of newborn piglets was directly correlated with the indicator of the number of weaned piglets r = 0.84 (p<0.001), as well as with the weight of the nest of weaned piglets r = 0.81 (p<0.001).

A close correlation was found between the indicator of the number of weaned piglets and the nest weight of newborn piglets, r = 0.84 (p<0.001). Also, the number of weaned piglets was related to the indicator of the weight of the nest of weaned piglets by a strong correlation r = 0.82 (p<0.001), similarly to the indicator and the number of newborn piglets r = 0.92 (p<0.001).

The weight of weaned piglets had a close direct correlation r = 0.80 (p<0.001) with the weight of weaned piglets. However, the weight of weaned piglets was negatively correlated with the multifertility index r = -0.45 (p<0.01).

The weight of the nest of weaned piglets was closely related to the multifertility indicator r = 0.81 (p<0.001). The weight of the nest of weaned piglets was closely correlated with the indicator of the weight of the nest of newborn piglets r = 0.81 (p<0.001), similarly to the indicator of the number of weaned piglets r = 0.82 (p<0.001) and similarly to by the weight of weaned piglets, r = 0.80 (p<0.001).

The correlation between piglet survival rate and sow fertility was moderate and inverse r =

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-0.44 (p<0.05). With the rest of the reproducible signs, the probable strength of the connections was not revealed.

Table 6. Correlation coefficients between the main indicators of reproducibility

Indicators	**Multifertility**	**Weight of piglets at birth**	**The nest weight of piglets at birth**	**Number of weaned piglets**	**The average weight of piglets at weaning**	**The weight of the nest of piglets at weaningi**	**Preservation of piglets**	**The duration of the sucking period**
Multifertility		-0.09	0.92***	0.89***	-0.45**	0.81***	-0.44*	0.22
Weight of piglets at birth	-0.09		0.12	-0.09	0.28	0.16*	0.002	-0.13
The nest weight of piglets at birth	0.92***	0.12		0.84***	0.47	0.81***	-0.35	0.23
Number of weaned piglets	0.89***	-0.09	0.84***		0.35	0.82***	-0.01	0.19
The average weight of piglets at weaning	-0.45**	0.28	0.47	0.35		0.80***	-0.30	-0.10
The weight of the nest of piglets at weaning	0.81***	-0.16*	0.81***	0.82***	0.80***		-0.18	0.02
Preservation of piglets	-0.44*	0.002	-0.35	-0.01	-0.30	-018		-0.18
The duration of the sucking period	0.22	-0.13	0.23	0.19	-0.10	0.02	-0.18	

* – P <0.05; ** – P <0.01; *** – P <0.001.
Source: own calculations.

Probable relationships between the duration of the subsucking period and other signs of reproductive performance have not been established.

The absence of a significant difference between the indicators of the reproductive qualities of pigs under different breeding methods was similar to similar results [19], which also showed the absence of any influence of the breeding method on the reproductive functions of pigs. In contrast to the reports [20], which indicated a reliable dependence of the number of weaned piglets on the breed of their closest ancestors, we did not detect the influence of the breed factor on the maternal qualities of lactating sows.

Similar to reports [14], in which the authors claimed that there is a negative strong correlation (r = – 0.70) between fertility and survival of piglets, we also established a negative inverse relationship between these indicators, but of medium strength. Similar to the results of the experiment [14], we found a correlation between the survival rate and the number of weaned piglets, but in our results it was weak and inverse (r = – 0.01), contrary to the average positive relationship found by the authors [14] (r = 0 ,52).

Also, the strength of the relationship established by us between the preservation of piglets and their number at the time of weaning (r = – 0.01) was significantly lower and reversed than in the mentioned experiment [14], where the correlation between the indicated indicators was average and positive (r = 0.52).

Survival in lower birth weight piglets tended to exceed survival in groups with higher birth weight piglets. This partially contradicts the findings of [8], which indicated that losses during rearing of piglets before weaning were highest in the group of piglets with the lowest birth weight.

We also found, similar to other scientists [27], that the duration of lactation did not have a reliable correlation relationship with the reproductive qualities of sows. From which we can conclude that there is no production need to make the lactation period longer.

CONCLUSIONS

The reproductive qualities of sows had a tendency to increase during their crossbreeding compared to purebred breeding, with the exception of the weight of one piglet at weaning. Both for the use of purebred breeding and for the use of crossbreeding, the weight of weaned piglets was higher in Landrace sows compared to counterparts born from Great White sows and compared to peers.

The effect of heterosis was confirmed on almost all reproductive characteristics of sows, including the weight of weaned piglets. It was found that the index of multiple fertility and the weight of the nest of newborn piglets were in a close direct correlation. Multifertility was also closely correlated with the number of weaned piglets and the weight of the nest of weaned piglets. Fertility and weight of weaned piglets were inversely correlated, as well as fertility and survival of piglets.

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EVALUATION OF STUD BULLS BY THE KAPPA-CASEIN GENOTYPE IN THE CONTEXT OF CONSERVATION OF LOCAL BROWN CATTLE BREEDS IN UKRAINE

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Abstract

Genotyping of 47 stud bulls of Brown breeds was carried out by the gene CSN3. The results of scientific studies indicate that both Brown purebred and cross-breed cattle bred in Ukraine are characterized by a significant difference in the frequency of genotypes by this trait. The genetic equilibrium established by us corresponds to the global trends of breed populations. The creation of the desired micro-populations with the desired homozygous BB genotype by kappa-casein makes it possible to improve the quality of milk as a raw material for milk processing enterprises specialized in cheese making. Therefore, the increased frequency of the BB genotype by kappa-casein may contribute to the preservation and distribution of Brown cattle in Ukrainian farms.

Key words: *breed, allele, genotype, kappa-casein, stud bull*

INTRODUCTION

Much attention is paid to the conservation of biological diversity at the global level. The vast majority of cattle breeds are represented by local populations that differ significantly not only in morphology, but also in the corresponding co-adaptive genetic complexes formed under the influence of natural and artificial selection against the background of specific growing conditions. During the genesis and further improvement of the breed, the selection of cattle that are selectively valuable from a breeding point of view, it is essential to have information on their productivity potential, the level of genetic polymorphism, genotype by genes of quantitative traits, the availability of unique alleles that are characteristic of representatives of this particular breed and have adaptive significance, and therefore create the basis for the need to preserve its gene pool [7].
Domestic Brown cattle of Ukraine are represented by the Lebedyn, Brown Carpathian breeds, and Ukrainian Brown dairy breed created on their basis. The Lebedyn breed was approved in 1950. It was created as a result of mating local, mainly Gray Ukrainian, cattle with the Swiss breed, the inter se breeding of hybrids, which lasted for more than 40 years. The local Swiss breed, whose stock has dramatically decreased over the past 20 years, is characterized by unique economic and useful traits, including adaptability to local, economic and feed conditions, endurance and resistance to diseases, long-term use, breeding plasticity, universal productivity. To be sure, it is almost impossible for it to compete in terms of milk yield with such world leaders as the Holstein breed. In this case, the quality of the resulting products should come to the fore. And to do this, in our opinion, it is necessary to know the genetic characteristics of cattle. The revival of the Lebedyn cattle breed can be carried out at the expense of both natural and artificial reproduction methods. For this purpose, the banks of genetic resources and breeding centers of Ukraine have a sufficient supply of semen of stud bulls. In particular, Sumy Breeding Center LLC stores the genetic material of 12 bulls of the Lebedyn breed and crossbreeds with the Swiss breed. A small number of stud bulls of the Lebedyn breed, whose semen is stored in breeding centers,

make it impossible to completely avoid inbreeding, which may lead to undesirable breeding consequences. Therefore, scientists of Sumy National Agrarian University have proposed a fundamentally new scheme for reproducing the genealogical structure of herds of local breeds, namely, working with the application of the population method of reciprocal reproduction [11, 20].

The Brown Carpathian cattle of the combined productivity are a local breed, whose area of distribution is the south-west of Ukraine. Cattle of this breed are characterized by extremely valuable economic features. They are adapted to mountain breeding conditions, have high viability and resistance, are characterized by a strong body composition, high reproductive capacity, long-term productive use, and high fat and protein content in milk. Genetic resources of the Brown Carpathian breed of the Transcarpathian region are represented by breeding stock, which is located in 69 settlements of 13 districts and has 15,800 heads. In addition, the Bank of Animal Genetic Resources of M. V. Zubets Institute of Animal Breeding and Genetics of the National Academy of Agrarian Science of Ukraine and Transcarpathian Breeding Farm JSC stores more than 259 thousand doses of semen. Today, the issue of preserving the Brown Carpathian cattle is being given more and more attention [18, 19, 20, 21].

Increasing requirements for the quality of dairy products have led to the use of genetic markers in breeding and the search for their relationship with the milk productivity of animals. In this situation, there is a need to change the methods of assessing the breeding characteristics of animals and develop new approaches based on the achievements of genetics and biotechnology [7, 8]. Thanks to the achievements of modern molecular genetics, it is possible to identify genes that control economically useful traits in cows. This makes it possible, in addition to traditional animal selection, to conduct selection directly at the DNA level. Among the many genes that affect the milk quantity and quality, we can distinguish a separate group that make the greatest contribution to the formation of milk productivity traits. These genetic markers include the following genes: kappa-casein (CSN3), beta-lactoglobulin (BLG), prolactin (PRL), and others [7].

Milk protein genes, especially kappa-casein (CSN3), are important for milk quality, as they significantly affect the cheese production process, which has been proven by a large number of studies [1, 12, 15]. Polymorphism of the kappa-casein gene is quite well studied today, scientists distinguish the following most common variants – A and B. Less common gene variants are: C, D, E, F, H, J, I, X, Az, A1. The most common genetic variants are A and B [17]. The kappa-casein B allele is associated with the production of milk with a more favorable chemical composition for cheese production. Therefore, for the production of cheese, it is better to use milk from animals with the BB genotype compared to milk from animals with a different genotype [4]. This leads to the use of the kappa-casein bovine genotype indicator to ensure successful breeding for cheese production. It is proved that different breeds of dairy cattle differ significantly in the frequency of genotypes and alleles by kappa-casein [2, 3, 8, 13, 14, 22].

One of the important productive features of the Brown cattle is that among all other breeds, the milk of these cattle contains the largest kappa-casein fraction of milk protein, which may determine its preservation [3, 7, 18, 22].

The objective of our research is to study the frequency of kappa-casein genotypes and alleles of purebred and local stud bulls of the Brown cattle in Ukraine.

MATERIALS AND METHODS

The research was conducted at the premises of the Laboratory of O. O. Bogomoletz Institute of Physiology of the National Academy of Sciences of Ukraine. The study was conducted on DNA samples obtained from the long-term storage semen of bulls: of Lebedyn breed (5 heads), Lebedyn crossbreeds with Swiss (7 heads) and original Brown German (19 heads); Brown Carpathian (4 heads), Brown Carpathian crossbreeds with Swiss (11 heads). The study was also conducted on blood samples taken from live stud bulls: Lebedyn crossbreeds with the original Brown German (19 heads); crossbreeds of Ukrainian Brown dairy and original German Brown (5 heads).

Blood samples were taken under sterile conditions into 2.7 mL monovettes containing EDTA potassium salt as an anticoagulant (Sarstedt, Germany), with the subsequent freezing and storage of samples at -20ºC.

For molecular genetic studies, one semen dose was used from 47 stud bulls (of the corresponding breed). 4 µL of a sample from the semen dose of each of the stud bulls of these breeds was taken to isolate genomic DNA.

Monarch® Genomic DNA Purification Kit New England BioLab kits (USA) according to the manufacturer's protocol was used to obtain DNA from samples for genotyping.

The TaqMan® SNP Genotyping Assays use TaqMan® 5′-nuclease chemistry for amplifying and detecting specific polymorphisms in purified genomic DNA samples. All assays are developed using Life Technologies robust bioinformatics assay design process relying on a pipeline using heuristic rules deduced from both manufacturing and assay performance data. These assays use TaqMan® minor groove-binding (MGB) probes for superior allelic discrimination, improved signal-to-noise ratios, and design flexibility. TaqMan real-time PCR Two primers were designed to amplify the 101 bp product involving SNP rs43703011 (genomic DNA: X14711 (http://www.ncbi.nih.gov); forward primer, 5′- AAG CAG TAG AGA GCA CTG TAG CTA -3′; reverse primer, 5′- TGA TCT CAG GTG GGC TCT CAA TAA -3′). Two fluorogenic TaqMan probes were designed with different fluorescent dye reporters to allow single-tube genotyping. The first probe was targeted at the wild type allele A (5′-VIC-CTTCTGGAGAAGCTTCTA-3′) and the second one at the mutated allele B (5′-FAM- CTTCTGGAGAATCTTCTA -FAM-3′) of the CSN3 gene. The NFQ quencher was linked to the 3′ end of both probes. Primers and probes were designed using Primer Express software, version 3.0 (Applied Biosystems, CA, USA) and were obtained from Applied Biosystems. The accuracy of the used sequence source was verified by comparison with sequences from the GenBank database using BLAST (http://www.ncbi.nlm.nih. gov/BLAST/).

Real-time PCR was performed in 20 µl reactions with 10 µl of TaqMan universal PCR master mix containing AmpliTaq Gold DNA Polymerase (Applied Biosystems, CA, USA), 200 nM concentration of forward and reverse primer, 100 nM of each probe and 2 µl (50–100 ng) of sample DNA. The PCR reaction was obtained using the FAST 7500 Real Time PCR System (Applied Biosystems). The time and temperature profile of the PCR reaction consisted of the following steps: 2 min at 50°C for UNG activation, 10 min at 95°C for starting AmpliTaq Gold activity, 40 cycles of 95°C for 15 s and 60°C for 1 min. As a negative control, we used a sample without a template. An allelic discrimination experiment consisted of three steps: a pre-read run, an amplification run and a post-read run. Each sample was visually verified by analyzing the generated PCR curves. The analyses of amplification products were performed using SDS software, version 4.2. The allele frequency was calculated taking into account the number of homozygotes and heterozygotes found in the corresponding allele using the following formula:

$$P(A) = \frac{2N_1+N_2}{2n} \qquad (1)$$

where:

N_1 and N_2 – number of homozygotes and heterozygotes for the studied allele, respectively;

n – sample number.

In order to assess the statistical reliability of the discrepancy between the distribution of the obtained results the Pearson criterion was used:

$$X^2 = \frac{\sum(A-T)^2}{T} \qquad (2)$$

where:

A – actual number of genotypes;

T – theoretical number of genotypes.
The actual (available) heterozygosity was determined by direct calculation using the following formula:

$H_0 = \frac{N_2}{n}$……...(3)

The expected heterozygosity was determined using the following formula:

$H_E = 1 - \sum_{l=1}^{n} p_i^2$.......................................(4)
where:
$p_1, p_2, \ldots p_n$ – frequency of alleles.
The fixation index was calculated using the following formula:
$F_{is} = \frac{H_E - H_0}{H_E}$…………………………….....(5)

RESULTS AND DISCUSSIONS

The results of DNA testing of the kappa-casein locus for the presence of A and B-allelic variants in stud bulls of the studied breeds and cross cattle have revealed that cattle of the Brown Carpathian breed are characterized by the frequency of the desired (BB) genotype at 50%, which is higher than all other breeds studied (Table 1).
Stud bulls of the Ukrainian Brown dairy breed were somewhat inferior to them in this respect. Crossbreeds of the Lebedyn breed with Swiss, original German and Brown Carpathian with the Swiss breed had a significantly lower frequency of this genotype. The desired genotype was not found at all in stud bulls of the Lebedyn breed.
Brown Carpathian and Swiss breeds differed in a higher proportion of the heterozygous genotype. Cattle of other breeds were inferior to them in terms of the share of this genotype.
Stud bulls of the Lebedyn breed were characterized by the availability of the AA genotype with a proportion of 50%, and none of them was found in cattle of the Brown Carpathian breed at all.
The use of the χ2 criterion has enabled to determine the degree of compliance of the actual distribution of genotypes with the expected values. Calculation using the Hardy-Weinberg formula shows no difference between the actual and expected genotype frequencies for most breeds.

Table 1. Frequency of alleles and genotypes by kappa-casein gene locus

Breed/crossbreed	Distribution	Frequency of genotypes			Frequency of alleles		χ2
		AA	AB	BB	A	B	
Lebedyn purebred	A	0.50	0.50	0	0.75	0.25	0.444
	E	0.56	0.38	0.06			
Crossbreeds of Lebedyn breed with Swiss breed	A	0.42	0.29	0.29	0.57	0.43	1.215
	E	0.33	0.49	0.18			
Purebred Brown Carpathian	A	0	0.50	0.50	0.25	0.75	0.444
	E	0.06	0.38	0.56			
Crossbreeds of Brown Carpathian with Swiss breed	A	0	0.73	0.27	0.36	0.64	3.591
	E	0.13	0.47	0.40			
Crossbreeds of Lebedyn breed with original German Brown breed	A	0.26	0.57	0.17	0.55	0.45	0.555
	E	0.31	0.49	0.20			
Crossbreeds of Ukrainian Brown dairy breed with original German Brown breed	A	0.20	0.40	0.40	0.40	0.60	0.139
	E	0.16	0.48	0.36			

Source: Own research.

This may indicate a lack of selection based on this trait and the preservation of genetic balance. It means cattle breeding is carried out on the basis of traditional methods for assessing milk productivity, without taking into account genetic factors that affect the qualitative composition of milk protein. The exception is made by local cattle of the Brown Carpathian breed with the Swiss one.
There is a popular opinion that a violation of random crossing should cause a deviation in genotype frequencies from the expected equilibrium according to the Hardy-Weinberg law. In cattle of the Lebedyn, Brown

Carpathian breeds, crossbreeds of Brown Carpathian and Swiss breeds, Lebedyn with the original Brown and Simmental breeds, the actual heterozygosity exceeded the expected one. A negative value of the Wright fixation index indicates a slight excess of heterozygotes in these samples.

In our opinion, measures for the preservation of the Lebedyn breed developed by specialists of Sumy National Agrarian University, namely, the work by the method of population reciprocal reproduction using stud bulls of the original Brown German breed, enables to increase the frequency of the kappa-casein B allele in gene pool herds.

This, in turn, will make it possible to obtain cattle with the desired quality indicators of dairy raw materials and stud bulls of the Lebedyn breed with the BB genotype by kappa-casein for custom mating. Therefore, we can safely assume that the conducted research and cooperation of scientists and producers can provide an opportunity to create dairy herds of Brown cattle to obtain milk for cheese making that will significantly increase the profitability of its production and processing, as well as the demand for dairy products. In turn, this may contribute to further measures to preserve the gene pool of Brown cattle in Ukraine.

Work with the Brown Carpathian breed should include individual work of scientists and breeders with livestock owners in order to obtain cattle with the desired kappa-casein genotype from custom pairs. This, in turn, will enable to obtain milk for cheese making from cows that will increase the competitiveness of this breed. However, it should be noted that due to the low share of cows of this breed among farmers, we can only talk about the manufacture of craft products (cheese). One of the options for popularizing the breed can be green tourism in the Carpathians.

Table 2. Values of the main indicators of variability by the kappa-casein gene

Breed	H_o	H_e	F_{is}
Lebedyn purebred	0.500	0.375	-0.333
Crossbreeds of Lebedyn breed with Swiss breed	0.286	0.490	0.417
Purebred Brown Carpathian	0.500	0.375	-0.333
Crossbreeds of Brown Carpathian with Swiss breed	0.727	0.463	-0.571
Crossbreeds of Lebedyn breed with original German Brown breed	0.579	0.494	-0.171
Crossbreeds of Ukrainian Brown dairy breed with original German Brown breed	0.400	0.480	0.167

Ho – actual heterozygosity, He – expected heterozygosity, Fis – fixation index
Source: Own research.

Based on the results of our studies, it was found that the highest frequency of the desired allele is characteristic of stud bulls of the Brown Carpathian cattle (0.750). In cattle of the Lebedyn breed, on the contrary, the frequency of A allele was 0.750, respectively, and the B allele – 0.25. The results obtained by us do not coincide with the previously obtained results of other scientists. According to the results of our studies, the frequency of the A allele is three times higher than the frequency of the B allele in stud bulls of the Lebedyn breed. While according to the results of other scientists, this difference is 1.16-1.9. Crossbreed stud bulls of the Lebedyn and Swiss breeds are characterized by a higher frequency of the A allele compared to the published results of other scientists. A allele is 1.32 times higher, while according to the literature data, the frequencies of the A and B alleles are the same. According to the results of our research, the Brown Carpathian breed has a very high frequency of the B allele – 0.75, which does not coincide with the previous studies. Cattle crossbred with the Swiss breed have a lower frequency of the desired allele. In our opinion, the increase in the frequency of the desired B allele in cattle of the Lebedyn breed subject to the use of stud bulls of the Swiss breed can be explained by the fact that cattle of the Swiss breed have a higher frequency of the B allele than A, which is proved by the previous studies (Table 3).

Table 3. Main Frequency of kappa-casein alleles (according to researchers)

Breed	Frequency of alleles		Source
	A	B	
Lebedyn*	0.600	0.380	Ovcharenko, V., Ladyka, V., 1999 [16]
Crossbreeds of Lebedyn* and Swiss	0.500	0.500	Ovcharenko, V., Ladyka, V., 1999 [16]
Lebedyn*	0.533	0.454	Eremenko V., Oblivantsov V., 2004 [5]
Ukrainian Brown dairy	0.500	0.500	Eremenko V., Oblivantsov V., 2004 [5]
Lebedyn	0.660	0.340	Ladyka V., Sklyarenko Yu., Pavlenko Yu., 2018 [10]
Lebedyn	0.463	0.537	Huzeiev, Yu.V., 2012 [7]
Brown Carpathian	0.564	0.436	Huzeiev, Yu.V., 2012 [7]
Brown Carpathian	0.619	0.381	Huzeiev, Yu., Sydorenko, O., Vishnevskyi, L., 2017 [9]
Swiss*	0.312	0.653	Gladyr ,O. O., 2001 [6]
Swiss of German* breeding	0.474	0.518	Eremenko V., Oblivantsov V., 2004 [5]

*Other alleles are available.
Source: Links to other studies.

CONCLUSIONS

This work has resulted in detecting the frequencies of alleles and genotypes in the kappa-casein locus. It is established that Brown breeds that are bred in Ukraine differ significantly in this trait among stud bulls. The genetic equilibrium revealed by our research reflects global trends in breed populations and indicates the absence of targeted breeding towards increasing BB homozygotes. Accelerated formation of the desired genetic combinations in micro-populations (herds), if required, by the processing industry, primarily cheese producers, is possible in populations of Brown cattle. Such micro-populations with the desired homozygous BB genotype by kappa-casein create prerequisites for improving the quality of milk as a raw material for milk processing enterprises specialized cheese making. The stabilization of the dairy cattle industry and its development in Ukraine will be significantly facilitated by an increase in the price of raw materials (milk), which is possible when selling batches of milk exclusively with BB genotypes by kappa-casein for cheese making. Due to the increase in the frequency of the BB genotype in Brown cattle, it is possible to preserve and spread them in Ukrainian farms.

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RESEARCH ON AGROECOLOGICAL ZONING FOR WINTER WHEAT (*TRITICUM AESTIVUM* L.) IN SOUTH-EASTERN ROMANIA

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Abstract

Pedoclimatic elements and smart technology act simultaneously on the biological processes of agricultural crops and on the level of harvest, which requires the study of their correlation to determine the continuous influence of these factors in obtaining the planned levels of production. In Romania, annually, over 2.1 million hectares of wheat are cultivated, with annual productions of over 10 million tons, placing wheat crops in the first place as economic importance. Knowing the management of natural resources in quantitative terms is especially valuable when we talk about their sustainable use. Our evaluation includes in this paper the relationship between the pedoclimatic resources of South-Eastern Romania and the zoning of wheat varieties in order to obtain superior quantitative and qualitative productions. The last 11 agricultural years are analyzed, both in terms of the influence of global warming and in terms of wheat zoning to obtain sustainable production to highlight the genetic potential of the varieties under the conditions of the Brailei Plain. A stability of the varieties Glosa, Miranda, Litera (varieties over 15 years old) was observed, but not least of the new ones created by the National Research and Development Institute from Fundulea such as: Pitar, Ursita, Adelina, Izvor.

Key words: *production, pedoclimatic conditions, varieties, zoning, winter wheat*

INTRODUCTION

Knowledge of resource management in quantitative terms is especially valuable when it comes to their sustainable use. Thus, there is a direct link between the productive potential of varieties and hybrids and zonal pedoclimatic factors [6]. The literature also uses the concept of climatic fertility, according to soil fertility [2]. Eastern Romania, more precisely in the Braila Plain, the knowledge of the climatic variations, of the soil fertility and of the genetic potential of the varieties contributes integrated to the obtaining of superior productions from a quantitative and qualitative point of view.

Knowing the reaction of new varieties to environmental conditions is important for judicious zoning in the territory and for specifying the place it must occupy in the structure of varieties for each area [8, 11].

We are going through a period in which the evaluation of the development of agriculture through the prism of ecological implications requires an increased attention of the interactions between the physico-chemical, biological, physiological and climatic components. In fact, [12] also explains the link between environmental productivity and climate change that requires in-depth analysis. He shows how climate is the critical factor in whether or not to support the sustainability of agricultural systems. On the other hand, geneticists and breeders obviously and systematically contribute to improving the genotypes of agricultural species, to obtain varieties and hybrids with tolerance to biotic and abiotic stressors, with selectivity to some pesticides, with resistance to diseases and pests, but, especially with high productive potential and quality agricultural products. There are also a number of technological links to improve productive potential through treatments with biofertilizers and biostimulators [13]. More than three-quarters of the global land area is unsuitable for agriculture, suffering from severe constraints such as cold weather (13%), dry climate (27%), steep topography (12%) or poor soil conditions (40%). %). In many cases in developing countries, cultivated land is only moderately suitable for agriculture because of multiple constraints [7]. European statistics on cereal production in the period 2010-2021 show that in the European Union, total annual production was between the minimum value of 260,276 thousand tons in 2010 and 306,219 thousand tons in 2014, and for 2022 a total production is estimated of 298,376 thousand tons (Table 1). For wheat, the annual productions in the last 12 years were between the minimum value of 112,969 thousand tons in 2010 and 132,15 thousand tons in 2019, and the average for the last 5 years was 126,205 thousand tons, estimating in 2022 an increase by 3.9% [5].

Table 1. Total cereal production for each species in the period 2010-2021,with EUROSTAT estimates for 2022

Crop	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020e	2021f	2022p	5-year TrimAvg	5-year TrimAvg vs 2022p
Soft wheat	112,969	115,885	112,652	124,300	133,042	136,106	120,641	128,306	115,751	132,156	119,270	131,040	131,090	126,205	3.9%
Durum wheat	9,443	8,583	8,414	8,054	7,698	8,388	9,675	8,810	8,767	7,476	7,420	7,809	7,630	8,017	-4.8%
Grain maize	59,944	70,696	59,529	66,973	77,736	59,239	62,963	65,049	69,309	70,416	68,252	72,561	73,743	69,326	6.4%
Barley	47,858	46,372	49,480	52,762	53,770	54,607	53,324	51,650	49,931	55,514	54,420	52,418	53,931	52,829	2.1%
Triticale	10,681	10,074	10,051	11,421	13,126	12,676	11,785	11,646	9,770	11,203	12,337	11,778	11,237	11,543	-2.7%
Oat	6,752	7,242	7,300	7,432	6,947	6,784	7,321	7,322	6,887	6,945	8,473	7,554	7,594	7,274	4.4%
Rye	7,694	6,782	8,679	10,417	8,994	7,739	7,349	7,309	6,174	8,455	8,910	7,944	8,231	7,903	4.2%
Sorghum	614	679	497	729	932	720	688	719	833	1,016	1,126	841	878	807	-2.1%
Other cereals	4,320	4,511	5,088	4,032	3,974	3,450	3,625	4,158	3,851	3,879	3,614	3,739	4,043	3,823	5.8%
Total cereals	260,276	270,824	261,689	286,120	306,219	289,709	277,371	284,967	271,272	297,060	283,821	295,685	298,376	288,158	3.5%

NOTE: e = estimate ; f = forecast ; p = projection.

Source: DG Agriculture and Rural Development based on Eurostat crop production annual data [4].

Traditionally, Romania is a large producer of cereals, especially corn, but the total production of wheat in the last 11 years was between the minimum of 5.28 thousand tons in 2012 and the maximum of 11.35 thousand tons in 2021, which meant a percentage between 4.67% and 8.65% of the total production of the EU member states (Tables 2 and 3).

Table 2. Total cereal production in the European Union and in Romania (thousand tons)
Cereales-Gross production by all crops (1,000 tonnes) for all Members States

Crop	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Soft wheat	112,969	115,885	112,652	124,300	133,042	136,106	120,641	128,306	115,751	132,156	119,270
Durum wheat	9,443	8,583	8,414	8,054	7,698	8,388	9,675	8,810	8,767	7,476	7,420
Maize	59,944	70,696	59,529	66,973	77,736	59,239	62,963	65,049	69,309	70,416	68,252
Barley	47,858	46,372	49,480	52,762	53,770	54,607	53,324	51,650	49,931	55,514	54,420
Totals	260,276	270,824	261,689	286,120	306,219	289,709	277,371	284,967	271,272	297,060	283,821

Crop	5-year TrimAvg	Latest year vs. 5-year TrimAvg
Soft wheat	126,205	3.87%
Durum wheat	8,017	-4.83%
Maize	69,326	6.37%
Total cereals	288,158	3.55%

Source: DG Agriculture and Rural Development based on Eurostat crop production annual data [4].

Table 3. Total cereal production in Romania (thousand tons)

Crop	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021e
Soft wheat	5,784	7,117	5,276	7,284	7,565	7,955	8,406	10,014	10,123	10,281	6,744	11,354
Durum wheat	28	15	22	13	19	8	25	21	21	17	11	33
Maize	9,042	11,718	5,953	11,305	11,989	9,021	10,746	14,326	18,664	17,432	10,942	15,186
Barley	1,311	1,330	986	1,542	1,713	1,626	1,817	1,907	1,871	1,880	1,155	2,435
Totals	16,651	20,777	12,773	20,842	22,026	19,283	21,721	27,096	31,510	30,372	19,349	29,653

Crop	5-year TrimAvg	Latest year vs. 5-year TrimAvg
Soft wheat	126,205	3.87%
Durum wheat	8,017	-4.83%
Maize	69,326	6.37%
Total cereals	288,158	3.55%

Source: DG Agriculture and Rural Development based on Eurostat crop production annual data [4].

EUROSTAT statistics show an increase in wheat production compared to the average of the last 5 years by 3.87% in Europe, while in Romania, the increase is only 1.90% .

The purpose of the work follows the acclimatization and stability from the genetic and productive point of view of new and old varieties, tested over a longer period of time and their resistance to different biotic and abiotic factors.

MATERIALS AND METHODS

The testing experiments of the different wheat varieties were carried out in the period 2010 - 2021, with the monitoring of the pedoclimatic data continuously, in order to highlight the genetic potential of the varieties in the conditions of the Braila Plain.

Climatic conditions were monitored daily, respectively minimum and maximum air and soil temperature, precipitation, sunshine, wind, wind orientation. Periodic soil analyzes were performed to establish the fertilization plan, according to the nutrient requirements for the optimal wheat cultivation technology.

The wheat varieties tested were different from year to year, depending on the results of the previous year and the requirements of the seed suppliers to be tested and zoned.

All the necessary biometrics have been made to evaluate the adaptation of the tested wheat varieties, but in this paper we will analyze only the productive potential.

The main objective of the research is to evaluate the genetic potential of wheat varieties for cultivation in the Brăila Plain, respectively the production capacity in conditions of pedological drought registered in recent agricultural years [3].

varieties, but in this paper we will analyze only the productive potential.

The main objective of the research is to evaluate the genetic potential of wheat varieties for cultivation in the Brăila Plain, respectively the production capacity in conditions of pedological drought registered in recent agricultural years.

Climate resources also directly affect the biodiversity of ecosystems, and this paper aims to assess the potential of land in Brăila County in terms of sustainability and climate change for wheat cultivation.

Therefore, we will include in our evaluation a series of evolving indicators that we will analyze further, namely:

- The evolution of the average monthly temperatures during the vegetation period;
- The evolution of the average monthly precipitations during the vegetation period;
- The productions obtained by the different wheat varieties tested in the period 2010 - 2021.

The varieties tested in the experience were: Boema 1, Litera, Miranda, Glosa, Bezostaia, Pitar, Otilia, Izvor, Otilia, Ursita, Adelina. The sown area of the experimental plot was 10 m^2, and the harvested area was 5 m^2. The field experiments were designed according to the experimental technique. The location scheme for the wheat crop is a latin rectangle, with a number of 11 variants.

Because the productivity of different wheat genotypes depends on climate, soil fertility, and water availability, they form the most important categories of environmental information needed to assess land suitability for production [1].

RESULTS AND DISCUSSIONS

Climate data results

The monitoring of the minimum and maximum daily temperatures allowed the calculation of the monthly averages for each of the 11 agricultural years studied. In the Braila Plain, compared to the multiannual monthly average calculated for the last century, there is a positive deviation in each calendar month, with values between the minimum deviation of + 0.5)^{0}C in October and + 1.75^{0}C in March (Fig. 1).

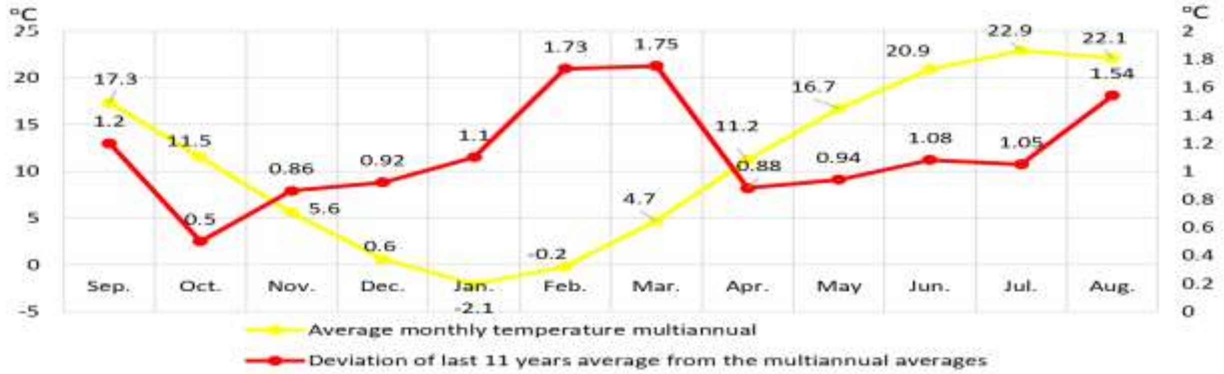

Fig. 1. Average monthly temperatures and deviations for the last 11 agricultural years, compared to multiannual monthly averages
Source: Own results based on CMR Dobrogea [3].

The average monthly precipitation calculated as the average of the last 11 agricultural years registered negative deviations in September, November, April, July and August, with values between the minimum deviation of -0.45 mm in November and the maximum deviation of –11.42 mm in August, while the significant positive deviations were in October (+ 24.42 mm), January (+ 14.04 mm) and June (+ 14.88 mm) (Fig. 2).

Fig. 2. GDU (growing degree units) and the precipitation accumulated during the wheat vegetation period in the last 11 agricultural years
Source: [3].

Results regarding the productions obtained for the wheat varieties tested in the 11 agricultural years in the Braila Plain, compared to the average production in Romania. The annual production averages were related to the national productions in the analyzed period and positive differences were observed in the good agricultural years, with sufficient precipitation in autumn, while in the dry agricultural years the differences of production compared to the national average were negative, from up to 1.3 t/ha tons (Fig. 3).

Fig. 3. Average productions obtained in the experience compared to the national average productions (red represents the lower productions, and green the higher productions)
Source: [9, 10].

Production results for the varieties tested in the 11 agricultural years, for the zoning of the Romanian wheat varieties in the Braila Plain.

In the agricultural year 2010 - 2011, the best production results were obtained by the Miranda, Boema and Glosa varieties, with production differences compared to the average experience between 667 kg/ha for the Glosa variety and 1,276 kg/ha, while the Izvor varieties and Bezostaia obtained significant negative differences with yields of less than 15-30% (Fig. 4).

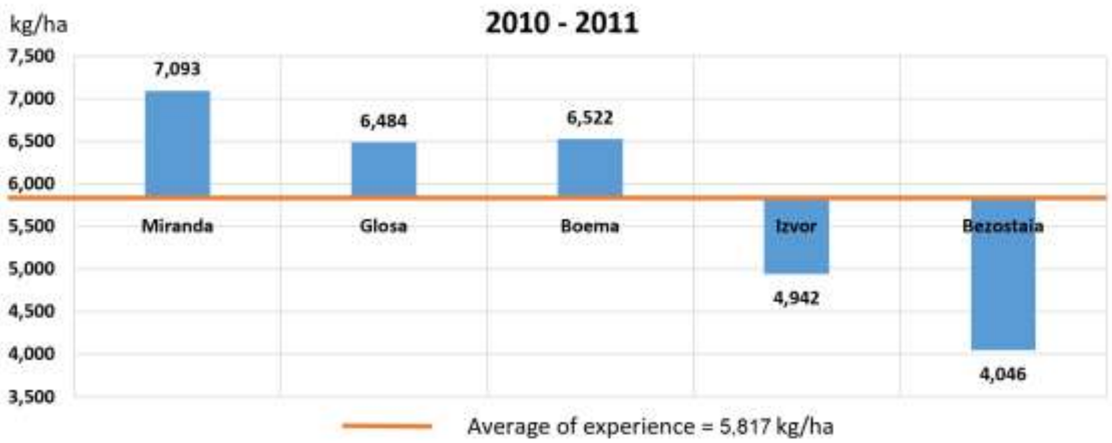

Fig. 4. Average productions obtained for the wheat varieties in 2010-2011, compared to the average experience
Source: Own results [10].

In the agricultural year 2011 - 2012, the production results were insignificant compared to the average experience, with differences between -1.04% for the Izvor variety and + 1.42% for the Glosa variety (Fig. 5). The average production in 2013 was 6,620 kg/ ha, and the best results compared to this average were obtained by the Glosa varieties, with a production difference of + 5.18%, and the weakest result was obtained by the variety Spring, with a production difference of -3.5% compared to the average experience and 9.1% compared to the Glosa variety (Fig. 6).

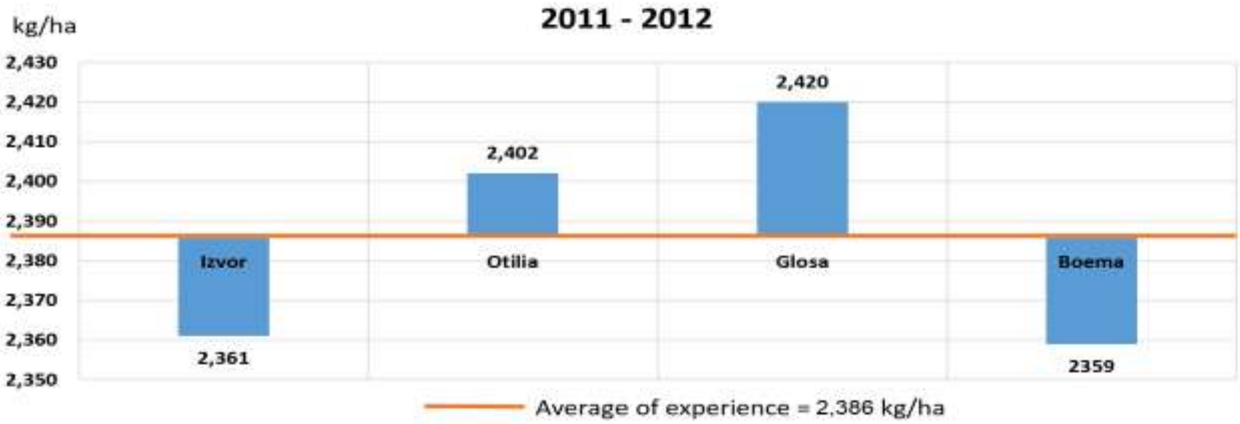

Fig. 5. Average productions obtained for the wheat varieties in 2011-2012, compared to the average experience
Source: Own results [10].

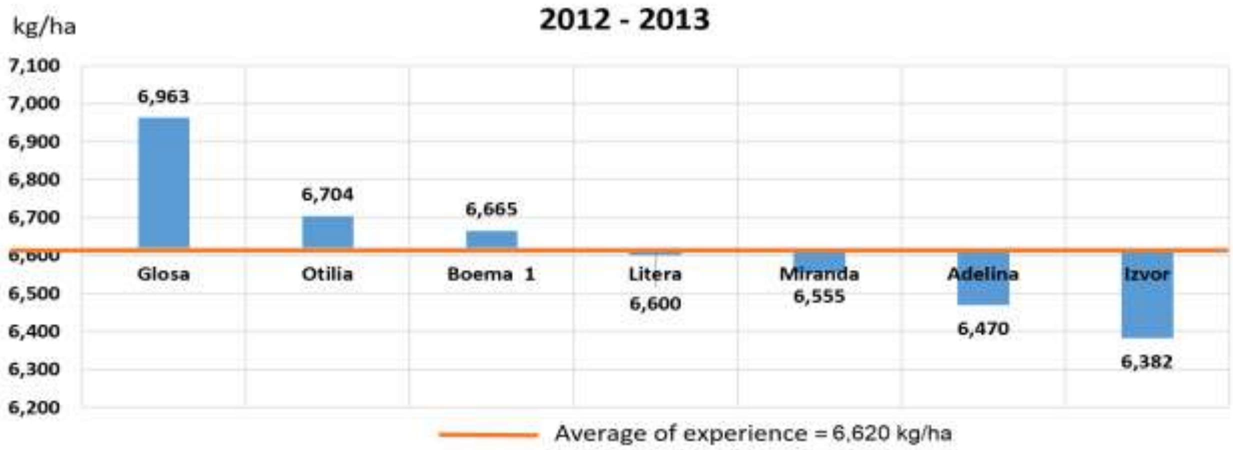

Fig. 6. Average productions obtained for the wheat varieties in 2013, compared to the average experience
Source: Own results [10].

In 2014, the best production results were obtained by the Boema variety, with a percentage of + 6.7%, followed by the Miranda varieties (with an increase of + 0.4%), and the weakest production result was of the Izvor variety with a production difference of - 4.39% compared to the control (Fig. 7).

In Figures 10, 11, 12, 13, 14 are presented the results for yields in the coming agricultural years compared to the average experience.

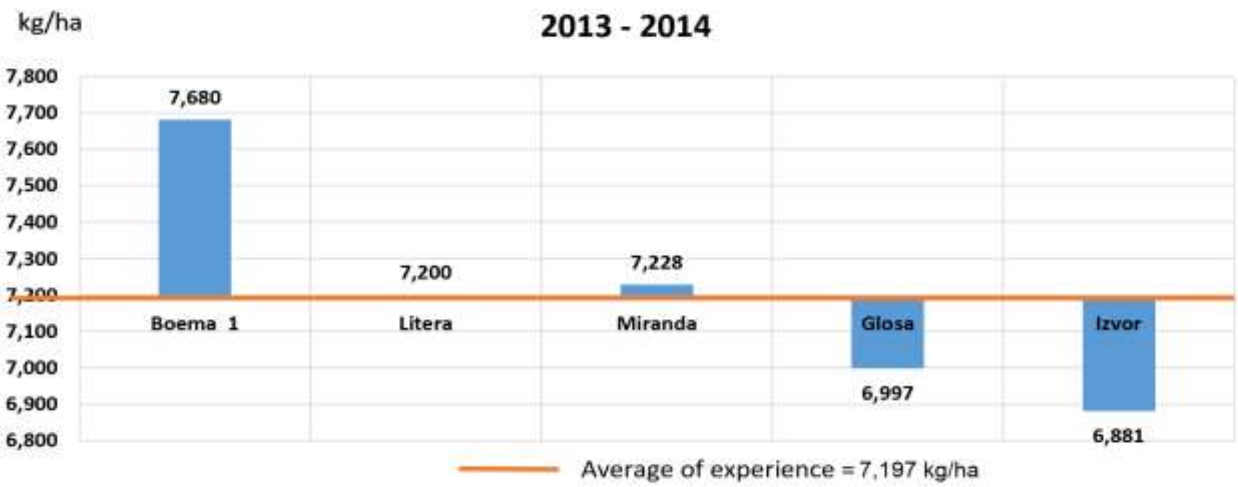

Fig. 7. Average productions obtained for the wheat varieties in 2014,compared to the average experience
Source: Own results [10].

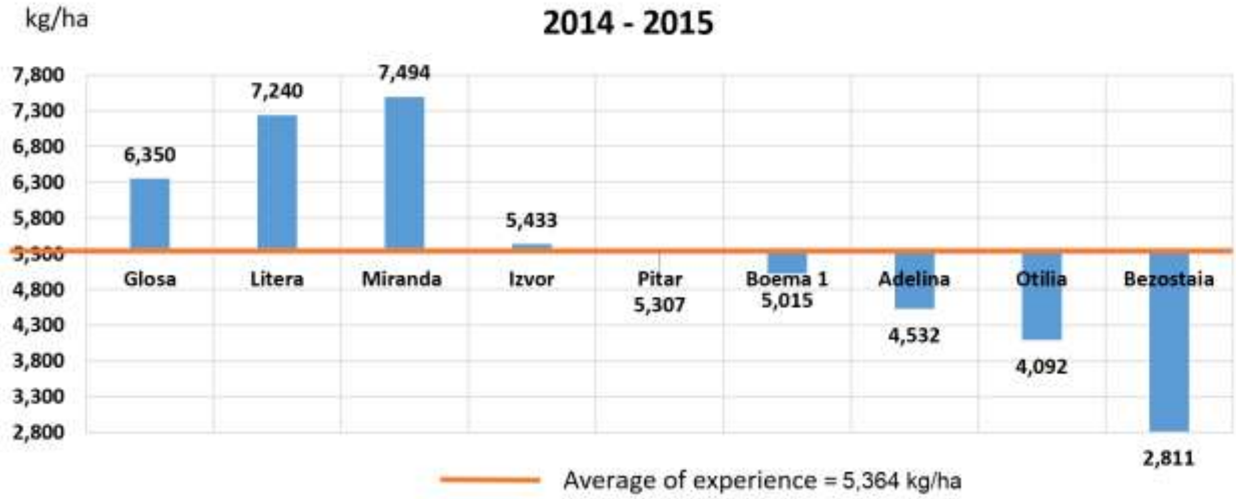

Fig. 8. Average porductions obtained for wheat varieties in 2015, compared to the average experience
Source: Own results [10].

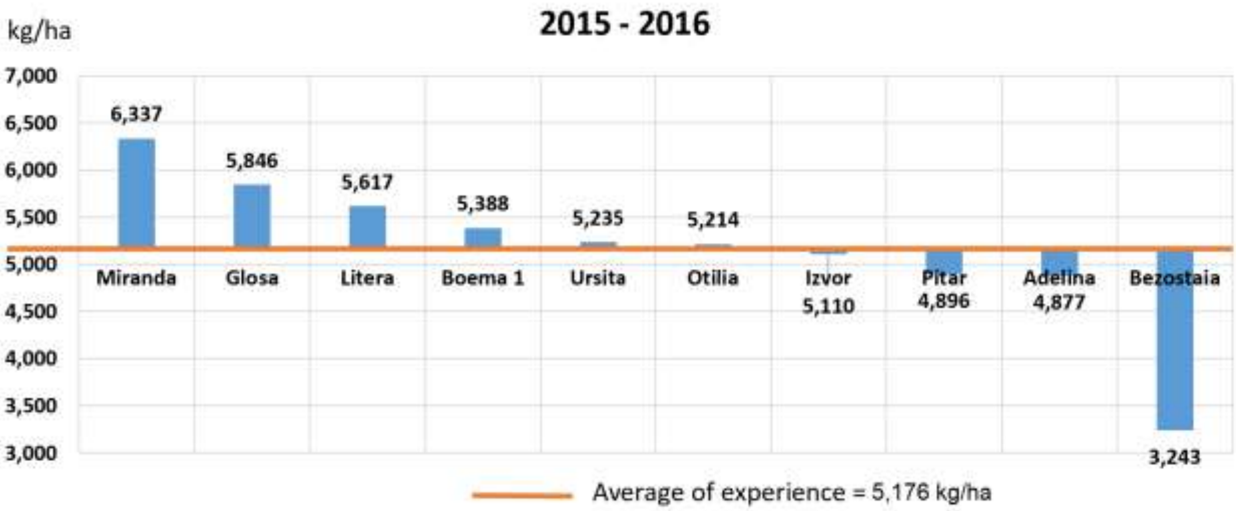

Fig. 9. The graph of the average productions obtained for the wheat varieties in 2016,compared to the average experience
Source: Own results [10].

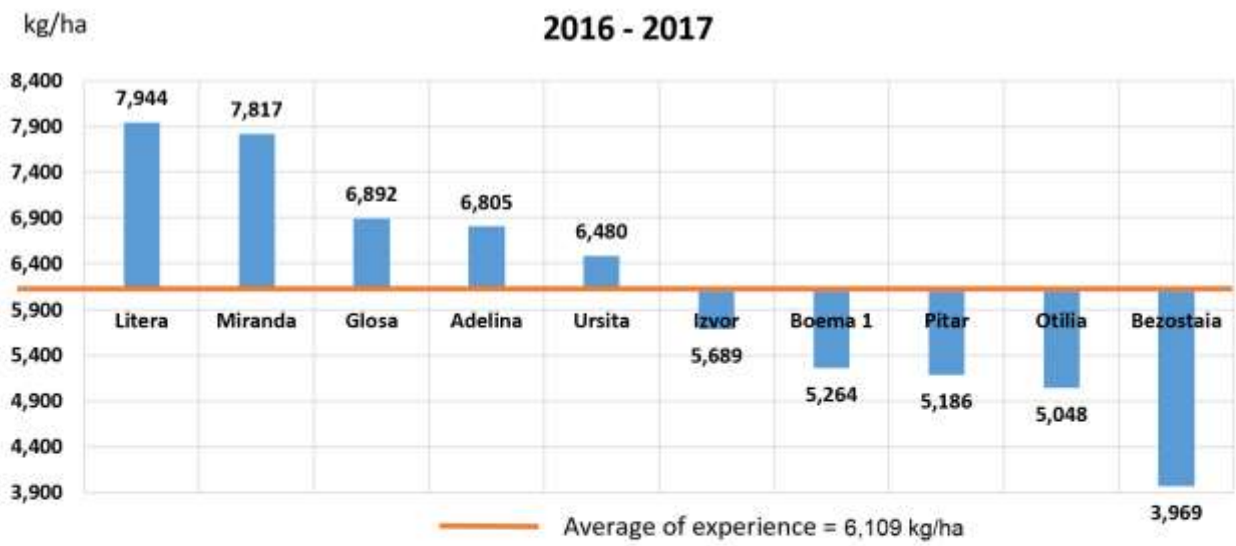

Fig. 10. Average productions obtained for wheat varieties in 2017, compared to the average experience
Source: Own results [10].

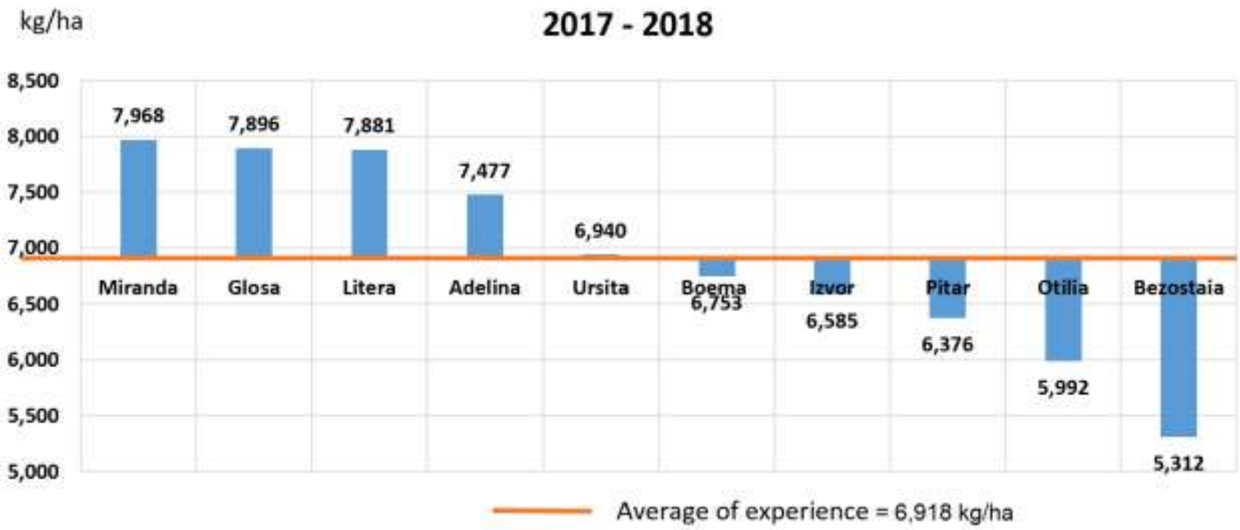

Fig. 11. Average productions obtained for the wheat varieties in 2018, compared to the average experience
Source: Own results [10].

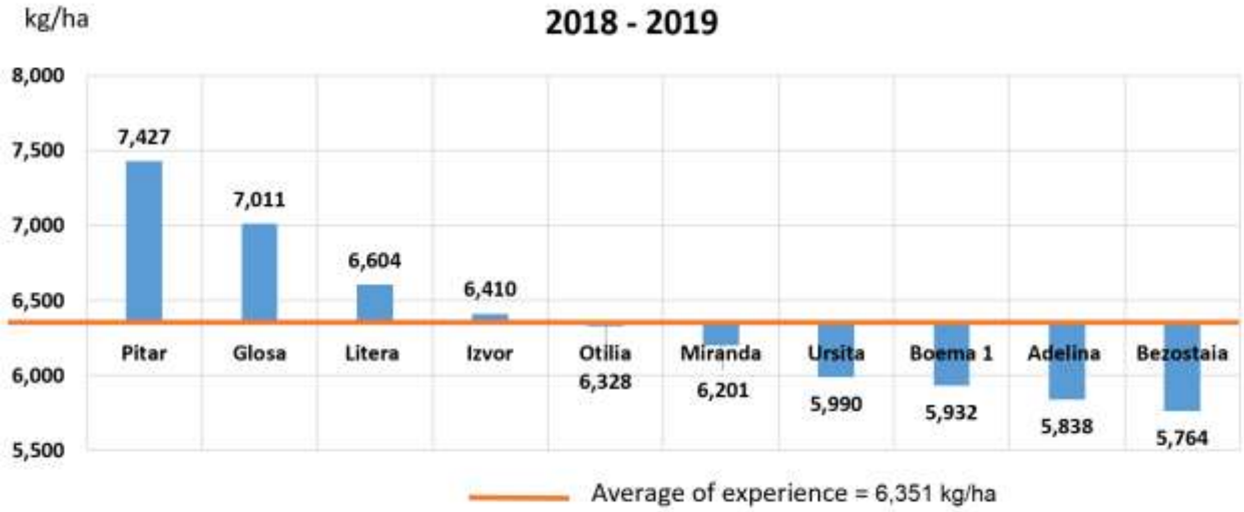

Fig. 12. Average productions obtained for the wheat varieties in 2019, compared to the average experience
Source: Own results [10].

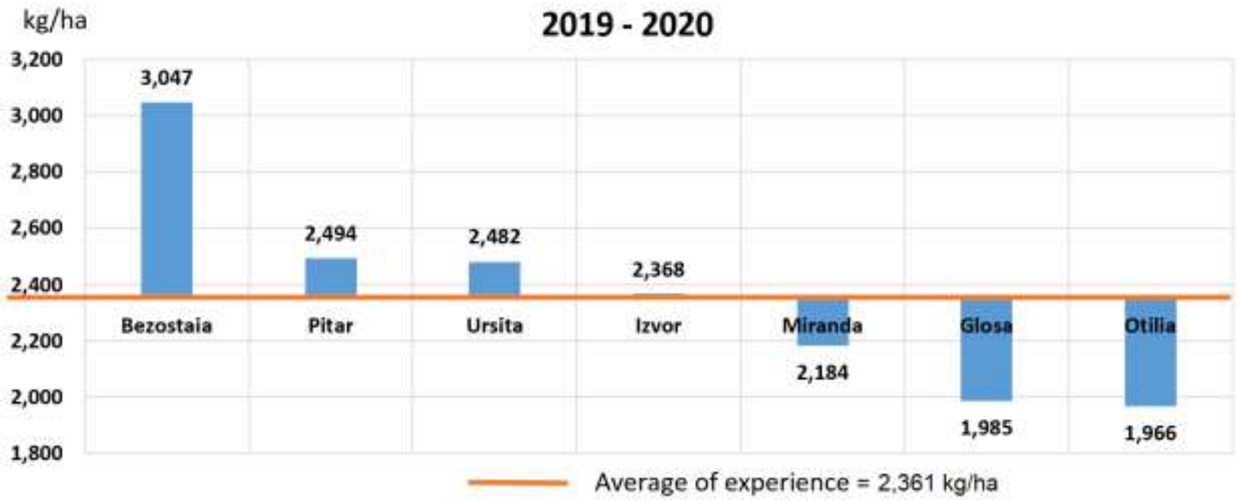

Fig. 13. Average productions obtained for wheat varieties in 2020, compared to the average experience
Source: Own results [10].

It is noteworthy that the Bezostaia variety, an old Romanian variety, obtained the best results in the driest year in the Braila Plain, with a production increase of + 29.05% compared to the average experience, followed by the Pitar and Ursita variety, with + 5.63% and 5.12% respectively (Fig. 13).

In the good years from the point of view of the autumn precipitations and at the end of winter, the most productive Romanian wheat varieties remain Ursita, Glosa, Adelina and Izvor, while the varieties Bezostaia, Pitar, Miranda, Otilia remain very good for the dry years (Fig. 14).

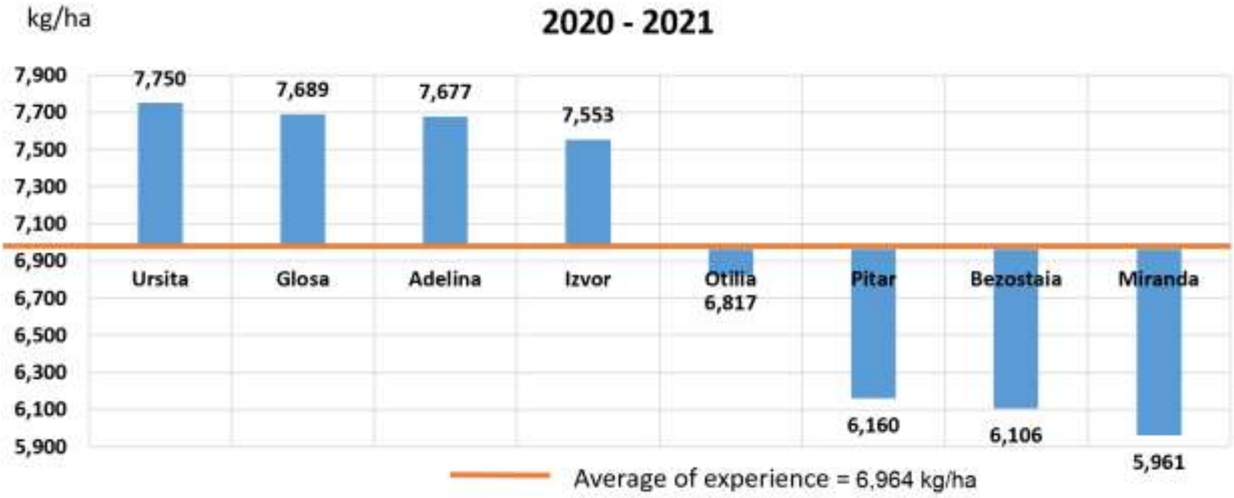

Fig. 14. Average productions obtained for wheat varieties in 2021, compared to the average experience
Source: Own results [10].

CONCLUSIONS

- The new winter wheat varieties are much more productive, compared to the older varieties, such as Bezostaia and Glosa, but they are much more resistant to current climate change, offering a stable production.
- The wheat varieties tested at S.C.D.A Braila in the period 2010 - 2022 reacted differently to the environmental conditions, being registered productions and a different hierarchy of them from year to year.
- There was a stability of the Glosa, Miranda, Litera varieties (varieties over 15 years old from the approval), but last but not least of the new ones created by the National Research-Development Institute from Fundulea such as: Pitar, Ursita, Adelina, Izvor.
- Some of the varieties mentioned above have entered the process of multiplication carried out by S.C.D.A. Brăila.
- In this way, quality seed material adapted to the pedoclimatic conditions specific to the area of influence in South-Eastern Romania is ensured.
-It was found a weak and positive correlation between temperatures and wheat yields , and a positive high correlation coefficient between yields and average rainfalls.

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DIRECT AND INDIRECT TAXATION AND ITS ROLE IN REDUCING THE BUDGET DEFICIT. CASE STUDY

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Abstract

Fiscal policy represents a problem of security and solidarity at the level of each individual state, but also at the community or world level, because ensuring tax revenues can contribute to ensuring economic, social and environmental stability, but at the same time it also contributes to economic development both current, as well as future generations. This can be achieved by improving some important sectors of activity, such as education or health. Each individual state establishes a certain fiscal policy, adapted to its own needs, in which the ratio between direct taxation and indirect taxation, the manner of their application can ensure sufficient fiscal revenues to cover both public expenses, but also allow the achievement of investments. The purpose of this paper is to analyze the two taxation systems, both at the level of Romania and at the level of other EU countries, with the aim of making comparisons and finding solutions regarding the way to improve the fiscal policy in Romania. The research methodology assumed both the analysis of the specialized literature regarding the characteristics of fiscal policies and their role in ensuring economic development, as well as the consultation of internal and international databases from which fiscal information was collected regarding direct taxes and indirect taxes. The data collected and systematized were subjected to an analysis with the help of some statistical indicators. The interpretation of the results allowed us to formulate conclusions that highlighted the fact that although Romania registers a GDP/inhabitant that places it very close to the average of EU countries (72%), in terms of the contribution of tax revenues in the formation of GDP, there is an imbalance, as a result of the weight of 26.3%. This imbalance is due to several factors, among which we were able to identify: low level of collection of fees and taxes to the state budget, granting exemptions from paying taxes or applying preferential fiscal regimes, permanent changes to the Fiscal Code, etc., aspect that, in addition to excessive financing of consumption, contributed to the appearance of the budget deficit.

Key words: *fiscal harmonization, direct taxes, indirect taxes, budget deficit, fiscal policy*

INTRODUCTION

At the level of the European Union, fiscal harmonization is an important objective that contributes to ensuring financial stability both at the community level and at the national level, being provided for in the European treaties and directives through which an alignment of policies was pursued both in terms of direct taxation, as well as indirect taxation. However, the different objectives pursued by each individual member state, the national peculiarities of fiscal policies, have meant that they cannot be applied in full, but efforts continue at the community level. On the other hand, at the level of the union, one of the common objectives was the economic and monetary assurance and consolidation, which is why, the main objective of the European states is to ensure the fiscal resources necessary to cover public expenses, eliminate or reduce budget deficits, which means that taxation is used as a financial, economic and social lever. Romania is also in this situation, which still does not manage to cover the budget deficit that perpetuates itself from one year to the next, thus making impossible a sustainable economic development based on investments and economic growth.

Moreover, in the last decades the world economy and its financial system faced numerous problems (economic crises, the Covid-19 pandemic, the war in Ukraine, etc.) which led to major changes in standards, paradigms, rules, which were influenced in their turn of globalization, digitization, etc. and which required finding solutions to mitigate the consequences of these events with economic, social and environmental impact [10]. This, however, cannot be achieved without building a consolidated strategic cooperation, within which each individual state has its own role [16].

The main tax categories are represented by: capital tax, labor tax, consumption tax, property tax and environmental tax. The way in which these taxes participate directly or indirectly in achieving tax revenues depends on the policy of each state, its level of development and financial stability. Moreover, the fiscal pressure is given by the ratio established between fiscal revenues and GDP [1].

Romania is one of the states that uses indirect taxes as the main source of income, that is, that taxes mainly work and consumption, and less capital and property [9, 11].

Ensuring fiscal revenues is necessary to cover public debts and reduce or eliminate budget deficits, which at the community level are imposed by signing the Maastricht Treaty in 1992 and which aim at the sustainability of public debt and the soundness of public finances. The European Union monitors the budget deficit of the EU states, imposing a limit of 3%, a limit that Romania has failed to meet in recent years [8].

In this context, the purpose of the paper was to compare the situation of fiscality in Romania with that of other member states of the European Union, so that finally to formulate recommendations for the ficsal policy could be improved.

MATERIALS AND METHODS

The research methodology involved the creation of an analysis plan that went through the following steps: preparing the plan, collecting information, verifying the collected information, determining the indicators, interpreting the results and formulating conclusions.

Prepare analysis plan was necessary in order to establish the researched elements that will be the basis of achieving the proposed objectives. It also included elements related to the sources used, the indicators used, the way of processing the information and presenting the results.

The sources of information used were represented by the existing specialized literature, as well as by data taken from international and domestic databases.

The verification of the collected data followed, on the one hand, the accuracy of the information, the degree to which it presents the level of the researched phenomenon, but also the way of its production. The logical examination of the links that exist both between the levels of the analyzed indicators, as well as between their values and the characteristics of the analyzed phenomenon from the period 2016-2021.

The data processing methods were comparison, qualitative and quantitative methods

The interpretation of the data allowed the establishment of conclusions that resulted from the processing of the collected and processed data.

RESULTS AND DISCUSSIONS

An important aspect that characterizes Romania's fiscal system is the fact that tax revenues have a low contribution to the formation of the Gross Domestic Product, which represents a vulnerability in the conditions that they cannot cover public expenses. Thus, at the level of 2022, the revenue contribution was 26%, compared to the average contribution registered at the community level, which was 40%. Another serious aspect is that of the public debt, which in 2022 reached almost 51%, thus becoming more and more difficult to refinance, but also accompanied by a structural deficit. The causes of these deficiencies are numerous, but an essential role is played by fiscal policy, the way in which fiscal revenues are established and collected that could contribute to reducing

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the budget deficit, which became excessive in March 2020 [12, 11].

What is criticized about the fiscal policy in Romania is both the poor collection (in 2022, Romania recorded a VAT non-collection rate of 35%, compared to an average rate of 10% recorded at the community level), as well as the granting of some more fiscal facilities or the application of an unbalanced taxation system in terms of direct and indirect taxes.

An obvious imbalance is registered at the level of Romania between the contribution of tax revenues to the formation of GDP (which is reduced compared to other EU countries, being approximately 26%) and GDP/capita which in 2020 reached 72% of the value recorded at the community level (Figure 1),

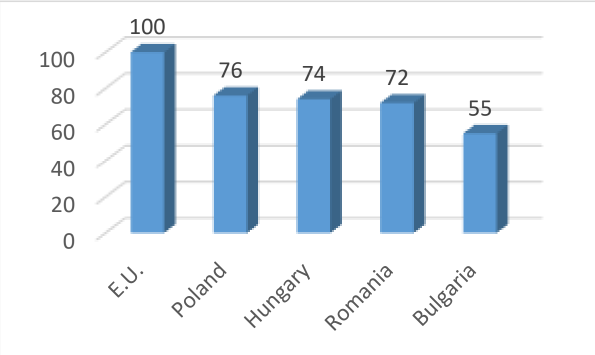

Fig. 1. The share of GDP/capita in Romania compared to the EU average and othe countries (%)
Source: own processing based on Eurostat data base [7].

An analysis of the evolution of direct taxes highlights the fact that the largest share is represented by the income from social contributions related to salary income, which, however, due to the fact that they are deductible from gross income, are correlated with the lower income from the salary tax. These revenues, with a weight of 12%, are below the European average of approximately 15%.

Another direct tax is the profit tax, respectively income or specific tax. The specific tax began to be applied to medium and large HoReCa entities starting in 2017, when the profit tax was eliminated, and from January 1, 2023 it no longer applies. It was found that this taxation system was ridiculous, but it was maintained as a result of the fact that the sector was heavily affected by the Covid-19 pandemic.

The income tax, of 16%, is paid by a relatively small number of economic entities, compared to the number of entities paying income tax, which until 2022 was 1%, respectively 3%. Starting with January 1, 2023, the income tax was restricted to 1%, the condition being that the respective entities have at least one employee. Also, the turnover was reduced up to which the economic entities can remain paying tax on the turnover.

Income from indirect taxes results from VAT, excise duties, customs duties, etc. that is, from consumption taxation.

From the data related to the revenues planned by the Budget Law for the period 2016-2021, we find that a significant increase in 2019 in revenues from turnover, this is due to the significant increase in payers, economic entities classified as micro-enterprises (by approximately 15% in 2019 compared to 2016). If in 2016, the share of micro-enterprises (turnover tax payers) from the total of economic activity tax paying entities was 72%, and 28% were profit tax paying entities, in 2019 their share increased to 87%, against 13% profit tax paying entities.

In order to have a real picture of the contribution of each category of income to the formation of the gross domestic product, the analysis followed the weight of the five categories of income and their evolution in the period 2016-2019 (Table 1).

Table 1. Evolution of revenues planned by the Budget Law (million lei)

Income	2016	2019	2021
Income from corporate tax	14,331,284	15,916,594	17,388,366
Income from turnover tax	553,119	2,644,929	2,668,958
Income from payroll tax	25,871,374	23,560,790	26,166,190
Income from social contributions	38,041,851	71,689, 581	73,504,857
VAT income	52,342,288	69,647,956	69,698,446

Source: Own processing based on teh data from [14, 15].

In this way, we note that the participation of income from the corporate profit tax contributed 1.46 - 1.89% to the formation of

GDP, with a reduction of this contribution in 2021 compared to the previous period. In terms of turnover revenues, they had the largest contribution to GDP formation in 2019 (0.26%). Moreover, there is a reduction in the contribution of all five categories of income in the formation of GDP for the year 2021. However, the largest contributions are the income from labor taxation (social contributions with weights of 5.01% of GDP in 2016, of 6.58% in 2021 and of 7.01 in 2019; but also payroll tax with contributions between 2.30% in 2019 and 3.41% in 2016) and VAT revenues which in 2016 contributed 6.89% to GDP formation, in 2019 with 6.81%, and in 2021 with 6.24 %.

What represents a negative aspect, emphasized before, is Romania's VAT GAP, which is among the largest among the countries of the European Union, and which is due to the reduced collection of revenues to the state budget. Although the VAT rates in Romania (5%, 9% and 19% until 2022) were close to those of the EU states, or above these rates, their contribution to GDP is 3% lower than the EU average (Figure 2).

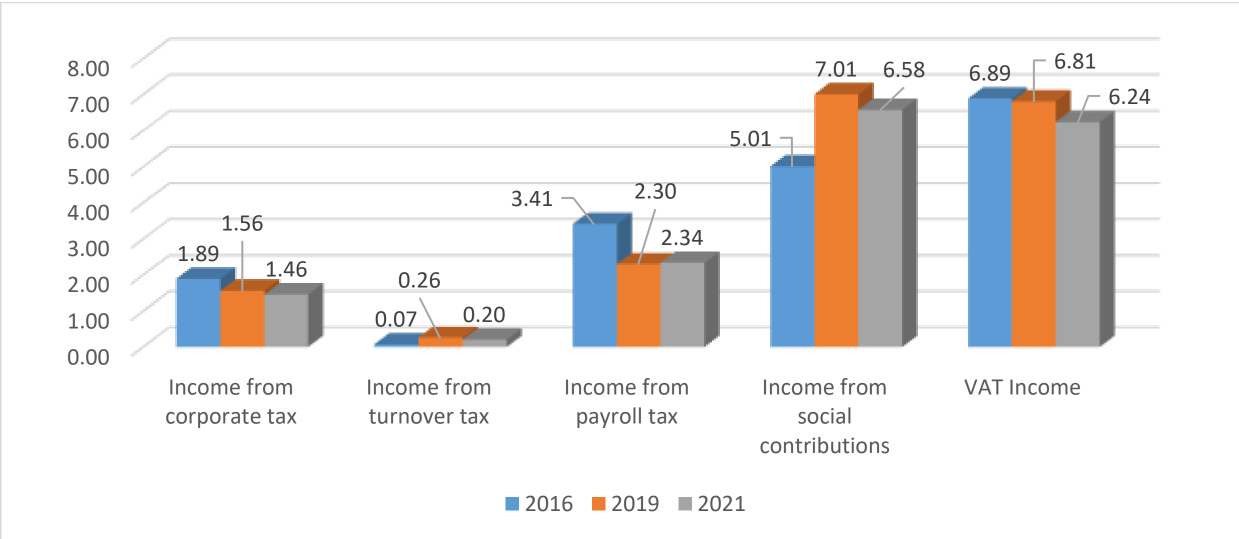

Fig. 2. Share of income from taxes and fees in GDP (%)
Source: own processing based on the data from [7].

The data for 2020 highlight the fact that compared to other European Union states, Romania participates with the lowest contribution of taxes to GDP formation (26.3%), compared to an average of 40.2% in the European Union or compared to 36.3% in Hungary and 35.7% in Poland. Bulgaria, for its part, contributes 30.6% to GDP from fees and taxes.

Another aspect that must be emphasized is the fact that, if at the level of the European Union the contribution of direct and indirect taxes is almost equal (13.0% direct taxes and 13.6% indirect taxes in 2016), both in Romania and in the other states in the analyzed sample there is a high share of indirect taxes in GDP (Figure 3).

But Romania has the lowest share of these contributions, indirect taxes participating with 6.4% in GDP formation, (compared to 7.1% in Poland, 7.3% in Hungary or 5.8% in Bulgaria) and 11.4% contribution from indirect taxes (compared to 18.2% in Hungary, 15.6% in Bulgaria or 13.6% in Poland) as it is show in Figure 3.

The same balance regarding teh direct and indirecct taxes in the EU is maintained in the next period (13.2% direct taxes and 13.7% indirect taxes in 2019; and 13.3% direct taxes and 13.4% indiresct taxes in 2020).

As we easily notice, in the EU, the share of direct taxes increased in the total GDP increased in the period 2016-2020, the smae trend was registered in Poland and Bulgaria.

Romania was the only country were the share of dircet taxes declined. If in 2016, the income from direct taxes contributed by 6.4% to GDO, in 2020, the share was only 4.7% (Figure 4).

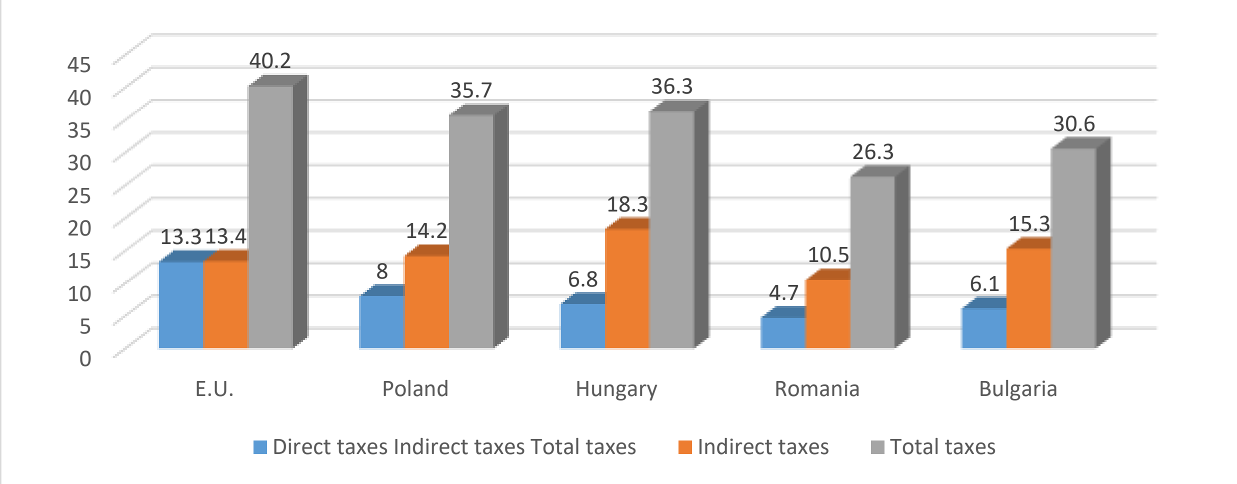

Fig. 3. The share of taxes in total GDP (%) in 2020
Source: own processing based on teh data from [4, 2, 3, 5, 6].

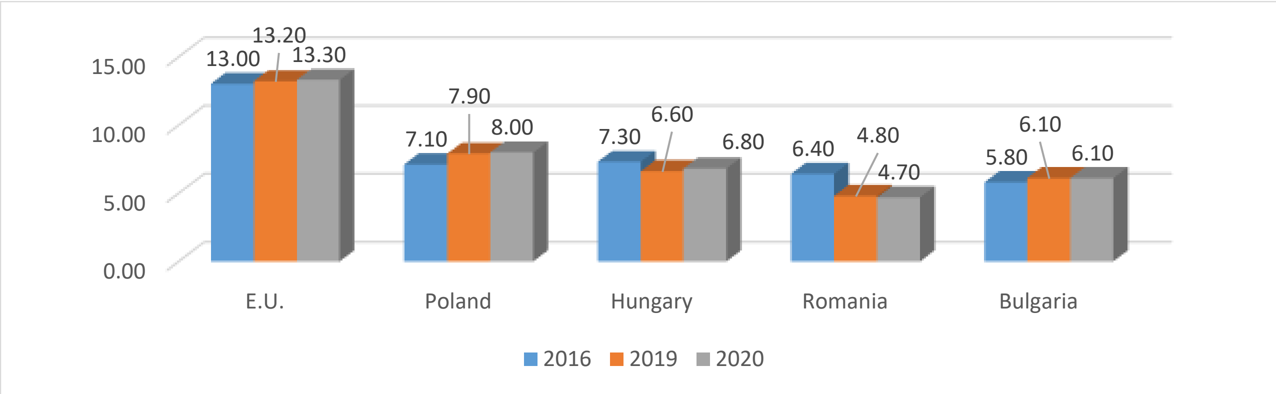

Fig. 4. Share of direct taxes in GDP in the period 2016-2020 (%)
Source: own processing based on the data from [4, 2, 3, 5, 6].

Concerning the contributions given by indirect taxes to GDP, we found out that Hungary, Poland and Bulgaria are situtaed over the EU average. But Romania continued to remain below this level with contributions to GDP of 10.5% in 2016, de 10.7% in 2019 si de 11.4% in 2020 (Figure 5).

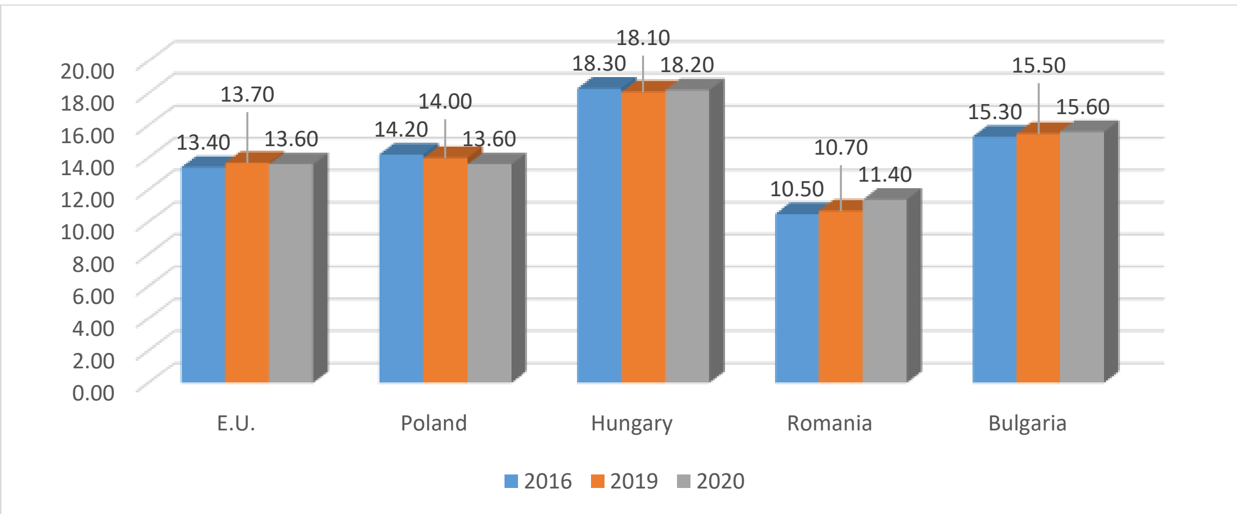

Fig. 5. Share of indirect taxes in GDP in the period 2016-2020 (%)
Source: own processing based on the data from [4, 2, 3, 5, 6].

Although social contributions in Romania have the highest weight among all fiscal revenues that contribute to the formation of GDP, they are both below the European Union average, but also below the values of other EU countries. We find that in 2016 the country that had a contribution higher than the EU average it was Hungary, and in 2019 and 2020 Poland. Bulgaria with figures of 7.7% of GDP in 2016, 8.8% in 2019 and 9.2% in 2020 is below the values of the other countries in the analyzed sample.

Although in Romania the value of social contributions in GDP is not at all small, there is also a problem related to "black" or "gray" work, which means that part of the contributions are not withheld and paid, which then contributes to the registration of tax revenues low (Figure 6).

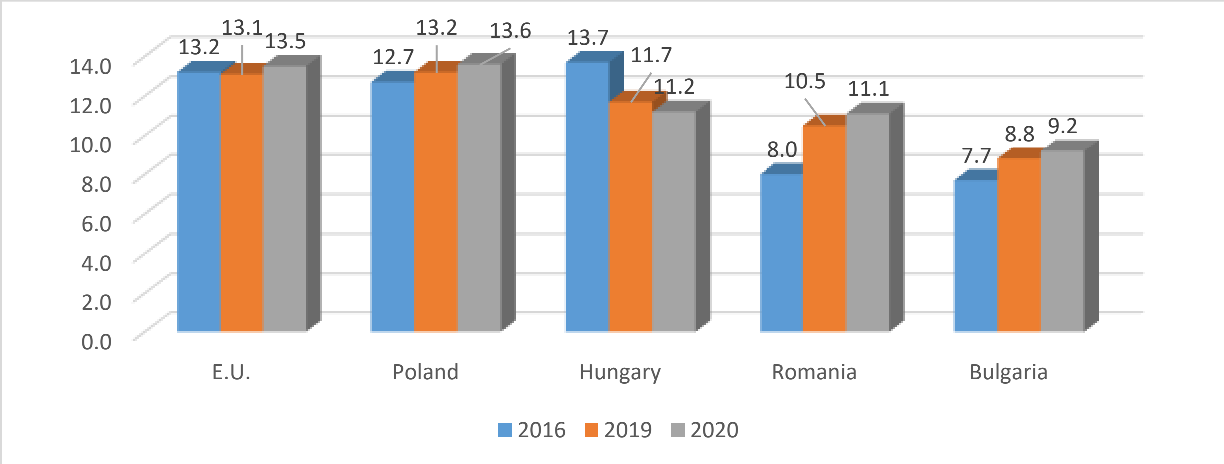

Fig. 6. Share of social contributions in GDP during 2016-2020 (%)
Source: own processing based on the data from [4, 2, 3, 5, 6].

From the analysis of the other categories of taxes represented by consumption tax, labor tax, capital tax, environmental tax and property tax, we find that in Romania the largest share in GDP, but also the closest value to the average of the Union European is owned by the consumption tax and the labor tax, this together with the social contributions being taxes withheld from the employee and paid by the employer, as a result of the fiscal changes of 2017. At the same time, but in terms of consumption tax and labor taxation, they have the closest value to the European Union average. In addition to these taxes, social contributions are also withheld from the employee, but are paid by the employer, this being established following the fiscal changes of 2017. Another observation related to the Romanian taxation system is that the property tax it is a relatively low one compared to the weight it registers at the level of the European Union. Its share is between 23-35% of it. A tax that comes close to that of the European Union is, however, the environmental tax, which, due to the legislation adopted and which has weights between 1.9-2.5% of GDP (Table 2).

Table 2. Evolution of revenues planned by the Budget Law (million lei)

Tax category	2016		2019		2020	
	E.U.	Romania	E.U.	Romania	E.U.	Romania
Consumption tax	11.1	10.1	11.1	10.2	10.8	10.0
Labor tax	20.5	10.0	20.7	12.0	13.0	21.5
Capital tax	8.1	5.1	8.1	3.9	7.9	3.3
Environmental tax	2.5	2.4	2.4	2.1	2.2	1.9
Property tax	2.3	0.8	2.2	0.7	2.3	0.6

Source: own processing based on the data from [4, 2, 3, 5, 6].

The environmental tax refers to different categories of taxes applied to energy, transport (with the exception of fuel tax) and pollution taxes. Energy taxes being close to the community ones, they can no longer be increased. As far as taxes on pollution and mineral resources are concerned, they are almost non-existent in Romania. Their application, as in the other EU states, could contribute to supplementing the revenues collected to the state budget.

CONCLUSIONS

What we find based on the analyzed data is that in Romania the level of tax revenues is low as a result of their taxation system. Thus, consumption is under-taxed compared to EU countries. Even if the stimulation of consumption is what leads to an increase in GDP, this is due to the increase in imports, which have the effect of creating a current account deficit. In 2021, this deficit reached 7% of GDP, far outside the European regulations.

What is found from the analysis of the Romanian tax system is the fact that both capital and property are undertaxed in Romania, with much lower weights compared to the EU countries.

The causes that contribute to this deficit in the registration of fiscal revenues are represented by the low level of collection of taxes and fees (as is the case with VAT), the fact that there are numerous exemptions and exemptions applied to different categories of payers or the application of preferential taxation regimes in certain sectors of activity (IT, construction, etc.) that lead to the reduction of the taxable base. Nor is the fact that digitalization is not yet implemented at the level of the other EU states an aspect to be neglected.

All these aspects contribute to the increase of the budget deficit which has become recurrent and which requires refinancing which must cover the consumption needs without allowing the realization of the much needed investments in infrastructure, health or education.

Romania's taxation system, based on indirect taxation, could contribute to the reduction of the budget deficit to a much greater extent than the application of direct taxation, but it must be accompanied by an increase in the level of collection and a reduction in tax evasion. In this way, direct taxation could be used for the purpose of attracting capital, by investors, thus using the model applied by Hungary, Poland or the Czech Republic.

The reduction of the budget deficit can only be achieved through a consolidation of the public budget which, however, will last for a few years, so that the economy can respond to the measures taken by the new Fiscal Code applied from January 1, 2023 and by which a sustainable correction of budget imbalance.

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STUDY ON THE PERCEPTION OF COMPANIES REGARDING SOCIAL RESPONSIBILITY AND THE IMPORTANCE OF NON-FINANCIAL REPORTING

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Abstract

Starting from the importance that non-financial reports have for sustainable development, through this work we have proposed to analyze the importance given by the management of companies to social responsibility activities, but also the degree of involvement in this category of activities, bearing in mind the fact that Romanian legislation requires the submission of non-financial reports, which accompany the financial reporting. The current research was structured in two parts, in which a documentary analysis of the specialized literature was carried out with the aim of defining corporate social responsibility and presenting the role it has both in the activity of a company and in the community in which it carries out its activity, but also in measuring the companies' perception of this concept. In this sense, a questionnaire consisting of 10 questions was applied to the companies obliged to make a non-financial report. The questionnaire was applied to a group of companies from Bucharest and Ilfov county, with more than 500 employees. The response rate was 79%, these being recorded between September 10 and December 10, 2022. The data collected were processed and interpreted statistically, so that conclusions can be drawn regarding the importance of social responsibility for companies. What was found empirically was the fact that companies that invest in corporate social responsibility have a plus in building their reputation, being able to consider it a component of their marketing policy, which has positive effects on economic performance. On the other hand, there is also an increase in their ability to adapt to change, easier access to financing sources or increased sales.

Key words: *corporate social responsibility, non-financial reporting, economic performance*

INTRODUCTION

In a world in constant change, where globalization was the concept that shaped business, society, the environment, the way of thinking and acting, new ideas related to equity, solidarity, responsibility appeared, which led the desire to "give back" something to the community, to act in the direction of sustainable development, of social responsibility, which thus became business concepts and which in turn left their mark on corporate governance, which also became a desire of the beginning of the sixth century XXI [12].

However, the concept of social responsibility is not a new one, it began to be developed after the Second World War, when large companies, being in a stage of economic growth, began to assume a role in society, being concerned with solving social problems. However, the term social responsibility does not overlap with socially responsible actions, because this concept, which appeared in the 19th century, refers to a singular action that is part of a company's strategy, without having a commitment to anyone or against some already existing social values. Either corporate social responsibility represents that commitment that the corporation makes voluntarily towards society, but also towards other parties involved in those actions that are part of the sphere of economic activities and that aim at the good of the community [1, 8, 10, 2, 17].

However, the modern foundations of social responsibility were laid in 1999, during the World Economic Forum in Davos, where the Global Compact initiative was presented, which through 10 universal principles (related to human rights, anti-corruption, labor standards, environmental protection, etc) promoted corporate responsibility.

Over time, social responsibility has been called: sustainability, business ethics, corporate social conscience, community business, corporate philanthropy, triple balance sheet, "corporate citizenship", being a concept that refers to the contribution of companies to the development of modern society [5, 16, 7, 9, 18, 19, 20].

Corporate social responsibility is defined by the World Business Council as an organization's contribution to sustainable economic development "the commitment of business environments to contribute to sustainable economic development by working with employees, their families, the community local and society as a whole to improve their quality of life" [21].

The European Commission considers that corporate social responsibility represents a way in which companies, through the actions and measures taken, voluntarily contribute to social development and environmental protection. These actions are included in their development strategies and involve both costs and benefits, which then indirectly contribute to increasing profitability and improving the company's image [3].

According to the legislative regulations, corporate social responsibility has a voluntary, but at the same time moral character, which is assumed by companies that, in addition to profitability, must also ensure a long-term social component and which must be included in the company's development strategy. Social responsibility carries costs, but profitability is determined by the credibility that the entity has in front of its business partners, its own shareholders, as well as the community, the social environment or the local, community environment in which it operates

Therefore, social responsibility has several categories of objectives: economic objectives, in that it creates wealth both for shareholders, associates, employees, the community), ecological objectives (ensuring the conservation and sustainable management of resources) and social objectives (ensuring social equity) .

Although Romania did not have a tradition of social responsibility until 1990, it started this activity through public or private NGOs that started to carry out humanitarian activities. With the change in legislation, with the alignment to European and world standards, with the emergence of large international private companies, different practices of social responsibility began to be developed. If initially social responsibility had the role of increasing consumer confidence, increasing the company's reputation or creating a certain image on the market, later the actions were also directed towards sustainable development and community development actions.

The development stages continued, but were influenced by the economic crisis that started in 2007 and had effects until 2010, 2011. In turn, the Covid-19 crisis, although it brought a reduction in the funds attributed to social responsibility actions, represented a moment when many companies were involved in such activities, offering support to the community.

Aware of the importance of social responsibility, an increasing number of companies have begun to "build" strategies and responsible practices that contribute to the general well-being. This is also supported by the national legislation aligned with community and international standards through which proactive product or service innovations can be brought that even if from an economic point of view they are not as efficient, they are more sustainable or meet social needs, being aimed at areas such as community support, education, the environment, etc., thus respecting the principles of sustainable development, i.e. maintaining a sustainable future for future generations [11].

Thus, from 2017, public interest companies that have more than 500 employees at the time of drawing up the balance sheet are obliged, according to OMFP 1938/2016 [13], to publish in the administrator's report a non-financial statement that refers to social aspects, the well-being of employees, of human rights, environment, combating corruption, and from 2019, through OMFP 3456/2018, the area of applicability of this non-financial information became mandatory for all categories of companies that exceed a maximum of 500 employees [14].

After the adoption of the Green Pact, at the level of the European Union, Regulation 852 was developed, appearing in 2020 and applicable from January 1, 2022 for the financial reports related to the financial year 2021, for those companies that apply the NFRD [4].

There is the obligation that, in addition to the information related to social responsibility, these non-financial reports should also include information that proves that the economic activities carried out by the entities are not only profitable, but they are sustainable for the environment.

The reporting includes a series of key performance indicators (the share of turnover resulting from environmentally sustainable economic activities, the share of capital expenditures and operating expenses related to assets or activities associated with sustainable economic activities from the point of view of the environment).

Those activities that can contribute to the stabilization of greenhouse gas emissions must also be identified, according to the long-term objective of limiting climate warming.

In this way, the companies, which can make this report voluntarily even if they do not have the limit of 500 employees, make public their sustainability and social involvement effort.

At the international level, there are other categories of reports that complement the non-financial report (GRI, SASB, IIRC, CDP; SDGs; DJSI) [6].

In this context, the objective of this paper was to assess the importance that the management of companies gives to their involvement in social responsibility activities, as a result of the mandatory submission together with the financial reporting and a non-financial reporting.

MATERIALS AND METHODS

The research methodology involved a bibliographic study on the importance of social responsibility within companies that report non-financially, as well as a case study carried out on a number of 26 companies from Bucharest and Ilfov, belonging to different fields (telecommunications, pharmaceutical, production, banking, retail, IT, etc.) to which a questionnaire was applied regarding corporate social responsibility.

The questionnaire, which had 10 questions, was applied between September 10 and December 10, 2022, with a response rate of 79%. The questions were open (question no. 10), dichotomous (question no. 2) and semi-open (questions 3-10), being appropriate, clear and undistorted [15].

The questions were the following:

(1) How many employees does your company have?

(2) In the development activity of your company, have you integrated corporate social responsibility activities?

(3) Did your company have a budget for social responsibility activities? What value did it have?

(4) Have you funded any corporate social responsibility activities through your company?

(5) Were corporate social responsibility activities directed at these social areas?

(6) Were non-profit institutions also involved in social responsibility actions?

(7) What were the programs you financed?

(8) What were the results of the social responsibility projects carried out?

(9) Who were the beneficiaries of the social responsibility actions?

(10) Are there other areas in which you would like to be involved in order to increase social responsibility?

RESULTS AND DISCUSSIONS

The questionnaire including the 10 questions was applied to companies that have the obligation of non-financial reporting. The respondents were persons involved in the management of the company or persons involved in the elaboration of non-financial reports. Based on the answers collected and processed, it was possible to analyze the existing perception at the company level regarding the importance of involvement in social responsibility activities and the advantages of reporting, both for the company and for the community.

Thus, from question no. 1 *How many employees does your company have?* it resulted that of the 26 entities that responded to the questionnaire, 31% have more than 10,000 employees, 23% have a number of employees between 5,000 and 10,000 employees, 19% have a number of employees between 1,000 and 3,000 employees, 15% have a number of employees between 500 and 1,000 employees, and 12% of the companies have a number of employees between 3,000 and 5,000 employees (Figure 1).

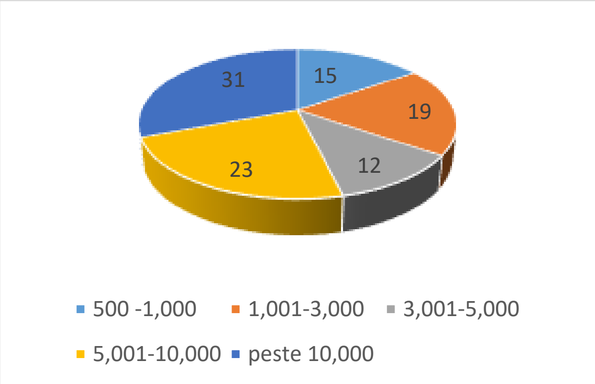

Fig. 1. The structure of the companies, according to the number of employees (%)
Source: own processing.

From the answers given to question no. 2 *In the development activity of your company, have you integrated corporate social responsibility activities?* it is found that 96% of the companies are involved in social responsibility activities.

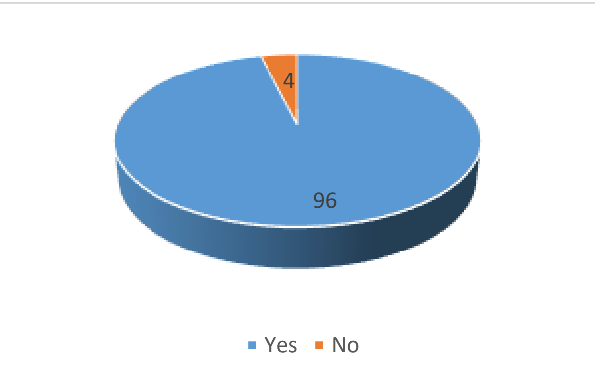

Fig. 2. Categories of companies involved in social responsibility actions (%)
Source: own processing.

From question no. 3 *Did your company have a budget for social responsibility activities? What value did it have?* It results that 19% of the companies allocated amounts less than 500,000 lei to support social responsibility activities. However, more than half of them allocate important funds to social responsibility actions (42% allocate amounts between 500,000 lei and 1,000,000 lei, and 15% with funds up to 5,000,000 lei (Figure 3).

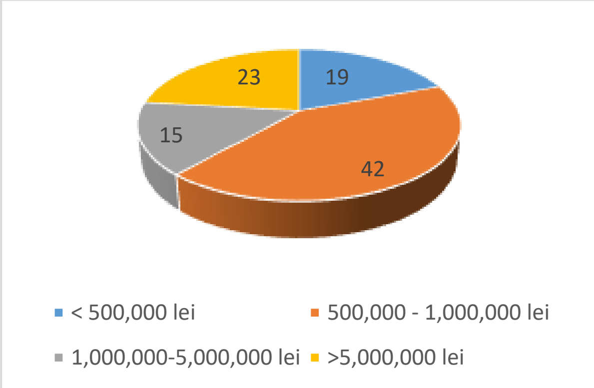

Fig. 2. The structure of companies involved in social responsibility actions, depending on the amounts allocated (%)
Source: own processing.

From question no. 4 *Have you funded any corporate social responsibility activities through your company?* the result was that 8% of the companies did not finance such actions, also due to the fact that financial reporting will become mandatory from the current financial year. However, what is found is that 4% of the companies, anticipating the mandatory reporting, have provided in their strategies different social responsibility activities.

A study prepared by CSR Media shows that during the #Stay at home campaign during the Covid-19 period, through the participation of over 100 companies, sums between 50,000-10,000,000 lei, respectively 20,000-1,000,000 euros were donated, which in total represented over 54 million lei and over 12 million euros that were donated to different hospitals, foundations or the Ministry of Health with the aim of supporting the fight against the Coronavirus.

From the answers given to question no. 5 *Corporate social responsibility activities were directed towards which social fields?* it turns out that most funds were allocated to support environmental protection actions (39%). Also, actions to support educational programs (18%) and sports programs (13%) are among those promoted by companies. Funds representing 13% of the total were allocated for actions to support the disadvantaged categories, especially those during religious holidays (Christmas and Easter) (Figure 4).

Fig. 4. Structure of social responsibility actions supported by companies (%)
Source: own processing.

From question no. 6 *Were non-profit institutions/ associations/foundations also involved in social responsibility actions?* it results that 52% of the funds granted to support social responsibility actions are directed to organizations involved in such activities.

From the answers given to question no. 7 *What were the programs you financed?* it is found that the largest share of funds (32%) are used in the promotion of business actions and in philanthropic actions (27%). Also, 12% of the funds were used in the promotion of social marketing actions, and 8% in volunteer activities (Figure 5).

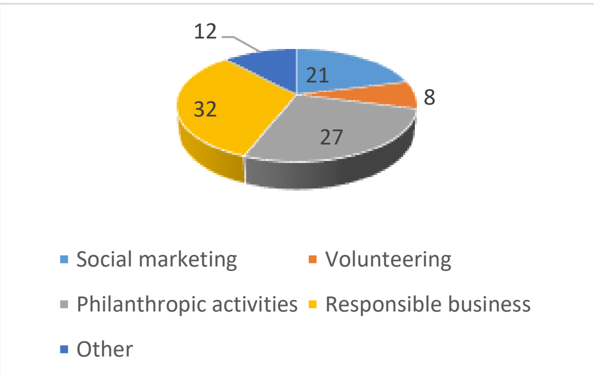

Fig. 5. Structure of social responsibility programs (%)
Source: own processing.

To the question with no. 8 *What were the results of the social responsibility projects carried out?* 17% of the respondents believed that they had increased trust in the company, 28% believed that the visibility of the company increased, 19% believed that there was an increase in sales, and 36% chose all 3 options of answer.

From the answers given to question no. 9 *Who were the beneficiaries of the social responsibility actions?* it resulted in a 100% proportion that the actions taken were useful both to the companies and to the community, the answer options offered being: for the company, for the community, for the company and the community.

From the open question with no. 10 *Are there other areas in which you would like to be involved in order to increase social responsibility?* it results, in the order of ordering of the domains that they are: education, health, employment, environment, sport, culture, human rights, others.

CONCLUSIONS

Social responsibility and non-financial reporting or sustainable reporting bring many advantages to companies. In addition to improving their reputation or increasing the trust of third parties, we can also add improving governance at the company level, increasing the degree of attractiveness for people interested in the company or reducing various risks. At the macroeconomic level, actions can contribute to the progress of society, to the improvement of people's living standards and their health worldwide.

The case study highlighted the involvement of companies with more than 500 employees in such actions. It is found that they still want to be involved in activities that belong to the fields of: education, health, employment, environment, sport, culture or human rights. Also, the representatives of the companies agree that in addition to the goal of development, communication, actions they had a beneficial effect on their economic entities.

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STUDY ON THE PERCEPTION OF GRADUATES REGARDING THE ATTRACTIVENESS OF JOBS IN AGRIBUSINESS

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Abstract

The objective of the current study was to identify the perception of the graduates of the Engineering and Management of Agricultural Businesses specialization within the Faculty of Management and Rural Development regarding the attractiveness of the agribusiness field. In the framework of the research, the answers were obtained from the graduates of the 2021 promotion, belonging to the form of distance education, based on a questionnaire. From the total of applied questionnaires, a response rate of 87% resulted. The number of valid answers was 128. Information collected based on the questionnaire was statistically processed, resulting in information regarding the perception of the importance of the agribusiness sector, regarding the desire to work in this field or regarding the motivation of choosing to pursue higher studies in the analyzed field. The research methodology also assumed the bibliographic study regarding the place occupied by agriculture and agribusiness in the Romanian economy, regarding the labor force in this field and the development possibilities. The obtained results highlighted the fact that agribusiness is an attractive field, in which the majority of graduates want to work as employees or as business owners (68%). The reasons for choosing to carry out the activity in the field of agribusiness are diverse, from the awareness of the importance of agriculture in ensuring food security, to the attractiveness of the income obtained or the ownership of agricultural land and the development of a business.

Key words: *agribusiness, graduates, motivation, attractiveness, workforce*

INTRODUCTION

The importance of agribusiness in economic, social and environmental development, although it is a current topic, was addressed by Adam Smith and David Ricardo who considered that the wealth of nations is determined by the value of production, but also by the structure of the branches of an economy [13, 15].

Starting from the fact that agriculture represents one of the important sectors of activity for Romania, and which until now has undergone important changes both in terms of the property structure, but especially in the approach to the production system, aligning thus the general trends of modernization and becoming more and more competitive, more adapted to market realities, more complex and more sophisticated due to the new technologies that include digitization in the production, storage, distribution and sales systems, we consider that it represents an important field that can to attract an important part of the labor force [17]. The place occupied by agriculture and agribusiness is due both to the agricultural potential of Romania, but especially to the investments made in this sector, both in equipment and in infrastructure. An important element that contributed to the development of the sector was represented by the awareness that added value has a high potential in terms of improving business profitability. The concept can be applied both at the global business level, but also at the local business level [3, 6, 7]. On the other hand, the agricultural potential must be doubled by the development of complementary, modern, sustainable businesses that can compete with other existing businesses at the community and global level, which are part of a large industry, and which must keep up with the permanent changes in technology that makes the difference between the existing players on the market, to face the competition of the existing prices on the global markets, and last but not least to take into account the preferences of the consumers which are in continuous change.

All these considerations have contributed to the emergence of stronger, more professional, more informed, more competitive and adaptable market players to the needs and profile of the modern buyer, players capable of adapting to buying and consumption behaviors, so as to in the face of increasingly high competition. In addition to the producers, the agribusiness market is also formed by the companies of input for agriculture, distribution, marketing, etc. that make this sector a complex one characterized by numerous connections [5]. These links are established with various other business categories located both vertically and horizontally and which include different fields: banking, financial, commercial, educational, etc. [14]. Therefore, between agriculture and agribusiness there is a strong synergy that allows the development of many areas, which can contribute to increasing incomes and reducing poverty in rural areas [2].

Some economists believe that vertical development was influenced by factors that had a negative effect on local economies, small farmers, with social and environmental implications (insufficiently regulated globalization, tariff barriers, low transport costs, intensive use of technology and inputs, etc.) [12], effects that had to be counteracted through various policies and measures. Increasing the competitiveness of small farmers is one of the objectives of the Common Agricultural Policy [4], which encourages the increase in the employment rate of the population in the rural environment, which will lead to economic growth and sustainable rural development [16].

At the level of Romania, agriculture is an important sector, and this also results from the degree of occupation of the population. At the level of this branch, the employed population totals almost 850,000 people on January 1, 2022. Out of all of them, 54% were men, that's the majority (about 97% work in the private sector). The difference is represented by the population working in the public sector (2.8%) or mixed (0.2%). Of the total employed population existing in Romania, approximately 11% work in agriculture and in other fields complementary to agriculture.

Thus, on January 1, 2022, the population employed in agriculture, forestry and fishing was 846,500 people, of which 54% were men and 46% were women. Of these, 96.8% work in the private sector, 3% in the public sector, and 0.2% in the public or mixed sector. It is thus established that the share of the population employed in agriculture and related fields is almost 11% of the total employed population. In relation to the professional status, the population in agriculture represented almost 16%.

In relation to the form of wages, we note that a significant proportion of the people who work in agriculture are private entrepreneurs, i.e. self-employed workers (53%), followed by unpaid workers as a result of the fact that they carry out their activity on their own farm (31 %). Employees represent 15%, and those who own the businesses as owners reach only 1%.

Of the total population employed in agriculture, the largest share is owned by the South-West Oltenia region (19%), and the smallest shares by the South-East (9%) and Center (10%) regions. Except for Bucharest, with 1%). The other development regions have relatively equal shares, between 11-14%.

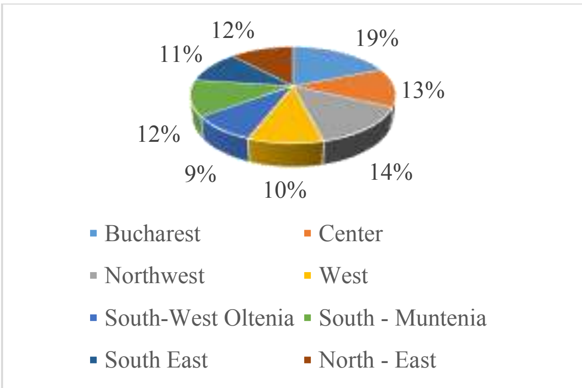

Fig. 1. Employment rate, by region, on January 1, 2022
Source: own processing [9, 10].

From the statistical data on the employed population, we find that in the South-West

Oltenia and North-East regions 17% of them work in the agricultural sector.

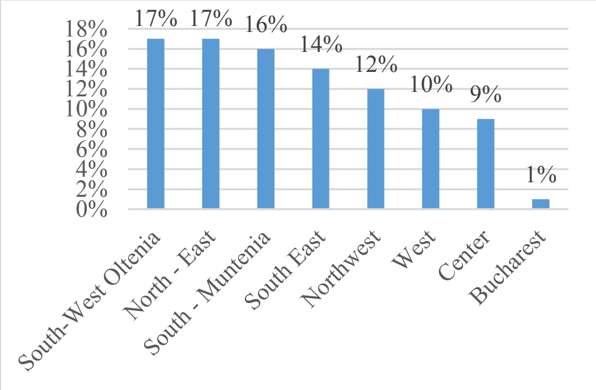

Fig. 2. The population employed in agriculture and complementary fields, by region, on January 1, 2022 (%)
Source: own processing [9, 10].

Also, in the South-Muntenia region, 16% of the employed population works in agriculture. The regions with the lowest shares of the population employed in agriculture are: West (10%) and Center (9%).

Considering the importance of the agricultural and agribusiness sector and the attractiveness of this field that contributes to ensuring the food needs and ensuring food security, the purpose of the paper was to identify what was the motivation of the students regarding the choice of the field of study and what were their expectations regarding the choice of a future job in the field of agribusiness.

Moreover, the existing statistics at the European level highlight the fact that in Romania, the share of higher education graduates is below the average recorded in the E.U. (which is about 41%). Compared to 2019, when they represented approximately 26% of the total population, in 2020 there was a decrease of one percent, and in 2021 another 2%. The tendency of the European Union is to increase the share of higher education graduates by 4%. Therefore, we find that Romania is still far from the desired levels related to the level of education of the population. Moreover, at the level of the E.U. occupies the last place, after Bulgaria, Hungary and Italy. However, it should be noted that in terms of agriculture and agribusiness, in recent years there has been an increase in the attractiveness of this field among high school graduates who wish to continue their higher studies.

MATERIALS AND METHODS

The research methodology involved the realization of an empirical study based on a questionnaire consisting of 12 questions, which was applied to the graduates of the Agricultural Business Engineering and Management specialization (distance learning) within the Faculty of Management and Rural Development belonging to the University of Agricultural Sciences and Veterinary Medicine from Bucharest. The questionnaire was applied in June 2022 to the graduates, who were aged between 22 and 57 years and who answered the voluntary and anonymous questionnaire. The response rate was 87%, resulting in a number of 128 respondents.

The first part of the questionnaire (3 questions) contained socio-demographic information, and the second part contained questions regarding the field of activity in which the respondents were active at that time or will be active, the usefulness of higher education, the desire to develop a business in the field of agribusiness, etc.

The 9 questions were the following:

(4) What were the reasons for choosing a faculty that prepares you in the field of agribusiness?

(5) Do you currently have a job?

(6) Is your current job in the field of agribusiness?

(7) If yes, what position do you hold within that company?

(8) Do you own a business in the field of agribusiness, but do you work in another field?

(9) After finishing the faculty, do you want to work in the field of agribusiness?

(10) What position do you want to occupy in the company?

(11) Do you consider that higher education will help you in your future work in the field of agribusiness?

(12) What is the motivation for choosing a job in agribusiness?

In order to collect empirical data, the omnibus questionnaire was used, which included questions grouped according to the following themes: biographical data; factual data regarding the choice of undergraduate degree program; factual data regarding choosing a job in agribusiness; factual data regarding the future job. Those questions that referred to the subjective evaluation of some aspects related to the study subjects or personal experiences related to them, considered little relevant to the research objective, were removed from the questionnaire. The sociological survey was a census type, due to the fact that it allowed each person to answer the questions, thus avoiding measurement errors specific to the use of probabilistic samples, which due to the exclusion of a certain number of respondents leads to the appearance of measurement errors [1, 3, 8, 11, 12]. The obtained results were the basis for establishing the conclusions regarding the perception of the graduates regarding the field of agribusiness.

RESULTS AND DISCUSSIONS

Starting from the 3 questions that aimed to establish demographic information, we were able to establish the profile of the respondents. It is found that of the 128 graduates, 52% come from the rural environment, and 48% from the urban environment. Of these, 41% are women, and 59% are men.

Table 1. The socio-demographic characteristics

	Frequency	Percentage
Gender		
Female	53	41
Man	75	59
Age		
20-34	48	38
35-45	37	29
45-55	26	20
55-65	17	13
Residence environment		
Urban	61	48
Rural	67	52

Source: Own calculation.

Regarding the age groups, the largest share is represented by young people between the ages of 20 and 34 (38%), followed by the 35-45 age group (29%), by the 45-55 age group years (20%) and the 55-65 age group (13%).

The second part of the questionnaire had 9 questions that aimed to determine the motivation of following the courses of a specialized faculty, but also the expectations of the graduates regarding the labor market in the field of agribusiness.

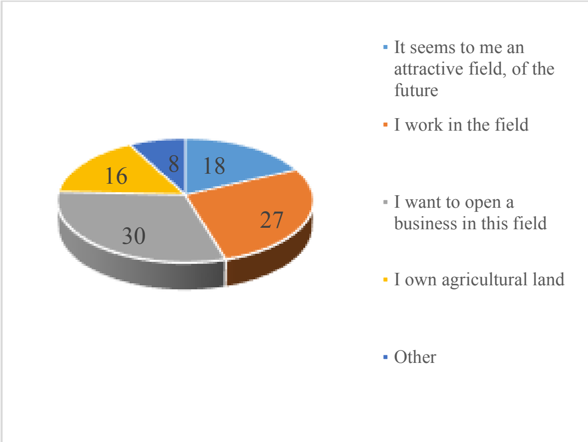

Fig. 3. Frequency of responses regarding the motivation for choosing professional studies (%)
Source: own processing.

Thus to question no. 4. *What were the reasons for choosing a faculty that prepares you in the field of agribusiness*? the answers were open-ended, noting that a significant proportion of the choice of field of study was determined by the desire to open a business in this field (30%), by the fact that some of the graduates already work in the field, but they do not have specialized studies (27%), because they find the field of agribusiness attractive (18%) or because they own agricultural land (16%), and 8% of respondents had other reasons (recommendations from parents, acquaintances, desire to pursue higher studies, etc.).

From question no. 5 *Do you currently have a job*? it turned out that 76% of those questioned have a job, of which 66% are men and 34% are women. Of the 24% who do not currently have a job, 58% are women, and 42% are men.

To question no. 6. *Is your current job in the field of agribusiness?* the answers highlight the fact that 48% of the respondents work in this field, the rest working in various other fields of activity. Some of them own agricultural land, although they are employed in other fields.

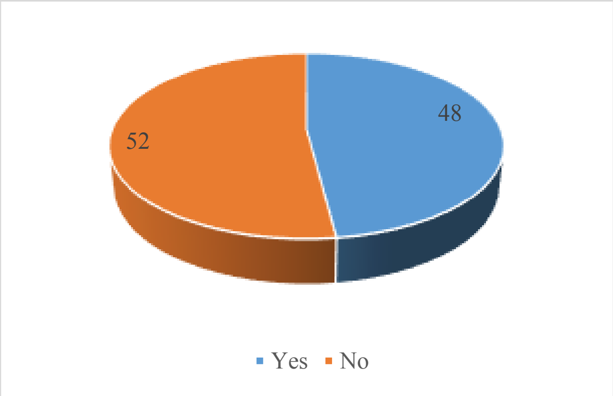

Fig. 4. Frequency of responses regarding the field of activity (%)
Source: own processing.

To question 7. *If yes, what position do you hold within that company?* the answers highlighted the fact that 66% of the respondents who work in a business are employed or own the business being employed in their own company, while 34% of them are the owners of the agricultural or agribusiness business.

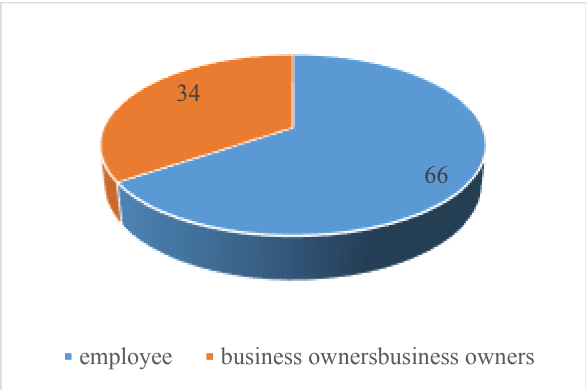

Fig. 5. Frequency of answers regarding the position held within the business (%)
Source: own processing.

From the answers given to question no. 8. *Do you own a business in the field of agribusiness, but do you work in another field?* it turns out that the 34% who declared themselves to be owners of agricultural businesses are administrators or just own that business, but work in another field different from the agricultural one.
To question no. 9. *After finishing college, do you want to work in the field of agribusiness?* among the 67 graduates who work in other fields of activity, 43 want to work in businesses that are in a direct relationship with agribusiness..
To question no. 10. *What position do you want to occupy in the company?* 68% answered that they want to start a business in the agribusiness field, whether only as landowners or as farmers.
The answers given to question no. 11. *Do you think that higher education will help you in your future work in the field of agribusiness?* highlighted the fact that the majority of graduates (94%) believe that the knowledge acquired in college will help them in starting a business or in developing the activity in a professional company. A percentage of 6% do not know yet, but no graduate considered that their studies will not help them in their future career (Figure 6).

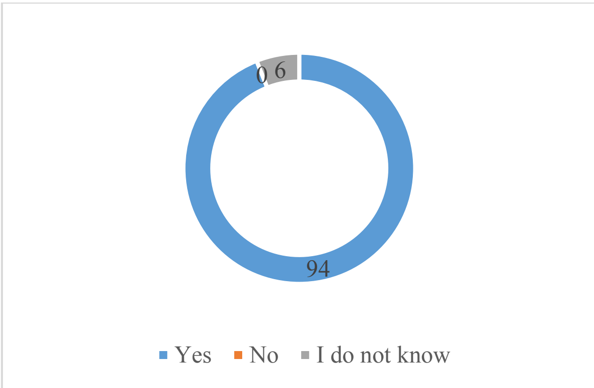

Fig. 6. Frequency of responses regarding the usefulness of studies (%)
Source: own processing

The open answers offered to question no. 12 *What is the motivation for choosing a job in agribusiness?* highlighted the fact that most of the respondents consider the field to be important for providing food and maintaining food security (28%). Also, 25% of the graduates believe that there is still a potential for development in this field. A share of 14% of the respondents believe that the income from agriculture is attractive and motivates them to open a business or work as employees in agribusiness, and 12% are motivated by the ownership of agricultural land. A percentage of 21% of graduates have other reasons (family tradition, taking over businesses from their parents, etc.) (Figure 7).

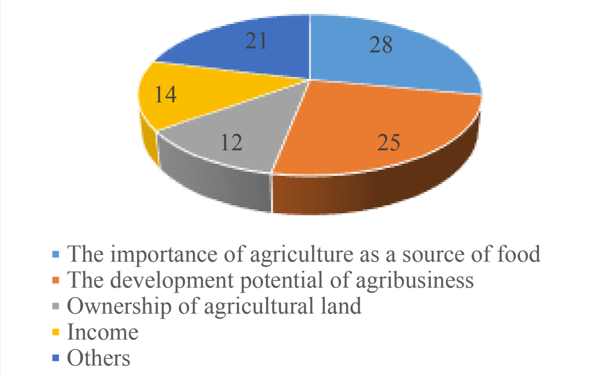

Fig. 7. Frequency of responses regarding the motivation for choosing a job in the field (%)
Source: own processing.

CONCLUSIONS

In conclusion, the field of agribusiness is an important one in the economy of any country considering the fact that it is the one that provides food for the population, the raw material necessary for different sectors of activity, being in close relation with the industrial sector. At the same time, at least as far as Romania is concerned, this sector ensures the employment of an important part of the labor force. The agribusiness sector is the one that can contribute to ensuring food security in a future that is faced with numerous economic, social and political threats and that must ensure the wound of a growing population, in the conditions of the reduction of the areas intended for agriculture as as a result of the less controllable results of global warming and its consequences. Therefore, the field of agribusiness is an important one not only at the local level, but also globally.

The present study highlights the fact that the graduates of the Agricultural Business Engineering and Management specialization at the University of Agricultural Sciences and Veterinary Medicine in Bucharest consider the field of agribusiness to be attractive and have a high potential for development. Most of the graduates chose this field of training out of the desire to consolidate their knowledge or to acquire knowledge with the aim of opening a business. Many of them own agricultural land and want to exploit it, even if they work in another field of activity.

The share of women among graduates is high, as is the case in the employment rate, even if the share of women who do not have a job is 4% higher than that of men.

The respondents are interested in the field of agribusiness, their motivation being linked to both employment opportunities and the possibility of opening a business that they can develop both independently and in parallel with their current occupation.

Although the results of the research are not exhaustive, they can provide us with information about the human resource in this sector, but it can also be useful to the decision-makers both in terms of the educational offer, but also in the elaboration of rural development policies.

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DEVELOPMENTS IN THE LITHUANIAN DAIRY SECTOR IN 2004–2021 AND THE MAIN FACTORS AFFECTING THEM

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Abstract

This study aimed at examining the developments in the Lithuanian dairy sector since the accession of the country into the EU and assessing the main factors affecting these developments. In order to achieve this aim, a descriptive method of statistical data analysis and document analysis was employed. The developments in milk production and dairy processing industry were presented by examining issues such as milk production, sales of raw milk for processing, quantities of milk sold directly, number of dairy cows, milk yield, self-sufficiency in milk, imports of raw milk, self-sufficiency in domestic raw milk, sales by the dairy processing industry, and exports of dairy products. The accession of Lithuania into the EU in 2004 initially had a positive effect on the primary dairy sector, with an increase in raw milk production, sales of raw milk for processing, and farm gate milk prices until 2007. However, in the period between 2008 and 2021, both raw milk production and sales of raw milk for processing showed a decreasing trend. The opposite trend was observed in the dairy processing industry. In 2021, as compared to 2004, sales of dairy products on both domestic and foreign markets increased significantly, by a factor of 2.5 and 3.0, respectively. The developments in milk production and dairy processing were affected by factors such as the levels of concentration among milk producers and processors, the cooperation between milk producers, and the shape of the Common Agricultural Policy.

Key words: *milk production, dairy processing industry, concentration of milk production, concentration of dairy processing, cooperation, Lithuania*

INTRODUCTION

In Lithuania, the dairy sector has long traditions. Favourable climatic conditions and fertile pastures lead to an orientation towards milk production. The primary dairy sector is one of the most important agricultural sectors in the country, as it has consistently been one of the largest contributors to the overall Lithuanian agricultural economy. For a long time, milk and grain crops have accounted for large shares of the value of gross agricultural production (in 2021, 16.1% and 33.9%, respectively). The dairy processing industry is one of the key sectors of the Lithuanian food industry. Over the years, dairy products have held the largest share of the value of total food industry production (in 2020, 25.4%). A wide range of dairy products are produced in Lithuania. Dairy products are a staple and fundamental in the Lithuanian diet. The dairy processing industry is fully capable of meeting domestic demand. About the half of the production produced is exported. Several Lithuanian dairy products are recognized at the EU level: cheese Liliputas and cottage cheese Lietuviškas varškės sūris are marked with the logo of a Protected Geographical Indication, while Žemaitiškas kastinys is marked with the logo of a Traditional Specialty Guaranteed.

Given the importance of the dairy sector in Lithuania, it is of great importance to determine the significance of changes taking place in this sector. Since the 1990s, the primary dairy sector and the dairy processing industry have undergone serious changes linked to political developments. The restoration of independence and the systemic transformation that followed, as well as the accession of the country into the European Union (EU) were the main events that affected the Lithuanian economy, including agriculture and dairy sector.

When Lithuania restored its independence in 1990, the transition from a centrally planned economy to a market economy began.

Privatization started both in agriculture and the food processing industry. In order to restore private ownership and management in the agricultural sector, major reforms were implemented. Land restitution and privatization enabled the development of family farms. At the same time, the restructuring of some collective farms led to the creation of agricultural holdings. All these changes had an impact on the primary dairy sector. The first decade of independence witnessed a marked contraction in milk production. Between 1990 and 2000, the total number of dairy farms fell from 848 to 494 thousand and total milk production dropped from 3,157 to 1,560 thousand tonnes. In this period, the primary dairy sector was characterised by small-scale farming, fragmentation of agricultural land, and a small number of dairy cows per farm [7; 9; 11]. Given these specificities, the scope for investment in modernisation and restructuring of dairy farms was limited. The systemic changes also caused a number of effects in the dairy processing industry. Strong competition in a market economy led to restructuring and concentration in this industry. Some companies went bankrupt, some merged with others. Between 1995 and 2000, the total number of dairy processing companies decreased from around 60 to 37. The largest dairy processing companies invested heavily in the modernisation of production equipment and technology. These companies succeeded in improving product quality and safety, as well as updating and expanding their product range. The dairy processing industry became one of the most concentrated and modern sectors of the Lithuanian food industry [8; 26].

The accession of Lithuania into the EU in 2004 led to significant changes at the level of both milk producers and dairy processors. Both sectors had to meet the EU quality requirements and implement the Common Agricultural Policy with direct payments, subsidies on investment, milk quotas, export subsidies, public intervention and aid for private storage, EU import licenses (sanitary certificates) and import tariffs, and other measures [22; 28]. The dairy sector has become largely dependent on the situation in the EU milk market, which is affected by policy changes and international consequences.

Over the last almost twenty years, the Lithuanian dairy sector has received attention in scientific literature. A number of studies have been carried out to analyse changes in the Lithuanian dairy sector since the country has joined the EU. The studies have described the phenomena occurring in this sector, as well as have identified causes and consequences of these phenomena. Some of previous studies have looked not only at the dairy sector in Lithuania but also at dairy sectors in other countries. These studies have mostly compared the performance of dairy sectors in the Baltic, Nordic, Eastern and Central Europe and all EU countries. The main focuses of previous studies include: a comparison of the performance of the Baltic countries and Finland in terms of milk production, processing, and foreign trade (1998–2008) [9]; the analysis of the economic effect according to the main dimensions of integration in the Baltic dairy processing sector (1996–2009) [19]; an overview of the dairy industry in Poland and Lithuania after the accession into the EU and the assessment of the economic situation of milk producers (2004–2012) [2]; the identification of market power in the raw milk markets in the Baltic countries and comparison of milk producers and the dairy industry in these countries (2004–2014) [23]; the assessment of the efficiency of Lithuanian dairy farms of different economic sizes [17]; the analysis of the dairy sector in the Baltic countries and trends in its historical development (2004–2018) [20]; the investigation of spatial raw milk price transmission in selected EU countries (2005–2020) [10]; the analysis of the Baltic dairy sector (2004–2019) and elaboration of prospects for its future development (2019–2025) [21]; the evaluation of the competitiveness of the EU dairy market in the periods before and after the abolition of milk quotas (2008–2018) [12]. As Lithuania approaches the 20th anniversary of its EU membership, it is important to assess the changes that have taken place in the dairy sector during this period.

MATERIALS AND METHODS

The aim of the present study is to examine the developments in the Lithuanian dairy sector since the accession of the country into the EU and to assess the main factors affecting these developments. This study employs a descriptive method of statistical data analysis and document analysis. In order to examine the developments in the Lithuanian dairy sector, data from various sources are used. These sources include data from the statistical office of the EU EUROSTAT [5], the Lithuanian Department of Statistics (Statistics Lithuania) [25], the EU Milk Market Observatory [3], the EU Farm Accountancy Data Network (FADN) [6], the State Enterprise Agricultural Information and Rural Business Centre [1], the State Food and Veterinary Service of the Republic of Lithuania [24], and the Nasdaq Baltic Stock Market [18]. In order to assess the main factors affecting the developments in the Lithuanian dairy sector, the literature on the subject is analysed.

In this study, the developments in the Lithuanian dairy sector since EU accession are presented by examining the following issues: milk production, sales of raw milk for processing, quantities of milk sold directly, number of dairy cows, milk yield, self-sufficiency in milk, imports of raw milk, self-sufficiency in domestic raw milk, sales by the dairy processing industry, and exports of dairy products. Later in this study, the effect of the main factors such as concentration in milk production and dairy processing, cooperation between milk producers, and EU agricultural and food policy on the developments in the Lithuanian dairy sector is defined.

This study covers the period from 2004 to 2021. The results are presented in the form of descriptive analysis and statistics.

RESULTS AND DISCUSSIONS

Developments in the Lithuanian dairy sector

Milk production. Between 2004 and 2007, both raw milk production and sales of raw milk for processing increased (Figure 1). Raw milk production in 2007 was the highest throughout the period analysed and reached 1,937 thousand tonnes. The global economic crisis in 2008–2009 had a significant impact on the Lithuanian dairy sector, with raw milk production starting to decline. Although demand for dairy products subsequently recovered and prices increased, raw milk production continued its downward trend. In 2021, compared to 2004, raw milk production decreased by one fifth (20.1%), from 1,849 to 1,477 thousand tonnes.

Raw milk production has been declining in line with the steady decrease in the number of dairy cows. In 2021, compared to 2004, the number of dairy cows in Lithuania fell by almost half (48.1%), from 433.9 to 225.2 thousand. During this period, there was only one year, 2007, when the number of dairy cows increased by 1.5% or 6 cows compared to the previous year. In all other years the number of dairy cows decreased (Figure 2). However, the average productivity of dairy cows increased by 53.9%, from 4,176 kg per cow in 2004 to 6,425 kg per cow in 2021. The average milk yield per cow was down between 0.5% and 1.8% compared to the previous year only in 2015–2016.

The increase in sales of raw milk for processing after EU accession was interrupted by the economic crisis of 2008–2009. Subsequently, these sales continued to grow, reaching 1,438 thousand tonnes in 2015. However, due to a significant drop in farm gate milk prices as a result of the Russian embargo on food imports from EU countries announced in August 2014 (until this date, Lithuanian dairy exports to Russia accounted for almost one third of total dairy exports) sales of raw milk for processing decreased in 2016. This downward trend continued until 2021. However, in the period of 2004–2021, sales of raw milk for processing in Lithuania increased by 16.9%, from 1,140 thousand tonnes in 2004 to 1,333 thousand tonnes in 2021. The composition of sold milk increased, from 4.12% to 4.24% for fat content and from 3.27% to 3.43% for protein content.

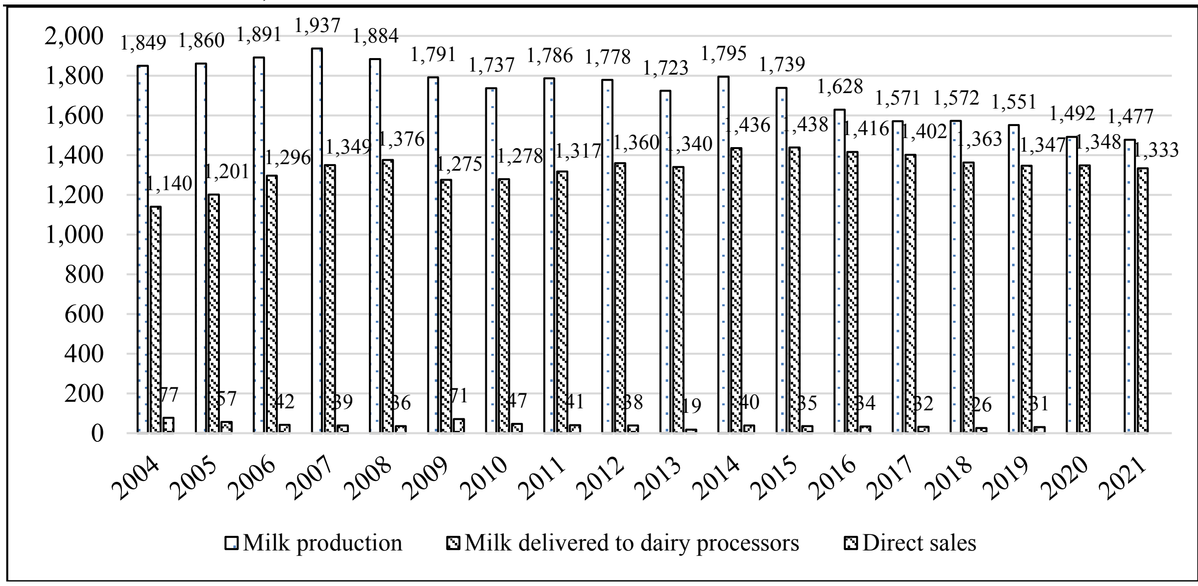

Fig. 1. Milk production, milk delivered to dairy processors, and direct sales in Lithuania in 2004–2021, thousand tonnes
Sources: Statistics Lithuania [25] and Agricultural Information and Rural Business Centre [1].

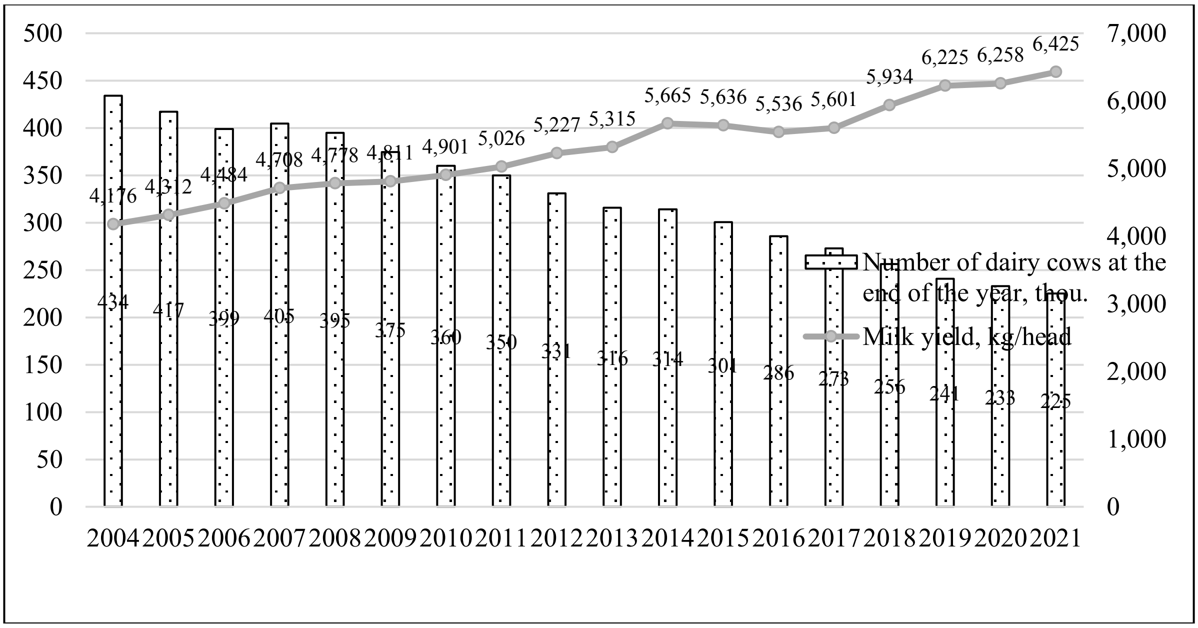

Fig. 2. Number of dairy cows at the end of the year and milk yield per cow in Lithuania in 2004–2021
Source: Statistics Lithuania [25].

The share of commercial milk steadily increased from 65.8% in 2004 to 91.3% in 2017, while milk consumption on farms was decreasing. In 2018–2019, the share of commercial milk dropped slightly to between 88.4% and 88.8% but increased again to between 90.3% and 90.4% in 2020–2021.

Milk sold directly accounted for a small share of total commercial milk over the analysis period. It was higher in the first years after EU accession: 77 thousand tonnes in 2004 (6.3% of total commercial milk), 57 thousand tonnes in 2005 (4.5% of total commercial milk), and 77 thousand tonnes in 2009, the year of crisis (6.3% of total commercial milk). In all other years, milk sold directly ranged from 19 to 47 thousand tonnes (between 1.4% and 3.5% of total commercial milk).

In Lithuania, milk production in 2004–2021 was higher than the amount needed to meet domestic demand. The percentage of self-sufficiency in milk ranged from 134% to 185% (Figure 3).

In 2021, the percentage of self-sufficiency in milk was the lowest in the whole period 2004–2021. This was due to a larger decrease in milk production (-20.1%) than in domestic consumption (-12.0%).

Although Lithuania produced more raw milk than it needed to meet domestic demand throughout the period under analysis, the amount of Lithuanian raw milk sold for processing was not sufficient to fully utilise the capacity of the dairy processing industry. In 2004, the Lithuanian dairy processing industry used only about 70% of its production capacity.

There was no foreign trade in raw milk before Lithuania joined the EU in May 2004. However, since 2005, taking advantage of the benefits of the EU single market, raw milk has been imported into Lithuania. In 2005, 40.0 thousand tonnes of raw milk were imported, and imports have continued to grow steadily since then. In 2021, compared to 2005, imports of raw milk increased more than 12-fold to 483.5 thousand tonnes. The self-sufficiency in domestic raw milk decreased from 100% in 2004 to 72.5% in 2021 (Table 1). Around 70% of imports of raw milk came from Latvia and around 30% from Estonia, while imports from other countries were sporadic and very small.

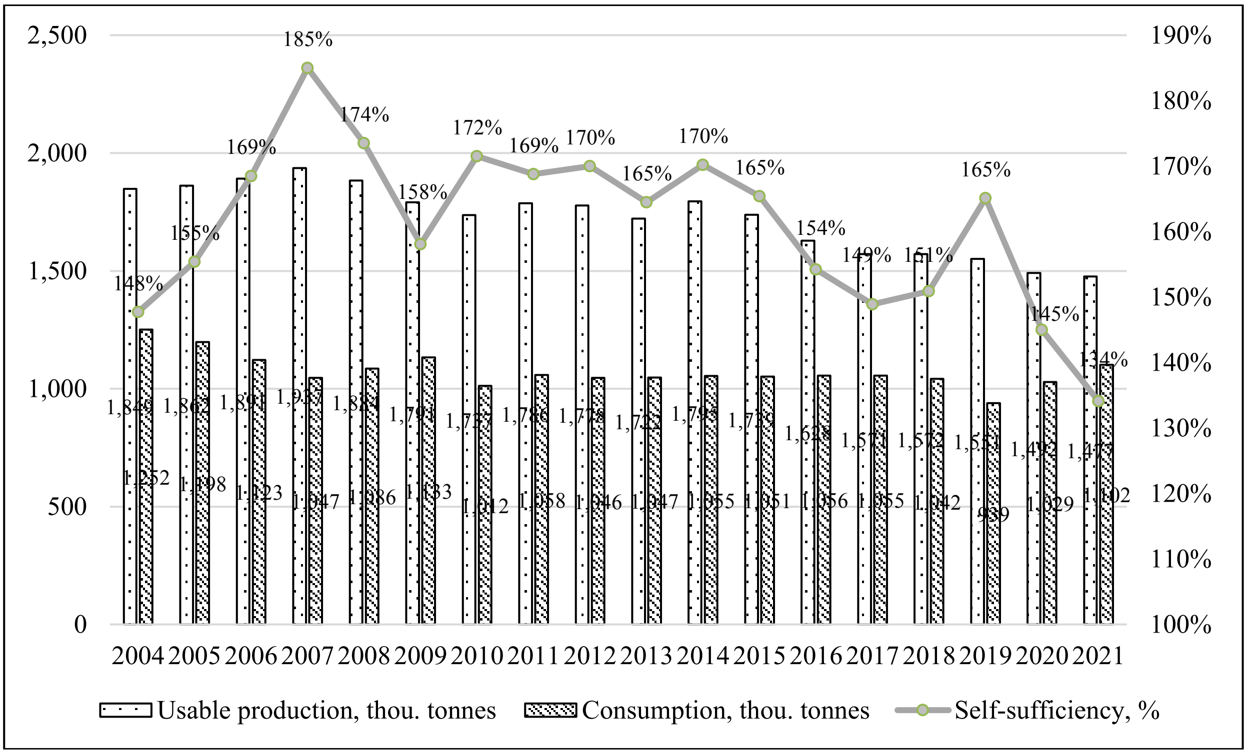

Fig. 3. Usable production, consumption, and self-sufficiency in milk in Lithuania in 2004–2021
Source: Statistics Lithuania [25].

Table 1. Raw milk purchases by the Lithuanian dairy processing industry, milk processed, and self-sufficiency in domestic raw milk in 2004, 2009, 2015, and 2021

	2004	2009	2015	2021	Change 2021, compared to 2004, %
Raw milk purchased in Lithuania	1,140.0	1,263.8	1,344.3	1,275.6	11.9
Imports of raw milk	0	167.6	334.6	483.5	–
Milk processed	1,140.0	1,431.4	1,678.9	1,759.1	54.3
Self-sufficiency in domestic raw milk, %	100.0	88.3	80.0	72.5	X

Source: Statistics Lithuania [25].

Dairy processing industry. In 2021, compared to 2005, sales by the Lithuanian dairy processing industry increased by a factor of 2.8 (Table 2). The value of dairy products sold on the domestic market increased slightly less over the same period, by a factor of 2.5. Between 2004 and 2021, the market share of all domestic dairy products in Lithuania decreased from 92.6% to 71.5%.

Before joining the EU single market, Lithuanian dairy processing companies produced dairy products that met quality standards. More than half of these products produced were exported. This proportion has been maintained throughout the period 2004–2021. Exports of most dairy products have been increasing. In 2021, compared to 2004, exports of ice cream and milk and cream increased the most (6.5 and 4.4 times, respectively). Of all dairy products, only exports of butter and casein decreased (Table 3).

Table 2. Sales by the Lithuanian dairy processing industry in 2004, 2009, 2015, and 2021

	2004	2009	2015	2021	Change 2021, compared to 2004, times
Sales of dairy products, including other milk-based products, mill. EUR	426.1	622.8	754.3	1,173.0	2.8
on domestic market	*203.4*	*313.5*	*375.0*	*501.4*	*2.5*
on foreign markets	*222.7*	*309.3*	*379.3*	*671.6*	*3.0*
Share of the value of dairy products sold on foreign markets, %	52.3	49.7	50.3	57.3	X

Source: Statistics Lithuania [25].

Table 3. Lithuanian exports of dairy products in 2004 and 2021, thousand tonnes

Products	2004	2021	Change 2021, compared to 2004, %
Milk & cream, not concentrated (excluding raw milk)	25.5	112.0	439.2
Milk & cream, concentrated	19.3	55.2	286.0
Fermented or acidified milk & cream	5.1	7.4	145.1
Whey & products consisting of natural milk constituents	18.1	70.8	391.2
Butter & other fats & oils derived from milk, dairy spreads	6.7	6.1	91.0
Curd & cheese	52.3	58.0	110.9
Ice cream	3.5	22.7	648.6
Casein	0.7	0	0.0
Milk sugar	3.9	11.8	302.6

Source: Statistics Lithuania [25].

The geographical structure of Lithuanian dairy exports in value terms has evolved. EU countries accounted for around 70% of total dairy exports over the whole period analysed. In the year before EU accession, i.e. in 2003, only 42% of total dairy exports went to EU countries. At that time, one of the most important foreign markets for Lithuanian dairy products was the USA, which accounted for 25% of total dairy exports. However, Lithuanian dairy exports to the USA have subsequently declined sharply, accounting for only 1–6% of total dairy exports. Until 2014, Russia was an important and profitable export market for Lithuanian dairy products, accounting for 27–30% of total dairy exports. However, after the embargo imposed by Russia on food imports from the EU in 2014, only 0.1% of Lithuanian dairy exports went there.

Cheese and curd accounted for the largest share of both total dairy sales and total dairy exports. Although the share of these dairy products has gradually decreased, it remained the highest throughout the period analysed. In 2004, cheese and curd represented 48.1% of total dairy sales and 55.3% of total dairy exports, while in 2021 these dairy products represented 37.4% of total dairy sales and 32.1% of total dairy exports. This decrease was not due to a decrease in sales of cheese and curd (in 2021, compared to 2004, sales of cheese and curd increased by a factor of 2.1, while exports increased by 68.2%) but to an increase in sales of other dairy products. Over the whole period analysed, sales of ice cream increased by a factor of 3.3 and exports by a factor of 10.2, sales of cream by a factor of 5.3 and exports by a factor of 4.6, and sales of whey and whey products by a factor of 7.0 and exports by a factor of 6.4. Sales of whey grew as their production increased.

Main factors affecting the developments in the Lithuanian dairy sector

Concentration in milk production and dairy processing. The Lithuanian dairy sector joined the EU with an oligopsony market structure. Milk production was dominated by a large number of small producers. A small number of large dairy farms were formed as a result of the transformation of Soviet farms and collective farms into agricultural holdings. Family farms were small, as they were mostly set up with 1–3 dairy cows when Lithuania regained its independence in 1990. In 2004, the number of large family farms was small. Farms with 1–5 dairy cows reared two third of all dairy cows (67.6%) and farms with 6–20 dairy cows reared slightly more than one fifth of all dairy cows (21.2%). Although the smallest farms with 1–20 dairy cows decreased by 86.9% between 2004 and 2021, while the remaining farms increased by 40.3%, the average dairy farm in 2021 was still relatively small, with 8.5 cows. Dairy farms with less than 100 cows accounted for 99.0% of all dairy farms (Table 4).

Changes in the number of dairy farm groups of different size have varied between periods. Over the whole period analysed, the number of farms with 1–20 cows has been decreasing, while the number of farms with more than 100 cows has been increasing.

Meanwhile, the number of farms with 21–100 cows increased by a factor of 3.1 in 2015, compared to 2004, but decreased by 19.6% in 2021, compared to 2015.

According to the Department of Statistics of Lithuania, between 2004 and 2021, there were between 27 and 69 dairy processing companies.

According to the State Food and Veterinary Service, the number of dairy processing companies with veterinary approval, excluding milk purchase spots, ranged from 31 to 39. However, already in 2004, the vast majority of all dairy products were produced and sold by five groups: Rokiškio sūris AB, Pieno žvaigždės AB, Žemaitijos pienas AB, Vilkyškių pieninė UAB (later AB), and Marijampolės pieno konservai UAB, each comprising 2–4 companies. In 2004, the degree of market concentration in terms of sales (RC5) of these five groups of dairy processing companies was 80.7%. Between 2008 and 2015, they retained 90–92% of total dairy sales.

This share fell to 83.6% in 2016, when Pienas LT ŽŪK, a new dairy processing company, was launched. As dairy production in Pienas LT gained momentum, between 2018 and 2021, the degree of market concentration in terms of sales (RC5) of the five groups of dairy processing companies mentioned above was 77–82%.

The raw milk procurement market in Lithuania can also be described as oligopsony. The five groups of dairy processing companies directly purchase around 60–65% of raw milk [29].

The high level of concentration in the dairy processing and the very low level of concentration in milk production led to unequal bargaining power between the parties when negotiating farm gate milk prices.

Dairy processors practically dictated farm gate milk prices for most milk producers. Particularly low prices were set for the smallest milk producers, who had the least bargaining power.

With the predominance of small milk producers receiving low prices for raw milk, the average farm gate milk price in 2004 was the lowest in the EU and stood at €12.05 per 100 kg, below the EU average, although it had already increased by 20.6% compared to 2003 (Figure 4).

Table 4. Dairy farms by number of cows in Lithuania in 2004, 2015, and 2021 (at the beginning of the year)

Number of cows per farm	Number of farms			Change 2021, compared to 2004, %	Number of cows			Change 2021, compared to 2004, %
	2004	2015	2021		2004	2015	2021	
1–5	184,768	50,987	21,331	-88.5	316,178	90,277	40,106	-87.3
6–20	9,622	6,680	4,116	-57.2	82,229	66,449	42,453	-48.4
21–30	373	934	734	96.8	9,194	23,244	18,262	98.6
31–50	205	775	610	197.6	7,833	30,215	23,798	203.8
51–100	113	464	403	256.6	7,632	32,311	28,014	267.1
>100	150	256	274	82.7	44,348	70,996	81,712	84.3
Total	195,231	60,096	27,468	-85.9	467,414	313,492	234,345	-49.9
Average per farm, heads	X	X	X	X	2.4	5.2	8.5	254.2

Source: Agricultural Information and Rural Business Centre [1].

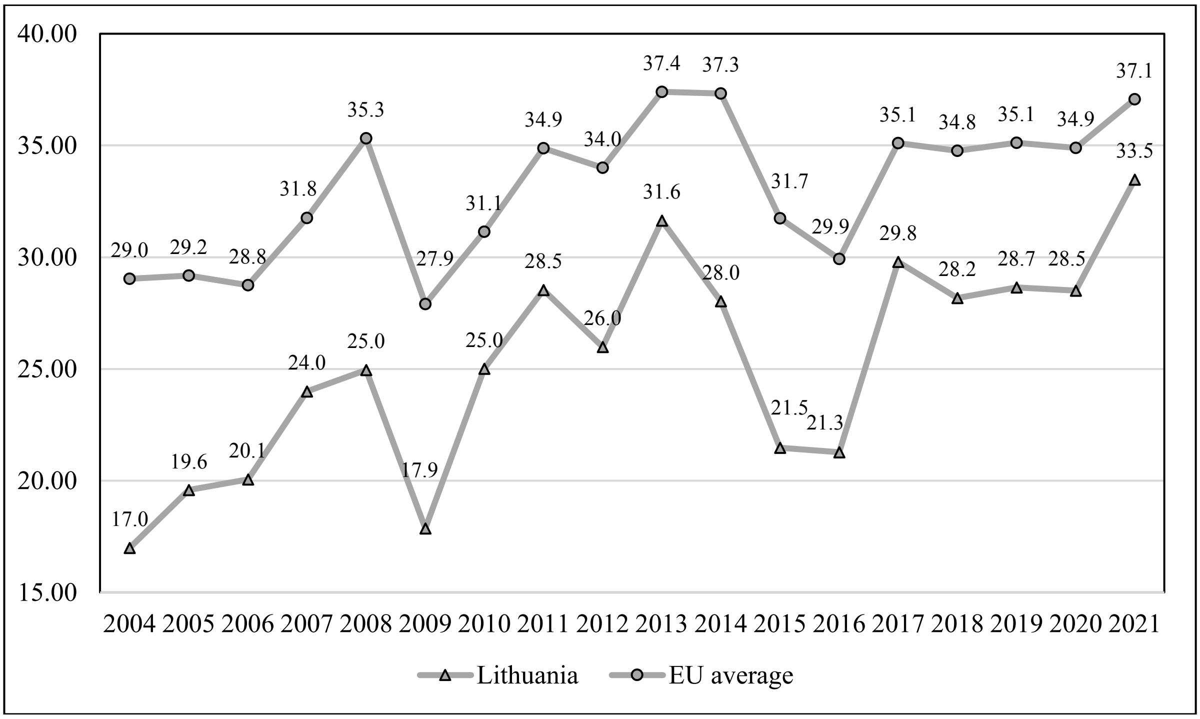

Fig. 4. Farm gate milk prices in Lithuania and the EU in 2004–2021, EUR per100 kg
Sources: EUROSTAT [5] and EU Milk Market Observatory [3].

Given the significant difference in farm gate milk prices between Lithuania and other EU countries, competition in the EU single market led to a rise in farm gate milk prices in Lithuania between 2004 and 2006, while in many other EU countries farm gate milk prices remained stable or even slightly decreased during that period. Thus, the difference between the Lithuanian farm gate milk price and the EU average fell from €12.05 per 100 kg in 2004 to €7.76 per 100 kg in 2007. However, this decreasing price difference did not help Lithuania to move up from last place among EU countries in terms of farm gate milk prices until 2020. In some years, Lithuania was only ahead of Romania, which joined the EU in 2007. Between 2007 and 2021, the trend in the Lithuanian farm gate milk price was similar to the EU average, with a correlation coefficient of 0.905. However, the Lithuanian farm gate milk price per 100 kg was €6–9 below the EU average, except in years when the demand for dairy products fell significantly, i.e. the years of the global economic crisis (2008–2009) and the years of the significant drop in world dairy prices (2014–2015). During these periods, the difference between the Lithuanian farm gate milk price per 100 kg and the EU average was more than €10. In this way, Lithuanian dairy processors, with a significant bargaining advantage due to their high concentration in the dairy processing, were able to absorb their losses due to the fall in dairy product prices by lowering farm gate milk prices. Low prices for raw milk provided dairy processors a competitive advantage on dairy markets. The situation started to change in 2021: as the quantities of raw milk purchased for processing in Lithuania have decreased and scope for increasing import opportunities for raw milk has decreased, the difference between the Lithuanian farm gate milk price per 100 kg and the EU average narrowed to €3.58, and the Lithuanian farm gate milk price was higher than in nine EU countries, including Latvia and Estonia.

According to data published on the Nasdaq Baltic Stock Market, the four largest groups of dairy processing companies (Rokiškio sūris AB, Pieno žvaigždės AB, Žemaitijos pienas AB, Vilkyškių pieninė UAB (later AB) combined profitability of 1.9% to 7.3% over the whole period 2004–2021, with the exception of 2008, when a loss of 1.6% was incurred. Large milk producers, which received higher farm gate milk prices, were also profitable. The profitability of milk production of agricultural holdings, even without subsidies, averaged 20% over the period analysed and only turned negative in 2009, at -0.4%. This encouraged agricultural holdings to expand production of commercial milk. In 2021, compared to 2004, 2.5 times more raw milk was purchased from agricultural holdings.

Meanwhile, for smaller milk producers, low farm gate milk prices did not only prevent them from expanding their farms, but often also from making a living. According to the FADN, the overall loss of specialised dairy farms with an average of 9.3–12.9 dairy cows, including costs for family work but excluding subsidies, averaged -37.1% between 2007 and 2020. Half of the years in this period were profitable if production subsidies were included, with an average profit on raw milk production of 2.6%. Nevertheless, even if subsidies were included, there were years when milk producers made a loss, e.g. -18.7% in 2009 or -11.0% in 2019. Smaller dairy farms that sold raw milk for processing were in an even worse financial situation. As a result, purchases of raw milk for processing from family farms in 2021 decreased by 0.4% compared to 2004. A large number of small milk producers withdrew from milk production throughout the period analysed, while there was a high degree of confrontation between the remaining small and medium-sized milk producers and the dairy processing companies. In order to solve this problem, in 2015, the Parliament of the Republic of Lithuania adopted the Law prohibiting unfair actions on the part of economic operators when buying and selling raw milk and marketing milk products [14]. This law established a classification of milk producers depending on the volume of raw milk of natural fat content sold per day (raw milk sellers are classified into ten groups I–X), and obliged purchasers of raw milk to offer the same price to all milk producers belonging to the same group. However, it did not solve the problem that raw milk of the same quality may be priced differently depending on the volume sold. For instance, in June 2017, the price of raw milk of basic indicators delivered to milk purchase points was 32.9% lower for milk producers belonging to Group I (selling up to 100 kg of raw milk per day) compared to milk producers belonging to Group VIII (selling between 4,000 and 10,000 kg of raw milk per day); milk producers belonging to Group I, from whom raw milk was collected directly from farms, were paid 34.7% less for raw milk than milk producers belonging to Group X (selling more than 20,000 kg of raw milk per day). In June 2020, these differences narrowed to only 29.0% and 30.5% respectively.

Cooperation between milk producers. One of the ways in which milk producers can increase their own bargaining power, when negotiating raw milk purchase prices, is through cooperation. Cooperatives were established in Lithuania before the country joined the EU. This process was not easy due to the strong hostility of dairy processing companies towards cooperating milk producers [30]. In 2004, 18 out of 54, or one-third, of all operators purchasing raw milk were cooperatives, in 2016, 30 out of 59, or 50.8%, and in 2021, 27 out of 55, or 49.1%. Cooperatives in Lithuania purchased about 29% of raw milk for processing [29].

Between 2020 and 2021, in Lithuania, raw milk was purchased by seven large recognised agricultural cooperatives [16], three of which processed all or part of the raw milk purchased (vertical integration). One of these three cooperatives was Pienas LT. This cooperative was the only one that processed all raw milk purchased from its members and produced and successfully marketed high value-added dairy products on domestic and foreign markets. The success of the establishment and operation of Pienas LT was partly due to significant support from EU funds and strong political support from the Lithuanian government. The other two cooperatives processed only part of the raw milk purchased, produced traditional dairy products and, due to the small scale of production, faced difficulties in marketing them in the concentrated Lithuanian retail market. The remaining recognised cooperatives only resold purchased raw milk to dairy processors (horizontal integration). Most of the other cooperatives (non-recognized) were small and only purchase raw milk and resold it to dairy processors (horizontal integration). According to the survey conducted by the Competition Council of the Republic of Lithuania in 2015 during the market study of the dairy sector [13], one third of the 33 cooperatives in the survey indicated that they have no or little bargaining power when negotiating raw milk prices with dairy processors. However, more than one fifth of the cooperatives rated their bargaining power as good. Most of these cooperatives were large, purchasing the largest quantities of raw milk.

The low bargaining power of small purchasers of raw milk is reflected in the price paid to them by dairy processors. In December 2021 (this information began to be published from October 2021), milk purchasing companies (both cooperatives and purchasers with another legal form) delivering between 300 and 1,000 kg of milk per day, when milk was taken directly from suppliers, were paid a price that was 14–15% lower than the price paid to milk producers delivering the same volume of raw milk. And only milk purchasers delivering 4,000 kilograms or more of milk per day were paid a price that was 0.2–8.9% higher than the price paid to milk producers delivering the same amount.

Council Regulation (EC) No 1234/2007 of 22 October 2007 establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products (Single CMO Regulation) [4] allows the setting up of milk producer organisations, which can collectively negotiate with dairy processing and other milk purchasing companies on the purchase price of raw milk and other contractual terms. In Lithuania, the rules for the administration of milk producer organisations and their associations were adopted in 2012, but so far milk producers have not made use of this instrument, and no recognised milk producer organisation has been set up.

EU agricultural and food policy. Since EU accession, the framework of EU agricultural and food policy has come into force for Lithuanian agriculture and food industry. For dairy farms, one of the biggest changes was the milk quota system, which was designed to limit the production of commercial milk. During the accession negotiations in the EU, Lithuania obtained a total milk quota of 1,647 thousand tonnes, including 1,256 thousand tonnes for deliveries to dairies and 390.5 thousand tonnes for direct sales at farm level. These proportions have subsequently changed, while the overall quota has been slightly increased, as in the EU as a whole. The negotiated quota amount did not limit the production of commercial milk. In different years, the implementation rate of quota for deliveries to dairies was 77–92% and quota for direct sales at farm level 19–61%. Lithuania has never had to pay a surplus levy. Individual milk producers who exceeded their individual quota or who wished to expand their production were able to obtain additional quota from the national milk quota reserve. Since 2007, the trade in milk quotas and the leasing of milk quotas in electronic auctions have been legalised. If in the first auction an average of €0.09 was paid for one kilogram of milk quota [15], then in the second auction it was only €0.01–0.02 [27]. Later, the price of milk quotas in auctions was even lower.

Milk producers, like all farmers in the EU, started receiving EU subsidies in 2004. According to the results of the FADN, in the years between 2014 and 2021, production subsidies per specialised dairy farm averaged €7,264.4 per year. By contrast, before EU accession, in 1999–2003, these subsidies per dairy farm averaged only €1,922.6 per year. It can be concluded that after EU accession, dairy farms received 3.8 times higher production subsidies. In individual years, they accounted for between 21.1% and 39.3% of the total farm income from agricultural economic activity, including subsidies.

Subsidies on investments per specialized dairy farm did not differ significantly before and after EU accession. In the years between 2014 and 2021, these subsidies per dairy farm averaged €2,827.1 per year, compared to €2,860.4 in 1999–2003. However, excluding payments from the Sapard programme financed by EU funds, the national investment support per specialised dairy farm amounted to €2,675.2 per year in 1999–2003. Thus, between 2004 and 2021, investment support for dairy farms was on average only 5.7% higher than national investment support between 1999 and 2003.

Before EU accession, Lithuanian dairy processing companies were not subject to a regulated support system or market regulation measures. Support was mainly provided in the event of individual crisis situations. In 2002–2003, following a significant drop in dairy prices on foreign markets, farm gate milk prices in Lithuania decreased by 10–11% per year. Therefore, €3.19 million was allocated to dairy processing companies in 2002 and €16.22 million in 2003 to support farm gate milk prices. This support accounted for 1.1 percent of the income of dairy processing companies in 2002, and 4.7 percent in 2003.

Since joining the EU, Lithuanian dairy processing companies have been able to benefit from all measures of common organisation of the market in milk and milk products. Most of the support came from export refunds to third countries during the period of 2004–2011. The largest amounts of export refunds were received in 2006 and 2007, amounting to more than €20 million per year. This represented 4.1% of the income of dairy processing companies in 2006, and 3.2% in 2007. In the remaining years the amounts of export refunds were lower.

Lithuanian dairy processing companies also benefited from other measures of common organisation of the market in milk and milk products. Support under other measures amounted to less than 0.1% of the annual income of dairy processing companies. However, it helped to maintain the income in the situations of global decreasing demand and prices for dairy products. Almost every year, dairy processing companies took advantage of private storage of dairy products, and in the periods of 2009–2011 and 2015–2018, intervention purchases of dairy products. Dairy processing companies received support for supplying to children in educational establishments milk and certain dairy products. This support ranged from €0.02 million in 2005 to €5.57 million in 2013. Over the period of 2005–2021, it averaged €2.23 million per year, or 0.27% of the income of dairy processing companies.

Lithuanian dairy processing companies also benefited from investment support from EU funds. According to data published on the Nasdaq Baltic Stock Market, one of the five largest groups of dairy processing companies received on average €724.1 thousand of investment support per year between 2004 and 2020, while the other group received €1,026.3 thousand. This support was mainly used to modernise milk processing and marketing, as well as to increase added value.

CONCLUSIONS

Summarising the developments in the Lithuanian dairy sector in 2004–2020 and the factors affecting them, the following conclusions can be drawn.

The accession of Lithuania into the EU initially had a positive effect on milk production, with an increase in raw milk production, sales of raw milk for processing, and farm gate milk prices until 2007, although the average farm gate milk price in the EU did not change significantly in 2004–2006. Between 2008 and 2021, milk production has been declining in line with the steady decrease in the number of dairy cows. Sales of raw milk for processing, which maintained a modest average annual growth rate of 0.8% until 2015, have been steadily decreasing since 2016 (except for 2020). It worth noting that at the same time demand for raw milk for processing has been growing. Dairy processing companies imported more and more raw milk. In 2021, compared to 2005, imports of raw milk increased more than 12 times. As a result of all this, milk production, which accounted for the largest share of the value of gross agricultural production in 2004 (23.8%), in 2021 was in third place with 16.1%.

The Lithuanian dairy processing industry was already well developed before EU accession. EU membership opened up new opportunities for exports of Lithuanian dairy products to other EU countries and third countries. Throughout the period of 2004–2021, dairy processing companies were producing dairy product that met quality standards. About half of the dairy production was sold on the domestic market while the other half was exported. In 2021, compared to 2004, sales of dairy products increased by a factor of 2.8, while exports increased by a factor of 3.0.

The different trends in milk production and dairy processing industry were mainly due to the oligopsony market structure that emerged before 2004. Many small-scale milk producers were involved in milk production. In 2004, the average dairy farm had only 2.4 dairy cows, while in 2021 this average was 8.5. In the meantime, the dairy processing industry was dominated by five groups of dairy processing companies. The degree of market concentration in terms of sales of these groups was 80.72% in 2004 and 77.1% in 2021. Dairy processors were better organised and had therefore a stronger bargaining power when negotiating farm gate milk prices. Small milk producers were paid low prices for raw milk, leaving them unable to expand their farms and make for a living. Between 2004 and 2020, the average farm gate milk price in Lithuania was either the lowest or the second lowest among all EU countries. Only in 2021, this price was higher than in nine other EU countries. Over the period of 2004–2021, 85.6% of milk producers in Lithuania left milk production. For dairy processors, low prices for raw milk provided a competitive advantage on dairy markets.

The bargaining power of milk producers has been partly improved by the cooperative movement which started before 2004. In 2021, of the 55 entities purchasing raw milk, almost half (27) were cooperatives. These cooperatives purchased about 29% of all raw milk sold for processing. Horizontal integration prevailed, which increased the bargaining power of milk producers only in cases where large cooperatives were set up. Between 2020 and 2021, there were four such cooperatives. Two other large cooperatives purchased raw milk and processed part of it, while another large cooperative processed all purchased raw milk. Of the remaining 20 cooperatives, most had no bargaining power when negotiating farm gate milk prices with dairy processors.

The EU agricultural and food policy and legal framework that came into force after EU accession had a positive impact on the Lithuanian dairy sector. The negotiated national milk production quota did not limit the production of commercial milk. The production subsidies received by dairy farms were 3.8 times higher than the national support received before EU accession. In individual years, these subsidies accounted for up to almost 40% of the total farm income from agricultural economic activity, including subsidies. Investment support for dairy farms was similar to what it was before EU accession. All support received allowed at least the larger milk producers to avoid losses year after year. Lithuanian dairy processing companies benefited from all measures of common organisation of the market in milk and milk products. Most of the support came from export refunds to third countries. In individual years, these refunds accounted for up to 4.1% of the total income received by dairy processing companies.

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SUSTAINABLE DEVELOPMENT THROUGH TOURIST ACCOMMODATION SERVICE PROVIDERS. CASE STUDY: CALARASI, GIURGIU, IALOMITA AND TELEORMAN COUNTIES, ROMANIA

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Abstract

This paper aimed to study several sustainable practices which tourist accommodation establishments can apply to contribute to sustainable development. The application of sustainable practices is essential, as tourist accommodation establishments are very resource-intensive. This paper is based on a quantitative research, and the data has been processed through statistical frequencies. The data were collected through a questionnaire, and the target group was made up of tourist accommodation establishments from four counties of Romania, more specifically Calarasi, Giurgiu, Ialomita and Teleorman. The method through which the results are presented is the graphical method. The obtained results confirmed that the tourist accommodation establishments in the four counties are poorly involved in activities aimed at sustainable development.

Key words: *Danube counties, sustainable development, sustainable practices, tourist accommodation establishments*

INTRODUCTION

Sustainable development represents the best remedy for inefficient consumption of resources, waste of resources, various socio-economic inequalities and for combating the negative impact that some socio-economic activities have on the environment.

Development can only be sustainable when "people become aware that ensuring the satisfaction of present needs must not compromise the satisfaction of the needs of posterity" [1, p. 16]. As a result, sustainable development has its roots in the present and its aspirations and effects in the future. Also, a particularly important aspect is related to the responsibility for sustainable development. Clearly, both individuals and legal entities are responsible for sustainable development. Through their contribution, stakeholders, which include local and central authorities, consumers, companies and society as a whole, can determine whether sustainable development will remain at the theoretical and attractive concept stage [11]. Of course, the responsibility fits on every dimension of sustainable development, namely the economic, environmental, social, cultural, political, managerial and technological dimensions [1]. Although several dimensions have been listed, only three of them are the main ones, namely the economic, environmental and social dimensions. Regarding tourism, it is considered that the sustainable development of tourism is achieved, among other things, through the efficient consumption of resources [18]. In other words, in order to achieve sustainable development, it is necessary for tourism service providers and tourists to consume resources efficiently.

Tourist accommodation services are provided by tourist accommodation establishments. In Romania, tourist accommodation establishments are of different types, such as: hotel, apartment hotel, motel, hostel, tourist villa, bungalow, tourist cottage, holiday village, camping, tourist stopover, camping cottages, tourist guesthouse, agro-tourism guesthouse, rooms for rent, ships and floating pontoons [16]. In order to support sustainable development, tourist accommodation establishments have at their disposal an international document of a voluntary but very comprehensive nature, namely the ISO 21401 Standard. The title of the standard is Tourism and Related Services - Sustainability Management System for Accommodation Units - Requirements [10]. The standard includes activities/practices for each main dimension of sustainable development, that tourist accommodation establishments can put into practice, so as to contribute to sustainable development. Another very comprehensive document is the European System of Tourism Indicators. This document includes a series of indicators that directly target tourist accommodation establishments and which measure whether tourist accommodation establishments fit into the sustainable management of the destination [6]. Most of the specialized studies focus on sustainable environmental practices that tourist accommodation establishments can implement. Thus, within tourist accommodation establishments, the most popular sustainable environmental practices are water saving, energy saving and waste management [13]. On the other hand, given that tourist accommodation establishments are legal entities, they can initiate practices related to Corporate Social Responsibility. In one way or another, initiatives related to Corporate Social Responsibility can be considered sustainable practices [12], and among them can be "gender equality, environmental conservation, charitable donations, supporting local traditions and art, waste management and water conservation" [19, p. 1031]. Other basic sustainable practices that tourist accommodation establishments can implement include selective waste collection, efficient use of water and electricity, use of local products and local labor [11]. Divided by the dimensions of sustainable development, the main sustainable practices related to the environmental dimension, that tourist accommodation establishments can implement are the use of renewable energies, efficient use of water and waste recycling; the main sustainable practices related to the social dimension are the fair treatment of employees and the provision of touristic accommodation services to persons with disabilities; the main sustainable practices related to the economic dimension are the use of local labor and the use of local products [11]. Certainly, there are other studies that refer to sustainable practices in tourist accommodation establishments, most of them targeting the environmental dimension of sustainable development [5, 8, 9, 14, 17]. Given that most specialized studies focus on the environmental dimension of sustainable development regarding tourist accommodation establishments, it should be noted that tourist accommodation establishments can obtain the European Union's Ecological Label, in so far as it complies with the imposed criteria, more precisely 22 covering criteria and 45 optional criteria [7].

The implementation of sustainable practices by tourist accommodation establishments range of advantages, such as positive public appreciation, which could translate into increased demand for the provided tourist services [2], saving energy [3], attracting a category of tourists who are willing to pay more if the accommodation establishments applies sustainable practices [20]. Based on the specialized literature, it can be admitted that among the main sustainable initiatives, which can be implemented by tourist accommodation establishments, can be included the creation of the opportunity for women to work in the field of tourist accommodation services; ensuring ethnic diversity among employees; providing accommodation for disabled tourists; socio-economic support of the local community; protecting the environment. As a result, the present study will analyze the number of female employees in relation to the number of male employees, the gender of manager of tourist accommodation establishments, the ethnicity of the employees, the capacity of tourist accommodation establishments to accommodate disabled tourists, the origin of the employees, the redistribution of the tax for profit within the local community by tourist accommodation establishments, selective waste collection, water saving and the use of alternative energy sources.

MATERIALS AND METHODS

The purpose of this study is to find out if the tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties support sustainable development through elementary sustainable practices. Calarasi, Giurgiu, Ialomita and Teleorman counties are located in the south of Romania, they are plain counties and are crossed by the Danube river. These counties of Romania were chosen for the study because they are little analyzed from a tourism point of view in the specialized literature, although they have tourism potential. The study started from the premise that it is necessary for tourist accommodation establishments to support sustainable development, at least in the light of the following sustainable initiatives: ensuring the opportunity for women to work in the field of tourist accommodation services; ensuring ethnic diversity among employees; providing accommodation for disabled tourists; socio-economic support of the local community; protecting the environment. As a result, the following research questions were formulated:

1. How is the number of female employees compared to the number of male employees in the tourist accommodation establishments in the four counties?
2. Do women have a chance to hold a management position in the tourist accommodation establishments in the four counties?
3. Is there ethnic diversity among the employees of the tourist accommodation establishments in the four counties?
4. Do tourists with disabilities have the opportunity to stay in tourist accommodation establishments in the four counties?
5. Do the tourist accommodation establishments in the four counties have the majority of employees from the locality where they are located?
6. Do the tourist accommodation establishments in the four counties redistribute the profit tax within the local community (hospitals, churches, schools, etc)?
7. Do the tourist accommodation establishments in the four counties selectively collect the waste produced by tourists?
8. Do the tourist accommodation establishments in the four counties save water?
9. Do the tourist accommodation establishments in the four counties use alternative sources of energy?

In the four counties analyzed, the number of tourist accommodation establishments is 103 [15]. The size of the representative sample was established by means of proportional stratified sampling [4]. The sampling resulted in a sample of 81 tourist accommodation establishments. Data from the 81 tourist accommodation establishments were collected through a questionnaire between February and August 2022. The data were analyzed by means of statistical frequencies, and the results are presented by means of the graphic method. The graphs were created using the Microsoft Excel program.

RESULTS AND DISCUSSIONS

The answer to the research question *How is the number of female employees compared to the number of male employees in the tourist accommodation establishments in the four counties?* is that in the majority of tourist accommodation units in Calarasi, Giurgiu, Ialomita and Teleorman counties, the number of female employees is higher than the number of male employees (Fig. 1).

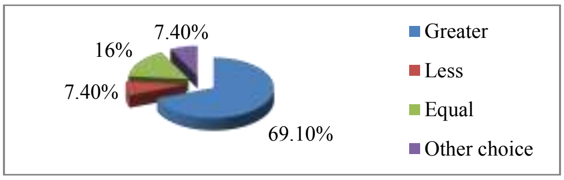

Fig. 1. The number of female employees compared to the number of male employees
Source: Own results.

Thus, the industry of tourist accommodation services in Calarasi, Giurgiu, Ialomita and Telorman counties is specific to women.

The answer to the research question *Are women likely to hold a management position in tourist accommodation establishments in the four counties?* is Yes, as most managers of tourist accommodation establishments in the four counties are females (Fig. 2).

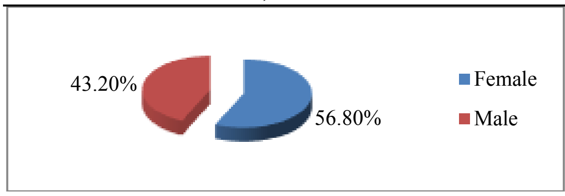

Fig. 2. Gender of the manager
Source: Own results.

As a result, the tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties ensure the opportunity for women to work in the field of tourist accommodation services. In other words, it gives them at least the same opportunities as men.

The answer to the research question: Is there ethnic diversity among employees in tourist accommodation establishments in the four counties? is No, because in most tourist accommodation establishments there are only Romanian employees (Fig. 3).

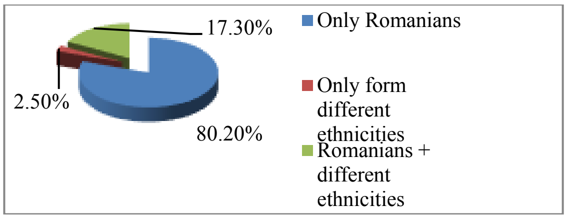

Fig. 3. Ethnicity of employees
Source: Own results.

As a result, the industry of tourist accommodation services in Calarasi, Giurgiu, Ialomita and Teleorman counties is specific for Romanian employees and less for employees from other ethnicities.

The answer to the research question *Do tourists with disabilities have the opportunity to stay in tourist accommodation establishments in the four counties?* is No, since most of the tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties do not provide specific facilities to disabled tourists (Fig. 4).

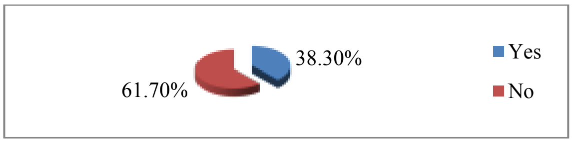

Fig. 4. The ability to make specific facilities available to disabled tourists
Source: Own results.

As a result, the tourist accommodation establishments in the counties of Calarasi, Giurgiu, Ialomita and Teleorman do not ensure the possibility of accommodation for disabled tourists.

The answer to the research question Do the tourist accommodation establishments in the four counties have majority employees from the locality where they are located? is No, because in most of the tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties, the employees come from the locality where the tourist accommodation establishments are located, but also from other localities (Fig. 5).

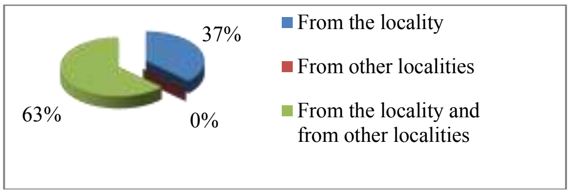

Fig. 5. Origin of employees
Source: Own results.

The answer to the research question *Do the tourist accommodation establishments in the four counties redistribute the profit tax within the local community (hospitals, churches, schools, etc.)?* is No, as most tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties do not redistribute the profit tax within the local community (Fig. 6).

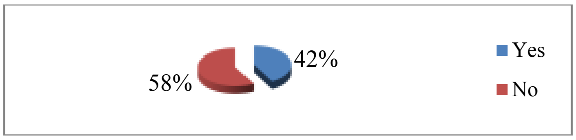

Fig. 6. Redistribution of profit tax within the local community
Source: Own results.

As a result, based on the analyzed practices, it is found that the tourist accommodation establishments in the four counties analyzed provide little support to the local community from a social and economic point of view.

The affirmative answer to the research question *Do the tourist accommodation establishments in the four counties selectively collect the waste produced by tourists?* is supported by the fact that more than half of the tourist accommodation establishments in the analyzed counties selectively collect the waste produced by tourists (Fig. 7).

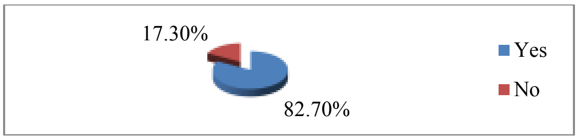

Fig. 7. Selective collection of waste produced by tourists
Source: Own results.

A very large proportion of tourist accommodation establishments selectively collect waste, which means that the managers of tourist accommodation establishments have become aware of the negative impact that waste has on the environment.
The answer to the research question *Do tourist accommodation units in the four counties save water?* is No, since most tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties do not save water (Fig. 8).

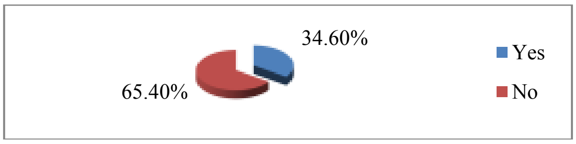

Fig. 8. Saving water
Source: Own results.

This denotes the fact that the managers of tourist accommodation establishments follow the concept that water is a renewable resource, but this concept must not give way to waste and inefficient consumption.
The answer to the research question *Do the tourist accommodation establishments in the four counties use alternative sources of energy?* is No, because most tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties do not use alternative energy sources (Fig. 9).

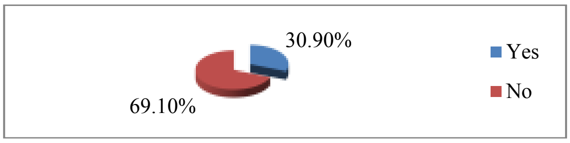

Fig. 9. Use of alternative energy sources
Source: Own results.

This denotes the fact that tourist accommodation establishments are followers of conventional energy sources and pay rather little attention to alternative energy sources. This can change in the context of an energy crisis, in the sense that due to very high costs, tourist accommodation establishments turn to alternative energy sources.
Failure to apply sustainable practices could bring higher costs to tourist accommodation establishments than if they applied these practices. Consequently, one of the reasons that could lead tourist accommodation establishments to implement sustainable practices could be costs.

CONCLUSIONS

The research has revealed that the field of tourist accommodation services is suitable for women, because the employees in the execution functions, as well as in the management functions, are predominantly female. This shows that gender equality is embraced in one form or another in the tourist accommodation establishments in Calarasi, Giurgiu, Ialomita and Teleorman counties.
On the other hand, considering two other aspects of the social dimension, more precisely the ethnic diversity among employees and the people with disabilities, it is found that these two aspects are impediments for the tourist accommodation establishments in the analyzed counties. As a result, two out of three aspects concerning the social side of sustainable development are not fulfilled, which is why it can be admitted that the tourist accommodation establishments in the analyzed counties are poorly involved in the social side of sustainable development. Also, due to the fact that the tourist accommodation establishments in the analyzed counties do not have the majority of employees from the locality where they are located and do not redistribute the profit tax within the local community, it can be concluded that the involvement in the economic dimension of sustainable development is reduced. Also, it is found that the tourist accommodation establishments in the analyzed counties selectively collect the waste produced by tourists, but they do not save water and do not use alternative energy sources. As a conclusion, the involvement in

the environmental dimension of the sustainable development of tourist accommodation establishments in the analyzed counties is relatively low. Thus, the general involvement of tourist accommodation establishments in the analyzed counties in sustainable development is relatively low.

The limits of the research refer to the number of sustainable practices/initiatives analyzed, in the sense that tourist accommodation units could implement other sustainable practices. This may constitute a new research direction.

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SUSTAINABILITY DISCLOSURE AND CORPORATE PERFORMANCE: A EUROPEAN EVIDENCE FROM AGRICULTURE INDUSTRY

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Abstract

This paper investigates the relationship between sustainability disclosure, measured by environmental, social, and governance (ESG) combined and individual scores on corporate performance of the agricultural companies from Europe. The main reason of this study is that on 15 November 2022 the worldwide population is more than 8 bn and is expected to increase at 9.6 bn in 2050, which will increase the pressure on agricultural industry to produce food and goods to serve the people needs. In this context and due to the new European regulation, companies must adopt strategies regarding the concerns for environment, social, and governance activities, developing an integrated report to show to investors how they are involved in social issues and environmental concerns. This study uses a multiple linear regression, data being collected from Thomson Reuters database for the period 2017-2021. The results indicate that companies with higher ESG scores have higher performance. This study may help investors and other stakeholders to have an overview as to which sector to orient their investment strategies.

Key words*: *sustainability disclosure, corporate performance, environmental, social, and governance, agriculture

INTRODUCTION

In the last two decades, the sustainability disclosure has been widely debated into literature by researchers. Sustainability disclosure is as well-known as corporate social responsibility (CSR) by researchers. Today, the topic of sustainability plays an important role due to the facts of the new regulation starting with the EU directive 2014/95/UE and the UE Commission strategy to be environmentally friendly, reducing the impact on the environment fighting against climate changes that will impact all aspects of humans (health, food, etc.).

The scholars have established that sustainability disclosure can be discussed with different company metrics and can be analyzed for companies in a specific industry. In the study conducted by [13] was analysed the impact of ESG factors for the companies from energy and healthcare industry on firm value. The results obtained revels that the sustainability disclosure doesn't have an impact on firm value for companies from healthcare industry while for companies from energy industry the impact on firm value is negatively associated.

The relationship between ESG factors on companies' corporate performance was analysed by several scholars. For example, [26] for power generation companies has analysed this impact. The results reveal that a good ESG disclosure can improve corporate performance. [25] identified that sustainability disclosure has a negative impact on the return of investment. Furthermore, the results identified in the literature were mixed. [4] show that social and governance scores are positively associated with financial performance, the environmental score is negatively associated for companies listed on the Amman Stock Exchange.

The impact of sustainability disclosure on financial performance has different results for each industry. In the IT sector, [15] identified that higher ESG ratings could increase company value. For the healthcare industry, [16] shows that a lower rate of environmental score increases financial performance, while the social score negatively affects ROA. Analysing the impact of ESG scores on financial performance in the energy sector, [2] identify that there is no significant relationship between ESG and ROE. [8] show that for the tourism sector the impact is opposite. A significant relationship is identified for operational performance, while for financial performance measured by ROE, the impact is insignificant.

When the relationship between sustainability reporting and corporate performance was analysed for companies in Europe, the identified results were mixed. [1] show a positive correlation between ESG performance and financial performance. Therefore, companies that report high ESG have high financial performance, while the size of the company moderates the relationship between ESG and financial performance. Similar results are provided by [17] for Norwegian listed companies. The authors find a strong and significant relationship between ESG score and financial performance, but with mixed outcomes. ESG initiatives have a negative impact on ROA, while there is a positive correlation between Tobin's Q and ESG. Furthermore, the authors observe that firm size and ESG score are correlated, larger companies invest more in ESG initiatives and have higher financial performance. [21] in another approach analysed for financial companies from Northern Europe the impact on financial performance of the sustainability disclosure. The authors identified that only ROA is significant associated with ESG factors while the other variables analysed was identified a negative relationship. For 350 listed European [7] examines the same relationship in a boarder context for the 2014-2019 period showing a non-linear variation of sustainability disclosure on financial performance, the company size and ESG scores being the variables which affect this relationship. Their findings are consistent with those of [17] in terms of company size and ESG.

Studies that analyse the impact of sustainability disclosure on corporate companies acting in the agriculture industry are relatively small ([23] [3], [9], [20] or [12]). In their study [13] they analysed how ESG scores impact financial performance in the European food industry. Data were collected from the CSRHub database, for the period 2017-2020, and analysed using ordinary least squares regression. The results show that companies who achieve higher ESG rates have better financial performance. For the agriculture and food industry, [3] identified a non-significant impact on corporate performance measured through operational (ROA), financial (ROE), and market (TQ) performance. The combined factors of ESG have no significant impact on the corporate performance of agriculture companies, but when taken individually a positive and significant impact was identified between the governance score and the performance of the market. Analysis in more details the sustainability reporting, [20] identified mixed results for both operational and financial performance of the agriculture companies. Furthermore, for the European agri-food listed companies [12] identify that environmental and social disclosure has a positive impact on profitability and market value, while governance disclosure has a negative impact on market value of agri-food companies.

The main hypothesis of this study analyses the impact of sustainability disclosure on corporate performance of agricultural companies, being expressed as follow:

H1: Sustainability disclosure, represented by ESG combined factors and each one individually taken, have an impact of corporate performance, represented by ROA, ROE, and Tobin Q ratio, of the European companies acting in agriculture sector.

This hypothesis can be developed in several secondary hypotheses, expressed as follows:

H1.1: The environmental score (ENV) has an impact of corporate performance of the European companies acting in agriculture sector.

H1.2: The social score (SOC) has an impact of corporate performance of the European companies acting in agriculture sector.

H1.3: The governance score (GOV) has an impact of corporate performance of the European companies acting in agriculture sector.

The summary of this paper advances as follows: The materials and methods are presented in the second section, while the results and discussions are presented in the third section, and in the last section of the paper the conclusions are presented.

MATERIALS AND METHODS

In this study, the impact of sustainability disclosure represented by combined and individual factors of ESG (environmental, social, and governance scores) on the performance of agricultural companies is analysed.

Table 1. Sample distributions by region

Europe Region	**Central Europe**	**East Europe**	**North Europe**	**South Europe**	**West Europe**	**Total**
A. Agricultural economic sector name						
Basic Materials	12	13	13	10	21	69
Consumer Cyclicals	10	4	16	11	112	153
Consumer Non-Cyclicals	91	7	107	61	330	596
Energy	29		21	11	19	80
Industrials			18	7	32	57
Utilities				8	20	28
Total	**142**	**24**	**175**	**108**	**534**	**983**
B. Agricultural industry name						
Agricultural Chemicals	10	13	5		14	42
Brewers			13		26	39
Consumer Goods Conglomerates	13		6		27	46
Department Stores	8	4	8	2	22	44
Distillers & Wineries	1		4		40	45
Environmental Services & Equipment			18	7	32	57
Fishing & Farming	8		12	8	34	62
Food Processing	44	2	48	23	109	226
Food Retail & Distribution	20	5	15	20	63	123
Forest & Wood Products	2		8	10	7	27
Non-Alcoholic Beverages	5			5	17	27
Renewable Energy Equipment & Services	22		16	11	14	63
Renewable Fuels	7		5		5	17
Restaurants & Bars			2	5	83	90
Textiles & Leather Goods	2		6	4	7	19
Tobacco			9	5	14	28
Water & Related Utilities				8	20	28
Total	**142**	**24**	**175**	**108**	**534**	**983**

Source: Own calculation based on data extracted from Thomson Reuters Database.

The data were extracted from Thomson Reuters Refinitiv Eikon DataStream, for the last 5 years (2017-2021) from the companies acting in 6 sectors (utilities, industrials, basic materials, energy, consumer cyclicals and consumer non-cyclicals) and 17 industries, represented by: Agricultural Chemicals, Brewers, Consumer Goods Conglomerates, Department Stores, Distillers & Wineries, Environmental Services & Equipment, Fishing & Farming, Food Processing, Food Retail & Distribution, Forest & Wood Products, Non-Alcoholic Beverages, Renewable Energy Equipment & Services, Renewable Fuels, Restaurants & Bars, Textiles & Leather Goods, Tobacco and Water & Related Utilities and 27 European countries, structured in five European regions, as are presented in Table 1. All the data are based on Refinitiv Eikon Datastream (the numerical values for ESG factors and the information for companies from the agriculture industry). Refinitiv Eikon Datastream is a well-known database due to its credibility and multiple data available for companies, being used by several authors, such as [20], [9], [12] or [5].

Table 2. Variables included in the study

Variable	**Abvr.**	**Explanation**
A. Dependent variables (Source: Computed with data from Thomson Reuters)		
Return of Assets	ROA	Calculated by dividing the net income on total assets, showing the profitability of total assets.
Return on Equity	ROE	It is calculated by dividing the net income on total equity, showing the profitability of the invested equity from the accounting perspective.
Tobin Q ratio	TQ	Is calculated by dividing the market value of the company by total assets, showing the market performance.
B. Independent variables (Source: Thomson Reuters)		
ESG Combined	ESG	The Refinitiv ESG Score is an overall company score based on self-reported information on the environmental, social, and corporate governance pillars.
Environmental	ENV	The environmental pillar measures a company's impact on living and nonliving natural systems, including the air, land, and water, as well as complete ecosystems.
Social	SOC	The social pillar measures a company's capacity to generate trust and loyalty with its workforce, customers, and society, through its use of best management practices.
Governance	GOV	The corporate governance pillar measures the systems and processes of a company that ensure that its board members and executives act in the best interests of its long-term shareholders.
C. Control variables (Source: Computed with data from Thomson Reuters)		
Firm size	FZ	The natural logarithm of total assets
Firm size	FZE	The natural logarithm of the total number of employees
Leverage	LV	Calculated by dividing the total liabilities by the total equity.

Source: Own representation based on prior literature.

To have a holistic approach for the performance of companies from agriculture sector, the performance is measured at three levels: operational (ROE), financial (ROA), and market performance (TQ). Furthermore, the sustainability disclosure is represented by ESG combined and individually scores. Furthermore, the econometric model contains three control variables, represented by two indicators for firm size and leverage. Table 2 presents dependent, independent, and control variables included in the econometric model.

As presented in Table 2, the dependent variables are represented by ROA, ROE, and TQ, are in accordance with the previous reviewed literature ([9]; [12] [5]; [6], [20] or [10]). Furthermore, the independent variable is represented by ESG scores and each individually taken (environmental, social and governance scores), based on the studies conducted by [23], [14], or [11] and calculated by Refinitiv Eikon DataStream. Moreover, studies such as [6], [9], [3] or [23] used as control variables firm size and leverage.

The model developed to express the impact of sustainability disclosure on the performance of agricultural companies is expressed as follows:

$$Perf_{it}= \beta_0+\beta_1 SD_{it}+\beta_2 FZ_{it}+\beta_3 FZE_{it}+\beta_4 LV_{it}+\varepsilon_{itg}$$

where:

$Perf_{it}$= represents the company performance, which will subsequently take the value of the ROA, ROE, and TQ ratio.

SD_{it}= represents the sustainability disclosure, which will subsequently take the value of the ESG combined score, ENV score, SOC score, and GOV score.

$\beta_{0=}$ is the constant.

$\beta_{1\text{-}4}$= the slope of the controls and the independent variables.

ε_{itg} = is the error.

RESULTS AND DISCUSSIONS

This section presents descriptive statistics, matrix corelation, and regression results to establish the impact of sustainability disclosure on agriculture companies' performance.

Fig. 1 shows the region differences for the combined and individual ESG scores. Southern Europe is leading the list, with the highest level of combined ESG scores. Southern Europe is followed by Western and Central Europe, having an average disclosure of ESG combined scores of 53-54%. In terms of GOV disclosure, Western Europe is leading, having the highest rates from the sample while on the opposite side is Northern Europe with the lowest rates for GOV. Furthermore, in terms of the SOC aspect, Southern Europe is leading and at the opposite side is Eastern Europe, with the lowest scores for the social aspect (40%).

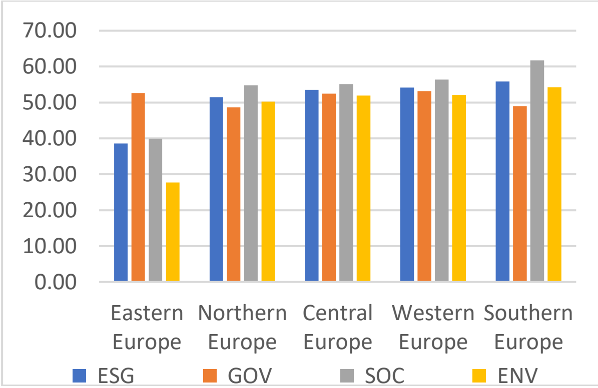

Fig. 1. Average of combined and individual ESG scores and performance distributed by region

Source: Source: Own calculation.

The descriptive statistics of the dependent variables (agriculture companies' performance), independent variables (ESG combined and individually scores), and control variables are presented in Table 3. In terms of financial performance, the mean ROA is 3.06%, with a min of -70.67% and a maximum of 50.71%.

Table 3. Descriptive Statistics of Variables

Variables	N	Minimum	Maximum	Mean	Std. Dev.
ROA	959	-70.67%	50.71%	3.06%	9.49%
ROE	935	-185.50%	194.48%	7.93%	27.61%
TQ	935	0.00	4.96	0.91	0.94
ESG	983	4.19	94.21	53.38	19.83
ENV	983	0.00	98.18	51.38	24.94
SOC	983	2.29	97.24	56.09	23.11
GOV	983	4.43	96.29	51.80	21.95
FZ	961	14.46	26.23	21.79	1.73
FZE	885	2.56	13.30	8.96	1.88
LV	961	0.00	1.10	0.32	0.19

Source: Own calculation based on data analysed with SPSS software.

Moreover, the operational performance has a mean of 7.93 with a standard deviation of

27.61 while the market value, represented by Tobin Q ratio, has a mean of 0.91% with a maximum of 496 and a minimum of 0.00. The mean value of the ESG score is 53.38, which is close to the ENV score of 51.38 and the GOV score of 51.80. The minimum SOC and GOV scores are 2.29 and 4.43 while the maximum values are 97.24, and 96.29. FZ has a mean of 21,79, while FZE has a mean of 8.96, with a standard deviation of 1.73 and 1.88, it is slightly distributed, while Leverage has a mean of 0.32 and a standard deviation of 0.19. Furthermore, Table 4 presents descriptive statistics that support the assumption that data are normally distributed and that a regression model based on these variables is valid [18].

Table 4. Skewness and Kurtosis distribution

Variables	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Std. Error
ROA	-2.580	0.079	19.579	0.158
ROE	-1.506	0.080	16.304	0.160
TQ	1.630	0.080	2.732	0.160
ESG	-0.275	0.078	-0.623	0.156
ENV	-0.168	0.078	-0.897	0.156
SOC	-0.338	0.078	-0.753	0.156
GOV	-0.041	0.078	-0.981	0.156
FZ	-0.138	0.079	0.418	0.158
FZE	-0.214	0.082	0.357	0.164
LV	0.626	0.079	0.763	0.158

Source: Own calculation based on data analysed with SPSS software.

Table 5 presents the Pearson (below the diagonal) and Spearman (above the diagonal) correlation matrix for all variables included in the study.

Table 5. Pearson/Spearman correlation matrix

V	(1)	(2)	(3)	($)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	1	.82**	.39**	.09**	.11**	.09**	0.04	-0.01	-0.03	-.22**
(2)	.55**	1	.25**	.13**	.12**	.15**	.07*	.09**	.09**	-0.05
(3)	.17**	.09**	1	.08*	.08**	0.06	0.06	-.16**	-.17**	-.21**
(4)	.14**	.10**	0.03	1	.87**	.91**	.67**	.60**	.57**	.11**
(5)	.12**	.09**	0.03	.88**	1	.75**	.39**	.50**	.44**	0.05
(6)	.11**	.09**	0.01	.92**	.76**	1	.44**	.58**	.55**	.17**
(7)	.12**	.08*	0.02	.68**	.4**	.45**	1	.39**	.41**	0.06
(8)	.12**	.10**	-.19**	.62**	.52**	.58**	.42**	1	.81**	.15**
(9)	.08*	.08*	-.19**	.59**	.46**	.57**	.42**	.83**	1	.16**
(10)	-.12**	-.11**	-.17**	.10**	0.02	.15**	.06*	.11**	.15**	1

Notes: **. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed). (1) ROA, (2) ROE, (3) TQ, (4) ESG, (5) ENV, (6) SOC, (7) GOV, (8) FZ, (9) FZE, (10) LV

Source: Own calculation based on data analysed with SPSS software.

Pearson's correlation (below the diagonal) shows that ESG, ENV, SOC, and GOV scores are all positively connected with ROA at the 0.01 level. The score is negatively associated with financial performance (ROA) at level 0.01, while it is favorably correlated with operational performance (ROE) at level 0.01 with the ESG, ENV, and SOC scores and at level 0.05 with the GOV scores. Furthermore, at the 0.05 level, a positive association is seen between market performance as reflected by the Tobin Q ratio and independent factors. With certain exceptions, the Spearmen correlation matrix supports the above-mentioned corelation. GOV, for example, is positively connected to ROA at the 0.05 level and to ROE at the 0.01 level. Furthermore, a strong correlation was identified between ESG scores and ENV scores with the Tobin Q ratio at the level of 0.05 and 0.01. It is important to note that all independent variables are positively related to the dependent variables.

To have a holistic approach and whit the purpose to identify potential outliers, this study used the Cook's Distance measure. The presence of outliers in the data sample can affect the regression results. In this study, the steps used by [23] were followed. Observations with the Cook distance being higher 4/N were eliminated. For example, the first four regression analysis conducted for ROA, was identified between 55 and 59 outliers which was eliminated. For the next regression analysis for ROE, between 43 and 45 outliers were identified and eliminated, and for TQ were identified between 54 and 55 outliers. This step was applied to ensure that the identified outliers do not influence the regression results. Furthermore, the variance inflation factor (VIF) was used to check the multicollinearity potential issues. The results obtain for each regression shows that the VIFs values for the independent variables are below 10 and the tolerance range is above 0,1 which means that the multicollinearity does not exist, according with [19] and [24].

Table 6 presents the results of the multiple linear regression analysis on the impact of sustainability disclosure on the financial performance of agriculture companies. The regression analysis shows that the econometric model may explain between 8,8% and 10,7% the variation of ROA when we control by FZ, FZE, and LV. Furthermore, the model used is valid, Anova sig. being

<0,05. The regression model results for ROA identified a positive relationship between sustainability disclosure and financial performance of agricultural companies.

Table 6. The Impact of Sustainability Disclosure on ROA

Variables	Coef.	Coef.	Coef.	Coef.
(Constant)	5.524	4.686	4.847	3.210
ESG	*0.03**			
ENV		*0.150*		
SOC			*0.320***	
GOV				0.009
FZ	0.030	0.48	0.540	0.134
FZE	-0.056	-0.006	-0.148	0.022
LV	*-10.052***	*-9.780***	*-10.195***	*-9.664***
F	23.794	24.664	25.761	20.895
Durbin-Watson	2.201	2.061	2.11	1.731
Adjusted R Square	0.099	0.103	0.107	0.088
Anova Sig.	<.001b	<.001b	<.001b	<.001b

Notes: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Source: Own calculation based on data analysed with SPSS software.

The results provided by the regression models also identified that the relationship is significant only for ESG factors al 0.05 and for SOC scores at the level 0.01. In addition, combined ESG scores and SOC scores have a significant impact on ROA, increasing the financial performance of agricultural companies. The identified results are similar to those of [23] showing that the ESG aspect, combined and individually, has a positive impact on the financial performance of agricultural companies. The identified results are partially in contradiction with those of [3] who identified a negative but not significant relationship between the combined factors of ESG and ROA for companies in the agricultural & food industries sector. Although similar results were identified by [9] for environmental and governance scores, the author found a nonsignificant and positive relationship between companies from all over the world that act in the agricultural sector.

Table 7 presents the results of the multiple linear regression analysis of the impact of sustainability disclosure on the operational performance of agriculture companies (ROE).

The regression analysis shows that the econometric model may explain between 5.5% and 7.0% the variation of ROE when we control by FZ, FZE and LV. Furthermore, the model used is valid, Anova sig. being <0.05. The regression models result for ROE identified a positive relationship between sustainability disclosure and operational performance of agricultural companies.

The results provided by the regression models also identified that the relationship is significant for the combined ESG score, the ENV and the SOC scores, at the level 0.01.

Table 7. The Impact of Sustainability Disclosure on ROE

Variables	Coef.	Coef.	Coef.	Coef.
(Constant)	2,128	0,916	1,438	-5,079
ESG	*0,117***			
ENV		*0,065***		
SOC			*0,111***	
GOV				0,034
FZ	-0,071	0,001	0,016	0,388
FZE	*0,768*	1,058	0,652	1,000**
LV	*-15,052***	*-14,676***	*-15,427***	*-15,878***
F	14,743	12,898	15,315	12,538
Durbin-Watson	1,661	2,018	1,920	1,831
Adjusted R Square	0,063	0,055	0,07	0,058
Anova Sig.	<,001b	<,001b	<,001b	<,001b

Notes: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Source: Own calculation based on data analysed with SPSS program.

In addition, the companies which are oriented to the social aspect of the employees and community and are involved in solving environmental issues, their operational performance increases. These results are contrary to those of [20] who identified that ESG aspects have a significant positive and negative impact on financial performance. Furthermore, the results identified in Table 7 are partially in agreement with those of [23] and completely in contradiction with those of [3] who identified a negative relationship with ROE. Furthermore, in analysing the impact of corporate social responsibility on the agribusiness industry in Bangladesh, [22] identified that CSR has a significant impact on ROE, these results supporting the results obtained for ROE.

Table 8 presents the results of the multiple linear regression analysis of the impact of sustainability disclosure on the market performance of agriculture companies (TQ).

The regression analysis shows that the econometric model may explain between 12.4% and 14.4% the variation of TQ when we control by FZ, FZE and LV. Furthermore, the model used is valid, Anova sig. being <0.05. The regression models result for the TQ ratio identified a positive relationship between sustainability disclosure and market performance of agricultural companies, both combined and individually related scores related to independent variables.

Table 8. The Impact of Sustainability Disclosure on TQ

Variables	Coef.	Coef.	Coef.	Coef.
(Constant)	*2.702***	*2.540***	*2.739***	*1.982***
ESG	*0.009***			
ENV		*0.005***		
SOC			*0.007***	
GOV				*0.004***
FZ	-0.061*	*-0.048*	-0.061*	-0.012
FZE	*-0.076***	*-0.066***	*-0.066***	*-0.079***
LV	*-1.148***	*-1.093***	*-1.180***	*-1.174***
F	34.682	30.410	31.742	29.61
Durbin-Watson	1.999	1.685	1.696	1.774
Adjusted R Square	0.144	0.128	0.133	0.124
Anova Sig.	<.001[b]	<.001[b]	<.001[b]	<.001[b]

Notes: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Source: Own calculation based on data analysed with SPSS program.

Moreover, a strong relationship at level 0.01 was identified between the dependent variable and independent variables. In addition, the companies that are oriented to have more corporate social responsibility achievements the higher their market performance. The results identified are contrary to those of [23] but similarly to those of [3].

CONCLUSIONS

The growing number of ESG issues has a specific impact on agriculture business. On the one hand, policymakers, and regulators such as the European Commission are imposing more restrictions and reporting obligations to increase the transparency referring to the social and environmental aspects. Moreover, investors and other stakeholders are interested to be informed about those companies that are eco-friendly and are involved in the community. This new regulation and this new attention given by stakeholders can affect the company's performance.

This aim of this study is to investigate the impact of sustainability disclosure on corporate performance of the companies acting in agriculture sector from Europe region. ROA, ROE and Tobin Q ratio are the dependent variables of the study representing the financial, operational and market performance. ESG combined scores and each one individually analysed, named as sustainability disclosure, represent the independent variables while the control variables are represented by the firm size and leverage of the companies. Data were collected from the Refinitiv Eikon database for European agriculture companies, for the period 2017-2021, divided into five European regions.

The results revel that the companies from agriculture sector who have a higher level of sustainability disclosure achieve a better performance (operational, financial and market performance). The identified results are similar to those of [23] who identified that both combined and individual ESG factors have a positive impact on both financial and operational performance of agriculture companies.

The findings identified have an important implication for companies, shareholders, regulators, and government because suggest the level of compliance of agricultural companies with the regulation regarding corporate social responsibility and European regulation. Furthermore, this study contributes to the literature by offering new insights referring to the link between sustainability disclosure and corporate performance of agricultural companies, viewed for the European regions. Moreover, this study may help investors and other stakeholders to have an overview as to which sector to orient their investment strategies.

This study has some limitations. First, the data are collected only for Europe, which offer only a European vision, not a worldwide Future studies may extend the database and the period. Second, the number of companies that disclose information about ESG data in Refinitiv Eikon is relatively small, especially for companies from emerging countries. Future studies may collect data from several other databases such as Bloomberg to combine and have more data available. Third, this study uses only multiple linear models.

Future studies may use OLS regression or fixed and random effects. Future studies may analyse the impact of sustainability disclosure on corporate performance for each European regions to provide new insights between European emerging countries and European developed.

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INFLUENCE OF VENTILATION SYSTEM TYPE ON MICROCLIMATE PARAMETERS IN FARROWING ROOM AND REPRODUCTIVE QUALITIES OF PIGS

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Abstract

The article studied the influence of temperature and humidity in the room for farrowing sows with different types of ventilation system on other microclimatic parameters and their relationship and dependence of the reproductive qualities of sows, the health of suckling piglets and the intensity of their growth on the method of room ventilation. An experiment was conducted in two separate groups of breeders (120 farrowing sows each), which were equipped with valve and geothermal systems for creating a microclimate. It was established that the valve ventilation system provides 2.12 mg/m^3 ($p < 0.01$) lower NH_3 content and 0.40 mg/m^3 ($p < 0.001$) lower H_2S content. At the same time, using the geothermal ventilation system, the weight of the piglets' nest at weaning was higher by 3.90 kg or 5.38% compared to the counterparts that were kept using valve ventilation. The level of morbidity and mortality of piglets, as well as the veterinary component of the cost of their growth, were lower when using the geothermal ventilation system. All indicators of the microclimate were in a reliable correlation relationship. In particular, as the internal temperature in the farrowing room increased, the content of CO_2 and H_2S also increased, but the content of NH_3 and relative humidity decreased. When the relative humidity increased, the content of hydrogen sulfide decreased, but the content of ammonia and carbon dioxide also increased. The contents of NH_3, CO_2 and H_2S were also correlated, but the relationship between them was weak.

Key words: *NH_3 content, CO_2 content, H_2S content, relative humidity, internal temperature*

INTRODUCTION

The productivity of pigs grown in industrial complexes depends on various factors, one of which is the microclimate of the farm premises [25]. Permanent global climate changes, combined with the use of pig genetics sensitive to stress factors, creates significant obstacles for efficient and cheap pork production. Since the parameters of the microclimatic environment in the farrowing room significantly affect the productivity of animals. This especially applies to suckling piglets, which are born with a limited supply of vital resources and are very sensitive to environmental factors in the first days of their lives. Therefore, there is an increased requirement to create the appropriate temperature, humidity and gas composition of the air in rooms for farrowing sows [1, 36].

The microclimate consists of a list of aggregated and interrelated parameters: temperature, humidity, air movement, chemical composition of the air, the content of dust, microbes, and harmful gases in it. It depends on various factors, such as the applicable care technologies, the number of animals, the systems for providing the animals with feed and water, the removal of manure, the use of waste, as well as the season and the external climate [13, 35]. Maintaining the microclimate is quite a difficult task at all times of the year, and especially during transitional seasonal periods, where there are frequent changes in external climatic parameters both during the day and during the calendar days. This task in the farrowing room is also complicated by the fact that the optimal microclimate parameters for the sow are mostly unacceptable for newborn piglets and vice versa [7, 30]. However, technological progress offers enough new engineering solutions and strategies for their application that will help mitigate the effects of stressors by modeling a healthy physical environment for the most efficient keeping of pigs [12, 13, 32].

The degree of humidity is one of the important parameters of the microclimate in the premises for keeping pigs and directly affects the metabolic processes in their bodies. When the air temperature in the middle of the room drops excessively, the concentration of moisture automatically increases, which leads to condensation settling on the surfaces and, as a result, to an increase in humidity and hypothermia of animals, the development of fungi and the spread of pathogenic microflora. At elevated temperatures, humidity critically decreases and the air becomes dry, as a result of which pigs overheat, which also negatively affects their general condition [6, 17].

Another, no less important parameter of the microclimate of a room for keeping pigs is the internal temperature of this space [14]. An increase in temperature leads to heat stress in animals. In previously published studies, heat stress has been reported to adversely affect health and growth in adult pigs [10, 11, 31] and especially in piglets [26]. In addition, the increase in temperature in the pig house is a complex problem and can not only worsen the productivity of pigs, but also affect other indicators of the microclimate, such as gassing with harmful gases [40].

The speed of air exchange has a direct effect on both humidity and temperature, as well as on the level of air contamination with harmful gases. Slowed and insufficient air exchange can result in the growth of the mentioned indicators above the critical level. Excessively accelerated air exchange in the farrowing room can cause heat loss and hypothermia of animals in the cold season and overheating in the warm season [2].

It is known that the intensity of the release of ammonia, hydrogen sulfide, and carbon dioxide produced by pigs depends on their weight, average daily growth, animal activity, the composition of their diet, and the type of bedding [3, 5, 18, 24, 27]. However, according to widespread data, it became known that the temperature and speed of air movement in the pigsty room also reliably affected the content of hydrogen sulfide, ammonia and carbon dioxide in it [33, 15, 16].

In particular, the increase in the internal temperature in the room for farrowing led to an increase in the concentration of NH_3. The daily content of NH_3 was directly correlated with the air temperature in the premises of the pig complex ($r = 0.86$-0.91). The increase in ammonia content occurred together with the increase in internal temperature [9]. According to scientists, the effect of ammonia on pigs is harmful and leads to a decrease in productivity and a decrease in their live weight gain and to a decrease in feed consumption [28, 38]. Exposure to ammonia may be the reason of pathological changes in many tissues and organs of pigs [39].

In recently published works, it was indicated that the increase in temperature in the room for keeping pigs with the simultaneous decrease in air movement speed led to an reduction in the concentration of H_2S there [23]. Exposure to hydrogen sulfide reduces average daily growth, average daily feed consumption and increases the frequency of diarrhea in piglets. Increasing the content of hydrogen sulfide in sow pens can increase the number and diversity of intestinal microbiota, which is a common cause of diarrhea [5].

Similarly, according to other data [9], the CO_2 content increased with an increase in the internal temperature of the pig house, which was explained by the presence of an average direct correlation between these indicators of the microclimate ($r = 0.42$-0.83). Exposure to carbon dioxide has a negative effect on pigs and their offspring, in particular, it increases the frequency of stillborn piglets and abortions in sows with confirmed farrowing [8].

However, no matter which technological group of pigs releases harmful gases into the room at different internal temperatures and humidity, the task of the microclimate management system in the pig house is to remove them outside and replace them with fresh, clean air. Ensuring a healthy microclimate in the production premises that meets the physiological needs of pigs is carried out with the help of ventilation of various designs and methods of preparation and supply of external air, among which the most common are valve and geothermal systems [19].

The geothermal ventilation system provides more stable air temperature and humidity indicators and the temperature of the piglets' and sow's den throughout all seasons of the year, compared to the valve system. At the same time, it creates worse air pollution indicators [20]. The valve ventilation system better removes gassed air from the farrowing room, minimizing the negative impact of harmful gases on the reproductive qualities of sows and the growth intensity of piglets [22]. It was also found that when pigs were kept in farrowing rooms equipped with a geothermal microclimate system, indicators such as the number of piglets at weaning and the nest weight of piglets at weaning were significantly higher than in animals kept under a microclimate valve system [21].

The relationship between the humidity and air temperature in the room for keeping pigs on the one hand and the indicators of gassing on the other is considered a confirmed phenomenon, however, its strength and characteristics are manifested in different ways with the use of different ventilation systems and, as a result, it has different effects on pigs and on the formation of microclimate parameters. The study of the dependence of the content of harmful gases on the temperature and humidity of the air in a pig house with various ventilation systems is still relevant, taking into account their constant modernization and noticeable climatic changes in the natural environment, especially in transitional seasons such as autumn and spring.

The purpose of our work is to study the dependence of the content of ammonia, hydrogen sulfide and carbon dioxide on temperature and humidity in the room for keeping pigs using different systems for creating a microclimate in them in the autumn season and their effect on the reproductive qualities of sows.

MATERIALS AND METHODS

In order to carry out the research on the basis of the commercial breeder of the LLC "Globynsky Pig Complex" of the Globinsky district of the Poltava region, Ukraine, two groups of 120 sows were formed according to the principle of groups of analogues, the farrowing of which fell on one calendar week and began on November 8 (Table 1).

Table 1. Scheme of the experiment to study the influence of the type of microclimate system on the gas composition of the air and the productivity of sows

Indicator	Valve ventilation	Geothermal ventilation
Method of intake of outside air	Air intake directly from the outside environment	Air intake through underground buried air ducts
The method of air distribution inside the farrowing room	Valve distribution of air flow from the walls	Air distribution through perforated air ducts above the main part of the farrowing pens
Method of exhaust air removal	Output through exhaust shaft	Output through exhaust shaft
A group of sows	Group I	Group II
The number of sows in the farrowing section	120	120
Breed features of sows	♀L×♂LW	♀L×♂LW
Number of boars	4	4
Genotype of boars	PIC-337	PIC-337

Source: own calculations.

All sows were presented two-breed crossbreeds, whose mothers belonged to the Landrace breed and whose fathers belonged to the Large White breed of origin from the English company PIC. All sows were inseminated with mixed sperm of four terminal boars of the synthetic parental line PIC-337 breeding of the same genetic company.

During the idle and farrowing period, all experimental sows were kept under identical conditions and had the same type of background of feeding with complete balanced feed for farrowing sows. In 3-5 days before the expected farrowing on November 8, they were transferred to the premises of the reproduction section. The animals of the control group were placed for farrowing and subsequent lactation in housing No. 6 under negative pressure valve ventilation manufactured and installed by specialists of the German company Big Dutchman. In this air exchange system, the outside air was supplied via supply air valves located on the walls perpendicular to the farrowing pens.

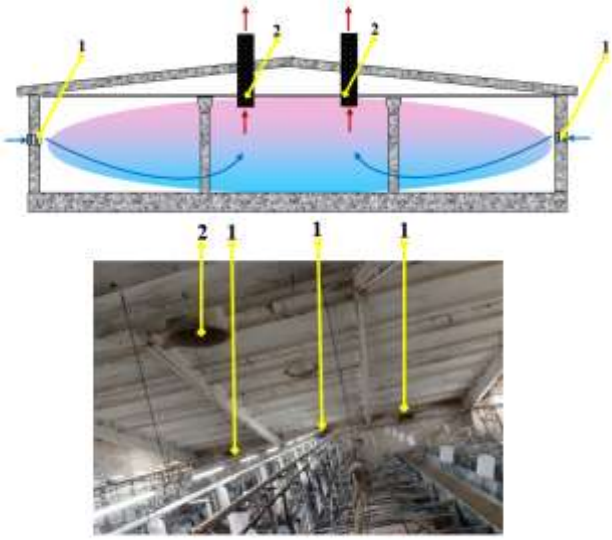

Fig. 1. Scheme of the valve system of ventilation at farrowing section in group I
1 - supply valve; 2 - exhaust shaft.
Source: Own determination.

On the same day, the animals of the experimental group were placed in an adjacent reconstructed farrowing room with an identical layout, also equipped with a negative pressure ventilation system of the same Big Dutchman company, but with a modified method of air intake, transportation and distribution. Air, under the influence of negative pressure created by the exhaust fans, enters through the air intake holes in the underground galleries located at a depth of 120 cm from the soil surface. These galleries along their entire length are filled with granite stones of large size. When passing through the galleries, the air stabilizes its temperature parameters relative to the soil temperature at this depth. Stabilized air enters the air ducts, which are located in the front part of the farrowing pens perpendicular to its location in the section, and due to the holes in its lower part, it is evenly distributed among the animals (Fig. 2).

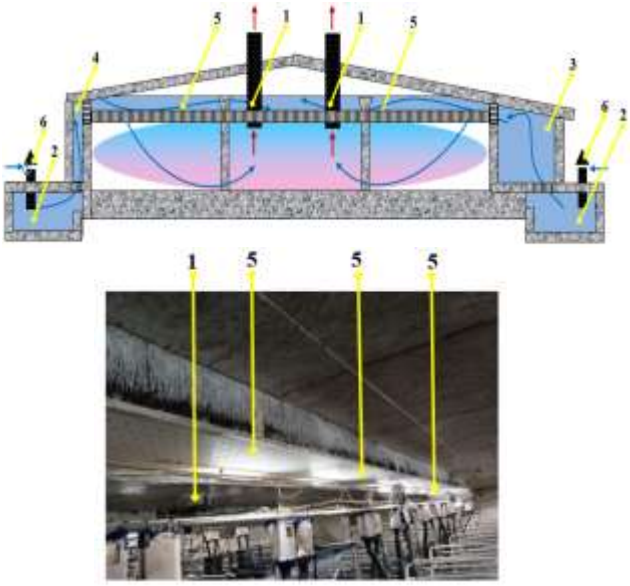

Fig. 2. Scheme of the geothermal system of ventilation at farrowing section in group II
1 - exhaust shafts; 2 - underground gallery; 3 - internal corridor; 4 - wall air duct; 5 - under-ceiling dispersive air ducts; 6 - inlet shafts.
Source: Own determination.

Coordination of the supply and exhaust elements of ventilation in both farrowing rooms was carried out by the same microclimate system control processor, based on temperature and air humidity.

During the research period, every Tuesday and Friday, the air temperature was determined using a Testo 425 thermal anemometer (Testo AG, Lenzkirch, Germany). The content of ammonia (NH_3), hydrogen sulfide (H_2S) and carbon dioxide (CO_2) was determined using a DOZOR-S-M gas analyzer (Testo AG, Lenzkirch, Germany). Air humidity was determined using a Testo 605 thermo-hygrometer (Testo

AG, Lenzkirch, Germany). All measurements were made at the level of the piglets lying 15 cm and the sow standing at 70 cm. Measurements were carried out in 8 pens of each section diagonally, in the morning from 7 to 9 o'clock and in the evening from 6 to 8 o'clock, each time in reverse order. In the experiment, the reproductive qualities of sows were studied according to generally accepted methods. The number of piglets born, fertility, weight of piglets at birth, nest weight of piglets at birth and at weaning were studied. The number of piglets in the nest when weaned at 21 days of age and their average weight, intensity of growth, percentage of morbidity in the weaning period and costs of funds for the prevention and treatment of animals during this period and the share of these costs in the total cost of raising one piglet.

For a comprehensive evaluation of the reproductive qualities of sows under different housing conditions, an evaluation index with a limited number of signs [34] was calculated according to the formula:

$$I = B + 2W + 35G \text{ ....(1)}$$

where:
I – index of reproduction qualities, points;
B – the number of piglets at birth, head;
W – number of weaned piglets, head;
G – average daily gain of piglets at weaning, kg.

For the same purpose, the selection index of reproductive qualities of sows was used according to the method [37]:

$$(SIRQS) = 6X_1 + 9.34\left(\frac{X_2}{X_3}\right) \text{..........(2)}$$

where: $SIRQS$ – selection index of reproductive qualities of sows;
X_1 – fertility, heads;
X_2 – weight of the nest at weaning, kg;
X_3 – weaning period, days.

During the experiment, all participants strictly followed the generally accepted rules of humane treatment of animals.

Statistical analysis of the results of the experiment was carried out in Microsoft Excel 2016. Values were considered statistically significant at the first – $p < 0.05$, the second – $p < 0.01$, the third – $p < 0.001$ thresholds of the Student's t-test.

RESULTS AND DISCUSSIONS

The analysis of microclimate parameters in the room for keeping suckling piglets showed that the ammonia content when using the geothermal type microclimate system was higher by 2.12 mg/m^3 ($p < 0.01$) compared to the room where the valve type of the microclimate maintenance system was used. It was also found that the hydrogen sulfide content in the brooder with experimental ventilation was 0.40 mg/m^3 ($p < 0.001$) (Table 2).

Table 2. Parameters of the microclimate in the premises at different ventilation system during the autumn season, (n = 90)

Indicator	Air temperature at the level of the pig's respiratory tract (60 cm), ºC	Relative humidity, % vol	Ammonia (NH_3) content, mg/m^3	Carbon dioxide (CO_2) content, % vol	Hydrogen sulfide (H_2S) content, mg/m^3
Group 1	19.43±0.24	67.20±0.72	13.30±0.59	0.23±0.01	2.16±0.07
Group 2	19.24±0.28	66.35±1.19	15.42±0.32**	0.25±0.01	2.56±0.15*

* – $P < 0.05$; ** – $P < 0.01$;
Source: own calculations.

No difference was found between the control and experimental rooms of the farrowing house in terms of carbon dioxide content, indoor temperature and relative humidity.

The evaluation of the correlations between the indicators of the microclimate in the room for keeping sows with suckling piglets in the autumn season showed a statistically confirmed weak interdependence between the temperature and the gas content. At the same time, the correlation of temperature with the content of NH_3 was inverse (r = -0.23; p <0.001), and with the content of CO_2 (r = 0.06; p <0.001) and the content of H_2S (r = 0.03; p <0.001) was direct. Indicators of temperature and relative air humidity were weakly correlated and had an inverse relationship (r = -0.03; p <0.001).

An inverse and weak but reliable relationship was found between relative humidity and hydrogen sulfide content (r = -020; p <0.001). Instead, relative humidity was directly correlated with both ammonia content (r = 0.29; p <0.001) and carbon dioxide content (r = 0.22; p <0.001) (Table 3).

Table 3. Correlation between microclimate indicators during the autumn season

	Temperature	Relative humidity	NH_3 content	CO_2 content	H_2S content
	r	R	r	r	r
Temperature	1.00	-0.03	-0.23	0.06	0.03
P-value	1.00	<0.001	<0.001	<0.001	<0.001
Relative humidity		1.00	0.29	0.22	-0.20
P-value		1.00	<0.001	<0.001	<0.001
NH_3 content			1.00	0.18	-0.21
P-value			1.00	<0.001	<0.001
CO_2 content				1.00	0.28
P-value				1.00	<0.001
H_2S content					1.00
P-value					1.00

Source: Own calculations.

At the same time, the gas content also correlated with each other, showing a weak dependence. The correlation relationship between NH_3 content and CO_2 content was direct (r = 0.18; p <0.001), and between NH_3 content and H_2S content, on the contrary, it was inverse (r = -0.21; p <0.001). Carbon dioxide and hydrogen sulfide were also weakly correlated (r = 0.28; p <0.001).

Regression analysis of the interdependence of indoor microclimate indicators showed that a 1.0 ^oC increase in internal temperature was due to a decrease in the content of NH_3 by 0.56 mg/m^3, an increase in the content of CO_2 by 0.001% vol (p <0.001) and an increase in the content of H_2S by 0.009 mg/m^3 (p <0.001) under the influence of the factor characteristic by 0.54%, 0.003% and 0.001%, respectively.

It was established that when the temperature increased by 1.0 ^oC, the relative humidity decreased by 0.10% vol (p <0.001), which was caused by the specified increase in the temperature index by 0.001% (Table 4).

Table 4. The regression analysis between air temperature at the level of the pig's respiratory tract (60 cm) and gases content and relative humidity during the autumn season

Indicator	Regression equations	R^2	Prob.
NH_3 content	y = -0.5699x + 24.378	0.0543	<0.001
CO_2 content	y = 0.0018x + 0.192	0.0039	<0.001
H_2S content	y = 0.0093x + 1.981	0.0010	<0.001
Relative humidity	y = -0.1024x + 75.188	0.0012	<0.001

Source: Own calculations.

Based on the results of the regression analysis, it was proved that when the relative humidity increased, the gas content also increased. In particular, the NH_3 content also increased by 0.009 mg/m^3 (p <0.001) for every 1.0% vol increase in relative humidity (under the influence of fluctuations in the humidity index with a strength of 0.001%).

At the same time, if the relative humidity in the farrowing room increased by 1.0% vol, then the CO_2 content there also increased by 0.23% vol (p <0.001) (under the influence of fluctuations in the humidity indicator with a force of 0.08%).

When the humidity increased by 1.0% vol, the H_2S content decreased by 0.002 mg/m^3 (p <0.001) (under the influence of fluctuations in the humidity index with a strength of 0.04%) (Table 5).

Table 5. The regression analysis between relative humidity and gases content during the autumn season

Indicator	Regression equations	R²	Prob.
NH_3 content	y = 0.0093x + 1.981	0.0010	<0.001
CO_2 content	y = 0.2353x – 3.9161	0.0835	<0.001
H_2S content	y = -0.0021x + 0.0734	0.0467	<0.001

Source: Own calculations.

Part of the reproductive performance of sows also depended on the system of creating and maintaining a microclimate in their farrowing rooms. Under different microclimate creation systems, domestic sows of English origin had high indicators of reproductive qualities (Table 6). There was no significant difference between sows of the experimental and control groups in terms of the total number of piglets born, multifertility, weight of piglets at birth and litter weight of piglets at birth.

Table 6. Productive indicators of sows kept in rooms with different ventilation systems

Indicator	Group 1	Group 2
The number of sows at the end of the experiment, head	117	119
Total piglets per farrowing, head	16.4±0.43	16.4±0.46
Multifertility, head	15.0±0.36	15.1±0.41
Weight of piglets at birth, kg	1.33±0.014	1.31±0.019
Nest weight of piglets at birth, kg	20.0±0.68	19.8±0.73
The number of piglets at weaning per 1 sow, head	12.5±0.22	12.9±0.17
The number of piglets that died during the suckling period, head	2.5	2.16
Share of piglets that were treated, %	26.3	17.2
Preservation of piglets, %	83.2	85.7
Average weight of 1 piglet at weaning, kg	5.8±0.17	5.9±0.14
Weight of the nest of piglets at weaning, kg	72.5±1.17	76.4±1.04*
Absolute growth, kg	4.48±0.13	4.59±0.11
Average daily increase, g	211±3.04	217±2.97
Average costs for the treatment of 1 head, EUR	1.16	0.88
Veterinary cost of 1 kg of gain, EUR	0.26	0.19
The share of veterinary costs in the cost of one piglet, %	9.19	7.54
I, points	47.36	48.56
SIRQS, points	122.25	124.56

* – P <0.05
Source: Own calculations

At the same time, in a farrowing room with a traditional valve ventilation system, a 9.1% higher share of piglets requiring veterinary intervention was found. Also, 0.36 heads (14.3%) more piglets died from this group during the suckling period compared to animals kept under geothermal ventilation. This caused a 2.5% deterioration in the survival of piglets in sows of the control group compared to the experimental group. This, in turn, led to a decrease of 0.46 heads or 3.7% in the number of weaned piglets in the nests of these sows. Then, as for the weight of one piglet at weaning, there was no practical difference between the animals of both experimental groups. At the same time, the greater number of piglets in the nest contributed to a probable (p <0.05) increase of 3.8 kg (5.3%) in the animals of the experimental group over the control weight of the nest of piglets at weaning. Whereas, according to the intensity of growth of piglets in the post-weaning period, no significant difference was found between the animals of both groups. More frequent manifestations of diseases of piglets in a farrowing room with a traditional microclimate system caused a 24.4% (EUR 0.28) increase in the cost of treatment of one average head of piglets. This caused an increase of EUR 0.07 or 26.2% of the veterinary component of the cost of one kilogram of suckling piglet growth. Which, in turn, led to a 1.61% increase in the share of veterinary costs in the total cost of raising one piglet until weaning. According to comprehensive indicators of reproductive qualities, sows that farrowed and raised their offspring in a farrowing room with a geothermal microclimate maintenance system had an advantage of 1.9-2.5% compared to animals whose farrowing took place in a farrowing room with classical valve ventilation. Thus, piglets that were kept during the suckling period in a farrowing room with a geothermal ventilation system were 9.1% less likely to be treated, had 2.5% better survival until weaning and 3.7% more of them during this period. This, in turn, contributed to a probable increase of 5.3% in the weight of their nest at weaning, a decrease of 24.4% of the funds spent on the treatment of one piglet, a decrease of 26.2% of the veterinary component of the cost of one kilogram of growth of suckling piglets and 1.61% share of costs for prevention and treatment in the cost of rearing one piglet until weaning compared to analogues that were kept in the room under the classical valve ventilation system. At the same time, in terms of the total number of piglets at birth, multifertility, weight of piglets at birth, weight of the litter of piglets at birth, the intensity of their growth during the suckling period and the weight of one piglet at weaning, no significant difference was found between sows kept under different microclimate maintenance systems.

The significantly higher value of the ammonia content indicator found by us in the farrowing room, where the geothermal microclimate system was used, did not have a significant effect on the indicators of piglet growth intensity, as other researchers [28, 38] claimed. In our experiment, the absolute and average daily increases were equal for both valve and geothermal ventilation despite the higher NH_3 level in the experimental room.

The increased content of hydrogen sulfide in the experimental brooder with underground preparation of outside air also had no confirmed effect on piglet gains, which were almost equal in both groups, which did not coincide with reports [5].

According to the results of the assessment of the relationship between the temperature indicator and the ammonia content in our experiment, the mentioned indicators had an inverse correlation dependence, the presence of which was not confirmed in other scientific works [9], which spoke of a direct correlation between the mentioned microclimate indicators. We assume that for the growth of the temperature index, we did not get an increase, but, on the contrary, a decrease in the content of ammonia in the farrowing room due to the automatic activation of the ventilation system, which, in order to lower the internal temperature, started the process of accelerated air exchange. Accelerated air exchange immediately removed NH_3 faster than other gases, since ammonia is twice as light as air, so it concentrated in the subceiling space in the immediate vicinity of the exhaust shafts. Carbon dioxide and hydrogen sulfide, on the contrary, are heavier than air and concentrated in the lower part of the interior space of the farrowing room due to these properties. In this regard, when the internal temperature increased and the ventilation was activated, extracting ammonia that was immediately near the exhaust shafts, the available CO_2 and H_2S required longer operation of the microclimate system in order to reduce their concentrations near the floor in the living area of the piglets. An increase in the temperature in the farrowing room leads to a more intense release of CO_2 by the animals, which begin to breathe more often, and to a more intense evaporation of H_2S from underground manure pits and channels, where the circulation of exhaust air is difficult and cleaning occurs with some delay [29]. This contributes to the increase in the content of carbon dioxide and hydrogen sulfide when the internal temperature increases, even despite the automatic forced increase of air exchange by the microclimate control system, which is consistent with other reports [33, 15, 23]. However, such an increase in the concentration of the specified gases in the specified space of the brooder room is not long-lasting, because despite a temporary increase in the accumulation of their volumes at the initial stage of ventilation, their further accumulation decreases as the intensity of air exchange increases to a level sufficient to remove CO_2 and H_2S and reduce their content to a safe level [22]. However, in the process of increasing air exchange when the exhaust ventilation system is activated in manure pits and channels, the intensity of air movement also increases, which accelerates not only the removal of hydrogen sulfide, but also its diffusion from the manure surface. At an elevated temperature in the farrowing room, the surface temperature of manure in manure pits and channels also increases, which comprehensively contributes to evaporation and the simultaneous accumulation of additional hydrogen sulfide for some time, until a sufficient decrease in its surface temperature occurs [4]. This explains the temporary increase in the content of hydrogen sulfide and carbon dioxide due to the increase in internal temperature and the increase in the intensity of air exchange when forced to accelerate it by the microclimate control system.

CONCLUSIONS

The geothermal ventilation system of the room for farrowing sows contributed to the reduction of the morbidity and mortality of piglets, funds for the prevention and treatment of piglets, the reduction of the veterinary component of the cost of growth and its share in the total cost of growth, the improvement of the survival of piglets and the increase of their nest weight at weaning.

The gassing level of the sow pig house depends reliably on fluctuations in internal temperature and relative humidity. As the internal temperature increased, the content of carbon dioxide and hydrogen sulfide increased, while the content of ammonia and relative humidity decreased slightly. When the relative humidity in the farrowing room increased, the content of NH_3 and CO_2 increased, while the content of H_2S, on the contrary, decreased slightly.

The valve ventilation system provided better cleaning of the farrowing room from the content of harmful gases compared to the geothermal ventilation, however, it did not affect the indicators of sows' reproductive characteristics and the intensity of piglets' growth.

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OBTAINING VITRO TUBERS OF WHITE AND PURPLE FLESH POTATOES IN ASEPTIC CULTURES OPERATED ON DOUBLE-PHASE TECHNIQUE

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Abstract

Due to the interest shown in our country regarding the cultivation and marketing of purple flesh potatoes, we set ourselves the problem of examining the aspects that facilitate in vitro cultivation and obtaining micro tubers that ensure the faster micropropagation of purple potato varieties, formations that in modern food are also consumed raw. The paper aimed to present the protocol for obtaining vitro tubers or also called micro tubers from two varieties of potato: Christian with regular colour of flesh and Salad Blue with purple flesh. This protocol is based on micropropagation technique which combine an agar-solidified phase succeeded by a liquid phase in the same vessel in aseptic conditions. Using the double-phase technique gave the opportunity to reduce the costs generated by the utilities.

***Key words*:** *purple flesh potatoes, in vitro tuberization, double-phase culture medium, resources management*

INTRODUCTION

The *in vitro* cultivation of potato (*Solanum tuberosum* L.) is practiced in laboratories, not only for the purpose of carrying out scientific research, but also in an intensive regime for the delivery to agricultural farms of planting material, free of viruses, made by cultures of meristematic explants on aseptic culture media [7].

In modern nutrition, we currently consume vegetables and fruits rich in organic compounds synthesized in their secondary metabolism and which have an important and varied therapeutic influence in a series of medical treatments. This category also includes plants that synthesize anthocyanins [17].

Medicinal plants are used either fresh, respectively raw, or boiled like tea or preserved in various dried forms, in natural treatments [1].

As a rule, the compounds that fall into the category of secondary metabolism products are organic, made up of complex substances, which often define the characteristic particularities of some plant species; their location being in all plant organs, including reserve organs, but mainly in fruits, especially on blueberries and black grapes [5; 8]. This category also includes anthocyanins, compounds that stand out in various plant organs of some plants whose presence is distinguished by their red, purple or blue colour and whose colour changes when the pH varies [10], from a shade of red at an acidic pH, to purple at a pH between 6-8 and even blue at a basic pH.

The variety of these anthocyanin compounds exceeds the number of 500 varieties [21], their chemical structure being complex [6]. In potato varieties with purple flesh, the presence o six types of anthocyanins is confirmed, namely: cyanidin, petunidin, pelargonidin, delphinidin, peonidin and malvidin [13].

From a medical point of view, anthocyanins exert excellent antioxidant, antimicrobial, anticancer, antidiabetic, anti-inflammatory, antiproliferative effects [21], but also strengthen immunity, delay aging, facilitate cerebrovascular and cardiovascular circulation [4], alleviate obesity, prevent liver disorders [6], and other benefits. On the category of plants rich in anthocyanins, we can also mention purple fleshed potatoes (*Solanum tuberosum* L.), the Salad Blue variety [19], which come from Peru and are mainly grown in China, but also in many other Asian and European countries, including our country. In addition to the use of purple flesh potato tubers in the kitchen for cooking, they are also used in the food industry [4], as natural dyes.

Due to the interest shown in our country regarding the cultivation and marketing of these purple flesh potatoes, we set ourselves the problem of examining the aspects that facilitate their cultivation *in vitro* and obtaining micro tubers that ensure the faster micropropagation of purple flesh potato varieties, formations that in modern food are also consume in raw form [20].

On the experiment carried out by us in this paper, to obtain micro tubers *in vitro*, we used bud explants taken from potato tubers (*Solanum tuberosum* L.) belonging to the Christian variety (control), with white flesh tuber and the Salad Blue variety with purple flesh tuber, due to the presence of anthocyanins in their cells.

The aim of this study is to obtain vitro tubers, also called micro tubers, after initiation on a classical culture media Murashige & Skoog (1962) [12] and transferred the obtained plantlets to a double-phase culture medium.

The paper contains *material and methods* section which describe the plant material used for the experiment, succeeded by *in vitro* culture initiation for stock vegetal material and *in vitro* culture tuberization which is divided in two parts: the first *in vitro* growth of potato plantlets and the second *in vitro* tuberization induction. The second section of the article reflect the *results and discussions* of the current experiment and in the end are presented the *conclusions* of these research paper which contains the importance of purple flesh potato and micro tuberization of it.

MATERIALS AND METHODS

It is known that potato tubers are a staple food [3], especially in the cold months, during the wintertime, being kept cold, in dark spaces, such as cellars, conditions in which – towards spring – the ”eyes” present on tubers generate buds and shoots (Fig. 1 A and B).

Plant material

The plant material used consists of shoots from two disease-free varieties of potato (*Solanum tuberosum* L.), namely Christian (the control) and Salad Blue. Both varieties were obtained from the National Institute of Research and Development for Potato and Sugar Beet from Brașov.

Christian is a Romanian potato variety, developed by the National Institute of Research and Development for Potato and Sugar Beet from Brașov. This is semi-early variety, with oval tuber shapes, reddish epidermis, and yellow flesh, developing a thick bush with leaves [14].

Salad Blue is a variety originally from Scotland, preserved on the seed collection of the National Institute of Research and Development for Potato and Sugar Beet from Brașov. This is an early variety, with oval tuber shapes, bluish-purple epidermis, and purple flesh with white insertions [15].

***In vitro* culture initiation**

From the apical area of the potato shoots from the studied varieties, after washing with sterile water, disinfecting them with 30% sodium hypochlorite solutions for 15 minutes and 3-4 time rinsing them with sterile water, upon removal of the apex coverings and proceeded to the ex-plantation of their apical zone – around 1-2 cm (Fig. 1 C (a)) – segment which then was inoculated, in a test tube with a volume of 10 ml solidified and aseptic Murashige & Skoog (1962) culture media, without growth regulators [13].

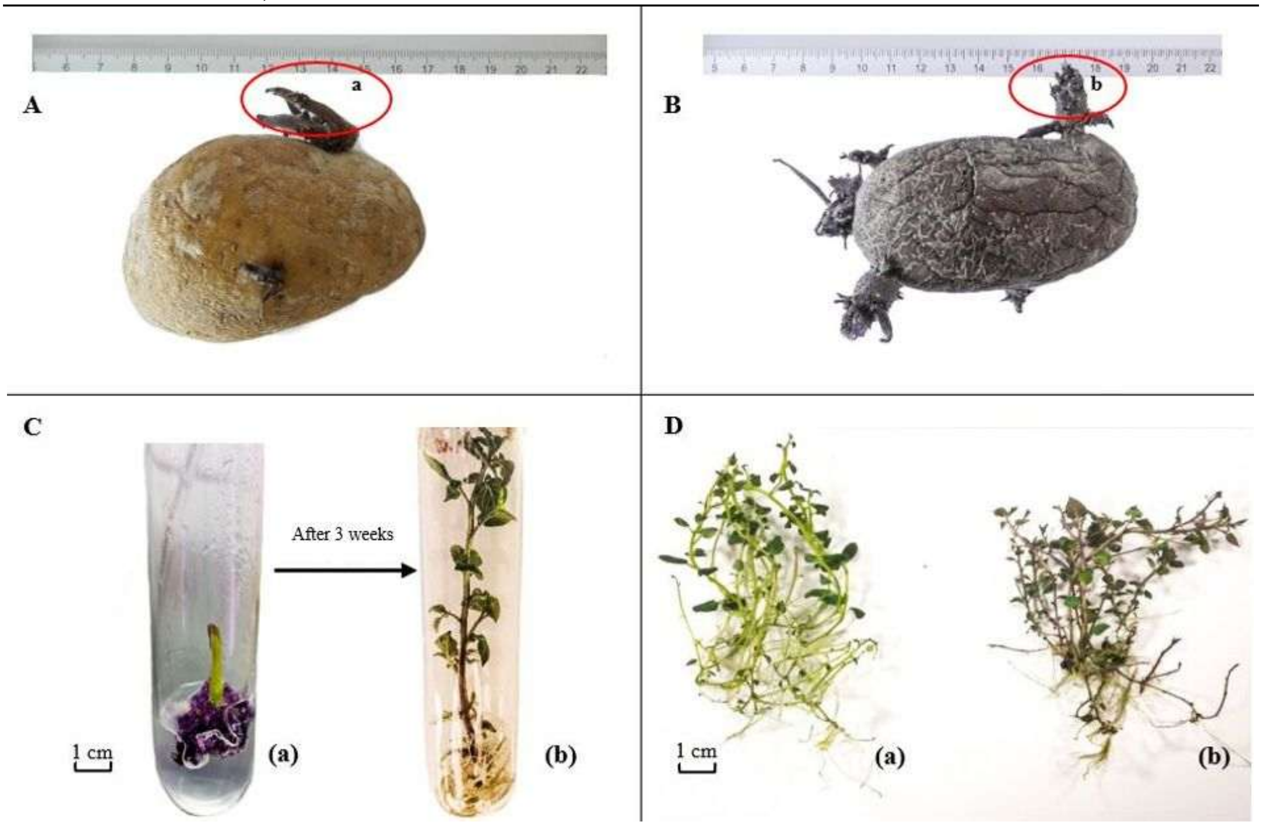

Fig. 1. The plant material used to initiate the potato *in vitro* culture; A – Christian potato variety tuber with white flesh (a – white buds); B – Buds of Salad Blue potato variety tuber with purple flesh (b – purple buds); C (a) – bud explants after 3 days of inoculation on solidified culture media; C (b) – The regeneration of potato plantlets from bud explants after 3 weeks from initiation; D – Potato ex vitro plants from variety Christian (a) and Salad Blue (b)
Source: Own determination.

These operations were carried out in a horizontal laminar flow hood of sterile air, the hood being in a sterile enclosure. The test tubes were all sealed.

After the completion of the inoculation operations, the samples (test tubes with explants) were transferred to the growth room, on shelves illuminated with neon tubes, with a photoperiod of 16 hours of light and 8 hours of darkness, at a temperature of 20°C ± 1°C.

***In vitro* culture tuberization**

From the first days after initiation, plantlets began to be generated from the inoculum, which within 3 weeks reached 7-8 cm in height (Fig. 1 C(b)).

The *in vitro* tuberization process involves two completions of two different culture phases (Table 1) on different grown condition (Table 2); first phase is the *in vitro* growth of potato plantlets succeeded by the second phase *in vitro* induction of tuberization.

Table 1. Culture media used for *in vitro* tuberization

Phase / Elements	1st phase: *In vitro* grown	2nd phase: *In vitro* tuberization induction
MS62	full	1/2
Sucrose	20 g/l	80 g/l
NAA	0.5 mg/l	-
Kinetin	-	0.5 mg/l
Coumarin	-	0.05 g/l
Agar	9 g/l	-

Source: Own calculation.

Table 2. Culture condition for *in vitro* tuberization

The process	Photoperiod		Temperature	Time for grown
	Light hours	Dark hours		
1st step: *In vitro* grown	16	8	20°C ± 1°C	3 weeks
2nd step: Tuberization induction *in vitro*	-	24	20°C ± 1°C	2 months

Source: Own calculation.

A. *In vitro* growth of potato plantlets

This phase aims at the optimal development of the plantlets that will later induce tuberization. These plantlets were transferred, also in aseptic mode, on solidified culture medium, MS62 supplemented with 0.5 mg/l α-naphthyl acetic acid (NAA), autoclaved at 121 ºC for 20 minutes in glass containers and after that placed under sterile conditions, in the hood, in larger, single-use pots made of transparent and colorless plastic (14 cm long, 8 cm wide and 8 cm height), hermetically closed with a lid of the same material, with a green filter, from Duchefa. Each pot contains in the solidified and aseptic medium 10 potato cuttings, with a length of approximately 2 cm. Cuttings were obtained from plant material initiated in test tubes. After the cuttings transfer operation was completed, the pots were transferred to the growth room, with a photoperiod of 16 hours of light and 8 hours of darkness, for 3 weeks, in an aseptic regime.

B. *In vitro* tuberization induction

The next step consisted in inducing tuberization *in vitro* by pouring a 1.5 cm substrate of liquid culture medium (about 100 ml) without agar into the culture vessels, so that the potato plantlets were subjected to *in vitro* culture in „double layer” (Fig. 2 A and B). This process took place after about 3 weeks, at which time the plantlets present in the culture vessels reached a height of 7-8 cm. The agar-free liquid culture medium had the following composition: ½ MS62, 0.05 g/l coumarin dissolved in 2.5 ml ethyl alcohol, 0.5 mg/l kinetin and 80 g/l sucrose.

After adding the tuberization medium (in the hood), the pots were transferred again to the growth room in the dark for 2 months at a temperature of 20ºC ± 1ºC.

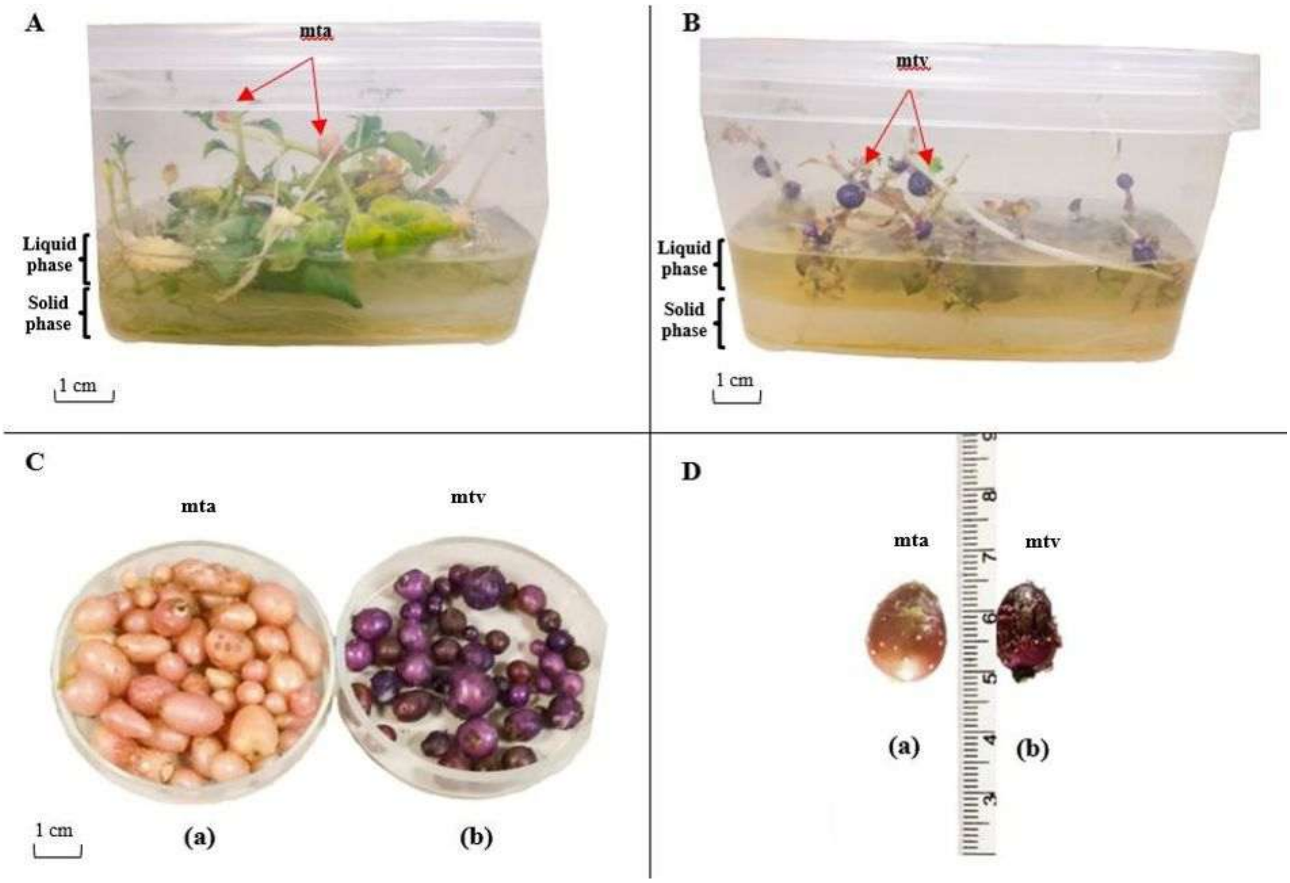

Fig.2. Appearance of Christian and Salad Blue potato micro tubers on „doble layer” culture media
A – Micro tubers of Christian variety on culture media (mta); B – Micro tubers of Salad Blue variety on culture media (mtv); C – Christian (a) and Salad Blue (b) micro tubers harvested from „double layer” culture media; D – The size of the Christian (a) and Salad Blue (b) micro tubers
Source: Own determination.

Experiment design and data analysis

For the present experiment, 10 culture vessels per potato variety were used, and the experiment had 3 repetitions. For each pot were used 10 potato micro-cuttings, resulting 100 micro-cuttings per variety in a single repetition and a total of 300 micro-cuttings per variety in the whole experiment.

For each culture vessel, the number of resulting micro tubers, their length and diameter were quantified, after which weighing's were also carried out for each individual micro tuber.

After collecting the data, they were processed using the Excel tool from the Microsoft Office package, and then interpreted with the Polifact statistical program, using the Duncan test.

RESULTS AND DISCUSSIONS

The research carried out in this work aimed to obtain potato micro tubers – white (as a control) and especially purple micro tubers – in a continuous flow, for the fact that this vegetable ensures the nutrition of the Earth`s population throughout the year [9], and the tubers of the purple potato varieties (such as the Salad Blue variety that we experimented with), contain anthocyanins (Fig. 2 C and D), thus consumers benefits from the exceptional effects that these by-products of metabolism expert on the human body, they can only be consumed raw [20].

After the tuberization period, the harvested micro tubers were disinfected with Domestos which contain as active substance sodium hypochlorite, at 20% solution concentration and subsequently washed and rinsed with sterile water, to remove traces of the culture media and to avoid further infections that may occur during their storage.

Then, the micro tubers are left to dry for 1-2 days at room`s temperature. They are placed in the refrigerator at 4-5°C, in the dark after dry. Micro tubers can also be stored in the freezer until planting, but no more than one year. They can later be planted in "insect proof" greenhouses and/or tunnels in a substrate consisting of a mixture of red peat with bentonite, black peat, and perlite. About 3 months after planting, the harvesting of mini tubers begins, which will later be used for planting and obtaining potato tubers by farmers.

For each pot, the micro tubers obtained were counted. Thus, for the Christian variety the average of micro tubers was 10.33 per pot, and for the Salad Blue variety the average of micro tubers was 20.67 micro tubers per pot (Fig. 3). It follows from this that following the application of the Duncan test, statistically guaranteed differences were obtained, and the culture medium in the double layer favored the obtaining of micro tubers from the Salad Blue variety, a variety of great interest, due to the rich content of anthocyanins.

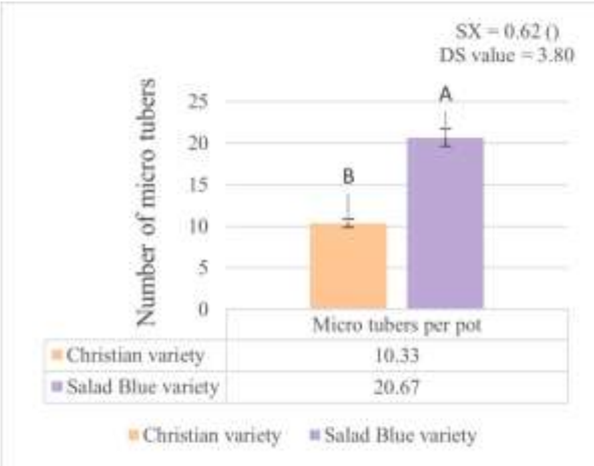

Fig.3. The potato variety influence for obtaining micro tubers on the „double layer" culture media
*A-B – significant statistical difference according Duncan test
Source: Own calculation.

According to the Duncan test, it follows that there were no statistically assured differences in weight (Fig. 4). Thus, the average weight for micro tubers obtained in double-layer culture, from the Christian variety was 0.92 g, while for those from the Salad Blue variety, the average weight was slightly higher, exactly 1.08 g, but the difference is insignificant.

Also, in the case of the length of the micro tubers, there were differences between the two varieties (Fig. 5); on the Salad Blue variety, micro tubers with a longer length (93 mm) were obtained, compared to those of the Christian variety (63 mm), and in this case, the differences not being significant from the statistical point of view.

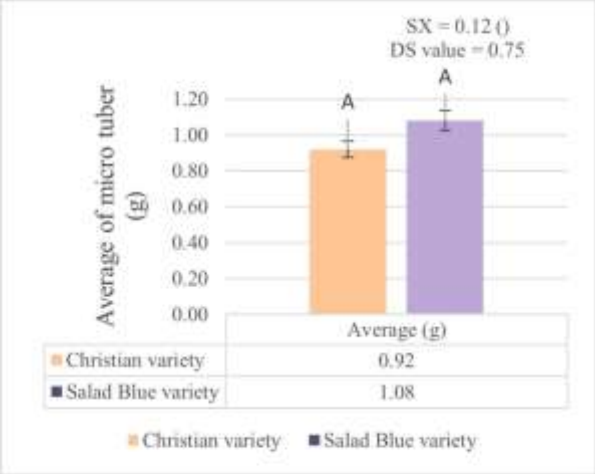

Fig. 4. The potato variety influence on weight of micro tubers obtained on the „double layer" culture media
*A-A – no significant statistical difference according Duncan test
Source: Own calculation.

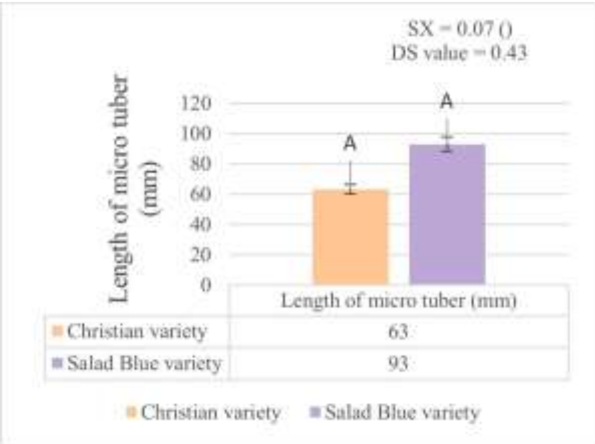

Fig. 5. The potato variety influence on micro tubers length obtained on the „double layer" culture media
*A-A – no significant statistical difference according Duncan test
Source: Own calculation.

Since the potato is propagated vegetatively [11], through tubers, and varieties with purple flesh tubers are still more difficult to access for European countries, and especially for the inhabitants of our country, we considered that the *in vitro* micropropagation procedures of the purple flesh potato are beneficial, with even more so as foods with anthocyanins increase immunity and mitigate the harmful consequences of many diseases.

In addition, we emphasize the advantages of purple flesh potato tubers consumption, respectively micro tubers produced by *in vitro* culture procedures, in a fresh state, without being cooked. Moreover, we are of the opinion that purple flesh potato ex vitro plants can also be eaten raw, in salads after are eating for decades in the European states bundles of seedlings from germinated seeds from different plant species such as red radishes, red cabbage, mustard, sunflower, onion, pepper, etc. (Fig. 6 A–E). Currently, they are called "sprouts" by traders (Fig. 6 A), being seedlings with cut roots (Fig. 6 B-E) sold in our country, following the model of other states.

The plants used for this purpose benefit from the fact that they contain meristems, which in their apexes hold stem cells, whose therapeutic and fortifying effects are highly valued. But seedlings from seed embryos (Fig. 6 A-E) have a short growth to the young seedling stage.

In contrast to the vitro plants, plants derived from seeds, respectively from zygotic embryos, cannot ensure the transmission of the characters of a specific genotype selected as a result of genetic engineering operations; instead, *in vitro* culture procedures ensure the continuous cloning of a certain genotype, as well as the preservation of these representatives in gene banks (in liquid nitrogen) and upon thawing of such plantlets, the continuous micropropagation of these genotypes is ensured.

A similar experiment was successfully carried out by Cachiță-Cosma and Zăpârțan (1991) [2], in which the pieces of potato micro tubers bearing buds were used in test tubes as plant material on *in vitro* culture process, on a two-layered aseptic substrate - agarized basal over which - after cooling - the inoculums and the liquid culture medium were placed, in a 2 cm layer. But, in the present work, the use - in stages of the bi-layered medium - of pots with a larger capacity, in which a volume of 100 ml of solid medium (1.5 cm layer height) and 100 ml of liquid medium (1.5 cm layer height) proved to be beneficial as it facilitated the implantation operation of the potato explants and favored both the growth of newly formed shoots at the phytoinoculs level and tuberization (Fig. 2 A-C).

Fig. 6. Seedlings from different plant species called „sprouts", of zygotic origin, without roots, sold and consumed raw in Romania; A – Closed pack with „sprouts"; B – Pack with „sprouts" of *Allium cepa*; C – Pack with „sprouts" of *Helianthus annuus*; D – Pack with „sprouts" of *Brassica oleracea*; E – Pack with „sprouts" of *Raphanus sativus*
Source: Own determination.

At the same time, we would like to underline the fact that micro tubers, but also potato plantlet shoots, resulting from *in vitro* cultures, as well as plantlets resulting from the seeds of other species germinated under aseptic regime, should be integrated within the terminology integrated into the gemmotherapy compendium (respectively of meristem therapy), field introduced in 1991, in naturist therapy procedures [16].

Such biological material - especially purple micro tubers - contain anthocyanins (valuable by-products of metabolism, with recognized therapeutic effects), which during autumn, winter and the first months of spring are absent in nature, and the products used in dry form do not they still have a therapeutic value like that of living organs.

In addition, the shoots, and plantlets that we have all year round in a fresh state contain not only meristems, but also stem cells, tissues with strong therapeutic and antioxidant value.

In the other hand, periodically, the vitro-cultured biological material can be fragmented - micro tubers or stalks - into mini-cuttings which - for a period of time - can be sub-cultivated, possibly even in the culture substrate from which they came, until the compounds it contained are exhausted, provided that the regime of guaranteed asepsis of the operations is ensured. Such vitro plants can be fragmented into uninodal micro cuttings that can be reinoculated *in vitro* and give rise to new vitro plants in continuous flow. Such procedures would expand the methods of obtaining new varieties of natural medical treatments, such as meristem therapy or gemmotherapy, which are modern natural medicine methodologies [18]. A diversification of gemmotherapy procedures can also be achieved by consuming purple micro tubers (Fig. 2 C) that hold in their reserve parenchyma cells, a large amount of anthocyanins. Such biomass, in modern biotechnologies, could be obtained in bioreactors, in continuous flow, and the procedure can serve to extract and capitalize the respective anthocyanins in bioindustry and in commerce, a procedure carried out in continuous flow.

CONCLUSIONS

In vitro tuberization in potatoes species, especially on the purple flesh variety Salad Blue, from explants sized at a waist of about 2 cm, taken from the buds formed on the surface of mature tubers kept in the cool and dark condition, which were inoculated on the culture medium solidified, and after that subcultured on a double-layer culture medium, with the addition of phytohormones (NAA in the solid medium, and kinetin, to which coumarin is added, reducing the MS concentration to ½ and increasing the sucrose concentration in the liquid substrate), placed in pots made of colorless and transparent plastic. The culture pots were kept in the dark for 2 months after the liquid medium substrate was added. This procedure facilitates the management of energy resources, by saving electricity. Through this procedure, we managed to obtain an average of 21 micro tubers of a size about 90 mm from the Salad Blue variety, while in the Christian variety, we obtained an average of 10 micro tubers of a size about 60 mm.

The novelty of the experiment consists in the use of larger culture vessels/pots, in which the vitro plants regenerated from the sprouted buds on normal tubers, kept in the dark initially on agar medium and later in a double layer regime (the first agar medium layer and then the plantlets of about 7-8 cm were flooded with the second layer of the liquid culture media). If we aim to obtain seed material, these micro tubers can be planted in "insect proof" greenhouses and/or greenhouses in a substrate consisting of a mixture of red peat with bentonite, black peat and perlite. About 3 months after planting, the harvesting of mini tubers begins, which will later be used for planting and obtaining potato tubers. Another aspect of the originality of the present paper consists in suggesting the use of purple flesh potato plantlets, the Salad Blue variety, of about 3-10 cm, in a fresh (raw) state, as a natural food (as the seedlings generated from the embryos are used in nutrition seeds), as the ex vitro plants are rich in stem cells, and the anthocyanins held in the tissue cells of the potato vitro plants and especially in the reserve parenchyma of the purple potato micro tubers are very beneficial in strengthening the human body.

Obtaining purple micro tubers in bioreactors could constitute usable biomass in the production of anthocyanin extracts, marketable and usable in naturopathic medicine.

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THE DEVELOPMENT OF TRADITIONAL ROMANIAN FOOD PRODUCTS

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Abstract

Traditional products preserve and promote local identity, culture and tradition. They also contribute to the local economy, environmental protection and public health. This paper studied the development of the traditional products sector in Romania in the period 2013-2022. The main objective was to show the distribution among product types and landforms. The information was gathered from two main sources, the "National Register of Traditional Products" and the "Catalogue of Certified Products and Activities" of the Romanian Ministry of Agriculture, Forestry and Rural Development. The research showed that almost 41.6% of traditional products are found in the meat and meat products category, followed by milk and dairy products with 18.2%. They are mainly produced in mountain and lowland areas. In the period 2013-2022, an increase in product structure can be observed in beverages and bakery products in lowland areas, vegetable and fruit products in mountain areas, and fish products in mountain areas.

Key words: *traditional products, lowland, hill, and mountain areas*

INTRODUCTION

The promotion of European products began in 1992 with the introduction of the Quality Scheme for Geographical Indications (PGI) [3]. The protected designation of origin (PDO) was also established in 1992 and aimed to preserve products that "have been produced, processed and developed in a specific geographical area, using the recognized know-how of local producers and ingredients from the region concerned [4]. The European quality scheme for agricultural and food products also protects products based on their method of production or composition by means of the TSG (traditional specialty guaranteed) label. The basic idea is to promote and valorize products that are produced by traditional methods and preserve local identity [12]. Because the certified producers (PDO/PGI/TSG) can promote them self better on the market, there is an increase in registrations. However, that do not mean implicit a success on the market because the prices of such products are higher and can involve additional costs [5].

In addition, producers from member states can apply to national authorities for approval as a traditional national/regional food product, a process similar to the European Union's Protected Geographical Status [2].

Traditional products were first defined in 2004 [6] and several amendments were added in 2013 [7] and 2020 [8]. Due to the 2013 legislation, the number of traditional products certified at the national level increased steadily. However, although we have a specific national and European legal framework that encourages food producers to take advantage of quality schemes, there are few products that are recognized at the European or global level [9].

In 2022, in Romania, we have 26 products certified with GI, 1 product with PDO and 2 with TSG [1]. With 735 traditional certified products and 2853 mountain certified products, RMARD (Romanian Ministry of Agriculture and Rural Development) certification for agricultural and food products remains the most important source of certification, along with regional certifications (like "*Bun de Maramureș*").

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The purpose of this paper is to examine the development in 2013-2022 period of traditional products in Romania with an emphasis on their distribution on product categories and landforms.

MATERIALS AND METHODS

In this paper we performed a quantitative analysis of the traditionally certified products in Romania. The source of information was the Ministry of Agriculture and Rural Development ("National Register of Traditional Products" [11] and "Catalogue of Certified Products and Activities" [1]). The analysis was performed by product categories and landforms (lowland, hill, and mountain). The distribution among landforms was made considering the classification of villages and towns made by the National Research and Development Institute of Pedology, Agrochemistry and Environmental Protection.

RESULTS AND DISCUSSIONS

According to Regulation No. 724/2013 [7], traditional products are "foods that use local raw materials, do not contain food additives, have a traditional recipe and a traditional production and/or processing method, and are different from other similar products in the same category." In 2013, 171 traditional products were registered, of which 43.9% were meat and meat products, 17.5% were milk and milk products, and 17.5% were vegetable and fruit products. The structure has not changed significantly in the period 2013-2022. We observe a slight increase in beverages and bakery and pastry products. The number of products has increased by 330% and currently there are 4-5 times more certified products (Table 1). Around 385 of the products certified in 2022 are locate in three counties, respectively Brasov, Maramures and Alba (Transilvania historic region).

However, we would like to point out that many of the products registered in 2013 are no longer on the market and have been replaced by new brands. Thus, in 2022, only 24 traditional products from 2013 are still certified. So basically, we cannot analyse the actual development in this sector, only the structure.

Table 1. The evolution of traditional products in 2013-2022 period by types of products

	2013		2022		2022/2013	
	Number	%	Number	%	+/-	pp
Beverages	5	2.9	29	3.9	24.0	1.0
Meat and meat products	75	43.9	306	41.6	231.0	-2.2
Milk and milk products	30	17.5	134	18.2	104.0	0.7
Vegetables-fruits	30	17.5	118	16.1	88.0	-1.5
Bread, bakery, and pastry products	23	13.5	114	15.5	91.0	2.1
Fish	7	4.1	28	3.8	21.0	-0.3
Other	1	0.6	6	0.8	5.0	0.2
Total	171	100.0	735	100.0	564.0	-

Source: Own determinations based on National Register of Traditional Products 2013 [10] and 2022 [11].

In 2013, 57 traditional products were obtained in lowland areas (33.3%), 15 in hill areas (8.8%) and 99 in mountain areas (57.9%). Beverages and other products were certified in mountain villages and fish products in lowland areas (Figure 1). Most beverages (spirits, cider) are usually obtained from fruit trees growing in mountain areas. The first certified fish species were carp (usually found in lowland rivers) and catfish (usually found in the Danube and Danube Delta).

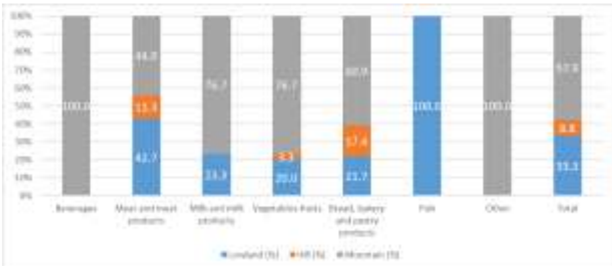

Fig. 1. The share of traditional products from lowlands, hill and mountain areas in total (2013)
Source: Own determinations based on National Register of Traditional Products 2013 [10].

Most traditional products from 2013 were found in mountain areas, except for meat products, where the distribution between mountain and lowland villages is almost equal The vegetable and fruit certified in mountain areas are primarily sweetness and jam from fruits found in mountain areas (blueberries, cherries, etc.). In 2022, 302 traditional products were obtained in lowland areas (41.1%), 85 in hill areas (11.6%) and 348 in mountain areas (47.3%). Lowland villages recorded the most traditional products in all categories except milk, vegetables, and fruits. 67.2% of milk and traditional dairy products were obtained in mountain villages (cheese, salty cheese, sweet cheese) (Figure 2).

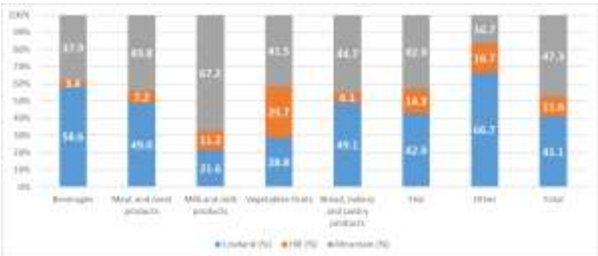

Fig. 2. The share of traditional products from lowlands, hill and mountain areas in total (2022)
Source: Own determinations based on National Register of Traditional Products 2022 [11].

In the vegetables and fruits category, the certified products from the hill areas represent almost 30% and consist mainly of juices and compotes.

The development of traditional products in lowland areas

In the lowland areas, development is far advanced in traditional products. Only 12 products from 2013 were certified in 2022 (5 products from the meat category, 1 from the vegetables and fruits category, 2 from the bread and pastries category, and 4 from the fish category). They come from the villages of Maramureș, Tulcea, Buzău, Botoșani and Olt counties. So, in 2022, 302 products were certified, of which only 12 have been approved since 2013. In 2022, most traditional products from lowland villages come from the meat and meat products category (49.7%) and the bread and bakery products category (18.5%) (Table 2). The situation is different from 2013, when meat, dairy and fish products were in the first place. The importance of bread, bakery and patisery products, meat and meat products from lowland villages has increased, reaching almost half of the products in this category in the whole country. The situation is more positive in the category of beverages, where the products from the lowlands account for 58.6% of the total.

Table 2. The evolution of traditional products in 2013-2022 period by types of products in lowlands

	2013		Share in total (%)	2022		Share in total (%)	2022/2013 (pp)
	Number	%		Number	%		
Beverages	0	0.0	0	17	5.6	58.6	58.6
Meat and meat products	32	56.1	42.7	150	49.7	49.0	6.4
Milk and milk products	7	12.3	23.3	29	9.6	21.6	-1.7
Vegetables-fruits	6	10.5	20.0	34	11.3	28.8	8.8
Bread, bakery, and pastry products	5	8.8	21.7	56	18.5	49.1	27.4
Fish	7	12.3	100.0	12	4.0	42.9	-57.1
Other	0	0.0	0.	4	1.3	66.7	66.7
Total	57	100.0	33.3	302	100.0	41.1	7.8

Source: Own determinations based on National Register of Traditional Products 2013 [10] and 2022 [11].

The development of traditional products in hill areas

In mountain areas, only 1 product from 2013 was certified in 2022 (from Bistrita-Năsăud County). We encounter in 2022 the Thus, in 2022, 84 new traditional products were registered, of which 41.2% are vegetable and fruit products, 25% meat products and 18% dairy products (Table 3). This is a different situation from 2013, when meat and bakery products were in first place. The share of hill areas in the total country was below 18% in all categories of traditional products. However, the importance of bakery products from hill areas has increased, reaching almost

30% of products in this category in the whole country.

Table 3. The evolution of traditional products in 2013-2022 period by types of products in the hill areas

	2013		Share in total (%)	2022		Share in total (%)	2022/2013 (pp)
	Number	%		Number			
Beverages	0	0.0	0.0	1	1.2	3.4	3.4
Meat and meat products	10	66.7	13.3	22	25.9	7.2	-6.1
Milk and milk products	0	0.0	0.0	15	17.6	11.2	11.2
Vegetables-fruits	1	6.7	3.3	35	41.2	29.7	26.3
Bread, bakery, and pastry products	4	26.7	17.4	7	8.2	6.1	-11.3
Fish	0	0.0	0.0	4	4.7	14.3	14.3
Other	0	0.0	0.0	1	1.2	16.7	16.7
Total	15	100.0	8.8	85	100.0	11.6	2.8

Source: Own determinations based on National Register of Traditional Products 2013 [10] and 2022 [11] .

The development of traditional products in mountain areas

In mountain areas, only 11 products were certified in 2022 from 2013 (7 products from the vegetables and fruits category; they are from Maramureș, Brașov and Neamț counties) and 337 new traditional products were registered. The traditional mountain products are generally derived from meat and milk (almost 65%) and about 28% are vegetable and fruit products and bakery products (Table 4). In 2013, the structure was almost the same, but we had only 99 certified products. In 2022, traditional mountain products account for more than 40% of national products in almost all categories, and as much as 67% in the dairy products category. However, if we compare the share of mountain products in the two years studied, we notice a sharp increase in the category of fish products

Table 4. The evolution of traditional products in 2013-2022 period by types of products in mountain areas

	2013		Share in total (%)	2022		Share in total (%)	2022/2013 (pp)
	Number	%		Number	%		
Beverages	5	5.1	100.0	11	3.2	37.9	-62.1
Meat and meat products	33	33.3	44.0	134	38.5	43.8	-0.2
Milk and milk products	23	23.2	76.7	90	25.9	67.2	-9.5
Vegetables-fruits	23	23.2	76.7	49	14.1	41.5	-35.1
Bread, bakery, and pastry products	14	14.1	60.9	51	14.7	44.7	-16.1
Fish	0	0.0	0.0	12	3.4	42.9	42.9
Other	1	1.0	100.0	1	0.3	16.7	-83.3
Total	99	100.0	57.9	348	100.0	47.3	-10.5

Source: Own determinations based on National Register of Traditional Products 2013 [10] and 2022 [11].

CONCLUSIONS

The list of traditional products certified by national authorities changes every year. Due to the high selling prices, it is very difficult to comply with the production conditions and stay on the market. Thus, in 2022, only 24 products were approved that were registered in 2013. However, in 2022 we have over 700 traditional products, of which 302 are in the lowlands, 85 in the hills and 348 in the mountains. These are meat products (over 40%), usually from pigs and sheep, dairy products (about 18%) (usually cheese) and vegetable and fruit products (about 16%) (juices, gems, etc.). We have also noticed an increase in bakery products (such as bread and cakes) in the lowlands and fish products in the mountain areas (especially trout).

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TERRITORIAL DISTRIBUTION OF TRADITIONAL ROMANIAN FOOD PRODUCTS

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Abstract

The sector of traditional products from Romania has been regulated since 2004, but it was not until 2013 that stricter licensing rules were introduced, resulting in a small number of certified products (171 in 2013). However, the sector has developed continuously and in 2022 there were 735 certified traditional products at national level. The purpose of this paper was to analyse the distribution of these products at regional level so we can emphasize a Romanian regional model based on their main characteristics. We used the database created by the Romanian Ministry of Agriculture, Forestry and Rural, respectively, the "National Register of Traditional Products", which can be found in the "Catalogue of Certified Products and Activities". The research showed the following profile of distribution: the most important traditional products are the ones made from meat and milk; in Brasov county was, it in the first place with almost 24% of total products; the certified products per producer reached an amount of 14 products in Galati county; most of the products are in Center, north-West and North-East regions. The regional model of distribution is characterized by a concentration of producers in mountainous and rural areas.

Key words*: *traditional products, regional distribution, counties, development regions

INTRODUCTION

The sector of traditional products in Romania was regulated for the first time in 2004 [5]. In 2008, the National Office of Romanian Traditional and Ecological Products was established in Brasov to promote the concept of "quality products" as well as the concept of "ecological products" [3]. Until 2013, when new restrictions and regulations to obtain certification were approved, there were over 4000 traditional products approved at the national level. In 2013, after the implementation of the new regulation [6], only 171 products received certification. Since then, only 24 traditional products were still certified in 2022 after the annual verification by authorities. In November 2017, the Catalog of Certified Food Products [1] was made available to producers, which allows online attestation of producers, including on national and European quality schemes. Through the mobile and desktop applications, you can view the list of certified products and view their position on the Romanian map.

In 2022 are 735 certified products, but there are many problems with current regulation and the logistics of valuation, which have led to large gaps between counties and regions [2] [10]. There is also a high concentration of traditional products due to the fact that "over 55% of the traditional products registered in NRTP come from just two Romanian regions, respectively the NW and the Center Region" [7]. So, there are major differences between product categories, counties, and regions [8]. Even if the development of these products has a proven direct impact at the local level (job creation, increase in revenue, diversification of local economies, etc.), it is very difficult for producers to remain on the market due to the lack of resources for marketing [11]. Also, the prices are very high, so they are usually consumed by people in the 34–65 age category with an income over 1,000 euros [4]. In these conditions, the aim of the paper was to present the distribution at regional level by landforms, counties, and development regions. The objective was to identify a model of distribution based on the main characteristic of traditional products sector.

MATERIALS AND METHODS

In this paper we analysed the traditional product offer from Romania. We used the database created by the Ministry of Agriculture and Rural Development ("Catalogue of Certified Products and Activities" [1]) based on the registration of producers in the "National Register of Traditional Products" [9]. We analysed the regional model of distribution of product by categories, landforms (plain, hill, and mountain), counties and development regions.

RESULTS AND DISCUSSIONS

Traditional products are "foods that use local raw materials, do not contain food additives, have a traditional recipe and a traditional production and/or processing method, and are different from other similar products in the same category." [6]

The main characteristics of traditional products

In 2022, 735 traditional products were registered by 192 producers from 156 villages (49 cities and 107 coomunes).

Around 47.3% of the traditional products come from mountain areas (348 products), 11.6% from hill areas (85 products) and 41.1% from plain areas (302 products) (Table 1).

Table 1. The evolution of traditional products in 2013-2022 period by types of products

	Plain	Hill	Mountain	Total	%
Producers	79	20	93	192	26.1
Beverages	17	1	11	29	3.9
Meat and meat products	150	22	134	306	41.6
Milk and milk products	29	15	90	134	18.2
Vegetables-fruits	34	35	49	118	16.1
Bread, bakery and pastry products	56	7	51	114	15.5
Fish	12	4	12	28	3.8
Other	4	1	1	6	0.8
Total	302	85	348	735	100.0
%	41.1	11.6	47.3	100.0	-

Source: Own determinations based on National Register of Traditional Products 2022 [9].

Most of the traditional products are obtained from meat (41.6%) and milk (18.2%), like sausages, pastrami, smoked products, bacon, cheese, etc. We also have: 26.1% beverages (strong beverages like *tuica* or *palinca*); 16.1% vegetable-fruit products (like compote, vegetable stew, syrup, jam, etc.); 15.5% bakery products (like bread, pie, noodles, etc.). In mountain areas the structure is almost similar with the one from national level, with 38.5% products in meat category, 25.9% in dairy category, 14.1% products from vegetables or fruits and 14.7% bakery products (Figure 1).

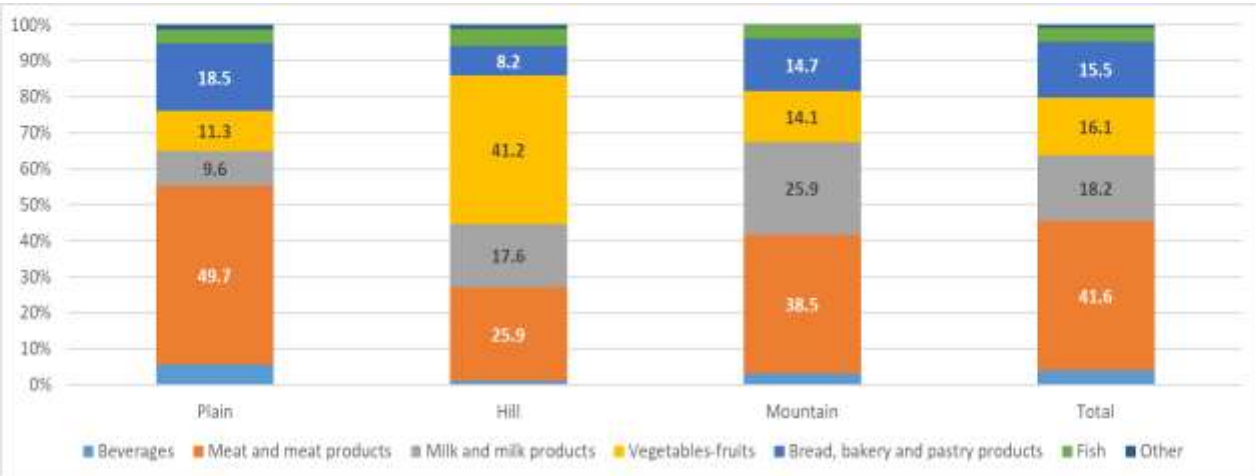

Fig. 1. The structure of traditional products by landforms (2013)
Source: Own determinations based on National Register of Traditional Products 2022 [9].

In plain areas meat products represent almost 50% of the certified traditional products and beverages represent 18.5%. On the other hand, in the villages and cities from hill area we find especially specialties from vegetables and fruits (41.2%) and from meat (25.9%).

The main characteristics of producers

Like we mentioned before, in the traditional products sector are certified 192 producers, with 735 products. From them 56.8% are Limited Liability Company, 16.1% are Sole Proprietorship and 14.1% are Self-employed Persons. Other forms include familial societies, natural persons, NGOs etc.

The regional distribution of traditional products

Romania has certified traditional products in 37 from 42 counties. On the first place we find Brașov with 173 products (Figure 2). Also, we may observe that there are five counties with 30-60 approved products (Maramureș, Bistrița-Năsăud, Alba, Argeș and Buzău) and 9 counties with 15-30 products. They are situated in the center and north of the country and many of them have a mountain landform or integrate territories with a strong local identity like Bucovina and Maramureș.

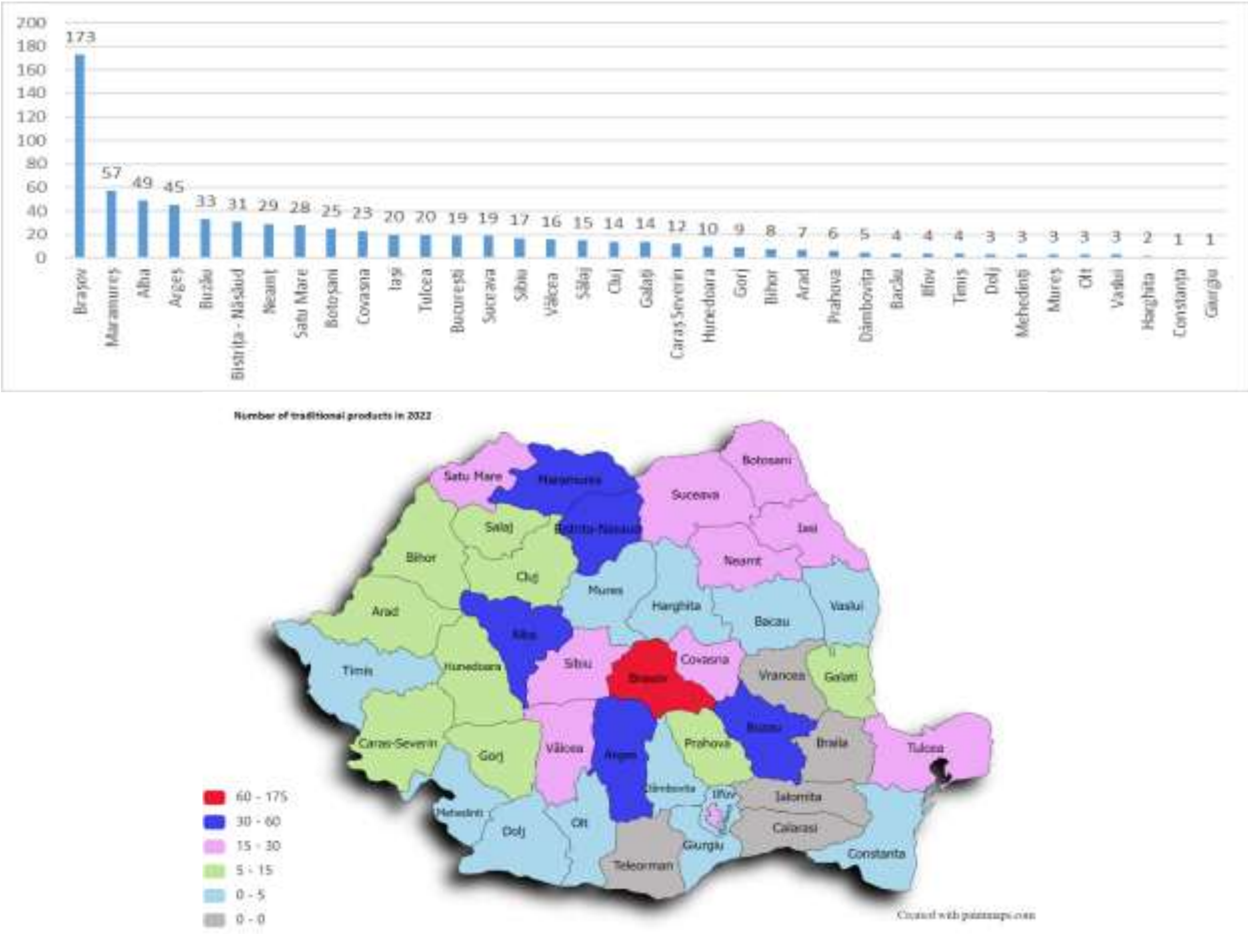

Fig. 2. The traditional products by counties (2022)
Source: Own determinations based on National Register of Traditional Products 2022 [9].

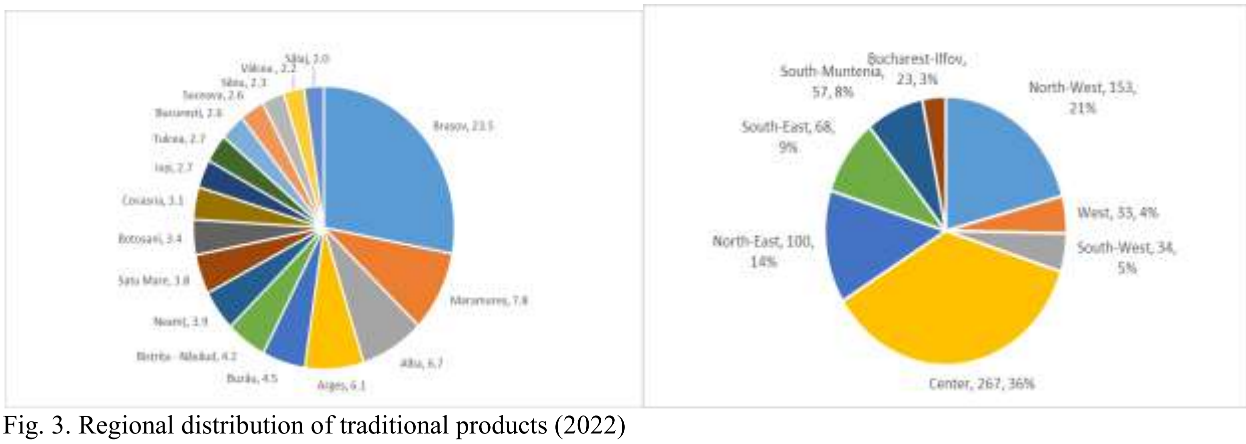

Fig. 3. Regional distribution of traditional products (2022)
Source: Own determinations based on National Register of Traditional Products 2022 [9].

Looking at the regional distribution, we find that 36% of the products are produced in the Central region (267 products), 21% in the North-West region (153 products) and 14% in the North-East region (100 products) (Figure 3).

The regional distribution of producers in 2022

Brasov County has the most producers of traditional products (23), 4 counties have 10-20 producers (Maramureş, Alba, Argeş and Buzău) and 6 counties have 5-10 producers. Most counties have less than 5 producers (Figure 4).

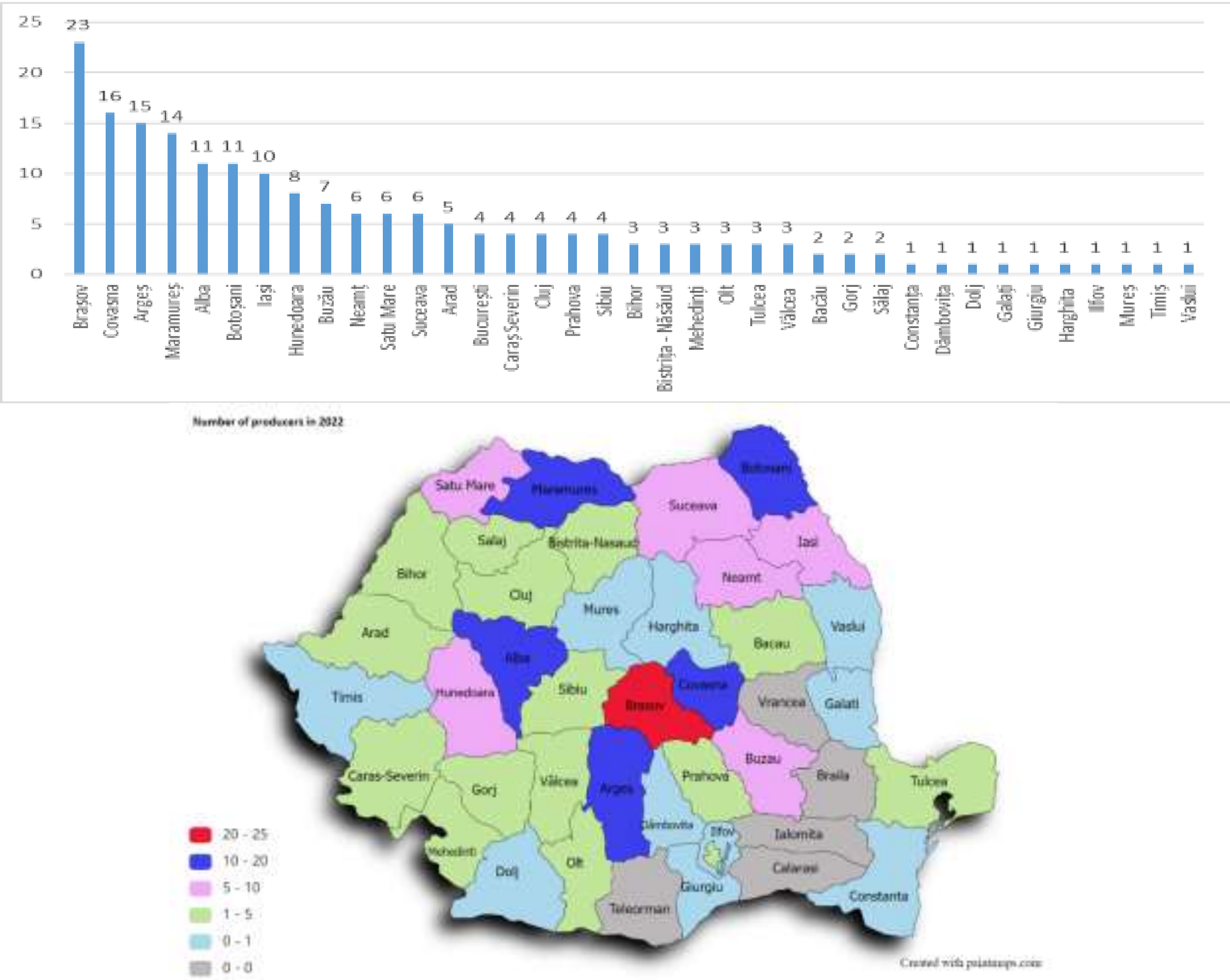

Fig. 4. The producers by counties (2022)
Source: Own determinations based on National Register of Traditional Products 2022 [9].

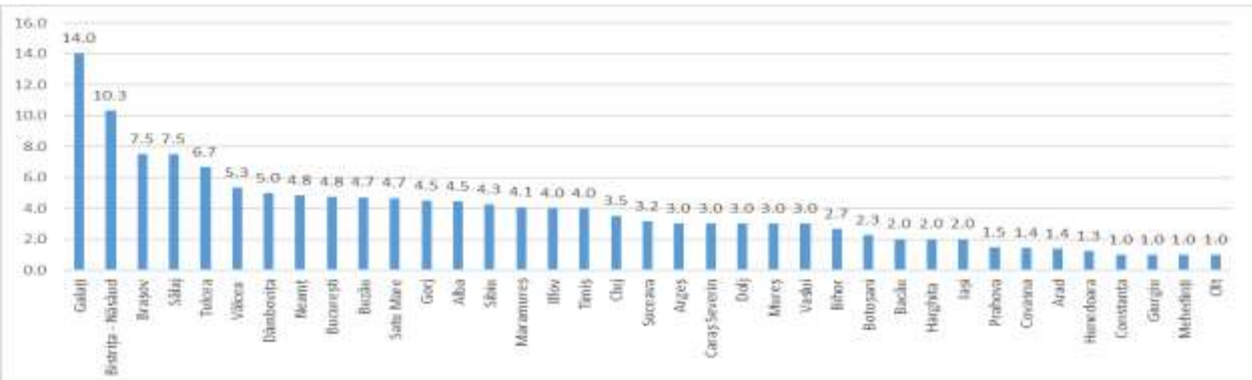

Fig. 5. The average number of traditional products per producer by county (2022)
Source: Own determinations based on National Register of Traditional Products 2022 [9].

If we analyze the average number of certified products of a producer, we find that Brașov County is only on the third place (Figure 5). The first place is occupied by a producer from Galati County, which has 14 approved products. Half of the counties have, on average, around 3-5 products approved per producer.

CONCLUSIONS

In conclusion, the traditional products from Romania have developed in the last decade, reaching a value of 735 products in 2022. These products are primarily obtained from meat and milk, but we observe a high development of products from vegetables and fruits in the Sub-Carpathian hills. The regional model of distribution is characterized by a concentration of producers in mountainous and rural areas. Most of the products are obtained in the Center, North-West, and North-East regions, especially in Brasov County (24%).

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INVESTMENT SECURITY OF STRATEGIC MANAGEMENT OF UKRAINE'S AGRICULTURAL SECTOR DEVELOPMENT

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Abstract

The current situation of the Ukrainian economy's agricultural sector and investment processes associated to its development, as well as the essential organizational measures aimed at assuring the long-term economic impact of the state economy's agrarian sector development, have been studied. The study is divided into three sections that provide the theoretical foundation of the concept of "investment"; analysis of the development of the agrarian sector of Ukraine, its role in the national economy with the determination of trends in the export potential of agricultural production; analysis of the capital investments volumes in the agricultural sector by their production directions and types of assets. Correlation and regression analysis has been applied in order to assess the influence of the actual amount of capital investment during 2010–2021 in the agrarian sector of the Ukrainian economy on the effectiveness of agricultural production, which is evaluated by the indicator of the gross added value amount of the agrarian sector. It has been established that the investment policy of Ukraine's agrarian sector is currently not an effective driver of the economic processes development in the agrarian industry. Due to this, the results of the activities of business entities are inefficient, which is caused, first of all, by the lack of financial and material resources, the disparity of prices and other organizational, economic and institutional factors. The importance of ensuring the competitiveness of agricultural production through the activation of investment support aimed at updating the organization of technological processes of production, the introduction of scientifically based norms of economic activity, and the systematization of the organizational and management system is highlighted.

Key words: *agricultural sector, investments, investment support, sources of investment resources, national economy.*

INTRODUCTION

The agricultural sector is an important strategic branch of the Ukrainian national economy. Not only the viability and self-sufficiency of the country, but also the foreign economic development of the state depend on the stable functioning and development of the agricultural sector. Ukraine is a country with a powerful agro-industrial potential and huge prospects for the development of agriculture, because it has high-quality land resources and favorable climatic conditions. The area of agricultural land in Ukraine is 42.7 million hectares, which is 70.7% of the total area of the country. This is one of the largest indicators among European countries, because the average indicator of the share of agricultural land in the total area of European countries is on average 46.8 %. The availability of such a large amount of agricultural land in Ukraine makes the agricultural sector one of the priority areas of the country's economy for the Ukrainian state. In addition to the stable supply of the country's population with high-quality, safe, affordable food, the agricultural sector of Ukraine is undoubtedly capable of making a significant contribution to solving the world hunger problem.

The issue of organizing and ensuring food security for every country is relevant at all times. Modern global challenges facing humanity today, in particular climate change, which affects massive natural disasters, the pandemic spread of new viral diseases, problems with overpopulation in some regions and depopulation in other parts of the world cause demographic problems on a global scale, the growth of armed conflicts on planet, have a negative impact on the spheres of human activity, and first of all, on areas that are impossible without the involvement of natural resources.

The Ukrainian agrarian sector, with the potential for the production of agricultural products, which significantly exceeds the needs of the domestic market, and primarily of grain and oil crops, is able to secure leading positions in the world market of agricultural products and food [4]. Confirmation of the importance of Ukraine as a supplier of food grains to the world market was the blocking of supplies of Ukrainian grain under international contracts after February 24, 2022 in connection with the beginning of Russia's military aggression against Ukraine. It caused a shortage of food consumption and a significant increase in food prices in countries of Africa, East Asia and Europe. The further entry and consolidation of Ukrainian agricultural products into the world economic space, the strengthening of the processes of globalization and trade liberalization require adaptation of the Ukrainian agriculture to new and constantly changing conditions, and, accordingly, the further improvement of the strategy for managing agrarian policy.

The papers of many researchers are devoted to the problems of investment support of the Ukrainian agriculture strategic development. Among the Ukrainian economists who study the theoretical aspects of investments in the economy such scientists as I. Umantsiv et al. [25], V. Makohon et al. [10] should be mentioned. The peculiarities of theoretical and methodological problems of investments and investment support of the economy agrarian sector development are studied by N. Bakhur [1], I. Bezpiata [2], A. Kucher [8; 9], T. Matsybora [11], N. Patyka [16], P. Sabluk, I. Khomyn [17]. Agrarian scientists today have a common opinion regarding the extreme relevance of investment support in order to activate the country's economic development. V. Mesel-Veseliak and M. Fedorov consider investments as the main tool for the transformation of the agriculture in terms of modern market conditions [12]. Ukrainian scientists P. Sabluk and I. Khomyn devote close attention to the difficulties of locating sources of investment activity and implementing appropriate mechanisms for financial support of the agriculture [17]. In the works of N. Bakhur, I. Bezpiata, A. Kucher, T. Matsybora [1; 2; 8; 9; 11], attention was paid to determining the role of investments in the economic development of the agrarian sphere.

General theoretical and applied aspects of investment activities regulation in agriculture are covered by the following authors: V. Ilchuk, T. Shpomer [5], I. Krukova [6], A. Mykhailov [14], V. Onegina, Y. Vitkovskyi [15], S. Savitska et al. [18]. Coverage of the theoretical and methodological principles and substantiation of promising directions for the transformation of the practice of investment activities regulation in the agriculture will provide a scientific foundation for enhancing the specified investment process, as well as contribute to the creation of a favorable investment climate and the attraction of foreign and domestic investments in the Ukrainian agricultural sector.

Taking into account a number of important theoretical, methodological and practical developments carried out by the mentioned scientists, the implementation of which caused significant positive changes in the economy of agricultural enterprises of Ukraine, the latest realities of economic and political changes raise a set of issues related to the need to intensify investment activities in the agricultural sphere of Ukraine, taking into account the strengthening of conditions of competition and development of today's globalization processes. That is why the problematic issues of strategic management investment support of Ukraine's economy agrarian sector development, the determination of financial aspects of the investment processes implementation in agricultural production require in-depth research on the basis of a holistic, systemic analysis which is of strategic importance for the development of the country's economy agrarian sector.

The purpose of the article is to study the current state and directions of investment development of Ukrainian economy's agrarian sector with the justification of conceptual approaches regarding investment support of the strategic development of the national economy agrarian sector.

MATERIALS AND METHODS

The methodological basis of the research is general scientific cognition methods. The theoretical basis of the research is the scientific works of domestic and foreign scientists in the field of investment science and the agrarian sphere development. The information basis of the research consists of legislative and regulatory acts of the Verkhovna Rada of Ukraine and the Cabinet of Ministers of Ukraine concerning investment support of the agrarian sector of the state's economy; statistical materials of the State Statistics Service of Ukraine, the Ministry of Agrarian Policy and Food of Ukraine; analytical reports of the World Bank, international rating agencies, scientific periodicals, monographic studies of domestic and foreign scientists. To achieve the goal and solve the set tasks, the following research methods were used: the method of analysis and synthesis (in the study of modern foundations of investment of the national economy agrarian sector provision); logical generalization (to generalize the features of investment support for the strategic development of the national agricultural sector); systemic approach (when justifying conceptual approaches regarding sources of investment support of the agricultural sector strategic development); economic and statistical methods (for a parametric analysis of the development processes of the agricultural sector and the state of its investment support).

RESULTS AND DISCUSSIONS

The effective functioning and development of the modern economy is largely determined by the sufficient provision of various resources, one of which is investment resources. Solving the problem of attracting investment resources is quite relevant for modern Ukraine, especially for the basic component of its economy, in which agrarian sector plays an important role. The development of the agricultural sector and its investment support depend on many factors and require an in-depth study of their essence.

In Ukraine, for the first time, the concept of investment was legally defined in the Law of Ukraine "On Investment Activity" dated September 18, 1991. It states that "investments are all types of property and intellectual values that are invested in business and other types of object's activities, as a result of which profit (income) is created and/or a social and environmental effect is achieved" (Article 1) [22]. Article 14 of the Tax Code of Ukraine stipulates that an investment is defined as "an economic transaction that involves the purchase of fixed assets, intangible assets, corporate rights and securities in exchange for funds or property" [23].

Taking into account the rather significant number of various approaches to defining the essence of "investment" that characterize the studied economic category in the selected field or field of scientific research, we suggest dividing the understanding of "investment" into groups:

- object of investment – means of production: property (movable and immovable), financial assets (securities, valuables, monetary assets), labor resources;
- the direction of investments – in the spheres of the economy, into entrepreneurial activity;
- method of application – purchase, investment, placement;
- term of investments – short-term, medium-term, long-term;
- the purpose of investments – to obtain income (profit), to increase capital, to obtain a future result, social effect.

Investments in the agricultural sector of the economy will have their own characteristics. First of all, this concerns the direction of investments, i.e. investments by sectors and their sub-sectors: crop production (growing of grain, technical, fodder crops, vegetable growing, berry growing, horticulture, cultivation of planting material, seed production), animal husbandry (in the development of cattle breeding, pig breeding, sheep breeding, poultry breeding and other sub-sectors of animal husbandry).

Land is a specific means of production in the agricultural sector. Land (land plot) as an investment object is mainly considered from the position of capital investment for the possibility of construction. In agricultural production, land, as the main means of production, is of interest to investors, as the object of production itself. Due to the possibility of expanding the lease of land areas, and with the introduction of the market agricultural land circulation from July 2021, the land turns into a rather attractive area for investment, with a fairly high growth potential.

Systematization and classification of investments are carried out for a proper understanding of the concept of investment management economic efficiency. In the context of the study of investment support of the agricultural sector strategic development, it is important to take into account such a criterion as the motivation or interest of the investor in the classification of types of investments. When classifying direct investments according to the directions that motivate investors to make capital investments, the main groups should most often be distinguished according to the following guidelines:

- resource provision (investment in natural resources (land, water supply), raw materials, equipment, labor resources);
- market direction (adaptation of goods and products to local and foreign markets, implementation and improvement of marketing policy);
- strategic management (striving to optimize production costs, implementation of integration processes aimed at combining material interests in the production and sale of final products).

The development and determination of issues of strategically oriented investments are decisive from the point of view of the investor's potential interest of in the implementation of the investment project and its characteristics. Strategically oriented investments are aimed at progress in solving the following issues:

- formation of innovatively oriented forms and methods of investment support;
- ensuring long-term relationships, effective communications, business contacts with elements of solving strategic tasks;
- involvement of the latest technologies and principles of cooperation, targeted information resources;
- study of the features and characteristics of the investment process, investment climate, investment culture, national and industry interests in the implementation of global and strategically significant projects;
- forecasting the priorities and prospects of investment support, taking into account global and national changes in the markets, in the business environment of the countries;
- perspectives of global trends and corresponding changes in the investment provision of the domestic producer of the respective countries;
- assessment of institutional changes, progress of institutional support in the investment resources involved.

Strategically oriented investments in the context of strategic development investment support, both the national economy and its individual branches, depending on the importance of achieving goals, can be divided into strategic and supporting investments. Investments with strategic goals involve directing capital into highly profitable projects, the task of which is to achieve a significant increase in capital. Therefore, the realization of the set goals encourages the owners of investment resources to carefully select investment objects in order to minimize the unpredictable costs of capital investments, which can be negatively marked when obtaining the final goal (income) from the investment project.

Thus, when solving long-term tasks for the strategic development of the agriculture of Ukraine with the involvement of investment support, it is important to take into account the motives and interests of strategic investors. The specification of goals and objectives in the realization of investment projects, taking into account the state and regional vision of the development of agricultural production in the country, makes it "transparent" and promotes the activation of the investment capital attraction in the industry.

Regarding the sources and forms of the agricultural sector investment support, the following types can be distinguished:

- self-financing, this is when a business entity invests its own resources in the development of production;
- attraction of credit funds, at the expense of bank loans, union loans and other funds raised;
- government, regional target programs for providing grants, subsidies, loans at the expense of budget funds of various directions;
- attraction of grant resources of domestic and international funds;
- due to the merger, unification of enterprises on a corporate basis;
- issue of shares, sale of securities;
- rent, leasing of the main means of production.

Agriculture is the basis of the agrarian sector of the economy. The field of its activity is the agricultural crops cultivation and animals breeding. As objects of investment, agricultural production has a number of specific features. First of all, the crop industry has a seasonal nature of production processes and is largely dependent on climatic conditions. The livestock industry is characterized by a high level of capital intensity and a significant period from growing products to their sale.

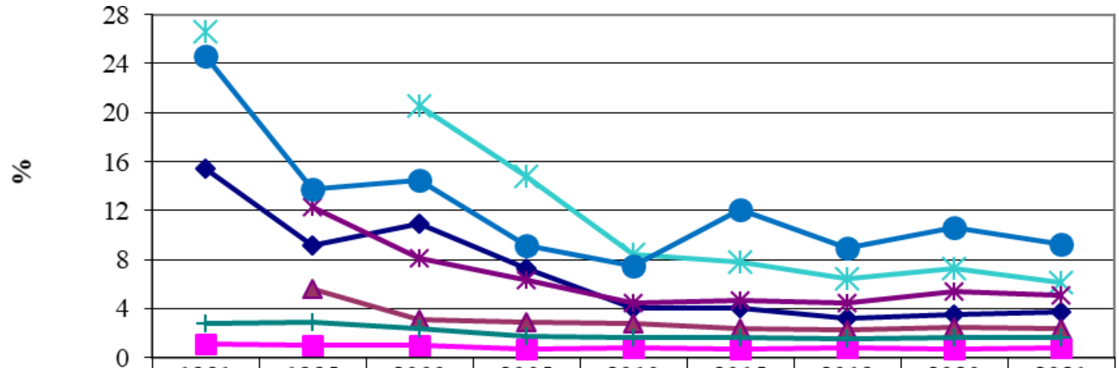
The specificity of agricultural production is characterized by the slow return of working capital and capital investments. Thus, when cultivating seasonal crops, the spent working capital can be returned in the form of income from product sales no sooner than six months after it was spent. This payback period is substantially longer in the sector of animal husbandry. Fixed capital investments, both in crop production and in animal production, have a somewhat long payback time and, on average, begin in the fifth to sixth year following investment.

At the same time, it should be noted that the agricultural sector, as a strategic branch of ensuring food resources, has a fairly significant investment attractiveness. The investment provision of this segment of the state economy reflects a certain system of economic relations between the subjects of investment processes in the branches of agricultural production, which interact with regard to the attraction, investment, distribution, use in their activities of property and intellectual values to achieve the socio-economic goals of the industry development as a whole.

The functioning of an effective agrarian sector, adapted to the conditions of a market economy, is impossible without an appropriate organizational and economic mechanism for attracting investment resources, which ensures the enhancement of the management system, organizational and industrial relations, profitability and financial stability, balancing the interests of companies, the state and society. The agricultural sector's growth in all of its economic and historical aspects has a variety of global, strategically oriented processes with drivers of innovation, technological and technical modernization, specific investment support, targeted allocation of resources. Analyzing the strategic changes that have taken place in the Ukrainian agriculture since independence, it is necessary to emphasize the high value of the reforms in agricultural industry. Development of the country's agrarian business was positively impacted by the adoption of land reform and the transition from collective management to organizational and legal forms of business entities based on private and private-lease forms. Today, the position of the agricultural sector of Ukraine is high in the world agricultural markets, the value of land and production potential is recognized all over the world [13].

In order to determine the state of the Ukrainian economy agrarian sector as well as to compare its state with other countries, individual indicators of the statistical database of the World Bank have been analyzed (from the section "Agriculture and development of rural areas") [24]. For a comparative analysis of the indicators of the condition and development of the Ukrainian economy agrarian sector, the world averages of relevant indicators, individual countries of the European Union and the post-Soviet space have been used.

An indicator that reflects the specific share of the production of gross agricultural products in the total amount of gross domestic product can be one of the main indicators that characterizes the place and role of the agricultural sector in the country's economy. This comparative analysis is shown in Figure 1.



	1991	1995	2000	2005	2010	2015	2019	2020	2021
Bulgary	15.39	9.22	10.97	7.28	4.01	4.02	3.24	3.51	3.73
Germany	1.10	1.00	0.99	0.73	0.80	0.68	0.78	0.74	0.80
Poland		5.58	3.13	2.91	2.83	2.37	2.32	2.50	2.37
Georgia	26.56		20.60	14.77	8.45	7.81	6.50	7.29	6.12
Kazakhstan		12.33	8.11	6.37	4.51	4.71	4.47	5.39	5.11
Ukraine	24.61	13.77	14.49	9.13	7.45	12.06	8.97	10.60	9.31
European Union	2.76	2.91	2.36	1.80	1.63	1.67	1.59	1.66	1.63

Fig. 1. Dynamics of the specific share of the agricultural sector gross production in the volume of gross domestic product (%)
Source: compiled by the authors based on [24].

The dynamics of the data shown in Figure 1 proves that in the countries that left the post-Soviet space (Ukraine, Kazakhstan, Georgia) between 1991 and 2000, the share of production of the agricultural sector remained quite high at the level of more than twenty percent of the gross national product. In Ukraine in 1991, the percentage of agricultural production in the volume of gross domestic product was 24.61 %. The specific share of agricultural products in the structure of the gross domestic product in Ukraine during 2000–2020 remained quite high, and for 2021 it is 9.31 %, which is the largest indicator among European countries and countries selected for comparison. An indicative rate that determines the degree of development of the economy's agricultural sector is the characteristics of available land resources in the country.

Table 1. Comparative characteristics of the state of land use in European countries and Ukraine

Indicator name	Ukraine	European countries	EU countries
Land area, million hectares	60.4	1015.6	437.4
Black soil area, million hectares	28	84	18
Area of agricultural land, million hectares	42.7	474.8	177.7
The share of agricultural land in the total area, %	70.7	46.8	40.6
Area of arable land, million hectares	32.5	277.8	115.7
The share of leased agricultural land, %	97.0	62.0	53.0

Source: compiled by the authors based on [7, p. 29].

Among European countries, Ukraine has the largest share of agricultural land, which occupies 70.7 % of the total area of the country and amounts to 42.7 million hectares.

Agricultural lands make up 96.7 % of agricultural lands.

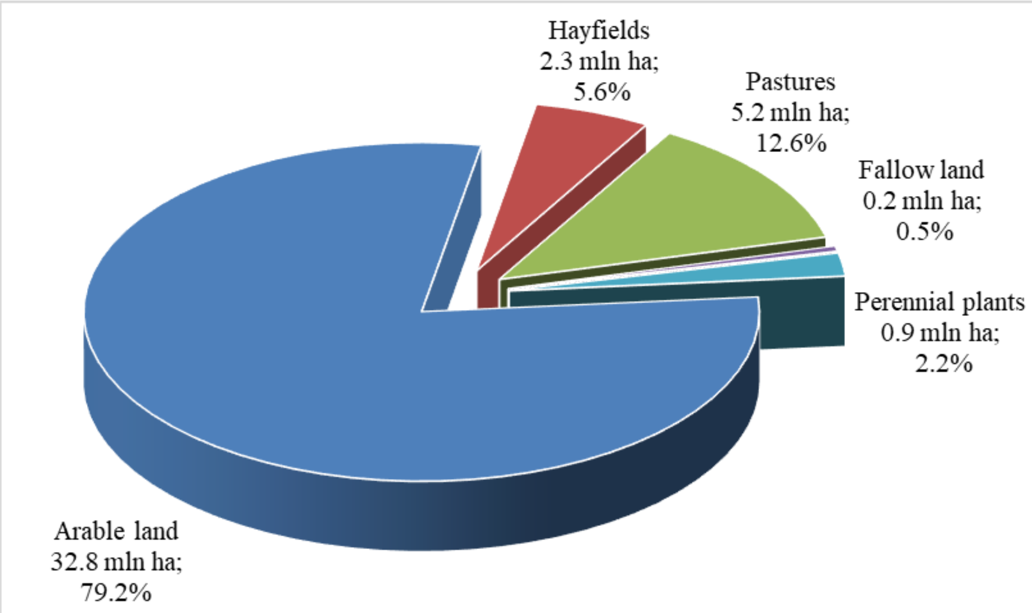


Fig. 2. The structure of agricultural land in Ukraine, 2020, million hectares, (%)
Source: built by the authors based on [19].

The land-resource potential of Ukraine is considered to be the primary foundation of the national economy, and in agriculture it is the main means of production. The country has 79.0 % of arable land in the structure of agricultural land, the total area of which is 32.8 million hectares, that is why the branch of crop production is the specialization of agricultural production (Table 2).

Table 2. Dynamics of the agricultural products production structure of Ukraine by species in percentage

Indicators	2010	2015	2018	2019	2020
Agricultural products	100,0	100,0	100,0	100,0	100,0
Crop production	70,5	75,9	78,9	79,1	77,3
- grain and leguminous crops	27,1	32,4	33,6	35,2	33,9
- technical crops	21,0	25,0	28,4	28,6	26,5
- potatoes, vegetables	14,5	13,0	12,1	11,4	12,9
- fruits and berries, grapes	2,7	2,5	2,6	2,1	2,2
- fodder crops	2,4	1,7	1,4	1,3	1,3
- other of crop production	2,8	1,3	0,8	0,5	0,5
Animal husbandry products	29,5	24,1	21,1	20,9	22,7
- breeding of agricultural animals	13,8	11,8	10,8	10,9	12,0
- milk	10,7	7,9	6,7	6,3	6,7
- eggs	4,2	3,3	2,8	2,8	3,1
- other livestock products	0,8	1,1	0,8	0,9	0,9

Source: compiled by the authors based on [19].

The analysis of the given data in Table 2 proves that the crop industry production remains a priority from year to year and the total share of its products is more than seventy percent in the total agricultural production. Traditionally, the volumes of grain and oil crops production remain almost unchanged and high. For 2020 their shares in the total agricultural production were 33.9 % and 26.5 %, respectively.

Having significant land resources, sufficient labor resources, and favorable climatic conditions, Ukraine is among the top five countries in the world that export grain crops, oil crops, and oil. At the same time, it should be noted that Ukraine exports oil crops as raw materials within 1.5 % of production, and 97.0 % of raw materials are processed in the state. Up to 96.0 % of the produced oil as a product of processing oil-rich crops is exported. The sale of processed agricultural products allows to increase the value of the product due to the production added value.

Table 3. Dynamics of the balance of grain and leguminous crops in Ukraine, thousand tons

Indicators	2010	2015	2017	2018	2019	2020
Production	39271	60126	61917	70057	75143	64933
Export	14239	38338	42499	42940	57925	52245
The share of exports from the total volume of production, %	36.3	63.7	68.6	61.3	77.1	80.5
Consumption fund	6808	5897	5655	5610	5470	5379
The share of the consumption volume from the total production volume, %	17.3	9.8	9.1	8.0	7.3	8.3

Source: compiled by the authors based on [19].

Cereal crops, the share of exports of which increases annually (Table 3), are sold by Ukraine on the international market in the form of raw materials, which significantly reduces financial income. In order to create added value for grain products, and first of all, for grain of the food group, investment projects should be considered and implemented to increase grain processing with the production of high-quality, competitive food group goods.

The most general indicator of the effectiveness of the economy agrarian sector investment provision can be the growth of the volume of gross added value of the agricultural production.

The successful functioning of agrarian business in modern conditions requires it to adapt to rapid changes in the needs of consumers in updating product assortments and their quality indicators. Achieving effective results is ensured by modernization and expansion of production, development of new directions and spheres of activity. All identified measures require the investment of financial and material resources, must be carefully planned, evaluated from the point of view of their expediency, economic efficiency and cannot be carried out spontaneously. World trends of globalization, rapid technical and technological growth of production, growth in the pace of national markets development, increased competition place high demands on the activities of economic entities.

Ukraine, which today leads a liberation war on its territory against Russian aggression, will need a lot of attention to the creation and implementation of promising investment programs to support the innovative development of all sectors of the economy, including agricultural production, which was and remains one of the driving segments of the state's economy. In connection with the high competition of agricultural products on the world market, Ukrainian farmers need to implement innovative production technologies that would ensure the production of competitive products, with a reasonable return on costs, increased labor productivity, and reduced production costs.

The dynamics of the capital investments volume in the economy of Ukraine and the economy agrarian sector (by type of activity "agriculture, forestry and fisheries") is shown in Table 4.

Table 4. The dynamics of capital investments into the economy and agricultural sector of Ukraine

Indicators	2010	2015	2018	2019	2020	2021
Capital investments into Ukraine's economy, million UAH	189061	273116	578726	623979	508217	528802
Growth rate until 2010, %	x	144.5	306.1	330.0	268.8	279.7
In agriculture, forestry and fisheries, million UAH	11568	30155	66104	59130	50680	49127
Share in the total volume of investments	6.1	11.0	11.4	9.5	10.0	9.3
Growth rate until 2010, %	x	260.7	571.4	511.2	438.1	424.7
Chain growth rate, %	x	260.7	219.2	89.4	85.7	96.9

Source: compiled by the authors based on [19].

During the analyzed period, the dynamics of the increase in the share of capital investments of the agricultural sector in the total amount of invested capital in the country's economy during the last ten years is monitored. In 2021, the share of capital investments in the agricultural sector made up 9.3 % in the total amount of capital investments of the national economy, which is 1.5 percentage points more compared to the corresponding indicator in

2010. The year 2018 was marked as the most productive year for the development of capital investments, both in the total amount of the country's economy and in its sub-sector "agrosector".

The highest growth of the average annual value of the capital investments basic growth rates (relative to 2010) into agricultural production was achieved in 2018, 2019. In comparison with the corresponding period (chain growth rate), during 2019–2021, there is a reduction in investments, but the difference of capital investments volume in the monetary equivalent during this period decreased. So, if in 2020, compared to 2019, the amount of investments decreased by 8,450 million UAH, in 2021, compared to the figure of 2020, it decreased by 1,553 million UAH.

Analyzing capital investments into the country's agriculture by types of assets (Figure 3), it can be stated that within 98 % of investments during the years 2019–2021 were invested in tangible assets. The largest share annually with a tendency to increase is the cost of updating machines, equipment, inventory: 47.9 % in 2019, 50.4 % in 2020, 51.3 % in 2021. During the analyzed period, the share of invested capital was 16.2 %–14.7 % for the renewal of vehicles. These facts indicate the modernization of production resources, which will have a positive effect on the increase in productivity. Considerable financial resources are also invested in the construction/reconstruction of non-residential and residential buildings, with slight fluctuations when the share of this type of investment decreased in 2021 (17.5 % in 2019–2020, 15.4 % in 2021).

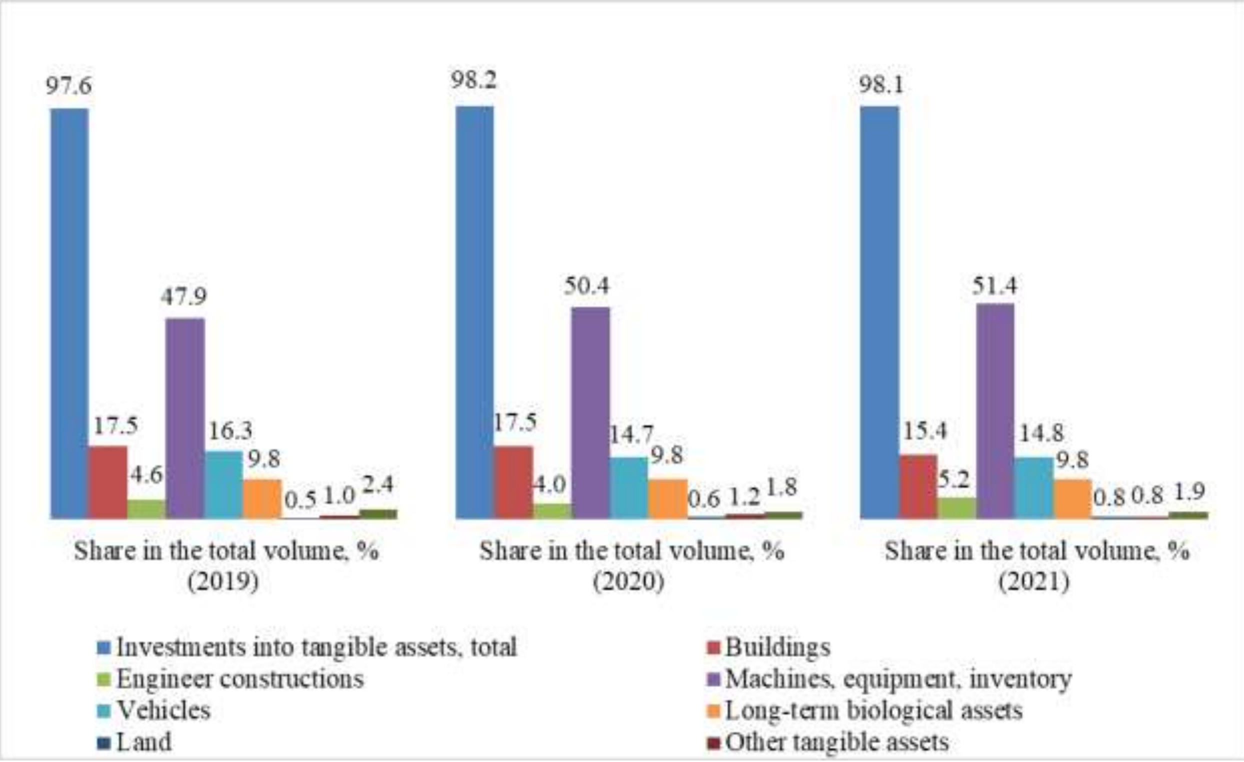


Fig. 3. Distribution of capital investments in Ukraine's agriculture by types of assets as a percentage of the total volume
Source: built by the authors based on [19].

As already noted above, the most important type of agricultural production is crop production, which produces more than 70.0 % of gross agricultural products. This specialization of agricultural production is caused by the available significant country's land resources and a shorter period of production processes, which allows the economic entity to return the invested into production financial resources (working capital) in a significantly shorter period and to receive income from the products in comparison with the livestock industry. Therefore, the field of crop production is more attractive for the implementation of investment projects and the attraction of capital investments (Fig. 4).

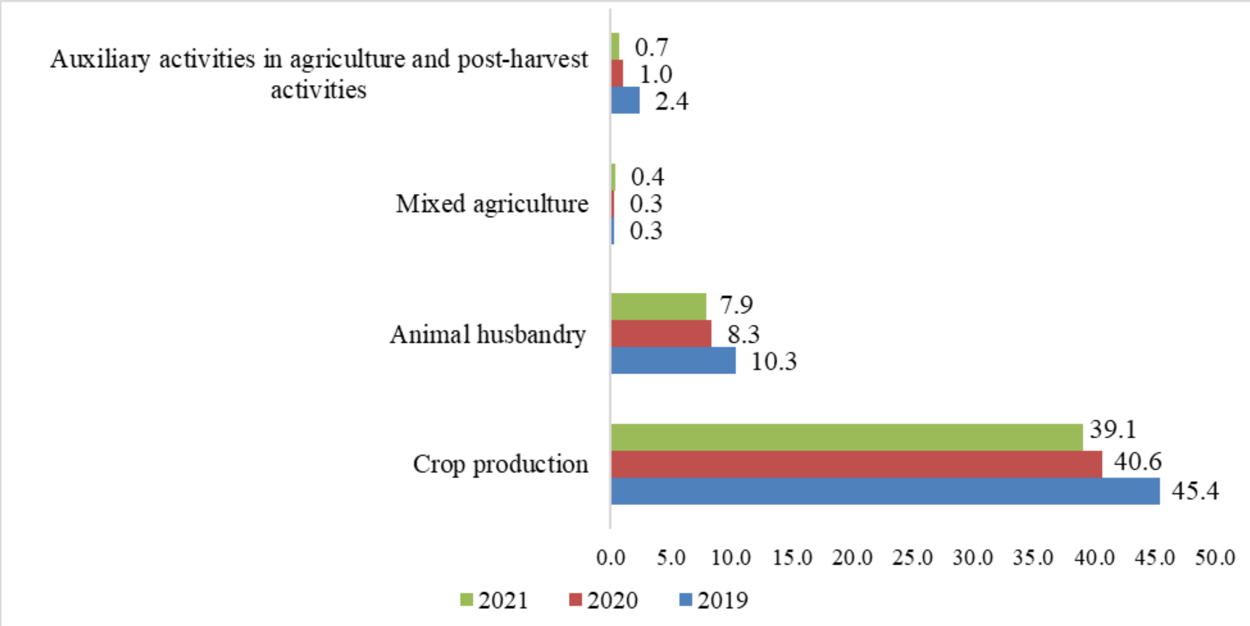
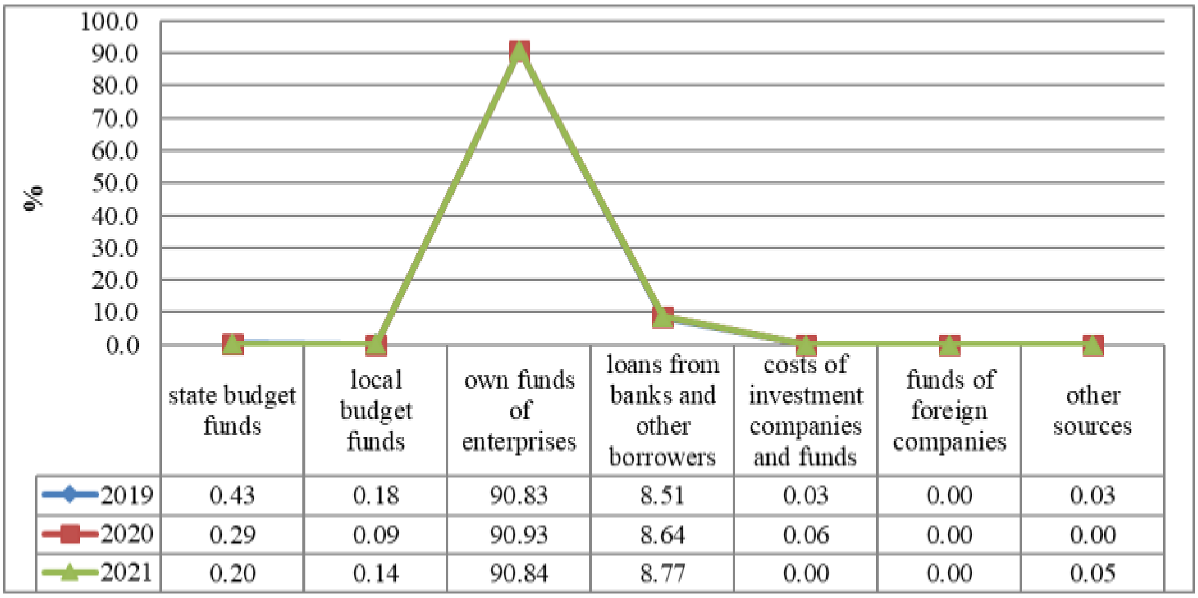


Fig. 4. Dynamics of capital investments into Ukraine's agriculture by production areas (billion UAH)
Source: built by the authors based on [21].

The evaluation of the main investment sources is an important factor in the analysis of the attraction of capital investments in the agricultural sector of the Ukrainian economy.



	state budget funds	local budget funds	own funds of enterprises	loans from banks and other borrowers	costs of investment companies and funds	funds of foreign companies	other sources
2019	0.43	0.18	90.83	8.51	0.03	0.00	0.03
2020	0.29	0.09	90.93	8.64	0.06	0.00	0.00
2021	0.20	0.14	90.84	8.77	0.00	0.00	0.05

Fig. 5. Dynamics of the structure of capital investments sources involved in the agricultural sector of Ukraine's economy as a percentage of the total
Source: built by the authors based on [20].

The analysis of the given data in Figure 5 shows that own funds of enterprises and organizations are the main source of financing capital investments in the agrarian sector of the Ukrainian economy. Their share annually is almost 91.0 % in the total volume of investments in the sector. Credit resources of the banking system and other borrowers occupy the second place among the sources of financing capital investments in the agricultural sector. During 2019–2021, the share of credit loans was from 8.5 to 8.8 %.

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The analyzed structure of sources of capital investments indicates that agrarian entrepreneurs themselves are the main investors in the agricultural sector, attracting their own funds and credit funds from banking institutions. The main goal of investment activity is to direct financial and material resources to ensure the growth of production volumes, which ultimately aims to increase the gross added value from economic activity.

An assessment of the actual capital investments influence during 2010–2021 in the agrarian sector of Ukraine's economy on the effectiveness of agricultural production has been conducted with the use of tools of correlation and regression analysis, It is evaluated by the indicator of the amount of gross added value. To carry out the analysis, the volume of mastered capital investments in general and by funding sources were selected as factor indicators: funds from state and local budgets, own funds of business entities (enterprises), borrowed funds, resources of investment companies and funds.

Table 5. Assessment of the dependence of the gross added value volume of the agricultural sector on investment support from various sources of investment resources according to the calculated coefficients of determination

Source	Function	Equation	R²	Dependence
Capital investments, billion UAH	Linear	$y = 5.6455x + 42.59$	0.606	average
	Logarithmic	$y = 195.22\ln(x) – 421.57$	0.661	average
	Polynomial	$y = -0.2146x^2 + 22.264x – 196.09$	0.725	significant
	Power	$y = 9.5448x^{0.9005}$	0.834	significant
	Exponential	$y = 81.792e^{0.0259x}$	0.754	significant
Investments at the expense of the state budget, billion UAH	Linear	$y = 1430.30x+140.58$	0.388	moderate
	Logarithmic	$y = 155.70\ln(x) + 688.1$	0.618	average
	Polynomial	$y = -16277x^2 + 5619.5x – 29.846$	0.715	significant
	Power	$y = 1570.4x^{0.712}$	0.768	significant
	Exponential	$y = 128.24e^{6.54x}$	0.480	moderate
Investments at the expense of the local budget, billion UAH	Linear	$y = 3339.6x+99.00$	0.459	moderate
	Logarithmic	$y = 168.241\ln(x) + 803.1$	0.557	average
	Polynomial	$y = -80346x^2 + 12376x – 81.39$	0.602	average
	Power	$y = 2675x^{0.772}$	0.695	average
	Exponential	$y = 106.64e^{15.15x}$	0.561	average
Investments at the expense of own funds, billion UAH	Linear	$y = 6.31x+52.45$	0.572	average
	Logarithmic	$y = 194.3\ln(x) – 387.67$	0.642	average
	Polynomial	$y = -0.2987x^2 + 26.726x – 208.27$	0.719	significant
	Power	$y = 11.256x^{0.893}$	0.805	significant
	Exponential	$y = 85.99e^{0.0288x}$	0.704	significant
Investments at the expense of bank loans and other borrowers, billion UAH	Linear	$y = 32.74x+120.0$	0.269	slight
	Logarithmic	$y = 166.18\ln(x) + 42.82$	0.387	moderate
	Polynomial	$y = -17.817x^2 + 212.1x – 227.5$	0.534	average
	Power	$y = 75.193x^{0.8272}$	0.568	average
	Exponential	$y = 108.87e^{0.1664x}$	0.412	moderate

Note: $R^2 < 0.1$ – there is no dependence; $0.1 < R^2 < 0.3$ – dependence is slight; $0.3 < R^2 < 0.5$ – dependence is moderate; $0.5 < R^2 < 0.7$ – dependence is average; $0.7 < R^2 < 0.9$ – dependence is significant; $0.9 < R^2 < 0.99$ – dependence is absolutely significant.

Source: authors' calculations.

The analysis carried out on the construction of the dependence between the mastered capital investments in the agrarian sector of Ukraine's economy (period 2010–2021) on the effective impact on the activity of agricultural production, which is expressed by the obtained gross added value volumes of agricultural products, demonstrates an average and significant dependence. Regarding the establishment of the most promising sources of investment support for the agricultural sector, taking into account the strategic vectors of its development, the own economic entities' investment resources are the most significant.

As part of the study "Ukraine Investment Attractiveness Index", the European Business Association (EBA) has been analyzing the investment attractiveness of Ukraine's economy for 12 years in a row.

The integral indicator of the Investment Attractiveness Index of Ukraine in the first half of 2022 due to the full-scale war in the country fell by half a point and is 2.17 out of 5 possible. This value is the lowest since 2013. However, it is worth noting that according to the results of the European

Business Association (EBA) study, 91.0 % of companies expressed their intention to continue working on the Ukrainian market, and 55.0 % declared their desire to invest in Ukraine even during wartime. Agricultural sector, energy, IT, construction remain the most investment-attractive industries.

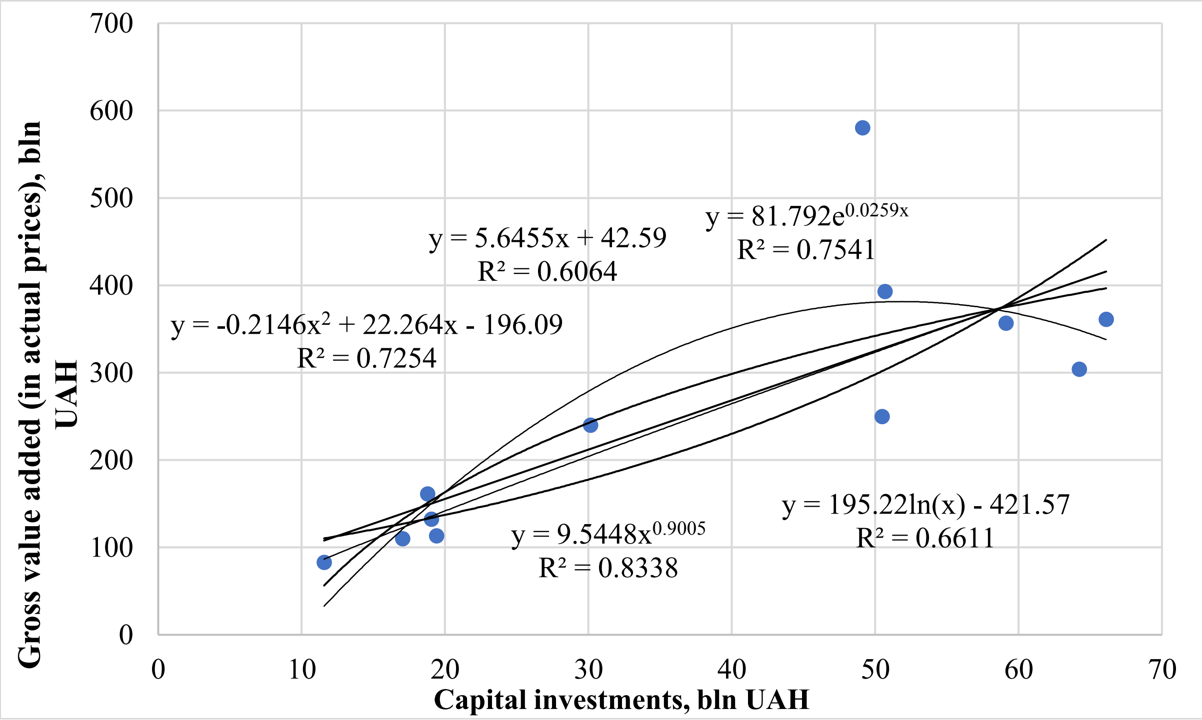

Fig. 6. Linear, logarithmic, polynomial, power and exponential trends of the gross added value volume dependence of Ukraine's agricultural sector on the capital investments volume during 2010-2021
Source: authors' calculations.

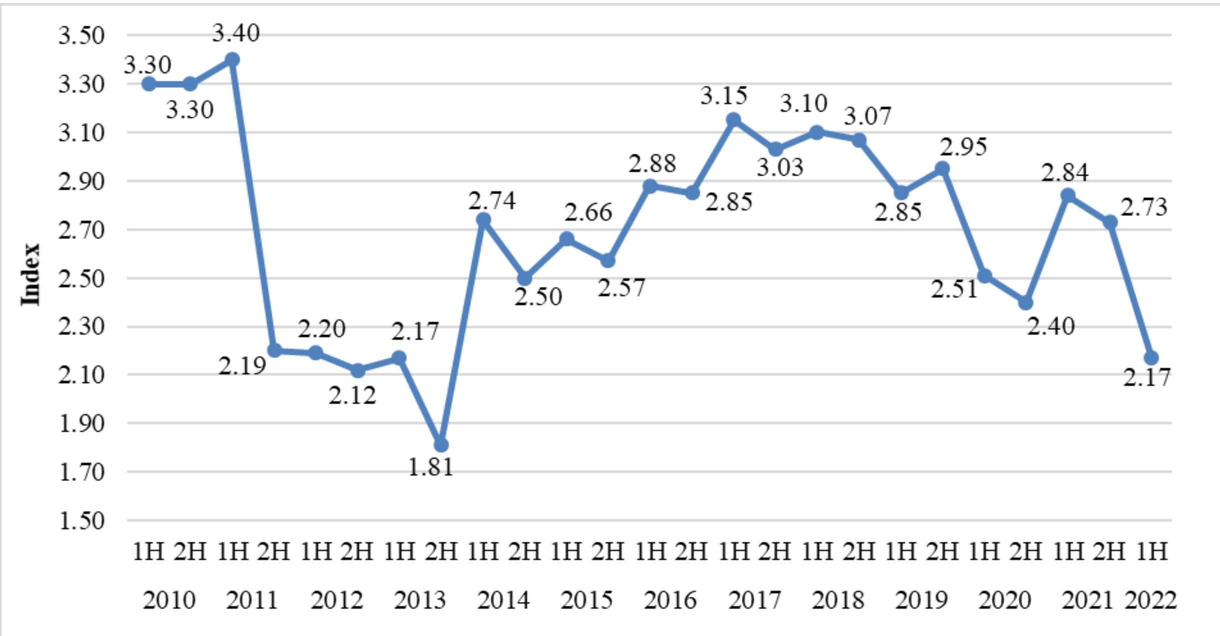

Fig. 7. Investment attractiveness index of Ukraine in the rating of the European Business Association
Source: built by the authors based on [3].

However, in the opinion of possible potential investors, the main factors that hold back the intensification of investment activity in Ukraine's economy and directly in the agricultural sector should include:

- low legislative level of investors' rights protection (instability of legislation, mistrust of the judicial system);
- instability of the national currency;
- high interest rates for attracting credit resources;
- price policy disparity between producers of agricultural products and products of industrial and chemical industries for the agricultural production needs;
- the issue of lifting the moratorium on the sale (circulation) of agricultural land was not resolved for a long time (the moratorium was in effect from 2002 to July 2021 with certain restrictions until 2024).

Conceptual approaches to determining the strategic foundations of the investment support development as a complex economic process in the conditions of uncertainty of most market changes, manifestations of crisis situations in the complex conditions of today caused by the conduct of military operations on the territory of Ukraine, form a logical inclusion of the relevant issues of the investment process in the government's and business' tactical field of action (measures). The issue of combining conceptual approaches with investment support and strategic plans of the government to match the strategy of the state's economy development for short and long-term periods in interaction with industry plans and programs, which forms the newest platform for partnership interaction in the movement towards an effective model of the agricultural sector of Ukraine's economy, becomes really important. It is necessary to form a sustainable interest of agricultural sector enterprises in improving investment processes, managing relevant projects, updating business communications, expanding partnership relations with domestic and foreign investors in order to adopt experience in the agricultural production development.

From the standpoint of promising conditions for the development of the agrarian sector of Ukraine's economy, the prerequisites for the strategic investment support of the industry can be the development and formation of scientifically based models of the cluster economy. Cluster local networks of territorial production systems are the sources and factors of ensuring a high level of agricultural production, its economic growth and sustainable territory development. Cluster associations as a platform for partnerships in competitive market involve solving a large number of problematic and conflicting issues with the involvement of state administration, the potential of science, the business environment into the directions of development of production and social – economy of the territory and the region. Such associations can contribute to ensuring the accumulation of best practices in production, improving the management system, opening up investment potentials, expanding areas of activity, etc.

CONCLUSIONS

The relevance of the issue of the economy's agricultural sector investment attractiveness in modern conditions is caused with the growing practical need of humanity for quality food products, the supply of processing industries with raw resources, as well as the impact on the socio-economic development of territories. In the most general sense, it is advisable to consider investment attractiveness as a certain set of characteristics of the investment object ("assessed characteristics of the condition" of the investment object), which satisfies the investor's requirements and convinces him of the feasibility of investing in this object, motivates and satisfies strategic interests. Available natural and labor resources, geographical location, developed market infrastructure can be the basic components that determine the level of investment attractiveness of Ukraine's agricultural sector.

It has been emphasized on the importance of agricultural production for the economy of Ukraine. It has been noted that investments are a key element of economic development, the use of which allows business entities to increase the capacity and volumes of production, processing and sales of products on the domestic and foreign markets.

The justification of a conceptual platform to the strategic vision of investment support for managing the development of the agrarian sector of Ukraine can be identified by the following sequence of actions:

1) formation of development priorities (investment support for the implementation of sustainable intensification according to European standards);

2) strategic planning taking into account the role of the agriculture in the development of the national economy (the unity of government-business cooperation platforms, self-development, commercial and business communication);

3) communication with international partners (integration into the global community).

Conceptual approaches have their own multiplicity, actualization of economic and management knowledge, which should form an active field of changes with target vectors of influence on the country's agricultural sector, ensure the variability of development, improve approaches to the formation of a targeted state investment policy in the agriculture, taking into account the priority interests of the national economy.

The basic principles of investment support as an instrument of strategic management in the implementation of investment policy in the agriculture should be: scientific principle, systematicity, prioritization of the industry and its economic and social aspects, market efficiency, partnership relations, development of risk protection, optimization of risks and profitability, consideration of regional specificity, dynamism, priority of strategic vision and national interests.

According to the results of the study, a solution to the scientific problem of forming conceptual approaches to increase the efficiency of investment support management for the strategic development of the agrarian sector of Ukrainian economy is proposed. One of the stages of promising conditions for the development of the national agricultural sector should be the development and formation of scientifically based models of cluster associations within partnership relations involving state administration, the potential of science, and the business environment in the directions of production development. Such associations can contribute to ensuring the accumulation of best experience in production management, improving the management system, unlocking the investment potential of agricultural production, and expanding the spheres of activity of the national agricultural sector.

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DETERMINING THE SHORT AND LONG TERM VOLATILITY SPILLOVERS BETWEEN WHEAT, COTTON AND CORN PRICES IN TURKEY USING THE ASYMMETRIC BEKK-GARCH-MEAN EQUATION MODEL

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Abstract

In the study, the price volatility relationship between wheat, cotton and corn markets was investigated and daily data for the period 02.04.2005-11.03.2020 were used. The VAR-Asymmetric BEKK-GARCH model, which analyzes the markets simultaneously in a single system, was chosen. Persistent long-term uncertainty in the wheat market affects the market positively. Long-term uncertainty in the cotton market creates uncertainty both in its own market and in the corn market. Persistent long-term uncertainty in the corn market creates permanent uncertainties both in its own market and in other markets, and these effects are statistically significant. Markets were more affected by long-term shocks.

Key words: *wheat, cotton, corn, price fluctuations, VAR-Asymmetric BEKK-GARCH-mean equation model, conditional variance*

INTRODUCTION

Agricultural commodity markets are of great importance in international trade. Wheat, cotton and corn markets lead the agricultural commodity markets. These markets have an important effect on the world production. Today, wheat is a product of indispensable importance for people, from the west of Europe to the north of India, from Scandinavian and Russia to Egypt, and Turkey. Corn, the most renowned agricultural product of the modern world, has economic value with every bit of it and takes part in production of 4,000 different products, directly or indirectly [15]. The fact that cotton, which has key importance in commodity markets, is both the means of livelihood of a large producer mass and the feedstock of national weaving industry, and hence the foreign currency inflow through the Turkish textile sector is realized mainly on account of cotton and cotton-based products lays bare the importance of cotton.

These markets are of great importance in production and yield. According to 2020 data, wheat production in the world is over 750 million tons and Turkey ranks eleventh in the world (with 20 million tons of wheat production) whereas it is among the top five countries in yield (2,000 kg/ha). As for the corn market, Turkey ranks twenty-first in the world and produces 6 million tons corn a year with a production yield of 9,000 kg/ha [2, 3]. In terms of yield, Turkey ranks third after the USA and Canada. Leading countries in cotton production are India (6,000 tons/ha), China (5,800 tons/ha), USA (4,378 tons/ha), Brazil (2,755 tons/ha), Pakistan (1,350 tons/ha) and Turkey (815 tons/ha) (ICAC 2020).

When the regions where cotton is produced in Turkey is examined, production is concentrated in the Aegean, Mediterranean and Southeastern Anatolia regions in general (Gençer et al. 2005) [11].

In cotton production, Turkey ranks 6th in the world, whereas in terms of yield in production, it ranks third in the world (with 1,567 kg/ha) after China (1,758 kg/ha) and Brazil (1,658 kg/ha) [13].

For three product markets, Turkey has foreign dependency in production, which is a factor that triggers price fluctuations, one of the biggest problems in the agricultural sector. Excessive price volatility poses a threat to the political stability of the relevant markets. In this regard, problems related to policies comes first among the problems encountered in production. Apart from political problems, high production costs in agriculture, problems related to production technique, and training problems related to production and processing techniques hinder the production to a large extent [11]. There are many studies on this matter in the literature. A study by [6], similar to this one, stresses that the impact of oil prices on food prices is inevitable, and underlines that analyzing agricultural product prices separately would yield more efficient results for a better understanding of the change in food prices. In similar studies conducted in the following years, [10] found that there was an interaction between the volatility of corn, wheat and crude oil markets. In another study it was reported, considering 24 agricultural product markets between 1980-2010, that oil prices have taken ahold of the agricultural commodity prices [14]. The study that is closest to this study and supports its findings was conducted by [6], in which they examined the volatility spillover among various agricultural futures markets from a new perspective, as single futures markets are deemed inappropriate due to the increasing interdependence of global markets. Having taken the data of corn, cotton and wheat markets, they showed, using generalized autoregressive conditional heteroskedasticity (GARCH VAR) model, that the impact of the volatility of corn futures returns on cotton and wheat futures returns is statistically significant, showing that volatility spillover can be observed in agricultural futures markets in the short run. They also revealed that the effects of speculation on one market may be contagious for other markets, and therefore they argued that the increase in volatility in agricultural prices in recent years is inevitable. In a study examining the level of interdependence among agricultural commodities (corn, wheat, soybeans and soybean oil) in 2017 with a focus on commodity financialization, it has been determined that there is greater spillover in the corn and wheat market, in contrast to, especially, soybean and soybean oil markets, and that surprising economic news have a strong impact on the volatility of agricultural commodities [12]. Among the studies conducted in the recent years, this topic still preserves its actuality. In a study conducted in China in 2018, stressing that the agricultural commodities are among the fastest growing futures market in the world, by means of Generalized Autoregressive Conditional Heteroskedasticity (GARCH VAR) model, they investigated whether there was speculative activity in the Chinese futures markets and found out that the speculation rate had a positive effect on contingent volatility for most commodities, also suggesting that the results were insufficient to hedge potential risk [7]. In a study conducted in 2020, researchers investigated the effect of positive and negative shocks between agricultural products, energy market and industrial materials. They showed that volatility in price changes can be positively or negatively related to demand shocks, depending on demand and supply elasticities. By using Asymmetric Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, they argue that a positive return shock creates higher volatility in prices, and they stated that there is only a leverage effect in crude oil. In addition, researchers emphasized that volatility is the main determinant of many financial decisions, and attested, in this respect, that their research was important in terms of shedding light on academic researchers and policy makers [8].

In line with the above cited studies, among the agricultural commodity markets, wheat, corn and cotton markets, which are of great importance in international trade, were preferred in this study. As daily price changes in the stock market are important for the study, the data used in the study, therefore, consisted daily market data for the period of 11.02.2005-06.03.2020, obtained from the Union of Chambers and Commodity Exchanges of Turkey (TOBB), İzmir Commodity Exchange, Şanlıurfa Commodity

Exchange, Adana Commodity Exchange and Çorum Commodity Exchange. Aimed in this study is to examine the volatility relationship between wheat, corn and cotton markets by using Baba-engle-kraft-kroner generalized self-coupled conditional multivariate VAR (1) – Asymmetric BEKK – GARCH (1,1) mean equation model in order to understand the wheat, corn and cotton price changes in the stock market. It is extremely important to examine the volatility pass-through between agricultural markets, and for the investor to make current and future investment decisions, it is crucial to know how an uncertainty activity in a market affects that market, as well as other substitute product markets, in the short and long term. Therefore, on account of snapping the uncertainty, being aware of the mobility of the receptors in the market can, at least, relieve the investor and can provide clearer information to the decision makers by revealing, for example, which market carries more risk and what the direction and severity of the spillover uncertainty in the pass-through from one market to another market is. In addition, quantitatively revealing how negative news in a market affects that market and other competing markets through receptors in a different aspect than positive news offers more robust and dynamic information for the investor to make investment decisions. Within the framework of all this information, this study presents information about how the spillover uncertainty, including the spillover effects of negative news, taking place in short and long term affects a market and how big a pass-through to competing markets it induces. At the same time, the results to be obtained from the study are very important in that, it can provide a foresight to the producer to make more pertinent production decisions and to enable the corn, wheat and cotton markets which constitute an important percentage in foreign trade and in the country's economy, to compete strongly with other producer countries.

MATERIALS AND METHODS

Data Set

In this research, among the agricultural commodity markets, wheat, corn and cotton markets, which are of great importance in international trade, were preferred. The daily values of relevant exchanges were followed as the data set. Since it is important to have daily market data in the stock market, daily data were obtained for these three markets. The daily data for the wheat and corn markets were obtained from the Union of Chambers and Commodity Exchanges of Turkey (TOBB), whereas the daily data for the cotton market were obtained from İzmir Commodity Exchange, Şanlıurfa Commodity Exchange, Adana Commodity Exchange and Çorum Commodity Exchange. The study covers the daily data of the markets for the period of 11.02.2005-06.03.2020. Three different data sets were obtained for the three markets in this period, and as a result of the pairing the data, a total of 176 observations were studied. In all models, returns, rather than price levels, were estimated as the dependent variable. The returns of the series are obtained using the formula 1:

$$R_{i,t} = \Delta log(P_{t,i}) = \log(\frac{P_{t,i}}{P_{t-1,i}}) \times 100 \qquad (1)$$

where:

i being 1, 2, and 3 (signifying wheat, cotton and corn), P_t is the current real price of the relevant market, $P_{t-1,i}$ is the price of $P_{t,i}$ in the previous period.

Econometric Method

VAR (1) – Asymmetric BEKK – GARCH (1, 1) mean equation method was used for the analysis of the data set. The asymmetric multivariate GARCH model evaluates potential price volatility spillovers and the model known as the Asymmetric BEKK-GARCH model (Engle and Kroner 1995; Grier et al. 2004) is applied. In this study, since the price volatility between the wheat, cotton and corn markets in question was investigated, the VAR (1) – Asymmetric BEKK – GARCH (1, 1) method, which consists two equations, was preferred as a method. One of the two equations consisted in the method is the average return equation, and the second one contains the return variances. The general representation of the average return equation discussed first is expressed as in equation (2):

$$R_{j,t} = \alpha_j + \sum_{i=1}^{p} \Gamma_i R_{j,t-i} + \varepsilon_t, \quad \varepsilon_t \sim (0, H_t)$$

$$H = \begin{pmatrix} h_{11} & \cdots & h_{1n,t} \\ \vdots & \ddots & \vdots \\ h_{1m,t} & \cdots & h_{mn,t} \end{pmatrix} \quad (2)$$

Here, j denotes wheat, cotton, corn markets, and i denotes the lag level determined by the AIC, BIC or HQ criteria. Here m=n=3 (representing three product markets).

The general expansion of the vector and parameter matrices in the return averages is as given in equation (3).

$$R_{j,t} = \begin{bmatrix} R_{1,t} \\ R_{2,t} \\ R_{3,t} \end{bmatrix}; \alpha = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix}; \Gamma_i = \begin{pmatrix} \Gamma_{11}^{(i)} & \cdots & \Gamma_{1n}^{(i)} \\ \vdots & \ddots & \vdots \\ \Gamma_{m1}^{(i)} & \cdots & \Gamma_{mn}^{(i)} \end{pmatrix}; \varepsilon_{j,t} = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} \quad (3)$$

In Equation (3), $R_{j,t}$ denotes yield vector of products, $R_{1,t}$, $R_{2,t}$, $R_{3,t}$ the parameter matrix of previous returns for wheat, cotton and corn, α_j fixed term parameter of each return, and Γi the parameter vector of the lag lengths determined by the AIC, BIC or HQ criteria for each return equation. Since the VAR equation supports only one lag, i.e., the relationship of a lag in, say, wheat, cotton or corn yields with the yield in wheat market can be determined, only one relationship was determined in this study. The same was applied to the return levels of the other two markets. On the other hand ε_t represents the error terms vector, which enables the short-term and asymmetrical relationship in the conditional variance equation be determined.

Considering the lag length, the algebraic representation of the variance equation that constitutes the second part of the VAR (1) – Asymmetric BEKK – GARCH (1, 1) model is:

$$H_t = C'C + B'H_{t-1}B + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + D'\xi_{t-1}\xi'_{t-1}D \quad (4)$$

The equation consists of $3x3$ matrices of H, C, A, B and D. The lower diagonal matrix C contains the constant coefficients of the variance equations. A and B matrices represent short-term shocks and long-term volatility in the markets, respectively. The parameters in the D matrix show the asymmetric effect. The matrix structure in Equation 4 is shown below.

$$H_t = CC' + \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \varepsilon_{t-1}\varepsilon'_{t-1} \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} + \begin{pmatrix} b_{11} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{m1} & \cdots & b_{mn} \end{pmatrix} H_{t-1} \begin{pmatrix} b_{11} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{m1} & \cdots & b_{mn} \end{pmatrix}$$
$$\begin{pmatrix} d_{11} & \cdots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{m1} & \cdots & d_{mn} \end{pmatrix} \xi_{t-1}\xi'_{t-1} \begin{pmatrix} d_{11} & \cdots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{m1} & \cdots & d_{mn} \end{pmatrix} \quad (5)$$

where:
m and n = 1, 2, 3.

The parameters in the matrices were calculated using maximum probability methods and marginal effects needed to be calculated due to nonlinear parameter combinations. In this regard, the standard deviations of the marginal effects were calculated using the delta method.

RESULTS AND DISCUSSIONS

In the study, after converting the series to real, the analyzes were made by obtaining the series of returns. The changes in the return and return squares for the series over the years are given in Figs. 1 and 2, and the change in the conditional correlation and variance between the returns over time is given in Figures 3 and 4.

When Figures 1 and 2 are examined in detail, a significant level of price volatility is observed in the returns of wheat, cotton and corn in a period of approximately 7-8 years, between 2008/09 and 2015. The highest price volatility is in the cotton market, followed by wheat and corn markets, respectively. One of the main reason for price volatility can be said to be the world food crisis occurred in 2008/09. In the return squares graph, again, cotton is seen to have the highest frequency range and corn, and wheat follow. The lowest price volatility is in the wheat market. In this regards, the uncertainty, showing up generally in the cotton market, affects the cotton producer and makes them sway to the wheat market, which has a more stable trend compared to cotton and corn.

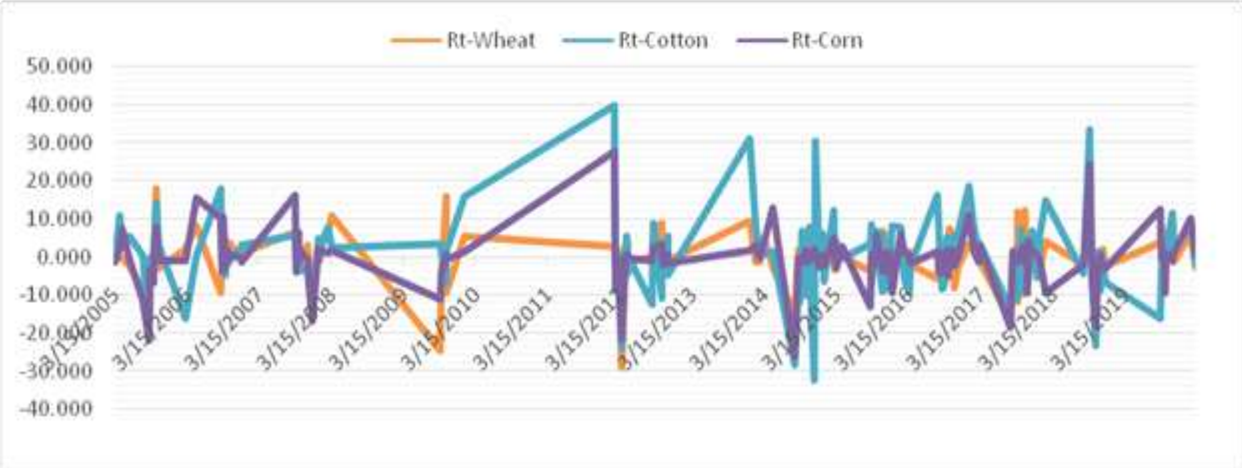

Fig.1. Changes in returns over the years
Source: Authors' own design and calculations.

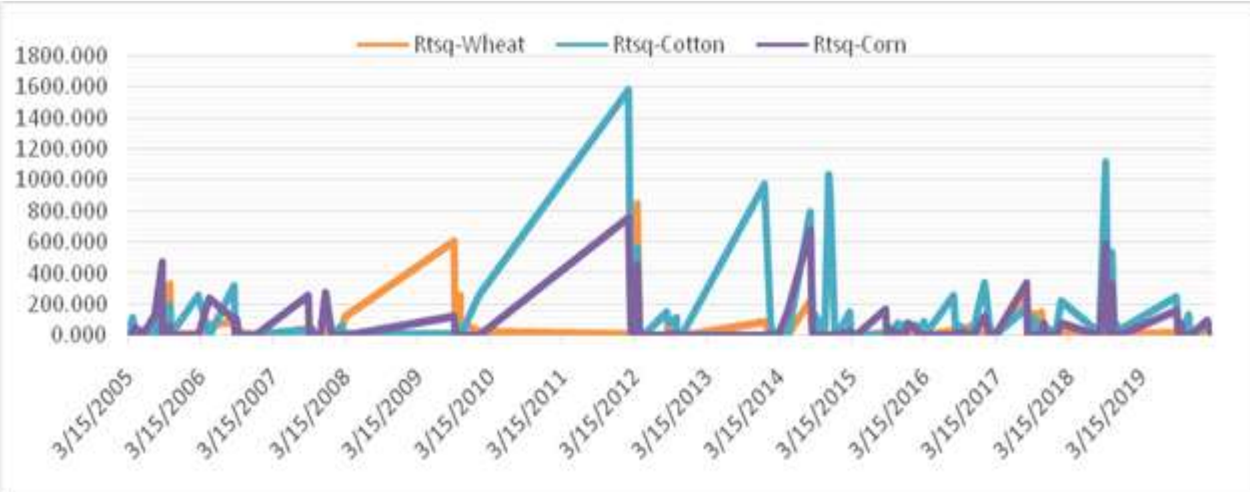

Fig. 2. Changes in return squares over the years
Source: Authors' own design and results.

Looking at the correlation in Fig 3, it is seen that the three product markets affect each other. An uncertainty in the wheat market will show up in the cotton and corn markets. In other words, an uncertainty showing up in the cotton market will have an impact on the wheat and corn markets, similarly the uncertainties in the corn market will have an impact on the other two markets. While the correlation between the three markets was stable until 2008, it showed great volatility in and after 2008. Especially in 2008, the corn market was more volatile than the other two markets. Later in the same year, this price volatility showed up in the cotton and wheat markets, respectively. This situation can be explained by the fact that the effect of the world food crisis that occurred in 2008 was effective in all the three product markets that year and remained in effect for many years. From 2008 to 2015, the volatility in the relationship between wheat, cotton and corn markets continued and uncertainties occurred in the markets due to the price volatility that occurred. Cotton market showed fluctuations the most between these years, corn and wheat markets followed cotton. In this context, it is stated that the wheat market is less affected by the world food crisis and the uncertainties that might have occurred in the markets, or the negative news in those years, compared to the cotton and corn markets. In one study, while cotton was the product that showed the most fluctuations between these years, corn and wheat markets follow cotton. In this context, the wheat market was the least affected from the world food crisis or the uncertainties or negative news that may occur in the markets in those years, compared to the cotton and corn markets. [19] noted that the prices of all agricultural futures exhibited a very volatile behavior due to weak US dollar, rising global revenues, trade restrictions by major grain suppliers, commodity financialization, and very apparent fluctuations in the oil prices, up to the year 2014, and that the volatility in all agricultural grain markets decreased significantly from 2014 onwards.

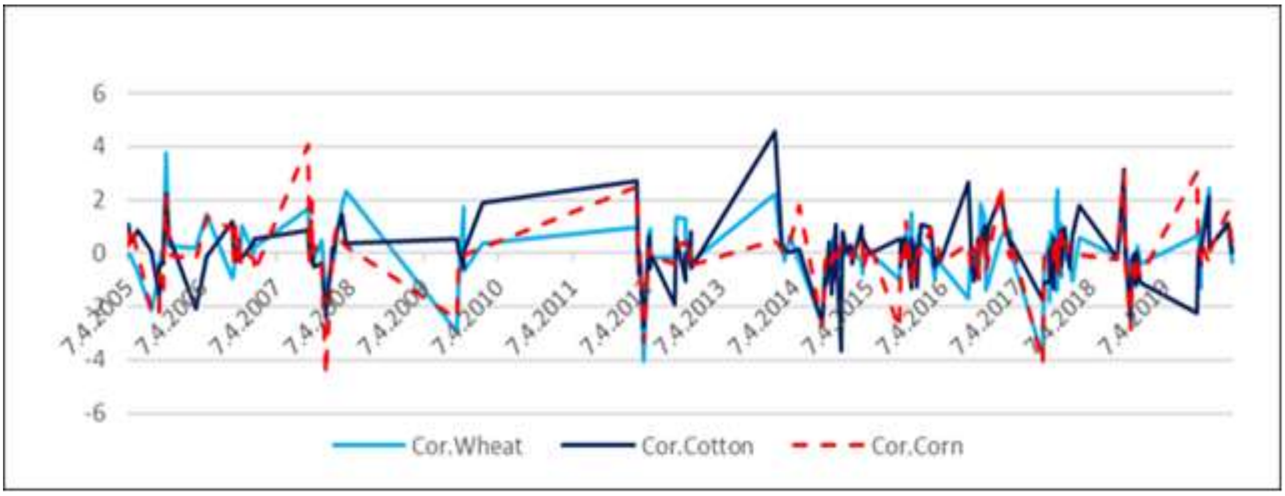

Fig. 3. Conditional correlation between returns over time
Source: Authors' own design and results.

Modeled by the conditional variance equation, conditional volatility and speculative activity measured by two ratios is shown in Fig. 4 [7]. Examining the change in the conditional variance of the wheat market over time, it is noted that wheat showed a considerable fluctuation in 2006, 2012 and 2017/18. While the conditional variance of cotton returns exhibited low volatility from 2005 to 2012, after this year, it showed a large volatility in 2013/14, a relatively less volatility in 2015 and 2017 compared to 2013/14, and the volatility is noted to have been decreasing, generally, since then to the present. The results show that the hedging ratio is not sufficient and it suggests that cotton has a negative effect on the conditional volatility [7], which supports the results obtained in the present study. The conditional variance of the corn returns is seen to have displayed a more stable structure in 2005 and increased significantly in 2007/8. After the year 2008, it exhibited a decrease and a more stable graphic until 2014, whereas from 2014 onwards it have been exhibiting a volatility of drastic increases and decreases. There is a large variation among all three conditional variances. Despite the increase in the conditional variance of corn returns in 2007 and 2008, no significant increase is there in the conditional variance of wheat and cotton returns. Compared to the increase in the conditional variance of cotton returns in 2013/14, the wheat market marked a slight increase, while corn marked a much smaller increase. In this regard, the uncertainty and high price volatility occurred in those years in the cotton market is thought to have made the cotton producer sway to wheat and corn, as an alternative, through which they can produce more profitably. In this context, the results show that the three relevant markets affect each other. A similar study reports that the corn prices increased by 43%, compared to the average of the previous 15 years, in the 2007/08 marketing year [4], hence supporting the results of the present study.

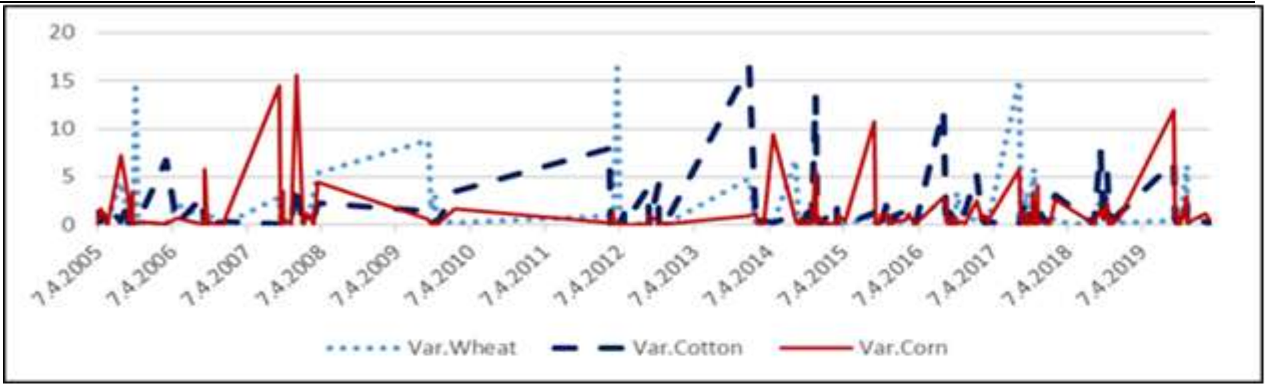

Fig. 4. Conditional variance between returns over time
Source: Authors' own design and results.

As seen in Table 1, the wheat market has higher returns than the cotton and corn markets. Compared to the other two markets, this situation can be explained by the limited supply of wheat, in respect of its position in the current market, and the high price it faces. When the unconditional variance obtained from the standard deviations of the returns of wheat, cotton and corn is examined, it is seen that cotton has higher volatility (standard deviation) than corn and wheat, which has the lowest standard deviation. In this context, cotton market is more volatile, while wheat and corn are relatively stable. Other important statistical value for the return series are the skewness and kurtosis values.

When the skewness coefficients of the return series are examined, it is observed that the return series have an asymmetric distribution. The kurtosis coefficient, on the other hand, indicates that the leptokurtic (fat-tail) values of the return series have a value greater than three and indicates a flat distribution. The presence of leptokurtic distribution in the series indicates that there may be an ARCH effect, that is, it suggests that the markets in question can react asymmetrically to negative and positive shocks in the short term [17]. Another important statistical value in return series is the Jarque-Bera statistic showing that the return series do not have a normal distribution.

Based on to the correlation values for the return series, there is a strong positive relationship between the series. While wheat market has a strong relationship with cotton and corn markets, cotton market has a strong relationship only with corn market. Studies show that the pass-through of volatility between markets is more intense during periods of increased market turbulence that occur due to the increasing financialization of commodity markets in the last two decades [1, 9].

Additionally, Ljung-Box statistic, an important value that shows whether price and return series have autocorrelation, of price levels and closing values were tested and the statistical results showed presence of autocorrelation in the returns of wheat (29.318***) and corn (20.708**), except cotton (13.371).

In order to test the ARCH effect on the return series, the ARCH-LM test introduced by Engle (1982) was applied. According to the results obtained, ARCH effect was observed only in wheat return series, no ARCH effect was observed in cotton and corn returns. However, when viewed simultaneously (MARCH–LM), ARCH effect is observed in the residues of the series, and in this regard, the series is said to have ARCH effect simultaneously, therefore the series need to be analyzed with the multivariate GARCH model. In the literature, the results of the LM tests support the use of the GARCH model, and therefore the volatility of the returns of the variables studied is represented by the conditional variances estimated by the GARCH model [7].

Augmented Dickey–Fuller (ADF) unit root test, proposed by Dickey and Fuller (1979), was applied to determine whether there is stationarity in the return series and the results are presented hereafter. As a result of the unit root test, return series were found to be stationary at the 5% significance level. KPSS test results confirmed the ADF unit root test results.

Table 1. Descriptive statistics

Statistics	Returns		
	$\Delta logPr_{wheat,t}$	$\Delta logPr_{cotton,t}$	$\Delta logPr_{corn,t}$
Mean	0.042	0.281	-0.060
Std. Deviation	5.711	9.052	6.086
t-statistics (mean = 0)	0.097 (0.922)	0.410 (0.682)	-0.130 (0.896)
Skewness	-1.051*** (0.000)	0.530*** (0.004)	-0.166 (0.374)
Kurtosis	5.883*** (0.000)	4.806*** (0.000)	7.563*** (0.000)
Jarque-Bera	282.989*** (0.000)	175,667*** (0.000)	415,596*** (0.000)
Correlation for Price Levels or Closing Values			
$\Delta logPr_{cotton,t}$	0.968		
$\Delta logPr_{corn,t}$	0.995	0.967	
Correlations for Return Series			
$\Delta logPr_{cotton,t}$	0.325		
$\Delta logPr_{corn,t}$	0.512	0.581	
Correlation Between Return Squares Series			
$\Delta logPr_{cotton,t}$	0.308		
$\Delta logPr_{corn,t}$	0.451	0.713	
Testing of Price Levels or Closing Values			
Ljung-Box Q (10)	29,318*** (0.001)	13,371 (0.203)	20.708** (0.023)
Ljung-Box Q2 (10)	19.678 ** (0.032)	7.342 (0.692)	5.122 (0.882)
HM-Q (10)	123.6048 **		(0.010)
Testing of ARCH or Closing Values at Price Levels			
ARCH-LM (10)	1.978** (0.039)	0.721 (0.704)	0.558 (0.845)
MARCH-LM (10)		1009.13*** (0.000)	
Stationarity Unit Root Test for Return Series			
ADF	-11,231** (lags=1)	-9,680** (lags=1)	-10.020** (lags=1)
KPSS	0.035 (lags=1)	0.016 (lags=1)	0.025 (lags=1)

Note: ARCH-LM and MARCH-LM refer to Lagrange and multivariate Lagrange tests, respectively, for ARCH effects.
Ljung-Box Q and Ljung-Box Q2 apply sequential dependency tests on residue and residue squares, respectively.
HM-Q refers to Hosking's sequential dependency test on multivariate residues.
The null hypothesis under the MARCH-LM test assumes a constant common variance and that the mean of the return series is zero.
ADF refers to the Augmented Dick-Fuller test, considering constants and trend variables. KPSS refers to the Kwiatkowski-Phillips-Schmidt-Shin test, which is used to test a null hypothesis that an observable time series is constant around a deterministic trend. Lag selections are based on AIC, BIC and HQ values. Critical values change with selected delays. Values in parentheses reflect p-values. *, ** and *** indicate the significance levels of the parameters at 10%, 5% and 1% levels, respectively.
Source: Authors' own results.

In the panel A section of Table 2, the mean equation and variance equations were examined amount the parameter estimations. According to the average equation values in the table, any positive or negative progress in the wheat market reduces the return (Γ_{11} = -0.247) in the wheat market and is statistically significant. While, a lagged return from cotton market (Γ_{21} = -0.016) and corn market return (Γ_{31} =0.054) affected the wheat market in a negative and positive way, their degree of influence was found to be statistically insignificant. In a similar study, it was determined that there was more spillover in the corn and wheat markets, apart from other commodity markets, and that economic news surprises had a strong effect on the volatility of agricultural commodities (Hamadi et al. 2017)[12]. The cotton market was negatively but insignificantly affected by its own lagged return (Γ_{22} = -0.073), and effect of the lagged returns from the other two competing markets was positive (wheat) and negative (corn). A similar situation applies to the return level of the corn market. The corn market return is negatively (Γ_{33} = - 0.094) affected by the lagged return of its own market, while it is positively (Γ_{13} = 0.131) affected by the lagged return of the wheat market and negatively (Γ_{23} = -0.02) affected by the lagged return of the cotton market. Result suggest that the markets are differently affected by the cross-markets while they are negatively affected by their own lagged returns. Although increasing return encourages the producer to produce more of the same product, the price level decreases with the excess supply and conforms with the spider web theory.

As the second step of Panel A, the coefficients of the equation of variance are given. In line with the results obtained, it is seen that the long-term uncertainty in wheat market positively affects both its short-term uncertainty (a_{11} = 0.463) and the corn market (a_{13} = 0.107), but while its positive effect on the corn market is not statistically significant, its positive effect on its own the market was found to be statistically significant. In a study conducted in this regard, they argued that a positive return shock induces higher volatility in prices [8]. Short-term uncertainties in the wheat market negatively affects the short-term uncertainty (a_{12} = -0.158) of the cotton market, but is not statistically significant.

Long-term uncertainty in the cotton market, according to the results obtained, is positively affected by both the short-term uncertainty in its own market (a_{22} = 0.896) and the short-term uncertainty in the corn market (a_{23} = 0.652), and it is statistically significant at 1% significance level. Beckmann and Czudaj (2014) [6] determined that the volatility of corn futures returns on cotton and wheat futures returns is statistically significant, showing that a spillover of uncertainty can be observed in agricultural futures markets in the short term, and the results support the results of our study. The short-run volatility spillover between cotton and corn markets supports the situation in the unconditional correlation relationship. The tight relationship between the cotton and corn production patterns constitutes a justification for the price uncertainty pass-through.

Being negatively affected by both its own short-term uncertainty (a_{31} = -0.317) and the short-term uncertainties in the wheat (a_{23} = 0.663) and cotton (a_{23} = 0.659) markets, the long-term uncertainty in the corn market was found to be statistically significant at 1% significance level. Consequently, the spillover of uncertainty, initially showing up in the corn market, will be adversely affected by the short-term uncertainties occurring both in its own market and in the other two competing product markets. In this context, short-term fluctuations in the markets are likely to adversely affect the corn market. [6] showed that the effects of speculation on one market can be contagious for other markets, and therefore, propounded that the increase in volatility in agricultural prices in the recent years was inevitable. Their results is in line with the results we obtained from the present study.

Having combined all the information above, it can be concluded that every agricultural product market is affected by its own short-term internal dynamics, while short-term uncertainties initially showed up in the wheat and cotton markets trigger long-term uncertainties in these markets to become more evident, whereas in the corn market, short-term uncertainty limits the long-term uncertainty of its own market. This situation depends on the transaction volume of selected agricultural products in the markets, and since the wheat and cotton markets constitute huge amounts in terms of transaction volumes, their short-term uncertainties in their markets create a permanent and increasing effect on the long-term uncertainties. In this context, long-term uncertainties of these markets can be limited by avoiding speculations and other short-term shocks that will cause short-term uncertainty in these markets. Interestingly, while the short-term uncertainties initially showing up in the wheat market and the long-term uncertainties of the other two competing markets induce an increasing persistence in the corn market, the short-term uncertainties in the cotton market limit the long-term uncertainties in the corn market, and the short-term uncertainties in the corn market, likewise, limits the spillover of long-term volatility in the cotton market.

In the long run, the uncertainty that may occur in the wheat market is negatively affected by the long-term uncertainty of both its own market and of the other two markets, but it is not statistically significant. The long-term uncertainty in the cotton market, the second product considered, is affected by the long-term uncertainty in the wheat market (b_{21} =-0.449) and is statistically significant. It is positively affected by long-term uncertainty particularly in its own market, and in the corn market, but is not statistically significant. In the light of all this information; the long-term uncertainties in the cotton market are affected by the long-term uncertainty initially showing up in the cotton market, and in a way, the long-term uncertainties in the cotton market eliminate the long-term persistence in the wheat market.

Lastly, the long-term uncertainties in the corn market are affected in a positive way by the long-term volatility that occurs in both its own market (b_{33} = 0.699) and in the other two competing markets (b_{31} = 0.994 for wheat and b_{32} = 0.641 for cotton) at a level that is statistically significant. In a similar study supporting the results obtained in the present study, the effect of volatility in the returns of corn futures on the returns of cotton and wheat futures was reported to be statistically significant, noting that there may be differences for both markets [6]. In the light of this information, the most fragile market can be said to be the corn market, which is affected by its own long-term uncertainty and by the long-term volatility showing up especially in the wheat and cotton markets, thus becoming a market with persistent and high-intensity long-term uncertainty. On the other hand, long-term uncertainties in the wheat market limit the long-term persistence in the cotton market, while increasing the long-term persistence in the corn market. Long-term uncertainties showing up in the cotton market only increase the spillover of long-term uncertainty in the corn market.

When the intermarket asymmetrical relationship is examined, the long-term uncertainties in the cotton market is negatively affected by the negative news from wheat (d_{21} =-0.211) and corn (d_{23}=-0.396**) markets and it is found to be statistically significant. Asymmetric spillover in other markets were found to be statistically insignificant. In this regards, short-term speculative news, especially in the wheat and corn markets, means, in a sense, good news for long-term uncertainties in the cotton market, and limits the spillover of uncertainty. Negative news, initially showing up in the wheat market, primarily triggers the long-term persistence in its own market, while at the same time increasing the long-term uncertainty in the corn market. Negative news, initially showing up in the cotton market, triggers long-term uncertainty in the wheat market and has a negative effect on the corn market.

Among the Panel B diagnostic statistics, Ljung-Box Q and Hosking Ljung-Box (MLBQ) tests were used and these tests show whether there is autocorrelation between the error terms and squares of the error terms obtained from each variance equation. The results showed that there is no autocorrelation between error terms and squares. In this regards, VAR (1) – Asymmetric BEKK – GARCH (1, 1) model is concluded to be valid in explaining the volatility (variance) of each return variable. Another important statistical value in the table is the ARCH effect. Whether the error terms has the ARCH effect or not was examined under the null hypothesis by using individual McLeod-Li and Multivariate LM tests. The results suggest that the error terms obtained from the uncertainty of the returns of respective markets do not have the ARCH effect.

In Panel C, the GARCH, asymmetric and causality relationships of the respective markets were examined by using the diagonal VAR test in the VAR-Asymmetric BEKK-GARCH (1,1) model. The Wald statistic value at 2244.975 ($p<0.000$) obtained by the hypothesis test established for the diagonal VAR test was found to be significant at 1% significance level. Since the statistical value is significant, The H_0 hypothesis (which asserts that A, B, D and all non-diagonal parameters are zero) was rejected.

In this context, it can be concluded that wheat, cotton and corn markets affect each other statistically significantly and that the uncertainties in market returns are affected by short, long and asymmetric uncertainties in other market returns. Among the results obtained in the present study is the fact that shocks that occur or may occur in other markets, or long-term uncertainty and asymmetry that is present in the market have an effect on the uncertainty of respective market [9]. On the other hand, the probability value of the Wald statistic of the hypothesis established to test the GARCH relationship between the markets under consideration was found to be statistically significant at 1% significance level, at 401.859 ($p<0.000$). With the statistical result being significant, the Ho hypothesis was rejected and it was concluded that there was a GARCH relationship between the markets under consideration. The results obtained, hereby, verify the existence of long-term volatility pass-through between the return series of the markets under consideration. It is seen that the coefficients extracted from the variance equation have asymmetric properties ($p<0.000$).

Finally, the causality relationship between the markets was examined. The established H_0 hypothesis states that there is no causal relationship between the market under consideration and the other two markets. Since the results obtained are statistically insignificant, the H_0 hypothesis was not rejected, verifying that there is no causal relationship between the returns of the markets. In this regard, the point reached as a result of all these tests is that the asymmetric BEKK-GARCH model proposed for the explanation of volatility (variance) parameter is coherent with the data [16,18].

Table 2. Parameter estimations of conditional variances, Panels A, B, C

Coefficients	$\Delta\text{logPr}_{wheat,t}$ **(i=1)**	$\Delta\text{logPr}_{cotton,t}$ **(i=2)**	$\Delta\text{logPr}_{corn,t}$ **(i=3)**
Panel A: Average Return Equation and Long-Run Volatility (Variance) Equation			
Average Equation			
α_0	0.056 (0.894)	0.300 (0.665)	-0.059 (0.898)
Γ_{1i}	-0.247 *** (0.005)	0.119 (0.401)	0.131 (0.167)
Γ_{2i}	-0.016 (0.777)	-0.073 (0.435)	-0.023 (0.711)
Γ_{3i}	0.054 (0.564)	-0.029 (0.848)	-0.094 (0.360)
Variance Equation			
c_{1i}	0.898 (0.146)		
c_{2i}	5,334 (0.000)	-0.000 (0.999)	
c_{3i}	-0.937 (0.028)	-0.000 (0.999)	-0.000 (0.999)
a_{1i}	0.463 *** (0.000)	-0.158 (0.185)	0.107 (0.182)
a_{2i}	0.138 (0.062)	0.896 *** (0.000)	0.652 *** (0.000)
a_{3i}	-0.317 *** (0.000)	-0.663 *** (0.000)	-0.659 *** (0.000)
b_{1i}	-0.228 (0.081)	-0.269 (0.108)	-0.140 (0.168)
b_{2i}	-0.449 *** (0.000)	0.189 (0.063)	0.041 (0.311)
b_{3i}	0.994 *** (0.000)	0.641 *** (0.000)	0.699 *** (0.000)
d_{1i}	0.326 (0.034)	0.074 (0.747)	0.037 (0.624)
d_{2i}	-0.211 *** (0.001)	0.450 (0.090)	-0.396 ** (0.025)
d_{3i}	0.029 (0.800)	-0.257 (0.405)	0.389 (0.071)
***Panel B:* Diagnostic Tests:**			
Ljung-Box Q (6)	10,432 (0.107)	2,408 (0.878)	4.805 (0.569)

Ljung-Box Q (10)	14.138 (0.166)	16.120 (0.096)	9,682 (0.468)
McLeod-Li (6)	0.988 (0.986)	2.939 (0.816)	4,040 (0.671)
McLeod-Li (10)	2.165 (0.994)	3,830 (0.954)	12,495 (0.253)
ARCH(6)	0.154 (0.988)	0.397 (0.879)	0.717 (0.636)
HM-Q (6)	68,171 (0.092)		
HM-Q (10)	108,514 (0.089)		
HM-Q^2 (6)	41,437 (0.894)		
HM-Q^2 (10)	67,139 (0.965)		
MARCH-LM(6)	183.20 (0.948)		
MARCH-LM(10)	440.56 (0.002)		
z_i	-0.014 (1.025)	0.020 (1.021)	-0.045 (1.049)
t-stats(z_i *=0)*	-0.192 (0.847)	0.261 (0.793)	-0.578 (0.563)
z_i^2	1.0194 (5.442)	0.983 (4.911)	0.992 (5,430)
t-stats(z_i^2 *=1)*	5.747 (0.000)	5.838 (0.000)	5.604 (0.000)
AIC	19,066		
SBC	19,886		
Hannan-Quinn	19,398		
Log likelihood value	19,078		
Panel C: Wald Test Result			
Diagonal YES	H_0: all non-diagonal elements are Γ_{ij} zero	2,244.975 (0.000)	
GARCH No Relationship	H_0: all i, j = 1,2,3 $a_{ij} = b_{ij} = d_{ij} = 0$	401.859 (0.000)	
No Asymmetrical Relationship	H_0: all i,j=1,2,3, $d_{ij} = 0$	28.874 (0.000)	
Wheat has no causal relationship on the returns of corn and cotton.	H_0: $\Gamma_{31} = \Gamma_{41} = 0$	1.728 (0.421)	
Cotton has no causal relationship on wheat and corn.	H_0: $\Gamma_{32} = \Gamma_{42} = 0$	0.795 (0.671)	
Corn has no causal relationship on cotton and wheat	H_0: $\Gamma_{33} = \Gamma_{43} = 0$	0.0336 (0.983)	

Source: Authors' own results.

CONCLUSIONS

In this study, the results of the examinations made on the aforementioned markets, which maintain their strategic importance in Turkey's economy and foreign trade, by determining the spillover processes of short and long-term risk among them were presented along with the information on how risk receptors in a market perceive the uncertainties that occur both in their own market and in the competing markets. It is very important to investigate the price volatility of the relevant markets because volatility spillover is a phenomenon that significantly affects the investment strategies and decision-making processes of investors in these three product markets. Studies indicate that good predictions on correlation and volatility are needed for risk management and hedging in such markets in this regard, whether a market shock affects the volatility in other markets and/or it spreads into those markets was investigated in this study.

The findings obtained from the analyses show that the conditional variances of returns, cross conditional variances of the variables, unit effects and many other related statistics were found to be statistically significant. It was confirmed with the results that the conditional variances of the returns of the three products under consideration have persistent effects and that there are persistent spillover between the conditional variances of their returns. In line with the results, it was concluded that cotton market has higher volatility (standard deviation) than those of wheat or corn. The product market with the lowest standard deviation is the wheat market. A leptokurtic distribution was observed in the series, and in this regard, it was found that the markets under consideration gave an asymmetric response to negative and positive shocks in the short term. Intermarket correlation results show that there is a strong relationship between the wheat market and the cotton and corn markets. This interaction is followed by wheat-corn, wheat-cotton and cotton-corn markets. When the relationship between the return series in the selected markets was considered; the highest level of relationship was found to be between the cotton market and the corn market, followed by the wheat-corn and wheat-cotton markets, respectively. Another important statistical value that was considered in the study is whether there is an ARCH effect in the series and the results obtained showed that there is only an ARCH effect in the wheat returns among the return series, whereas there is no ARCH effect in the returns of cotton or corn. However, when the simultaneous analysis of three markets in a system (MARCH–LM) was considered, ARCH effect was observed in the residues of the series, through which, it has been determined that the series have ARCH effect simultaneously.

Summarizing the results of the values of mean equation, positive or negative progresses in the wheat market reduce the return in its own market. The cotton market was negatively affected by its own lagged return and positively affected by the lagged values of the other two markets. While the yield of the corn market was negatively affected by the lagged value of its own market, it was positively affected by the lagged value of the wheat market and negatively by the lagged value of the cotton market. In this regard, while the markets were negatively affected by their own lagged values, they were also differently affected by the cross-markets.

Although increasing returns encourage the producer to produce more of the same product, the price level decreases with the excess supply and conforms with the spider web theory. Long-term uncertainties, on the other hand, are affected by the long-term uncertainty of the cotton market, and in a way, the long-term uncertainties in the cotton market eliminate the long-term persistence in the wheat market. In the light of this information, it has been determined that the most fragile market is the corn market, whereas the most robust market is the wheat market, followed by the cotton market.

It has been found that the markets are affected more by the long-term shocks than the short-term shocks and that there is a cross-interaction between the markets, which was explained above in detail in the research findings and discussion section. In line with the hypotheses established by stating how negative and positive news in the economy affect each market, the theory that negative news affects markets more than positive news was seem to conform with empirical findings. Therefore, policy makers should develop opportunities to protect the market makers from possible risk in the short term and strategies that will minimize the price volatility caused short-term shocks. In the study, it has been determined that the shocks that may occur in the long term have a significant impact on both the risks in their own markets and other relevant markets. In this case, it is recommended that policy makers make strategic plans to protect the producer in order to minimize the risks that long-term shocks, as well as short-term shocks, will create in the market. The minimization of risk in product markets in parallel to such decisions expects investors to invest in these markets. On the other hand, the results show that corn is affected more by the shocks than the other two competing markets. Therefore, it is advised that decision makers prioritize the corn market while taking decisions regarding risk minimization. In line with the information given in the study about the spillover of risk within the wheat, cotton and corn markets and between other markets, it is of great importance for the policy makers to minimize the risks that may occur in the markets.

Volatility, a key determinant of many financial decisions, and its critical role in pricing, risk management and investing in financial and physical markets is noted once again in this study. By establishing strong systematic links between the markets under consideration, information that is useful not only to the participants of wheat, cotton and corn markets, but also to national and international investors, producers and consumers, and agricultural product markets with similar characteristics was provided. Therefore, understanding the return-volatility relationship is not only a matter of academic interest, but also of important practical application. Considering that the findings presented in this study will attract the attention of academic researchers, policy makers and industry practitioners, it is necessary to take precautionary decisions in order to make the markets more profitable in the face of short and long-term shocks, speculations or negative and positive news. In line with the suggestions made in the similar studies in the literature and with the results obtained in this study, recommendations deemed to be beneficial to the respective departments and concerned parties mentioned above was made.

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CONSUMER DYNAMICS FOR POULTRY PURCHASING BEHAVIOUR IN TURKEY

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Abstract

The recent increases in red meat prices have caused poultry consumption to come to the fore. This research aimed to determine factors affecting consumers' poultry consumption, their preferences for poultry outlets by their income, and their consumption and purchasing frequencies. A diagnostic questionnaire was completed with 345 households. All data were analyzed using SPSS 23.0 program. Crosstables were used to verify possible associations among the study variables. Consumers mostly purchased chicken once a week (36.5%) and turkey on special occasions (17.7%) and 1-3 times a year (12.2%). Consumers primarily consume chicken several times a week (48.1%) and turkey once a month (42.6%). Production date was most important (66.4%) in poultry preference factors, followed by taste (64.6%) and freshness (60.9%). Advertising (19.4%) and product region/origin (9%) were the least important factors in poultry preference. The consumers participating in the survey mostly purchased chicken from discount markets (31.9%). Less turkey was consumed than chicken. The consumers' lack of turkey consumption habits affected the consumption frequency. Consumers should be informed of the nutritional value of turkey to increase the frequency of turkey consumption in Bursa. Turkey producers should be given more support, and its sales channels should be increased.

Key words*: chicken meat, consumption behaviour, poultry consumption, purchase outlets, turkey meat*

INTRODUCTION

Adequate and balanced nutrition is vital for a healthy life. Animal-derived food is essential in a balanced diet because meat provides a significant part of daily protein. Health experts recommend that at least 33% of daily protein needs be of animal origin. Poultry is the wealthiest animal food in digestible protein. Its nutritional value is very high. It is easier to digest than red meat due to its low fibre, connective tissue and fat ratio. It is rich in B group vitamins and has essential amino acids and unsaturated fatty acids supporting the nervous system. It helps keep the cholesterol level balanced [29]. Doctors and dietitians recommend poultry for weight problems like obesity and other health problems. Additionally, studies show that excessive red meat consumption increases the risk of cardiovascular problems. Experts recommend limiting red meat consumption to 500 g per week and consuming poultry instead [13]. Consumers are turning to poultry due to the rise in red meat prices. Poultry being relatively cheaper [1, 5] makes it one of the most preferred animal protein sources [1].

Chicken is the first thing that comes to mind when poultry is the highest production and consumption rate in rural areas. Besides the chicken, turkey, duck, goose, quail and ostrich are also included in poultry. Poultry farming has increased significantly in the last 15-20 years. The increase in modern hen yards and poultry slaughterhouses and technological developments has made Turkey an essential country in poultry production. Meat consumption per capita was 36.1 kgs. This amount consisted of 21.0 kg of poultry, 13.6 kg of bovine, and 1.5 kg of ovine [9]. Poultry consumption per capita in 2019 consisted of 20.47 kilograms of chicken and 0.56 kg of turkey.

Goose and duck breeding are substantial economic activities in many countries globally. However, goose and duck breeding in Turkey is generally carried out as a family business in rural areas on a small scale, with traditional methods and their share in total poultry production is less than 1%. Therefore, only chicken and turkey were included in the study under poultry consumption.

Numerous factors such as income, quality, brand, advertisement, place of purchase, packaging, flavour, region/origin and date of manufacture affect poultry consumption [20]. The primary purpose of this research is to investigate the poultry consumption preferences of consumers in Turkey with the example of Bursa. In this context, the household's poultry purchasing frequency, the factors determining the consumption frequency and the common purchasing places will be examined.

Factors affecting poultry preferences

Socioeconomic changes, religious beliefs, and cultural factors affect poultry consumption preferences [29]. It is possible to group these factors under three headings: consumers' personal preferences, product features and environmental factors [25].

Brand in food products is amongst the leading factors affecting consumer preferences. Possible microbiological deterioration in any part of the supply chain or infectious diseases that may transmit can create severe problems for consumer health. Brands that have been on the market for a long time obtain mandatory food certifications and are subject to audits. Brands expand their product range in line with consumer demands and respond more constructively to possible consumer complaints. Therefore, consumers also see the brand as an element of trust [14, 24, 28, 38].

However, advertisements, price, previous consumer experiences, and satisfaction affect brand preferences [32, 37]. These advertisements attract consumers' attention and show the unique features of a brand and product. Another way to distinguish similar products from others is the packaging. Meat can be exposed to bacterial spoilage more quickly than other foods. These deteriorations are prevented by packaging, and it maintains their durability until consumption [11]. Packaging helps meat products preserve their freshness for a longer time. The study examining the factors affecting chicken consumption in Ankara stated that consumers care most about the freshness factor [7]. The date of manufacture, colour, smell and appearance of the package is often an indicator of its freshness. The use of environmentally friendly materials, the ability to protect the food against external factors, its appearance and labelling information are among the features consumers pay attention to in packaging [17].

Consumers particularly pay attention to the production date on their packaging when purchasing food products. Aytop [5] research underlined that consumers paid particular attention to the production date when purchasing chicken. Production date is as important as the ingredients in assessing food quality [26]. Quality is the degree to which a product or service can meet the wants and needs of consumers. High-quality products meet the consumers' expectations, and as a result, consumer satisfaction increases. The quality of meat is determined by flavours, freshness, smell and appearance [23]. In poultry farming, the state of the poultry houses and the quality of feed given to the chicken and turkey affect the quality of meat [19]. Consumers' awareness of animal welfare has increased [10]. Animal welfare is defined as "the physical and psychological well-being of animals. According to a study conducted in the USA, 73% of consumers prefer products that consider animal welfare [12].

Poultry purchase places

Consumers have more options for poultry purchase outlets than in the past. Consumers who primarily shopped from butchers until 20 years ago have wider purchasing options with the spread of supermarkets and local and discount markets. With the onset of the Covid-19 epidemic, it has become common for consumers to use online channels for meat orders, and those who eat healthier are turning to farmers and organic markets.

Butchers mainly sell red meat; they also sell poultry. Butcher is a local artisan. Some butchers sell the meat from their farms or know the source of the meat; there are fewer intermediaries involved in the meat sold by butchers. Butchers generally know their customers personally, understand their preferences and advise them on meat selection. Consequently, consumers trust local butchers more than chain markets. Most local butchers also sell on account, which is very convenient for consumers who as short on cash at certain times [33]. Especially in recent years, consumers have become increasingly conscious of supporting local merchants, and they divert their purchases to local merchants as much as possible.

Rapidly increasing urbanization, prolongation of business hours, and intense and stressful daily life have caused food shopping to be done less frequently. Still, in larger quantities, and as a result, markets and supermarkets have become increasingly widespread. However, due to the economic fluctuations experienced in the country's economy in recent years, discount markets have begun to take their place in the market in response to local and national supermarkets.

Discount markets sell less variety of products, more local, less-known brands, and lower prices than supermarkets [8]. These markets employ fewer people and provide more limited shelf arrangements and services [2]. Despite their increasing appearance and popularity since they sell lesser-known brands and shops have more straightforward layouts than supermarkets, some consumers believe that such markets sell lower quality products. On the other hand, supermarkets appeal to consumers of wider income groups. They sell better-known and national brands. They also appeal to more price-sensitive audiences with their labelled products. More choice on offer because shops are bigger. Ease of payment, transportation and parking are also among the advantages of supermarkets [2]. More staff are employed in the market, they can control the shelves more frequently, and meal cards and gift cards are also effective in their preference. Having butcher aisles in supermarkets has provided consumers with all-in-one shopping convenience.

Turkey has developed a poultry industry, and poultry is fundamental in Turkish cuisine still; research on poultry consumption is scarce [3, 7, 35]. Existing research primarily focused on the types and amounts of chicken consumed. Factors affecting chicken and poultry consumption, poultry shopping outlets and reasons for choosing those outlets were not examined in detail. Additionally, the existing research was generally focused on poultry production rather than on chicken consumption. Poultry consumption, particularly turkey consumption preferences of consumers living in metropolitan areas, have not been examined explicitly. This research aimed to explore consumers' preferences in Bursa, an economically developed industrial city where more individuals are in business life.

This research seeks answers to the following questions:

1)What factors affect consumers' preferences for poultry?

2)Where do consumers buy poultry?

3)How often do consumers buy and consume poultry?

MATERIALS AND METHODS

Study area

Bursa province is the 4th most populous city in Turkey. The city has a surface area of 10,886.38 square meters and is located in the South Marmara Region, between 40˚ West longitude and 29˚ North latitude circles. The province has a population of 3,147,818 million (1,573,362 males and 1,574,456 females). 35% of its population is young, 51% is middle-aged, and 14% is elderly. It is one of the most economically developed cities in Turkey, and a significant part of the country's major industrial facilities are located in this province. The average household size in Turkey was 3.3 people, and in Bursa was 3.24 people. The total number of households in Turkey in 2020 was 25,329,833. There was a total of 966,765 households in Bursa. Food and non-alcoholic beverages constituted 20.8% of household consumption expenditures in Turkey [34].

The survey was conducted with the person responsible for main shopping in the family. If the person who does the shopping in the family does not consume poultry himself, the questionnaire was asked to be answered by considering the people who consume poultry from the family members.

Sampling

A simple random sampling method was used to determine the number of households to be surveyed. This method ensures that participants can participate in the sample with the same probability. Below formula was used to determine the sample size [31]:

$$n = \frac{t^2 2[1+(0,02)(b-1)]pq}{E^2} \quad (1)$$

Here; n: sample size, t: significance level (assumed 95%), p: the probability of consuming poultry, q: the probability of not consuming poultry, E: accepted error (assumed to be 5%). The sample size was calculated as 340. Taken the Considering the possibility of missing and missing data, the survey study was carried out with 350 participants and 345 questionnaires were used.

Data collection and analysis

This study was conducted in September-December 2021 with a family member responsible for the main food shopping in the family. A structured questionnaire was used in the study. Participants were interviewed face-to-face, but they were asked to fill out the questionnaire in person. Before applying the questionnaire, the participants' consent was obtained. Participants were ensured that their personal information would be carefully stored and information they provided would be used for academic purposes only. The questions were obtained and adapted from the relevant research [1, 15, 22, 36].

To ensure the clarity of the questions, the questions were shown to an expert academician. Before the survey was applied, a pilot study was conducted with 20 graduate students in the Department of Agricultural Economics at Bursa Uludag University. Data from the pilot study were not included in the primary sample.

The questionnaire consisted of 26 questions. The first 10 questions in the survey aimed at determining the demographic characteristics of the participants. 14 questions were about determining the poultry consumption. The remaining 2 questions are related to the factors affecting chicken and turkey preferences and purchasing place preferences and were prepared on a 4-point Likert Scale (1=Strongly Agree; 2=Disagree, 3=Agree; Prepared as 4=Strongly Agree).

The data were analysed using the SPSS 23.0 Package Program. Cronbach's alpha coefficient was found as α=0.901. The analysis results being 0.8<α<1.00 means "the scale is highly reliable." Frequency tables were prepared to test the research hypotheses.

RESULTS AND DISCUSSIONS

Sociodemographic characteristics of the participants

Table 1. Demographic characteristics of the participants

		N	%
Gender	Male	209	60.6
	Female	136	39.4
Marital status	Married	253	73.3
	Single	92	26.7
Education	Literate	14	4.1
	Primary school	58	16.8
	Secondary school	53	15.4
	High school	89	25.8
	Graduate	115	33.3
	Postgraduate	16	4.6
Age	23-30	74	21.4
	31-40	68	19.7
	41-50	70	20.3
	51-60	67	19.4
	61 ≥	66	19.1
Profession	Retired	78	22.6
	Officer	69	20.0
	Worker	65	18.8
	Self-employment	48	13.9
	Housewife	27	7.8
	Unemployed	22	6.4
	Executive	14	4.1
	Other	13	3.8
	Student	9	2.6
Household size	1	42	12.2
	2	74	21.4
	3	68	19.7
	4	97	28.1
	5 ≥	64	18.06
Executive household monthly income (TL)	≥ 2,825	47	13.6
	2,826-4,000	82	23.8
	4,001-6,000	100	29.0
	6,001-8,000	77	22.3
	8,001 TL ≥	39	11.3
Share of food expenditures in total expenditure (%)	≥ 25	48	13.9
	26-35	114	33.0
	36-50	121	35.1
	51-75	55	15.9
	76 ≥	7	2.0
	≥ 25	149	43.2
	26-35	112	32.5
	36-50	57	16.5
	51-75	23	6.7
	76 ≥	4	1.2

Source: Field Survey Data Analysis, 2021.

Details of demographic information, including gender, age, education level, marital status, number of individuals in the family and occupation, are given in Table 1. More than half of the surveyed participants were male (60.6%), and 39.4% were female. Participants' ages were proportionally distributed. 22.6% of the respondents were retired, and 20% were civil servants. A third (33.3%) of the participants were graduates, and 25.8% attended high school. The average in the household was 3.27. Accordingly, one-fifth of the participants consisted of only a husband and wife or a single parent or child, and approximately one-third consisted of nuclear families with two children. Half of the participating families consisted of families called nuclear families. Bursa is a metropolitan city; families are more diminutive in urban areas than rural areas. About a third (29%) of the participants had an income between 4,001- 6,000 Turkish Lira (TL), and a quarter had an income between 2,826 -4,000 TL (23.8%). About a third (35.1%) of participants' food expenditures were between 36-50% of their total household expenditures. Nearly half of the 345 participants (43.2%) spent a quarter or less of their household expenditure on poultry (Table 1). Food and non-alcoholic beverages accounted for 20.8% of household consumption expenditures in Turkey in 2019. Food expenditures in Bursa were above the country data.

Poultry purchasing and consumption frequency

Poultry purchase and consumption have increased rapidly in Turkey. Experts often recommend poultry due to its health benefits. At the same time, the high price of red meat leads consumers to switch o poultry. Poultry being a cheaper alternative increases purchase and consumption frequency. Less than a third (36.5%) of the participants bought chicken only once a week, while the other third (33%) purchased chicken several times a week. On the other hand, 49.6% of the participants did not buy a turkey. 17.7% of the participants bought on special occasions and 12.2% one to three times a year'. When asked about the chicken consumption frequency, participants stated that they primarily consumed 'several times a week' (48.1%). A third (32.2%) of the participants consumed chicken 'once a week'. Turkey was not consumed by 46.1%, while 42.6% consumed turkey 'once a month' (Table 2).

Table 2. Frequency of purchasing/ consumption of chicken and turkey

		N	%
Frequency of chicken purchase	Once a week	126	36.5
	Several times a week	114	33.0
	Once a month	32	9.3
	Several times a month	61	17.7
	Several times a year	5	1.4
	On special occasions	2	0.6
	Never	5	1.4
Frequency of turkey purchase	Everyday	1	0.3
	Once a week	17	4.9
	Several times a week	3	0.9
	Once a month	27	7.8
	Several times a month	23	6.7
	Several times a year	42	12.2
	On special occasions	61	17.7
	Never	171	49.6
Frequency of chicken consumption	Everyday	5	1.4
	Once a week	111	32.2
	Several times a week	166	48.1
	Once a month	59	17.1
	Never	4	1.2
Frequency of turkey consumption	Everyday	1	0.3
	Once a week	16	4.6
	Several times a week	15	4.3
	Once a month	147	42.6
	Several times a year	5	1.4
	On special occasions	2	0.6
	Never	159	46.1

Source: Field Survey Data Analysis, 2021.

Factors affecting poultry preferences

Many factors affect consumers' poultry preferences. Demographic factors such as age, income, and gender affect consumer preferences. Consumers attach more importance to factors arising from the product's characteristics. In this context, the factors affecting consumers' poultry preferences were examined in the study. 66.4% of the consumers who participated in the survey thought the production date critical. Taste (64.6%), freshness (60.9%) and quality (52.5%) followed respectively. Participants did not care much about an advertisement (19.4%) and the region/origin of the product (9%) while buying poultry (Table 3).

Table 3. Factors affecting the chicken/ turkey preferences

	1		2		3		4	
	N	%	N	%	N	%	N	%
Organic certificate	15	4.3	48	13.9	174	50.4	106	30.7
Having good agricultural practice /Animal welfare	9	2.6	51	14.8	177	51.3	107	31.0
Place of purchase	5	1.4	25	7.2	188	54.5	125	36.2
Freshness	3	0.9	7	2.0	123	35.7	210	60.9
Price	10	2.9	40	11.6	154	44.6	138	40.0
Packaging	17	4.9	59	17.1	162	47.0	106	30.7
Quality	3	0.9	9	2.6	151	43.8	181	52.5
Brand	12	3.5	65	18.8	161	46.7	106	30.7
Advertisement	67	19.4	158	45.8	77	22.3	42	12.2
Flavour	3	0.9	7	2.0	111	32.2	223	64.6
Place of origin	31	9.0	97	28.1	136	39.4	78	22.6
Manufacturing history	9	2.6	8	2.3	97	28.1	229	66.4

1=Highly unimportant 2=Unimportant 3=Important 4=Highly important
Source: Field Survey Data Analysis, 2021

Poultry purchase outlet preferences

The rapid migration from rural to urban areas has led to communities from a wide array of economic and social backgrounds. Thus, as in other food needs, meat purchasing places have been diversified. Thus, national markets that most of which are supermarkets, local and regional markets, and discount markets, have appeared rapidly as competitors to butchers. Consumers' choice of these purchasing places depends on their income and the conveniences those places offer. Today, very few people buy live chickens or turkeys from farms. A sizeable 31.9% of surveyed consumers purchased chicken from discount markets. 23.5% of them purchased chicken from butchers and 15.4% from local markets. A quarter of the respondents who buy turkey (16.5%) purchased live from animal markets for the New Year's Eve and killed themselves. 13% were purchased from discount markets and 12.5% from supermarkets (Table 4).

Table 4. Chicken and turkey purchase preferences

		N	%*
Chicken	Supermarket /National markets	48	13.9
	Discount market	110	31.9
	Local market	53	15.4
	Butcher	81	23.5
	I buy it alive and kill myself	12	3.5
	Other	37	10.7
	Do not consume chicken	2	0.6
	Personally grown	2	0.6
Turkey	Supermarket /National markets	43	12.5
	Discount market	45	13.0
	Local market	25	7.2
	Butcher	32	9.3
	I buy it alive and kill myself	57	16.5
	Other	16	4.6
	Do not consume turkey	124	35.9
	Personally grown	3	0.9

*Percentage of those who consume chicken and turkey
Source: Field Survey Data Analysis, 2021

Table 5. Poultry Purchasing Places by Income

		≤2825	2,826-4,000	4,001-6,000	6,001-8,000	8,001≥	Total
Chicken	Supermarket/National market	4	11	9	19	5	48
	Discount market	20	36	35	12	7	110
	Local/Regional market	8	9	16	11	9	53
	Butcher	8	13	24	24	12	81
	I buy it alive and kill myself	2	4	5	1	0	12
	Other	4	9	9	10	5	37
	Do not consume chicken	0	0	1	0	1	2
	Personally grown	1	0	1	0	0	2
Turkey	Supermarket/National market	1	9	12	17	4	43
	Discount market	8	15	11	9	2	45
	Local/Regional market	4	6	5	4	6	25
	Butcher	5	2	14	6	5	32
	I buy it alive and kill myself	7	19	17	12	2	57
	Other	0	3	8	5	0	16
	Do not consume turkey	20	28	32	24	20	124
	Personally grown	2	0	1	0	0	3

Source: Field Survey Data Analysis, 2021.

Table 5 shows the distribution of the chicken and poultry purchases outlets by household income. 110 participants (31.9%) purchased chicken from discount markets for income groups. While 56 of 110 participants had an income of 4,000 TL or less, 54 had an income of 4,001 TL or more. Of the 81 people (23.5%) who bought chicken from the butcher, 60 (74.07%) earned more than 4,000 TL. Consumers in the highest income group prefer butchers for chicken too. Chicken preference from supermarkets (13.9%) lagged behind local markets (15.4%). While 32 of the 221 consumers who consumed turkey purchased it from butchers, 45 from discount markets, 43 from supermarkets, and 57 of them brought a live turkey. As the household income increased, the rate of buying turkey alive decreased, and these consumers turned to supermarkets (Table 5).

Discussions

Poultry consumption

Individuals can lead a healthy life through adequate and balanced nutrition. The first step toward a proper and balanced diet is to take the daily required protein. However, consumers have a certain income, and meat prices are constantly on the rise may restrict the protein intake from meat products. Consumers' income is one factor that most affects the frequency of purchasing white meat. Consumers determine their purchasing frequency according to their income and the price of white meat.

In the Blacksea region, 37.61% of the participants purchased chicken once every fortnight' and 30.64% once a week [21]. In another similar study in Central Anatolia, consumers mostly purchased chicken 'every week' (59%) [4]. Participants (36.5%) bought chicken once a week and 33% several times a week in the current study (Table 2). Households buy chicken more frequently in Bursa. The higher household income affects high purchase frequency. The easy access to chicken in metropolitan cities, its nutritional value, and it can be quickly cooked with other dishes or alone explain the high purchase frequency in these studies.

Turkey's meat production is high. However, the amount of consumption is not at the desired level compared to production levels (Table 2). Produced turkey is generally exported [30]. Research findings confirmed that consumers mostly bought a turkey several times a year on special occasions, and it is most preferred on New Year's. Turkey is generally sold in selected supermarkets/ national markets. Discount markets also sell it before New Year. Depending on the local demand, selected grocery stores and butchers can also sell turkey. Along with the intense work tempo, the time spent in the kitchen has also decreased. Resulting, consumers prefer to cook dishes that are easier and quicker. Poultry cooks quicker.

Ayvazoglu Demir and Aydin's [6] research showed that consumers primarily consumed chicken 2 to 3 times a week (41.9%) and at least 4-5 times a week (21.1%). Similarly, Aldemir et al. [3] revealed that most households (73.6%) consumed chicken 2 to 3 times a week. Half of the participants consumed chicken 'several times a week' (48.1%) in the current study. Meat has an important place in Turkish cuisine. A recipe without meat is almost non-existent. However, consumers who do not consume red meat or do not prefer other types of meat for health or economic reasons are turning to chicken. In Ayvazoglu Demir and Aydin's [6] research, consumers with an income of 1500 TL and below consumed chicken more frequently. Aldemir et al. [3] emphasised that students' income was meagre, so they preferred chicken, which is relatively cheaper to meet their protein needs. Existing research that the changes in household incomes are reflected in the consumption of chicken [7].

Turkey is a larger animal, primarily consumed in crowded families. Chicken is often the choice of smaller families. The current study determined that half of the participants were from small families. This limits turkey consumption. In a study examining turkey consumption habits, participants mostly consumed turkey 'once a month' and 'once a year, respectively [35]. Similarly, nearly half of (42.6%) households in Bursa consumed turkey once a month. The findings obtained from the present study coincide with the other research results. The fact that turkey is more expensive than chicken, consumers are not accustomed to its taste, and it takes time to cook explains the frequent consumption of turkey.

Factors affecting poultry consumption preferences

In addition to their sociodemographic characteristics, the product characteristics and the places where the products are offered for sale may affect the intake and consumption of poultry. The place where the product is sold, the ease of access, its price, packaging, brand, advertisement and region/origin directly affect the product and purchasing preferences. Freshness, quality, taste and date of manufacture are factors arising from the product's characteristics. Freshness, taste and quality factors are constant factors for consumers. The price may vary according to the consumers' income.

Aytop [5], in his research in South-eastern Turkey, determined that the factors that most affect the consumers' chicken preferences were expiration date, freshness and quality. Similarly, Kara et al. [18] found that while the expiry date was the most critical for consumers, the packaging was the element they cared least about. In the current research, the price was expected to be the most critical element; it turned out that the production date was much more vital for consumers. In addition, existing research underlined that production date was the most factor affecting chicken preferences. Consumers in these studies attached importance to the production date due to their increased concern for food safety. The number of microorganisms and bacteria increases in poultry whose production date has expired. Consumption of these products poses a risk to human health. Today, consumers from all walks of life have become increasingly conscientious about the production history of food products, particularly easily perishable poultry.

According to Sengul and Zeybek [27], consumers in another southern Anatolian province preferred chicken because it was economical. Consumers found the price factor (40%) less important than other factors in the current research. The findings in this study differed from the mentioned research. The income disparity of households caused this difference. The consumers' income in Sengul and Zeybek's [27] analysis was lower than the consumers' income in the current research. Generally, the eastern and south-eastern parts of the country are economically less developed. Households are more crowded, and fewer people are in the active workforce. For this reason, families pay attention to the cheapness of meat in their meat purchases.

Poultry purchase point preferences

Purchasing locations differ when purchasing chicken and turkey. Chicken is widely available in many outlets, while turkey can be found in selected places. Low turkey consumption is key to these restricted sale points. Consumers also account for hygiene conditions and ease of access when choosing the purchase outlet.

Numerous studies have revealed that consumers mostly buy chicken from markets and butchers [5, 16, 18]. In the current study, consumers mostly bought chicken from discount markets (31.9%) and butchers (23.5%). When consumers purchased chicken, they preferred markets in the first place. Discounts and various promotions in the markets reduce the price of chicken. The cheapness of chicken has made these places attractive to consumers. The fact that consumers can find all the products they want together in the markets is one of the reasons why the markets are preferred. Following markets, consumers mostly shop from butchers. Consumers tend to buy from reliable places when purchasing poultry. The fact that butchers are local tradesmen and have been serving in the same area for many years creates trust. Most consumers buy poultry while buying red meat not to waste time. Consumers generally (16.5%) purchased a turkey for New Year's Eve and live. The remaining consumers preferred discount markets and supermarkets. Turkey is a more expensive product than chicken. Instead of buying a turkey, consumers prefer chicken that is more suitable for their income. The high price significantly prevents consumers from purchasing turkey frequently so that they can only make an effort on special days such as New Year's Eve.

Sales place preferences by income group

Besides demographic and product-related characteristics, purchase outlets affect households' poultry purchase behaviour.

Consumers attach importance to proximity to their home, hygiene, location, layout, services, promotions, reputation, shopping convenience, etc. Meat purchasing points are not independent of household income levels. As the income increases, the features expected from the place of purchase increase at the same rate. The research results revealed that consumers with an income of less than 6000 TL predominantly bought chicken from discount markets. As the household income increased, the percentage of consumers shopping from butchers increased, and the number of consumers shopping from discount markets decreased (Table 5). In their research, Inci et al. [16], as the consumers' income increased, their tendency to buy from the butchers also increased. Butchers generally sell meat and meat products. They also sell small amounts of chicken. They do this for the convenience of their consumers so that consumers can complete all of their household's meat purchases in one spot. Chicken sold in butchers is usually organic or free-range. Although chicken sold in butchers is more expensive than in markets, it is of higher quality, similar to red meat, and with the increase in income, consumers turn to butchers for poultry.

As the income group increases, purchases from discount markets decrease in turkey as in chicken. Consumers with higher incomes prefer supermarkets more. High-income consumers pay more attention to the quality of the product than the price. Consumers who cannot find the quality they desire in discount markets turn to supermarkets. Turkey purchases for New Year's Eve tend to decrease as income increases. Because high-income earners generally celebrate New Year's Eve outside. Lower-income consumers buy turkey because the animal is bigger and suitable for larger family gatherings.

CONCLUSIONS

Meat prices are a major cause of the animal-derived protein deficit in Turkey is high meat prices. Poultry is the most cost-effective way to make up the animal protein deficit. The current research aims to reveal consumers' poultry consumption behaviour. The study investigated factors affecting poultry consumption preferences and purchasing patterns. The results showed that purchase amount and places have in tight correlation with consumers' income. As income increased, consumers were more inclined to shop from organic markets and butchers.

It is frequently emphasised that turkey consumption is low in Turkey. The current research has once again highlighted this low consumption with the example of the Bursa. Chicken consumption was higher as expected. Household income is a significant factor in the choice of chicken. However, the news about feeding chicken with genetically modified (GM) feeds adversely affects its consumption. The Ministry of Agriculture and Forestry, the poultry and food processing industry should regularly ensure the final buyers that GM feed is not used, and chicken consumption is healthy. If all the stakeholders in the system lose consumers' trust in production methods, they will move away from chicken.

Following the emergence of the Covid-19 epidemic, consumers have begun to attach more importance to hygiene. Consumers tend to be more meticulous when purchasing meat and avoid seemingly unhygienic environments. Slaughterhouses and sales outlets must obtain a hygiene certificate and are regularly disinfected.

In conventional production, broilers reach slaughter weight in 42 days. Frequent and grim news in the media that antibiotics and hormones are used for chickens that reach live slaughter weight quickly concerns consumers. Additionally, animal-borne diseases such as bird flu have reduced chicken consumption. The university, non-governmental organisations, and the public should inform the public that using hormones and antibiotics is costly and only used if there is a disease. Further, relevant officers must regularly inspect poultry farms and ensure that no chemical supplements were used in poultry farming.

Consumers are not sufficiently knowledgeable about the health benefits of turkey. Consumers' awareness should be increased on turkey via public spots. The number of turkey sales channels should be increased. Policymakers should give more incentives to turkey producers and revitalise the sector. In-service training should be given to the Provincial Directorates of Agriculture and Forestry employees so that local producers can do proper breeding.

This study has several limitations. First of all, the research was carried out only in Bursa. Expanding the analysis to include other provinces of the Marmara Region will help confirm the current research findings. The study examined household preferences and the factors affecting household preferences. Considering that consumers live more on their own in metropolitan cities, the analysis can be repeated, concentrating on individual preferences. Additionally, processed white meat consumption and other types of white meat options (goose, Guinea fowl, fish) were not included. We recommend addressing these issues in future studies.

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CRITICAL FACTORS AFFECTING HOUSEHOLDS' RED MEAT CONSUMPTION IN TURKEY

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Abstract

Red meat consumption is vital for a balanced diet. This research examines the factors that cause consumers to prefer red meat, determines the shopping channels from which red meat is purchased, and the frequency and consumption of red meat. A face-to-face survey was applied to 273 households selected by simple random sampling. Data were analyzed using SPSS 23.0. The decisive factor in the participants' red meat preferences in the study was taste (61.5%), followed by production date (60.2%) and freshness (58.5%). According to this result, consumers were more pleasure-oriented in choosing red meat products. Advertising was the least important factor. 58.2% of the purchased red meat was from butchers, 10.6% from discount markets and 9.5% from local markets. Participants bought red meat several times a month (26.4% of them.) and consumed it several times a week (44.7%.) Half of the total meat consumed in the households was red meat. The purchasing and consumption frequency of red meat in the families in Bursa was low. Decreasing red meat prices will increase households' purchasing and consumption frequency. Farmers need a subsidy to lower production costs and increase productivity, thus reducing retail meat prices.

Key words: *meat consumption, purchase patterns, purchase outlets, product preferences*

INTRODUCTION

A balanced diet is necessary for people to continue their daily activities [27]. The report prepared by the United Nations Food and Agriculture Organization states that the world population will increase up to 10 billion in 2050 and that Turkey will exceed 110 million [36]. Feeding the growing population in the world and Turkey and meeting the increasing food demand always maintains its importance. Individuals should consume the necessary vitamins, minerals, carbohydrates, fats and proteins for a healthy diet. Red meat provides a significant share of animal protein sources [3], [6]. Daily protein consumption of animal origin is 72.7 g in the United States and 63 g in Germany [8]. According to OECD [20] data, the daily consumption of animal origin protein per capita in Turkey is 37.12 g. In Turkey, red meat consumption is lower than in developed countries. Consumption habits may differ from country to country, region to region, and regionally. Traditions and religion can affect eating culture. For example, fruit and vegetable consumption may be more common in Mediterranean countries. Muslim countries primarily consume beef and mutton, and the demand for pork and its products is high in other countries. Due to Hindu religious beliefs, beef is not consumed in India. The economic development levels of the countries also affect the meat preference of the consumers. Further, new trends such as health concerns, shopping convenience, enjoyment, sustainability, authenticity, and technology lead to diversity in consumption [33], [19]. The primary purpose of this study is to examine consumers' red meat consumption preferences through the example of Bursa province. This research aims to reveal the factors that lead consumers to prefer red meat, consumers' shopping channels and the purchasing and consumption frequency of red meat.

Literature review

Factors affecting red meat preferences

Many factors can influence red meat preferences. Freshness is one of the most sought-after properties in food products [24]. Meat products, which have an essential role in human health, should preserve their freshness.

However, microbial development and chemical changes affect the freshness of food products. Products that lose their freshness can cause various health problems, especially food poisoning [23]. For this reason, especially in meat products, freshness is one of the most important features for consumers.

Meat and meat products are high-priced. They constitute a substantial percentage of the family budget. Especially in low-income families, the budget size allocated to meat products forces the family to spend carefully on these products. Therefore, consumers aim to obtain the best quality meat at the lowest price. The rise in meat prices causes the family to consume less meat [15]. Parents may only buy meat to meet their children's protein needs in some cases.

Another factor that consumers consider when deciding to buy food products is quality. The quality of food distinguishes one food product from another. It consists of the combination of features that play a role in the consumers' food preferences and that can be measured and controlled separately. Quality subjectively includes the degree of usefulness, practicality, price, and reliability of the firm that consumers seek. Objectively quality refers to the product's features that can be measured and determined by quality standards and regulations [26]. Consumers also perceive products with high nutritional content and produced under conditions that suitable for health as high quality. The high price of meat products also raises the quality expectations of consumers. The animal should be slaughtered and meat transported and stored in a hygienic environment. It is crucial for the consumer whether the meat in the aisle ways is kept clean. Selling meat to consumers without complying with sanitary conditions can cause food-borne diseases [25]. The product's hygiene can also be accepted as an indicator of quality. A product offered for sale in unhygienic environments can be considered poor quality. In some cases, hygiene may be more important than freshness in the eyes of the consumer. Likewise, Lorcu and Bolat [17], in their research examining the consumption of red meat of consumers in Edirne, showed that the most crucial factor in the choice of red meat was providing hygienic conditions with 32.7%, and freshness was in the lower ranks with 17.3%.

Packages provide resistance to temperature and weather conditions that foods need and protect them from bacteria and moulds [28]. It attracts consumers' attention with its colour, shape, material, whether it has an intelligent packaging system and whether it can be opened easily [10]. Packaging provides communication between the consumer and the product. This communication takes place through giving information on how the product will be consumed on the packages, writing the package content information in detail, specifying the expiration date, and the appropriate size of the text on the container. In addition to the specified features, it is vital to display information such as origin, slaughter date, processing date, and animals' certificate number [30]. Meat is very susceptible to bacterial spoilage. Therefore, the packaging ensures that the colour of the meat is preserved, as well as preventing water loss and preventing microbiological spoilage. The presence of production date affects consumer decisions. This factor indicates the shelf life of food items. Products whose shelf life has expired can cause severe consequences such as poisoning.

Brand affects consumer preferences. Features that help identify a product or service, promote them and distinguish them from competitors' products or services are defined as brands. It is getting harder to choose between products, prices and brands that are increasing and differentiating day by day. Therefore, consumers tend to buy products from well-known brands at affordable prices. The brand is also prominent in food products. Consumers prefer branded products because brands sell products that are inspected, healthy and with a quality certificate. When a problem is encountered, brands generally stand behind their goods and solve problems more effectively [13].

Advertisements are one of the most frequently used resources to provide brand recognition. All kinds of work with advertisements aim to influence consumers' shopping peferences [21]. Advertisements present product information, inform about taste, appearance, promotions, and discounts, and pass messages using images, sound, and slogans to attract consumers' attention.

For some agricultural products, consumers particularly want to know their origin. Meat and meat products are particularly included in these agricultural products. For example, meat and meat products obtained from animals in Eastern Anatolia are more in demand. There are specific breeds; the fauna is richer so that the meat is tastier [18].

Purchase points of red meat and factors affected that choice

Consumers could purchase red meat only from butchers in the past. They can buy it from a wide variety of places today. Local markets, chain markets, farmer's markets, and organic markets are places where meat is bought frequently. What extent to which consumers can consume red meat from these places varies according to household income, food prices, and the local food and shopping culture. In addition, trust in the quality of the meat offered habit, ease of transportation, ease of payment, price, hygiene, knowing where the meat comes from and the feeling of trust in the seller and the company have an essential place in the selection of the place of purchase for red meat.

Butchers are the most common and most common places to buy red meat. The fact that the butcher is a local artisan and the meat's origin is known ensures the continuation of trust and demand for butchers. Butchers generally know their customers personally, know their preferences, advise them on meat selection, and offer convenience in payment (sell on account) [32]. Especially in recent years, consumers have become increasingly conscious of supporting local merchants, and they divert their purchases to local merchants as much as possible. After the Covid-19 pandemic in March 2020, the number of online orders for all foodstuffs increased rapidly. Meat and meat products also benefited from this increase. Online food shopping increased by 19% at the beginning of the Covid-19 epidemic in Taiwan [9]. A study conducted in Turkey revealed that online shopping increased by 85% in 2020. At this rate, the share of food expenditures was 22.5% [11].

Consumers' red meat purchasing places have shifted from traditional butchers to supermarkets and discount markets. Supermarkets in Turkey are generally of foreign origins, such as Migros (Switzerland), Carrefour (France) and Metro (Germany) and generally operate throughout the country. In addition, Turkish branded markets are generally based on a specific province or region. However, discount markets like Lidl in Germany and Billa in Austria operating throughout the country have become widespread and preferred by consumers in recent years. Supermarkets contain a vast number of products, offer a wide range of quality and have long opening hours. These markets can promote more frequently and various products. Markets offer promotions more regularly and on a wider variety of products. Consumers can pay by credit card in supermarkets, which is handy for consumers who are short of cash. Supermarkets pay more attention to the shelf life and storage conditions. Unlike bazaars, they can choose the product themselves. In larger cities, the convenient parking that markets offer gives an advantage. Most markets in Turkey offer a shuttle service to consumers, making the market a desirable shopping place.

The popularity of discount markets is increasing due to the increasing food demand after covid, the rise in food prices, and the country's economic contraction. Discount markets offer a lower price policy compared to other retail stores and sell local or less known brands [4]. These markets have fewer employees. They pay less attention to shelf layouts than supermarkets [2]. Similar to supermarkets but on a restricted scale, discount markets offer discounts. Consumers tend to shop at such markets on special occasions when large amounts of food are consumed. Discount markets are about to replace local corner shops [16].

Many people in Turkey still buy red meat directly from livestock farmers. Notably, large families, families that care about the origin of the beef, and families with connections or family members in villages prefer this option.

Turkey has developed animal husbandry, and meat is fundamental in Turkish cuisine still; research on red meat consumption is scarce [22], [24], [3].

Existing research primarily focused on the types and amounts of meat consumed. Factors affecting meat consumption, red meat shopping outlets and reasons for choosing those outlets were not examined in detail. Additionally, the existing research was generally carried out in rural provinces where livestock production is intense. Meat consumption preferences of consumers living in metropolitan areas have not been examined explicitly. This research aimed to explore consumers' preferences in Bursa, an economically developed industrial city where more individuals are in business life.

This research seeks answers to the following questions:

1) What factors affect consumers' preferences for red meat?
2) Where do consumers buy red meat?
3) How often do consumers buy and consume red meat?

MATERIALS AND METHODS

Study area

Bursa province is the 4th most populous city in Turkey. The city has a surface area of 10,886.38 square meters and is located in the South Marmara Region, between 40˚ West longitude and 29˚ North latitude circles. The province has a population of 3,147,818 million (1,573,362 males and 1,574,456 females). 35% of its population is young, 51% is middle-aged, and 14% is elderly. It is one of the most economically developed cities in Turkey, and a significant part of the country's major industrial facilities are located in this province. The average household size in Turkey was 3.3 people, and in Bursa was 3.24 people. The total number of households in Turkey in 2020 was 25,329,833. There were a total of 966,765 households in Bursa. Food and non-alcoholic beverages constituted 20.8% of household consumption expenditures in Turkey [34], [35]. The survey was conducted with the person responsible for main shopping in the family. If the person who does the shopping in the family does not consume red meat himself, the questionnaire was asked to be answered by considering the people who consume red meat from the family members.

Sampling

A simple random sampling method was used to determine the number of households to be surveyed. This method ensures that participants can participate in the sample with the same probability. Below formula was used to determine the sample size [31]:

$$n = \frac{t^2 2[1+(0,02)(b-1)]pq}{E^2} = 257 \qquad (1)$$

where:

n: sample size, t: significance level (assumed 95%), p: the probability of consuming red meat, q: the probability of not consuming red meat, E: accepted error (assumed to be 5%).

The survey was terminated with 270 participants. Considering the possibility of missing or misleading data, 257 questionnaires were included in the analyses.

Data collection

This study was conducted in September-December 2021 with a family member responsible for the main food shopping in the family. Face to face structured survey was conducted. Before applying the questionnaire, the participants' consent was obtained. Participants were ensured that their personal information would be carefully stored and information they provided would be used for academic purposes only.

The questions were obtained and adapted from the relevant research. To ensure the clarity of the questions, the questions were shown to an expert academician. Before the survey was applied, a pilot study was conducted with 20 graduate students in the Department of Agricultural Economics at Bursa Uludag University. Data from the pilot study were not included in the primary sample.

The red meat consumption questionnaire consists of 39 questions. The first 10 questions in the survey are aimed at determining the demographic characteristics of the participants. 25 questions are about determining the red meat consumption of the participants. The remaining 4 questions are related to choosing red meat, not choosing red meat, processed foods, red meat preference and frequency, and were prepared in a 4-point Likert Scale (1=Strongly Agree; 2=Disagree, 3=Agree; Prepared as 4=Strongly Agree).

The data were analyzed using the SPSS 23.0 Package Program. Cronbach's alpha coefficient was found as α=0.905. The analysis results being 0.8<α<1.00 means "the scale is highly reliable" [14]. Frequency tables were prepared to test the research hypotheses.

RESULTS AND DISCUSSIONS

Socio-demographic characteristics of the participants

The gender, marital status, age, education level, number of people living in the household, occupation and monthly income were examined. Details of the findings are given in Table 1. Over half of the participants (59.7%) were men, 40.3% were women, 72.5% were married, and 27.5% were single. In Turkey, the rate of single individuals aged 15 and over was 27.4%, and for married individuals, this rate was 63.8% [35]. Therefore, the survey results coincide with the data for Turkey. The highest participant group in the study was families with three people (24.9%) in the household, followed by families with four (24.2%). In other words, half of the participants (49.1%) were from nuclear families. Almost a quarter (24.9%) of the participants were civil servants, 19.4% were retired, and 18.6% were blue-collar workers. Confirming this finding, 42.1% of the participants were graduates.

Participants were mainly from the middle-income group. While 22.7% of the respondents had an income between 4,000 Turkish Lira (T.L.) and the minimum wage, 69.5% of them had an income of more than 4,000 TL. As the family income increases, the ratio of food expenditures to income decreases [7]. The present research supports this thesis.

Approximately half of (46.2%) participants' food expenditures constituted less than 35% of their total household expenditures. A third (35%) of participants' food expenditure made up between 36% to 50% of the total spending. In contrast, the study conducted by Alev [3] reported that approximately 56% of the participants spent the most on food.

Table 1. Demographic characteristics of participants (N=273)

		N	%
Gender	Female	110	40.3
	Male	163	59.7
Marital Status	Married	198	72.5
	Single	75	27.5
Age	23-30	63	23.1
	31-40	56	20.5
	41-50	56	20.5
	51-60	47	17.2
	61≥	51	18.7
Education	Illiterate	1	0.4
	Literate	18	6.6
	Primary School	31	11.4
	Secondary Sch.	32	11.7
	High School	58	21.2
	Graduate	115	42.1
	Postgraduate	18	6.6
Number of people in the family	1	19	7.0
	2	51	18.6
	3	68	24.9
	4	66	24.2
	5	33	12.1
	6 ≥	36	18.6
Occupation	Artisan	32	11.7
	Blue-collar	51	18.6
	Civil servant	68	24.9
	Retired	53	19.4
	Unemployed	19	7
	Student	9	3.6
	Private sector	2	0.7
	Housewife	16	5.8
	White-collar	5	1.8
	Other	18	6.5
Total monthly household income (T.L.)	≥ 2825 TL	21	7.7
	2826-4000	62	22.7
	4001-6000	88	32.2
	6001-8000	67	24.5
	8001 TL ≥	35	12.9
Share of food expenditures in total expenditures	≥ %25	33	12.1
	%26-35	93	34.1
	%36-50	96	35.2
	%51-75	48	17.6
	%76≥	3	1

Source: Field Survey Data Analysis, 2021

Meat consumption and purchasing habits of participants

26.4% of the participants purchased red meat several times a month; another quarter (24.2%) purchased it weekly. When asked about the frequency of red meat consumption, 44.7% of the participants consumed it several times a week. When the participants were asked about the share of red meat in the total meat consumption, 71 (26%) declared that half of the total meat consumption consisted of red meat (Table 2).

Table 2. Participants' attitudes towards red meat consumption

		N	%
How often do you buy red meat?	Everyday	5	1.8
	Once a week	66	24.2
	Several times a week	52	19.0
	Once a month	51	18.7
	Several times a month	72	26.4
	Several times a year	14	5.1
	Only on special occasions	9	3.3
	Never	4	1.5
How often do you consume red meat?	Everyday	6	2.2
	Several times a week	122	44.7
	Once a week	77	28.2
	Once a month	65	23.8
	Never	3	1.1
What is the share of red meat in the total meat you consume?	One-quarter	69	25.3
	One-third	67	24.5
	Half	71	26.0
	More than half	57	20.9
	All	7	2.6
	I don't consume	2	0.7

Source: Field Survey Data Analysis, 2021.

The reasons for preferring and not preferring red meat

Of the 273 participants who participated in the survey, 127 (46.5%) expressed that palatability as "very important" in their red meat preferences. 104 participants (38.1%) bought red meat because they found it beneficial for health.

The most insignificant factors in the meat preferences were the ease of finding (15.5%) and habit (14.7%).

When the respondents were asked about the reasons for not primarily consuming red meat, the most critical factor was that the meat was expensive (37.4%), followed by the disease risk in meat (20.9%).

The most insignificant factor for not consuming red meat was that the individual had a vegan and vegetarian style (60.1%) (Table 3).

Table 3. The reasons for preferring or not preferring red meat over other meat types

	1	2	3	4
The reasons why you primarily prefer red meat?				
Habit	12.1	22.7	50.5	14.7
Easy to find	16.8	24.5	43.2	15.5
Palatable	8.8	5.1	39.6	46.5
Filling	9.2	11.0	47.6	32.2
Healthier	7.3	9.5	45.1	38.1
Easy to cook (especially minced meat)	11.7	25.3	38.5	24.5
Kids like it	9.9	24.5	37.0	28.6
The reasons why you primarily do NOT prefer red meat?				
Expensive	22.3	13.9	26.4	37.4
Do not like the smell	41.4	28.2	19.0	11.4
Health reasons	28.6	24.5	30.4	16.5
Not used to eating meat	41.0	33.7	20.1	5.2
Do not like the taste	45.1	27.5	16.1	11.3
Disease risks that can be transmitted from red meat	38.5	23.4	17.2	20.9
Having a Vegan or vegetarian diet	60.1	23.8	9.1	7.0
Prefer white meat more	32.2	28.2	26.0	13.6
Concern for animal welfare	42.9	33.7	16.1	7.3

(1=Highly Unimportant, 2=Unimportant, 3= Important, 4=Highly Important)
Source: Field Survey Data Analysis, 2021.

Factors affecting consumers' choices of red meat

Respondents primarily found the taste "very important" when purchasing red meat (61.5%) (Table 4).

The date of manufacture (60.1%), freshness (58.5%) and quality (58.2%) were other important factors. On the other hand, advertisements were the least important factor (25.6%).

Table 4. Factors affecting the purchasing preferences of red meat products

	1	2	3	4
Good farming/livestock practice	9.2	16.5	47.6	26.7
Place of purchase	4.4	6.2	46.9	42.5
Freshness	2.6	2.6	36.3	58.5
Price	3.7	5.9	42.1	48.3
Packaging	7.0	18.6	41.4	33.0
Quality	1.5	4.0	36.3	58.2
Brand	8.4	20.6	41.0	30.0
Advertising	25.6	43.2	18.7	12.5
Taste	3.7	1.8	33.0	61.5
Place of Origin	10.3	28.9	34.8	26.0
Date of manufacture	1.8	5.5	32.5	60.2

(1=Highly Unimportant, 2=Unimportant, 3= Important, 4=Highly Important)
Source: Field Survey Data Analysis, 2021.

Places where red meat are purchased

Table 5 shows that 58.2% of the participants bought red meat from butchers. Only 10.6% purchased red meat from discount markets. Similarly, supermarkets (7%) and local markets (9.5%) are less preferred places for meat purchase.

Table 5. Purchasing places of red meat products

	N	%
Super Markets (Migros, Carrefour)	19	7.0
Discounted Markets (A101, Bim, Sok)	29	10.6
Local Markets (Ozhan, Yıldırım, Onur etc.)	26	9.5
Butcher	159	58.2
Others*	40	14.7

* Those who shopped a combination of the above places.
Source: Field Survey Data Analysis, 2021.

Discussions

Households' frequency of purchasing and consuming red meat

Individuals lead their lives healthily if they follow an adequate and balanced diet. The first step of sufficient and balanced nutrition is to take the daily protein needed regularly. Experts also recommend red meat, which has many health benefits. However, red meat prices are high, and consumer incomes are limited, which affects their purchasing frequency. Red meat is more expensive than other types of meat. However, it has an important place in Turkish food culture. Families make an effort to include red meat in their meals, albeit forcing their means. In the present study, less than one fifth (18.7%) of the participating families bought red meat once a month. The high meat prices can explain this low rate. About half of the participants could consume red meat only once a week or several times a month. Similarly, Karakaya and Kiziloglu [12] underlined that 62.2% of local people purchased red meat once a month. A relatively larger portion of consumers in Bursa could consume red meat. More people work in the household, and more money comes to the family due to the higher education. However, the constant increase in meat prices and the fact that white meat is cheaper lead consumers to buy white meat. Therefore, consumers buy red meat less frequently. Participants, who were aware of the importance of red meat for health, made an effort to buy red meat at least once a month.

Red meat consumption frequency

Socio-demographic characteristics affected the consumption frequency of individuals due to their red meat purchases. In particular, the difference in the income levels of consumers directly affected the frequency of meat consumption. Low-income families bought and consume red meat less frequently, while high-income families did more regularly. Studies also support the variation in the frequency of red meat consumption. Akcay and Vatansever [1], in their study on red meat consumption in Kocaeli, a province close to Bursa, stated that 37.1% of them consumed red meat once a week, 26.57% of them once a month. In the current study, 28.2% of the participants consumed meat once a week and 23.8% once a month (Table 2). The research areas' geographical proximity and economic development ensured similar consumption patterns. Consumers confirmed that half of their total meat consumption (71 people) consists of red meat in the current study. Sixty-nine participants (25.3%) who participated in the survey stated that a quarter of their total meat consumption was red meat. According to OECD [20] data, the share of red meat in Turkey's total meat consumption was 41.03%. According to these data, consumers in Bursa consume less red meat than consumers in the country on average. The share of red meat consumption in total meat consumption was 83% in Uruguay, 72.9% in South Korea, 66.8% in the European Union, 65.6% in Pakistan, 63.6% in Bangladesh, 61.7% in Japan, 54.4% in Russia and 50.1% in the U.S. Red meat consumption is declining in the world. This is due to health concerns in developed countries. However, this is primarily an economic reason for Turkey. Still, red meat consumption in those countries, including developing countries such as Uruguay, Bangladesh and Pakistan, was higher than in Turkey [5].

Factors affecting red meat purchase

Many factors affect consumers' red meat preferences. Besides demographic factors consumer preferences are influenced by factors originating from product characteristics and environmental factors. Factors stemming from freshness, taste, and quality; advertisements, price, packaging, and brand are among the factors originating from the environment. Among these factors, price is a factor that varies in line with the income of consumers. Lorcu and Bolat [17] stated that the factors that most affect consumers' red meat preferences were taste (53.7%), being nutritious (20.7%) and being healthy (12.6%). In the same study, the least important factor was the ease of finding. Similarly, Yaylak et al. [37] stated that the factor that consumers paid most attention to was taste (52%). Both current and existing research confirmed that taste was the most critical factor affecting red meat purchase. Since meat is expensive and the high cost of red meat vastly affects purchase volume, the price was not the top factor that affected red meat preference. The taste was decisive for consumers. For a person who has provided basic needs, eating is also an activity of pleasure. The most prominent role in this pleasure is the taste of the consumed product. Additionally, taste stimulates appetite, provides pleasant smells and leaves indelible traces on the palate. Freshness is among the first three factors in the current study. The findings obtained from the research are similar to the results of Alev [3]. Meats are perishable products. Any chemical change that will occur in these products affects the freshness. Products that lose their freshness, food poisoning, etc. lead to adverse events. The fact that consumers have faced such negativities in the past increases the importance they attach to freshness. According to the data obtained from the research findings, advertisements were the least important factor. Advertisements aim to create a particular effect on the consumer audience and inform the consumer about the product. It also directs the purchasing tendencies of consumers. Advertisements being insignificant for the participants can be associated with the level of education. Almost half of the consumers in Bursa were university graduates. Participants with a high level of education are less affected by advertisements in their product preferences. Those people rely on their own choices and have more heightened product awareness.

Red meat purchase points

The increase in population in cities resulted in increased variety and number of meat purchase outlets. Consequently, farmers' markets, discount markets, supermarkets, local shops, and organic bazaars started selling red meat and meat products besides butchers. Consumers choose to buy their red meat depending on their income and product preferences. Besides numerous factors, consumers consider the hygiene environment when selecting their purchasing places. The ease of access is another critical factor in choosing the purchase point. More than half of the consumers bought red meat from butchers (58.2%) in the current study. This was followed by discount markets (10.6%) and local markets (9.5%) (Table 5). Similarly, 51.9% of consumers in Mersin purchased meat from butchers [29] and 11.7% from markets [29] in Mersin. It is noteworthy that discount markets ranked second for meat purchases. Red meat is primarily purchased from butchers because butchers are local and traditional outlets. The fact that the butcher is a local tradesman, that the consumers know it, that the butchers know their customers' tastes and that they offer products in line with their preferences are influential in selecting these places. Further, butchers sell on credit to their acquainted customers.

The study's findings confirmed that discount markets were preferred in the second, and local markets were preferred in the third. It is a valuable finding that supermarkets did not stand out in meat preference.

Consumers who are price-sensitive about meat prefer discount markets, while consumers who want the ease of transportation prefer local markets.

Compared to the butchers, consumers who value a broader range of selection and easy payment (by using a credit card in the absence of cash) prefer markets.

Campaigns and promotions in the markets were another reason for selecting purchase points.

CONCLUSIONS

Healthy and balanced nutrition is a must for individuals to survive. The human body must take in the fat, carbohydrates and protein it needs regularly and adequately. Almost half of the daily protein amount should be of animal origin. Red meat is an essential source of nutrients in providing proteins of animal origin. This study investigated the red meat consumption status of consumers living in Bursa. The research was carried out to reveal the frequency of red meat purchase and consumption patterns of consumers, examine the factors affecting red meat purchase and determine common meat purchase places. The study has shown that the most critical factor in the purchase was taste. Butchers were the first choice to buy red meat. The participants mainly bought red meat a few times a month (26.4%) and consumed it several times a week (44.7%). It is vital to raise society's awareness of increasing the frequency of red meat purchases and participants' consumption. Publication and training studies should be carried out to provide people with healthy, high quality and balanced nutrition habits. The nutritional content of red meat and its importance in human life should be explained in all channels and media.

Vaccines and drugs used in the treatment of animals, veterinary services, and energy spent for heating the barns and animal feed are some of the inputs used in livestock. Input prices have been increasing rapidly in recent years. Rising input prices are reflected in retail meat prices. Consequently, consumers cater for meat more expensively. For this reason, policymakers should increase the amount of support given to increasing input prices.

There is constant instability in the feed market. Animals should be grazed on pastures in their natural habitats. Pastures should be protected, and sanctions should be applied for the misuse of these areas. Policymakers should review the rights of producers on rangelands. The relevant ministry and agricultural engineers should carry out activities that guide the correct use of pastures. Animal welfare aims to increase animal productivity by exhibiting appropriate behaviours in better conditions. Some consumers think that animals are mistreated during feeding and slaughter. For this reason, consumers give up eating meat and tend to become vegetarian. Animal shelters should be built and operated following the regulations to break this perception. The relevant officers should inspect housing and slaughtering areas at regular intervals. More emphasis should be given to health and behavioural issues before and after slaughter, and producers should be aware of good livestock practices. Consumers should also be encouraged to seek these practices.

Anthrax, one of the oldest known diseases, is a disease transmitted to humans from grass-fed animals such as cattle, sheep and goats. This disease is considered a threat to consumers. The news about anthrax directly affects the meat consumption of consumers. To prevent anthrax-containing meat in the market, veterinarians should identify animals with anthrax, and health checks of animals should be done frequently. In addition, to discourage the producer from production, the compensation support given to animals who lost their lives due to anthrax should be increased. Butchers and markets are the places where red meat is purchased the most. The opening of butcher aisles in the markets causes the butchers, who are local tradesmen, to be less preferred. For this reason, municipalities should promote the butchers in their regions, support the local artisans, and promote the use of local butchers through advertising activities. People pay attention not only to the price but also to hygiene issues in the consumption of red meat. Especially with the covid-19 epidemic, people started to pay more attention to hygiene. During the Covid-19 pandemic, the media warned that the epidemic could be transmitted through food. This scare has led to decreased meat consumption. Hygiene issues should be given extra priority in meat purchasing places to increase meat consumption. More attention should be paid to the packaging of meat products, and the relevant authorities should inspect whether the products are produced following food safety legislation.

This study has several limitations. First of all, the research was carried out only in Bursa. Expanding the analysis to include other provinces of the Marmara Region will help confirm the current research findings. The study examined household preferences and the factors affecting household preferences. Considering that consumers live more on their own in metropolitan cities, the analysis can be repeated, concentrating on individual preferences. Additionally, processed red meat consumption (salami, sausage, sausage, etc.) and carcass preferences (minced meat, cubed, tenderloin steak) were not included. We recommend addressing these issues in future studies.

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HAVE THE EU PRE-ACCESSION FUNDS ACHIEVED THEIR PURPOSE? BENEFICIARY PERSPECTIVES ON THE EFFECTS OF THE FUNDS ON PRODUCTION QUALITY, RURAL DEVELOPMENT AND SUSTAINABILITY

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Abstract

Turkey's relations with the European Union (EU) financial assistance, which began in 1963, continue today. The IPARD (Instrument for Pre-Accession Assistance Rural Development) program aims to increase the efficiency of enterprises and achieve Community quality and quality management standards to achieve rural development and sustainability. This research aimed to measure investors' perceptions of the quality (QA), after-sales quality (ASQ), and rural development for IPARD (Instrument for Pre-Accession Assistance Rural Development) funds. Additional points are given for investor and company characteristics in some measures. This research reveals whether additional scores make a significant difference. 97 enterprises that received support from IPARD I and IPARD II in Bursa province, Turkey, were interviewed. Results showed that the participants' overall perception of RDS was higher than QA and ASQ. The quality perceptions were the lowest. 25 years old and younger investors had the highest QA and ASQ perceptions. An increase in educational level has led to a rise in the QA, ASQ, and RDS perceptions. No stable trend was observed between the increase in experience and the increase in QA and ASQ perceptions. The perception of RDS is higher among the investors who claim to follow rural development activities.

Key words: *IPARD, EU Funds, grant assessment, rural development, beneficiary assessment*

INTRODUCTION

Various state policies have supported the agricultural sector and its producers from the industrial revolution to the present day. These supports must continue due to the importance of agriculture in human nutrition, the global population growth rate, and food security. With industrialisation, migration from rural areas to cities has increased, and the population in rural areas has decreased and continues to decrease. Rural development projects have become a critical intervention tool to support the agricultural sector, prevent migration, eliminate interregional development differences, increase the incomes of agricultural producers living in rural areas, and increase their welfare levels.

The IPARD (Instrument for Pre-Accession Assistance Rural Development) Program's main objective is to prepare the EU Common Agricultural Policy acquis and achieve sustainable adaptation of the agricultural sector and rural areas in the candidate countries [8]. In this context, priority is given to market efficiency measures, improving quality and health standards, and creating new employment in rural areas.

The IPA budget for 2007-2013 was €11.5 billion. The IPA II budget was €12.8 billion for 2014-2020. Additionally, IPA III (2021-2027) has a budget of €14.162 billion. The program's current beneficiaries are Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, Serbia, and Turkey. A significant part of IPARD support has been allocated to Turkey (Table 1).

Table 1. 2014 Indicative IPARD budget (Million EUR)

	2014	2015	2016	2017	2018	2019	2020	Total
All countries	74	94	112	203	211	227	233	1154
Albania	0	0	13	14	12	16	16	71
Montenegro	0	5	5	6	7	8	8	39
North Macedonia	5	5	5	6	10	14	15	60
Serbia	0	15	20	25	30	40	45	175
Turkey	69	69	69	148	148	149	149	801

Source: Olgun and Sevilmiş [24].

IPARD III period will continue to enable

Turkey to benefit from investments and the Western Balkan countries. To ensure the effectiveness of EU funds, it is essential to determine whether the project investors in Turkey have achieved the program's objectives [12].

In enterprises that will operate in line with the Common Agricultural Policy (CAP) and the World Trade Organization (WTO), it is imperative to use quality inputs, achieve optimum enterprise size and use new technologies for high-quality, competitive and sustainable production. Businesses with low agricultural income cannot provide the necessary inputs and turn to technological innovations. Therefore, it is vital to determine the type, amount, and time of support while carrying out agricultural support policies. However, the fact that support policies are often not implemented effectively, lack of continuity, and insufficient support reduce the effectiveness of these policies. In addition, the prominence of short-term support policies instead of long-term structural policies prevents the fundamental solution to agricultural problems. Eliminating the issues faced during agricultural support policies necessitates addressing and analysing the structural difficulties of local agricultural enterprises and the target audience's socioeconomic and demographic characteristics [14].

Conceptual framework

Business managers have been focusing on product quality prominently. Current research determined an undeniable correlation between quality and operating profitability. Product and service quality, customer satisfaction, and business profitability are highly interconnected. High quality brings high customer satisfaction, and increased customer satisfaction offers the opportunity to sell the product at a high price. Many factors affect consumers' perception of quality. These can be listed as price, technical specifications, brand name, store name, packaging, country of origin, and other related factors. In addition, these factors may not be equally effective in all product groups or cultures.

Perceived quality refers to the level of meeting customers' expectations from their point of view. The product is perceived as high quality if customer expectations are met and exceeded [22]. Companies present documents such as ISO certificates as proof of quality. Taken holistically, certification alone is not sufficient in quality measurement. While certificates check the product's compliance with specific standards, "quality" in the sense we use today, requires exceeding customer expectations by exceeding the standards. Therefore, consumer evaluations are the most crucial determinant of quality. Today's consumer has ceased to be an "economic man" who takes rational decisions, and emotional values have become more critical. This development has brought different dimensions to the quality perceptions of consumers. In addition to the technical quality that addresses the product's technical specifications, the functional quality that addresses other values that the product offers customers gains importance [13].

After-sales services provide customer satisfaction by ensuring the customer's correct and purposeful use of finished products, providing service and spare parts services at the right, fast and affordable price in case of failure or complaint. *Service quality* can be defined as an organisation's ability to meet or exceed customer expectations. The quality perceived by the customer is paramount in services. Therefore, we can say that the quality of service is the level of performance perceived by the customer or the customer's level of satisfaction with the service. Customers think about quality together with the reliability of finished products and the reliability of after-sales services. In many customer surveys, it becomes clear that after-sales services are increasingly emphasised in the selection of products by customers and are an essential factor in the perception and choice of finished products. Customers want to have the help and suggestions of the manufacturer, the prestige and brand image of the business, the supply of spare parts, maintenance and repair, ease of payment and warranty, and physical characteristics when purchasing a product [21].

The development policies of rural societies aim to increase their welfare levels by improving their economic, social, and cultural opportunities in rural areas. Rural development strategies and policies aim to ensure the development of disadvantaged societies in the agricultural, economic and socio-cultural fields through self-help and external support [16]. Turkey has made some progress in developing rural areas and increasing people's quality of life by implementing policies to minimise developmental disparities [15]. These developments have not reached the desired level yet, and developmental differences have remained [32].

Sustainable development is a development model that deals with ecological balance and economic growth in the long term, ensures effective use of natural resources, and attaches importance to environmental quality. Sustainable development is a process of change. Resources, technological development, and institutional changes should be harmonious in this change. It should enrich the potential of humanity to meet its present and future needs and expectations.

Sustainable rural development can be defined as changing the economic, social, and cultural structures of rural areas, increasing people's living standards, and increasing the quality of the physical environment and the region's welfare while protecting natural resources, the environment, and historical and natural heritage. There are three components of sustainable development and sustainable rural development: ecological, environmental, biological), economic (income, finance), and social (demographic, cultural) components. Sustainable rural development requires orientation in rural areas, coordination between institutions, participation of the public and those concerned, and solution-based on discussion, monitoring, and evaluation. In rural development projects, targets should be set to increase farmers' incomes instead of increasing agricultural products, and alternative income areas should be explored [33]. For this purpose, various grant programs are being implemented to support rural producers and rural development projects using multiple resources [23]. These programs are implemented with national resources, as in the Rural Development Investment Support Program (RDISP), or with funds provided by international organisations, as seen in the IPARD program.

Effect of applicant and firm characteristics

To ensure that the suitable projects benefit from IPARD programs and increase the effectiveness of the aid provided within the scope of IPARD, it is necessary to correctly understand the characteristics of the individuals (natural persons) and the companies (legal entity) applying for the project. Two of the most critical factors affecting the investment decision of entrepreneurs in the IPARD program are the grant ratio and the ranking criteria. The project can support natural and legal entities with specific characteristics by giving additional points to specific ranking criteria in certain calls. Although it was not included in the scope of this research, the applicant's priority of being a woman in the IPARD I program in the ranking criteria was minimal. This shortcoming was compensated in the IPARD II program, and women's applications began to be given priority. There are some advantages of the applicant being under 40 in natural persons or the authorised person to apply in legal entities. Age support leads to an increase in the grant rate of 5% in measure 101. Moreover, it increases the ranking score of Measure 302 by 5-15 points compared to the call periods. Measure 101 of the IPARD program eligibility criteria include a professional competence requirement. This requirement has also been applied for measures 103 and 302 up to the 12th Call periods of the IPARD I. The same applies to the 302 Measure for the IPARD II budget period. An additional 15 points are given if the applicant has a professional certificate, diploma, or three years of working experience in agriculture or other relevant fields. Budget differences between measures in the IPARD program are not very large. However, the number and rates of projects in the dairy and meat processing and fruit and vegetable sectors, which require relatively high investment costs, may remain at lower levels. In the 101 measure, the existing businesses were given 20 points in the ranking criteria during the IPARD II 1st and 5th call periods. For the 103 Measure, 40 points were given to existing businesses in the 1st, 2nd, and 5th call periods. In the IPARD I period, the existing business applications did not provide any ranking advantage.

IPARD strives to increase the target audience and effectiveness of the program by giving priority to the individual and company characteristics in the rankings in the application requirements. Individual and company characteristics, which are given priority in the rankings in the application conditions for IPARD projects, may also differ in the perceptions of the participants who benefit from the program on product quality, after-sales service quality, and sustainability issues. This research examines whether there is a relationship between applicants' individual and company characteristics and the dimensions created within the research framework. Thus, IPARD policymakers and country-based policy investors will ensure that the programs reach the right target audience and have the opportunity to analyse whether the program's objectives are fulfilled in the eyes of the participants.

The number of studies in the literature regarding EU IPARD funds is scarce [14, 28]. Current research determined the producers' willingness to benefit from agricultural support policies [38]. The factors affecting the use of these funds by the investors have been inspected [1, 2, 10, 36]. The profiles of the entrepreneurs who want to benefit from the IPARD funds have been investigated [18]. The effects of IPARD funds on rural development [13, 42]; and the effectiveness of those funds [17, 20] went under scrutiny, and the specific sector was examined [19, 37, 39, 40] and investors who received and did not receive IPARD support were compared [27]. Several studies have investigated the satisfaction levels of beneficiary investors [35, 41]. Few studies have examined the effects of IPARD funds on rural tourism [26, 43].

This research aimed to determine the perceptions of the project beneficiaries on quality, rural development, and sustainability issues by adding the after-sales service quality dimension, which is now considered an essential complement to product quality. Specific measures have been investigated whether these perceptions change between the application requirements given additional points in the IPARD. Both investor characteristics and firm characteristics have been included.

The research aimed to examine the following hypotheses:

Is there a statistically significant relationship between the applicant characteristics (ages, educational level, and work experience) and the product quality (QA), after-sale service quality (ASQ), and rural development and sustainability (RDS) perceptions of applicants benefiting from the IPARD program?

Is there a statistically significant relationship between the business characteristics (business entity, business status, following rural development activities, and having industrial training) and the product quality (QA), service quality (ASQ), and rural development and sustainability (RDS) perceptions of applicants benefiting from the IPARD program?

Is there a statistically significant relationship between the *business operating sector, business net monthly income,* and *ownership of the firm* and the product quality (QA), service quality (ASQ), and rural development and sustainability (RDS) perceptions of applicants benefiting from the IPARD program?

MATERIALS AND METHODS

Population and sample

Bursa province received accreditation in the second phase of 42 provinces where the IPARD Program was implemented. 185.99 million TL investment was made in Bursa, where 81.47 million TL grant support was provided to 213 projects in total, based on 2012-2016. Bursa is in 13th place among 42 provinces regarding the number of grants paid. As of May 2019, 253 projects were carried out, and 88.3 million TL support was paid to these projects [29].

IPARD I and IPARD II Programs for Bursa were taken together, and 247 projects were included in the sample. In order to determine the study sample, a homogeneous purposeful sampling method was used. Purposive sampling is a sampling method in which there is no probability effect. It allows for a more detailed examination by selecting vital areas as data. This method is preferred when working with notable cases with specific criteria or qualifications. The purpose of homogeneous sampling is to conduct an in-depth analysis by selecting a small and similar sample [30].

A total of 73 projects and local products received support from measures 101 and 103 under the IPARD I Program in Bursa province, and 16 projects from rural tourism sub-measures were included in the scope of the study. In addition, 8 projects have been selected that have received support from the relevant sectors from the IPARD II Program and whose payment has ended. Due to the small population, a complete count method was applied. Accordingly, the total sample volume was determined to be 97.

Data collection

The first part contained 22 questions about the applicants' demographic characteristics and the enterprises applying for the project. The second part included 33 statements on rural development, product quality, and after-sale service quality.

The survey aimed to measure the participants' quality after-sales quality and rural development sustainability perceptions. The statements were arranged according to a 5-point Likert scale indicating as strongly disagree (1), disagree (2), no opinion (3), agree (4), and strongly agree (5). It was conducted face-to-face for 97 projects included in the sampling between January 2018 and February 2019. The survey was conducted with the grant applier in natural person and the authorised person to sign in legal entity applications. Before the survey was conducted, the participants were informed about the subject and the purpose of the study. It was emphasised that the data obtained would be confidential and used in academic research.

Data Analysis

To analyse the participants' data, reliability analysis, normality test, independent sample t-test, one-way analysis of variance (ANOVA), and crosstabs were used using SPSS package program version 25. The Cronbach's [9] alpha value of the scale was 0.902. Cronbach's alpha being $(\alpha)\geq 0.90$ confirms that the survey is "highly reliable." We also performed a Shapiro-Wilk test to test the normality assumption. The analysis showed that (D(97)p=0.877, p>0.05); the data did not show a normal distribution. Therefore, we used curvature and kurtosis values. We found the skewness values of -0.040 (SE= 0.148) and the kurtosis values of -0.173 (SE= 0.342). Tabachnick and Fidell [34] stated that the skewness and kurtosis values of +1.5 and −1.5 met the normality assumption, so we accepted that the data were distributed normally.

RESULTS AND DISCUSSIONS

Demographic results

We examined the demographic characteristics of the participants of the supported enterprises and the general characteristics of the projects in Bursa. The demographic characteristics are shown in Table 2.

The majority of the beneficiaries of the project (78.4%) were male and between the ages of 36-55 (68.1%), and nearly half of them (43.3%) had a university education. Similarly, almost half of the participants (40.2%) had a professional experience of 5 years or less. Although the participants were highly educated, a significant portion of them did not have relevant education related to the sector in which the investment is made (83.5%). Despite this drawback, 76.3% of the participants did not hold vocational training unless the IPARD applications were required.

A significant proportion of IPARD support was received for newly established companies (84.5%). About half of them were legal entities. Mostly meat (36.1%), milk producers (25.8%), and those with monthly net incomes of €10 thousand and more received funds.

Findings on the perception of investors

The survey questionnaire consisted of 3 sub-dimensions. These were classified as product quality perception, rural development and sustainability perception and after-sales service quality perception. Descriptive statistics for the entire survey and its sub-dimensions are given in Table 3.

The mean score of the survey was $\overline{x}$=3.8. The survey's highest perception was sustainability and rural development ($\overline{x}$= 4.19, SD= 0.53), and the lowest was quality ($\overline{x}$= 3.50; SD= 0.58).

Table 2. Demographic characteristics of the participants and participating businesses

		N	%
Gender	Female	21	21.6
	Male	76	78.4
Marital status	Married	88	90.7
	Single	9	9.3
Age	≤ 25	2	2.1
	26-35	18	18.6
	36-45	31	32.0
	46-55	35	36.1
	56 ≤	11	11.3
Education	Primary sch.	12	12.4
	Secondary sch.	19	19.6
	High school	24	24.7
	Undergraduate	40	41.2
	Graduate	2	2.1
Professional experience (years)	1–5	39	40.2
	5–10	17	17.5
	10–15	16	16.5
	15–20	11	11.3
	20+	14	14.4
Enterprise type	New	82	84.5
	Existing	15	15.5
Business entity	Normal person	47	48.5
	Legal person	50	51.5
Monthly net income (€)	≤ 5,000	5	5.2
	5,001-10,000	19	19.6
	10,001-15,000	23	23.7
	15,001-20,000	19	19.6
	20,001 ≤	31	32.0
Do you have formal education related to the sector?	Yes	16	16.5
	No	81	83.5
Have you attended a vocational course?	Yes	23	23.7
	No	74	76.3
Who is the head of the business?	Myself	69	71.1
	Other	10	10.3
	Family member	18	18.6
Supported sectors	Milk-producing agricultural holdings	25	25.8
	Red meat-producing agricultural holdings	35	36.1
	Processing and marketing of milk and milk products	2	2.1
	Processing and marketing of red meat and meat products	5	5.2
	Crafts and artisanal added value product enterprises	11	11.3
	Rural tourism and recreational activities	7	7.2

Source: Author's calculation.

The survey result shows that investors are not sure about the effectiveness of the IPARD aid in achieving product quality. However, investors seem to have perceived IPARD's goal of rural development. Of course, quality cannot be achieved with financial aid alone. It is a philosophy and requires a companywide commitment to achieve quality. Investors seem to have understood that after-sales service quality is integral to the product image. Attention needs to be paid to offering better after-sales service.

Table 3. Descriptive data of QA, RDS, and ASQ perceptions

	Mean	SD	Min	Max	Skewness	Kurtosis
QA	3.50	0.58	1.88	5.00	-0.07	-0.05
RDS	4.19	0.53	2.43	5.00	-0.79	0.87
ASQ	4.05	0.51	2.67	4.89	-0.76	0.30
Survey	3.85	0.38	2.97	4.85	-0.04	-0.17

QA= Quality RDS= Rural development and sustainability ASQ= After-sale quality
SD= Standard Deviation
Source: Author's calculation.

Findings on the perception of investors on the survey dimensions

The first part examined the difference between the demographic characteristics of the managers participating in the survey on behalf of the agricultural enterprises and the dimensions examined in the research by ANOVA Tests. The demographic characteristics investigated were the participant's age, educational background, and professional experience.

In the second part, the business characteristics and the scale dimensions were compared. Of these, an independent sample T-Test examined the *type of business*, whether the company is *new or existing*, and whether the participant has a *relevant certified education*. ANOVA analysis has been used to determine the statistical relation between the *monthly net income*, the top *management status*, operating *sectors*, and scale dimensions.

Findings on the QA, ASQ, and RDS perceptions according to the demographic characteristics of managers.

One-way ANOVA results confirmed that there was no statistically significant difference between perceptions of quality, rural development and sustainability (RDS) and aftersales service quality (ASQ) and *age* and *work experience*. On the other hand, there was a statistically significant difference between the education levels of the participants and their quality perceptions ($F_{(4-92)}$=2.856, p=0.028, p<0.05) (Table 4). Tukey's post hoc result confirms a statistically significant difference in quality perceptions between project owners whose education levels were high school ($\bar{x}$=3.29) and associate degree/undergraduate ($\bar{x}$=3.70). In addition, there was a statistically significant difference between the participants' *education levels* and their RDS perceptions ($F_{(4-92)}$=3.050, p=0.021, p<0.05). Tukey post hoc results showed that statistical significance occurred between primary ($\bar{x}$=3.73) and secondary education ($\bar{x}$=4.28), between primary ($\bar{x}$=3.73) and high school ($\bar{x}$=4.29) and between primary ($\bar{x}$=3.73) and associate/undergraduate degree ($\bar{x}$=4.23). RDS perceptions were at the lowest level of primary education and the highest at the high school level (Table 5).

Table 4. ANOVA test between the participants' quality, rural development and sustainability and after-sales service quality perceptions and age, education and professional experience variables.

	Age		Education		Experience	
	F	*p*	*F*	*p*	*F*	*p*
QA	1.477	0.216	2.856	0.028*[1]	1.547	0.195
RDS	0.088	0.986	3.050	0.021*[2]	0.424	0.791
ASQ	0.205	0.935	1.152	0.337	1.646	0.169

* p < 0.05; [1] Difference (Tukey): 4-5 [2] Difference (Tukey): 1-2, 1-3,1-4
[(1) Primary School (2) Secondary School (3) High school (4) Graduate (5) Postgraduate].
Source: Author's calculation.

Table 5. Perceptions of quality, sustainability and rural development by age, work experience and education.

Age	QA	ASQ	RDS	Work Experience (Years)	QA	ASQ	RDS	Education	QA	ASQ	RDS
≤25	4.23	4.13	4.17	1–5	3.80	3.78	3.99	Primary	3.56	3.44	3.63
26-35	3.65	3.71	3.98	5–10	3.61	3.57	3.80	Secondary	3.61	3.76	3.98
36-45	3.77	3.77	4.01	10–15	3.93	3.82	4.00	High Sch.	3.73	3.80	4.03
46-55	3.86	3.81	3.94	15–20	3.61	3.84	4.09	Graduate	3.94	3.84	4.05
56 ≤	3.65	3.64	3.96	21≤	3.88	3.85	4.05	Post Grad.	4.00	3.79	4.00

Source: Author's calculation.

Findings on the QA, ASQ and RDS perceptions according to beneficiary business characteristics

Independent sample T-Test analysis revealed no statistically significant relationship between the survey's sub-dimensions and the project owners' *business statu*s, whether they *follow rural development activities* and whether they have relevant *industrial training* or *vocational education*. However, a statistically significant difference between the enterprise status, whether the enterprise is *a legal or natural person*), and the RDS perception was apparent (*p*=0.046, *p*<0.05) (Table 6). Accordingly, investors who are legal entities ($\bar{x}$=4.29) have a higher level of RDS perception than those who are natural persons ($\bar{x}$=4.08).

Scale Comparison with Enterprises Sectors, Top Management, and Net Monthly Income. ANOVA analysis was conducted to determine whether there was a significant difference between the enterprises' sectors and the status of *top managers*, and the quality RDS perceptions of the participants. No statistically significant results were obtained for any of the sub-dimensions for these two variables. There was no statistically significant difference between the net monthly income of the enterprises participating and their RDS (*F*(4-92)=2.238, *p*=0,071, *p*>0,05) and ASQ (*F*(4-92)=2.026,*p*=0,097,*p*>0,05) perceptions. On the other hand, there was a statistically significant difference between the monthly net income of the enterprises and their quality perceptions (F (4-92) = 2.521, p=0.046, p<0.05) (Table 8).

Table 6. T-Test Analysis of business features and quality, rural development and sustainability and after-sales quality perceptions

			N	X̄	SD	df	t	p
Business Entity	Quality	Natural Entity	47	3.4920	0.60310	95	-0.172	0.864
		Legal Entity	50	3.5125	0.57213			
	RDS	Natural Entity	47	4.0760	0.57672	95	-2.024	0.046*
		Legal Entity	50	4.2914	0.46891			
	ASQ	Natural Entity	47	4.0189	0.48671	95	-0.528	0.599
		Legal Entity	50	4.0733	0.52674			
			N	X̄	SD	df	t	p
Business Status	Quality	New	82	3.5168	0.56750	95	0.557	0.579
		Existing	15	3.4250	0.68596			
	RDS	New	82	4.1882	0.51868	95	0.048	0.962
		Existing	15	4.1810	0.62145			
	ASQ	New	82	4.0190	0.51934	95	-1.279	0.204
		Existing	15	4.2000	0.40543			
			N	X̄	SD	df	t	p
Follow-Up of Rural Development Activities	Quality	Yes	87	3.5101	0.58853	95	0.370	0.712
		No	10	3.4375	0.57206			
	RDS	Yes	87	4.2102	0.51131	95	1.267	0.208
		No	10	3.9857	0.68826			
	ASQ	Yes	87	4.0715	0.49138	95	1.418	0.160
		No	10	3.8333	0.6462			
			N	X̄	SD	df	t	p
Industrial Training/ Certificate	Quality	Yes	23	3.6413	0.43515	95	1.308	0.194
		No	74	3.4595	0.61971			
	RDS	Yes	23	4.2298	0.47133	95	0.439	0.661
		No	74	4.1737	0.55216			
	ASQ	Yes	23	3.9565	0.63718	95	-0.982	0.329
		No	74	4.0751	0.45908			

* p < 0.05.
Source: Author's calculation.

Table 7. Perceptions of quality, sustainability and rural development according to sector, top management and monthly net income of enterprises

Who is the head of the business?				Monthly Agricultural Net Income				Operating Sector			
	QA	ASQ	RDS		QA	ASQ	RDS		QA	ASQ	RDS
Myself	3.80	3.79	4.01	≤5,000	3.39	3.32	3.49	MP	3.70	3.73	3.96
Family member	3.70	3.68	3.93	5,001-10,000	3.77	3.85	4.06	RMP	3.64	3.59	3.83
Other	3.74	3.72	3.82	10,001-15,000	3.55	3.60	3.85	MMP	4.05	3.92	4.17
				15,001-20,000	3.87	3.86	4.16	RMMP	4.09	3.93	3.91
				20,001 ≥	3.95	3.84	3.99	F&V	3.82	3.93	4.05
								CAP	4.14	4.13	4.38
								RT	3.80	3.70	3.98

MP=Milk Producers; RMP= Red Meat Producers; MMP= Milk and Milk Prod. Processors; RMMP= Red Meat and Meat Prod Processors; F&V= Fruits and Vegetables CAP= Crafts and Artisanal Products; RT= Rural Tourism
Source: Author's calculation.

Table 8. ANOVA test of the participants' quality, rural development and sustainability and after-sales service quality perceptions and sector, net monthly income and top management

	Sector		Net Monthly Income		Top Management	
	F	*p*	*F*	*p*	*F*	*p*
QA	0.418	0.889	0.046	0.046*[1]	1.644	0.199
RDS	1.549	0.161	2.238	0.071	0.586	0.558
ASQ	1.549	0.161	2.026	0.097	1.191	0.308

* p < 0.05; [1] Difference (Tukey): 3-5 [(1) ≤€5000 (2) €5001-10 000 (3) €10 001-15 000 (4)] €150001-20 000 (5) ≥€20 000]
Source: Author's calculation.

According to the Tukey post hoc result, there was a statistically significant difference in quality perceptions of projects with monthly net incomes between €10,000 - 15,000

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($\overline{x}$=3.22) and over €20,000($\overline{x}$ =3.67) (Table 7).

Discussions

Examination of the QA, ASQ, and RDS perceptions according to the demographic characteristics of managers.

We expect that there will be an increase in the perception of quality and sustainability along with a rise in the professional experience and industry knowledge of the investors as they age. Alternatively, we predicted that young investors would closely follow the sector developments and have more sensitive environmental awareness. Their perception of rural development and sustainability would be high.

The group with the highest product and after-sales quality perception is 25 years old and younger. Young investors start their careers more enthusiastically, have higher education levels than older investors, and follow sector developments more closely, leading to a higher perception. Product and after-sales quality perceptions increase until age 26-55 and decrease after 55. the perception of RDS is higher at all ages.

Those dealing with the farming profession in Turkey have not yet been fully institutionalised. QA and SAQ were relatively low in age groups, as the producers do not give their products directly to the consumer but to the intermediary. However, investors' high RDS perceptions indicate that the increasing importance of these factors has begun to be perceived in all age groups. However, no statistically significant relationship was found between age and QA, ASQ, and RDS.

In the literature, various studies [2, 41] examining the effectiveness of bovine grants given within the scope of the IPARD program found a negative relationship between the age of the farmer and benefiting from the supports. Olsen and Lund [25] examined the incentives and socioeconomic effects that affect investment behaviour in agriculture. They emphasised that young farmers are more likely to invest than older farmers. The investment tendency is also related to experience. As farmers age, their willingness to benefit from agricultural support policies decreases. Older farmers traditionally use their resources and do not like to depend on or borrow from third parties. However, the age effect in these studies is not statistically significant.

An increase in educational level has led to a rise in the QA, ASQ, and RDS perceptions. The ASQ perception was lowest in primary school graduates. An increase in the education level has not translated into an increase in ASQ perception. Although the QA and ASQ perceptions of participants with undergraduate and graduate degrees increased relatively, this increase was limited. Nevertheless, a statistically significant difference was observed between the educational status of the beneficiaries and their perceptions of QA and ASQ. The noteworthy point is that there were no significant changes in quality perceptions with the increase in education. IPARD beneficiary enterprises seem to be better regarding the owner's education or the project application. However, the formal education system, including universities, has not adequately covered sustainability issues. Berjozkina and Melanthiou [5] through the example of tourism and hospitality education, state that sustainability education in universities remains extremely limited. The literature has fully established the relationship between education and benefiting from IPARD projects. Beşen et al. [6] found a significant difference between the training periods of the producers who received and did not receive drip irrigation support in the province of Antalya (X^2=1.752, p=0.416) and Aydın et al. [4] in Edirne (p=0.716). Yardimci et al. [40] on the other hand, found a significant difference between the beneficiary and non-beneficiary dairy enterprises on the educational level of the owner (X^2= 26.58 p=0.000).

The increased professional experience could create a difference in investors' perceptions of QA and ASQ compared to their less experienced colleagues; their quality perceptions could have increased. We expected investors who had just started their careers to be more sensitive to KKS issues. However, no stable trend was observed between the increase in experience and the increase in QA and ASQ perceptions. QA perceptions of those with 10-15 years of professional experience and ASQ and RDS perceptions of investors with 20 years or more of professional experience are higher. No statistically significant relationship was found in the perceptions of QA, ASQ, and RDS in professional expertise. Professional experience does not constitute a statistically significant relationship between producers benefiting from and not benefiting from agricultural support within the scope of IPARD aids [3, 7, 10].

Examination of the QA, ASQ and RDS perceptions according to beneficiary business characteristics

Natural person enterprises are commercial or industrial enterprises that a person owns and operates alone. These are generally family-type businesses with relatively low volume incapacity. On the other hand, legal entity enterprises consist of joint-stock, limited liability, unlimited liability, and cooperative enterprises with more corporate, professional management and higher capacities.

The QA, ASQ, and RDS perceptions of legal entity operations are marginally higher than natural persons. Legal entity enterprises are often more institutionalised, produce in higher volume, work more for export, apply more procedures, and are more frequently exposed to audit mechanisms. These factors could have led to higher perceptions of legal entities. There was no statistically significant difference between the legal status of the company and the quality after-sales quality perceptions. However, the perception of RDS was significant at the 5% level. Likewise, since companies with legal entities may have broader environmental damage and be subject to stricter environmental sanctions, there is likely to be a statistical difference between their perceptions of RDS.

Beşen et al. [7] and Doğan et al. [11] found a negative but statistically insignificant relationship between the application rate of the beneficiaries of the young farmer project and agricultural enterprises' being natural persons. Altıntaş et al. [3] have found a statistically significant relationship between the use of young farmer support and ownership of the business.

Theoretically, existing enterprises will have a higher perception of quality due to their operational experience. There will be an already existing customer base, and to retain this audience, they should pay more attention to after-sales quality. New companies have also been expected to show environmental sensitivity when choosing location, machinery, and equipment; at least they would have to follow environmental laws and sanctions and have higher sustainability due to current intensive discourses in business activities. However, there was no statistically significant difference between the oldness of the enterprises receiving support from the IPARD program, whether they were existing or newly set up, and the perceptions of QA, ASQ, and RDS. In other words, their perceptions were not different between the new and existing businesses. A significant majority of the investors participating in the study were new businesses may also have caused this insignificance.

The perceptions of investors who follow rural development activities are slightly higher than those who do not. The perception of RDS is higher among investors who claim to follow rural development activities. The difference between the RDS perceptions of the investors who appear to follow rural development activities is not statistically significant.

Monitoring rural development activities is necessary for every company in every sector operating in the rural area. Companies established in rural areas provide economic prosperity to the region by providing employment and increasing the purchasing power of the people. However, on the other hand, companies may have environmental damage. In addition, companies may also be affected by disasters that may be the result of climate change.

Companies operating in rural areas follow special incentives and legal sanctions related to these regions. Sanctions are even more critical, especially for agricultural companies, which directly affect human health. Therefore, these sanctions will impact the company's operations and subsequent product quality and firm sustainability. However, considering that the vast majority of the participants were high school and university graduates, not having a statistically significant difference in the perception of AQ, ASQ, and RDS on following the activities of KKS is concerning.

Aydın et al. [4] between reading the agricultural publication and benefiting from drip irrigation grants, Sezgin et al. [31] between willingness to pay for extension services in Erzincan province and follow innovations, have failed to find a statistically significant relationship.

As anticipated, the participating project owners who have attended sector or subject-related training possessed higher QA and RDS perceptions. However, after-sales quality perceptions of investors with no professional certificate were higher. However, this difference was not statistically significant in all survey categories.

Certificates obtained from vocational courses given by adult education centres are predominantly used to fulfil the professional qualification criterion required for measure 302 until IPARD I budget period 12th call. However, training certificates and courses are obtained due to professional qualification criteria and are only necessary for projects belonging to Measure 302. Therefore, it did not create any statistical differences in investors' perceptions of whether they had received a professional certificate or a course. Altıntaş et al. [3] found a statistically significant difference between participation in agricultural production-related education and benefiting from young farmer project support, while Beşen et al. [7] did not.

On a sectoral basis, red meat and dairy producer investors, mainly included in 103 measures, participated in the study (61.9%). Stringent quality and hygiene standards are applied in both sectors. For such enterprises to continue their activities, they must be aware of these standards and use them continuously. These sectors witness high competition. Customer satisfaction is highly fragile, and customer loyalty will be lost at the slightest quality problem. However, the lowest perception of quality is in meat-producing ($\bar{x}$=3.64) and milk-producing ($\bar{x}$=3.70) companies. The quality perceptions of meat ($\bar{x}$=4.09) and milk processing ($\bar{x}$=4.05) companies are not at the desired level.

After-sales quality is vital for processing companies, rural tourism, and local arts and crafts businesses. Rural development and sustainability, too, are crucial for rural tourism businesses. The lowest ASQ was observed in rural tourism. This indicates that locals still did not grasp the importance of repeat visits. The ASQ perception of local product manufacturers is the highest ($\bar{x}$=4.13). RDS perception is highest in local products ($\bar{x}$=4.38) and milk processing companies ($\bar{x}$=4.05). However, there was no statistically significant difference between the sectoral status of the enterprises participating in the study and the perceptions of quality, rural development, sustainability, and after-sales quality. The fact that most companies receiving support from the project are newly launched companies may be why QA, ASQ, and RDS perceptions are not yet fully embedded in these sectors.

Ağır and Akbay [2] did not find a statistically significant relationship between producers' use of fattening cattle support and their business type (combined or solely fattening) (p(0.581) p= 0.295). Sezgin et a. [31] stated that predominantly animal production was not statistically significant in the willingness of farmers to pay for agricultural consulting services (p= 0.358).

Confirming the monthly net income QA, ASQ, and RDS perceptions are below average. As expected, the lowest QA ($\bar{x}$=3.59) was observed in enterprises with the most insufficient operating income. These companies tend to save the day and survive by deducting their expenses; as the active income increases, the perception of quality increases. Expectedly, the lowest QA ($\bar{x}$=3.59) was observed in enterprises with the most insufficient operating income. These companies tend to save the day and survive by deducting their expenses. As the active income increases, the perception of quality increases.

There is a statistically significant difference between the monthly net income and perceptions of the enterprises covered by the study. This difference occurs between enterprises with monthly incomes of TL 10,001-15,000 and TL 20,000 and above. Investors' perceptions of ASQ and RDS increased with operating income but decreased after operating income of TL 20,000. While businesses are a customer and environment-oriented up to a certain point, they may lose focus after reaching a certain growth point. Because businesses are being more careful about establishing and holding on to the sector and market, service quality and sustainability concerns may remain in the background while diversifying their activities in the future stages. There was no statistically significant difference between the monthly net income of enterprises and their perceptions of RDS and ASQ. Hence, the increase in perception recorded by the rise in the income of enterprises has been minimal. Different results have been reached in the literature between operating income and the subject studied within the scope of the IPARD program.

Yüzbaşıoğlu and Kızılaslan [41] found no statistically significant relationship between the status of the producer benefiting from animal support and income. The authors concluded that the number of animals owned, the knowledge of support, and the benefit of support, rather than income, statistically affected satisfaction. Topçu [38] reported a positive and significant relationship between farmers' willingness to benefit from agricultural support policies and agricultural activity income [p (0.175) = 0.0280]. Sezgin et al [31] found that agriculture's primary source of income does not affect the willingness to not pay for agricultural extension services.

QA, ASQ, and RDS perceptions were the highest in businesses where the business owner was the manager. While the perception of QA and ASQ were higher in businesses with a professional management team, KKS was higher in the business where the manager was a family member. However, only 10% of the companies receiving the IPARD project are managed by professional managers, and family members manage less than 20%.

Quality and after-sales service are paramount for newly established and owner-managed companies to survive and sustain in the competitive market. Companies managed by professionals in Turkey are also practically family-owned companies. In other words, the family has a high level of influence in management, even if the business has a professional management team. Therefore, ownership status has not changed the supported enterprises' QA, ASQ, and RDS perceptions.

Beşen et al. [7] research has found a statistically significant relationship in terms of owning agricultural businesses between enterprises that receive young farmers' investment support and those that do not receive it (p=0.008). Investors who own agricultural enterprises and apply for IPARD support have a higher number (56.9%). In enterprises where the manager is the parent (52.8%), they show reservations about applying to the IPARD project. However, owning an agricultural enterprise does not statistically affect the producers' benefitting young farmers' support (p=0.792).

CONCLUSIONS

The results showed that the participants' overall perception of RDS was higher than QA and ASK. The quality perceptions of the participants were the lowest. Although it is pleasing that the RDS perceptions of the participants are high, it is concerning that the quality perceptions are low. A significant portion of the IPARD project beneficiaries consists of investors operating in other sectors and taking advantage of the incentives given to this sector. It may take time for investors benefiting from incentives to adapt to quality standards in this new industry. On the other hand, after-sales quality is a newly emerging phenomena in the agricultural sector. Manufacturers usually sell to brokerage firms and do not effectively benefit from after-sale consumer feedback. In particular, meat and dairy producers adhere to intermediary companies for quality improvement. Eventually, meat and milk processing enterprises, rural tourism, and local product sectors will understand that after-sales service quality is essential to product quality.

The implementer of the program, ARDSI, has given sustainability training to the beneficiaries for the post-implementation period. Although this training is beneficial, it would be appropriate to increase the knowledge and awareness of the beneficiaries about EU standards on issues such as quality management, food safety, hygiene, product, raw material quality, and after-sales service quality.

Evaluation of the characteristics of the investors and companies applying to the IPARD program showed that QA, ASQ, and RDS revealed no statistically significant results in most researched components.

The level of education of beneficiaries in Bursa province within the scope of the research is higher than in other regions. However, the fact that the training received is not related to the applied grant area affects these investors' quality, SSK, and KKS perceptions. This research includes investors benefiting from IPARD 1 and IPARD2 support in the Bursa Province. The current research findings provide a general framework for the QA, ASQ, and RDS perceptions of IPARD beneficiaries. However, expanding and repeating the research on a regional and country basis will help confirm the findings and determine the effectiveness of IPARD funds. The study can be repeated to evaluate and compare the IPARD and IPARD 2 periods separately. Thus EU policymakers and ARDSI can observe whether there is an improvement in QA, ASQ, and perceptions between IPARD I and IPARD II.

Adopting and implementing a high-quality perception and understanding of after-sales quality will improve the sector's regional and national economies. The additional points system required for specific measures has not shown the desired impact in practice. Specific characteristics such as gender, education, and professional experience were given additional points in specific measures that did not significantly differ in QA, ASQ, and RDS perceptions. Therefore, the control of these desired properties should be carried out more strictly as per measures. In particular, the need for education in the sector should be further expanded and its content enriched.

Improving the agricultural structure and revenues by benefitting from agricultural support necessitates blending users' perceptions with the priorities of the funds. Considering the characteristics of agricultural business practitioners and firms in adopting and implementing local policies will provide significant advantages to policymakers and producers. Effective use of scarce resources needed for production can be best utilised if the support policies are shaped following the target audiences' needs. Thereby the adverse effects of cost pressure on manufacturers can be eliminated. With the increase in the quality standard in enterprises, a more competitive company structure can be achieved, and thus the living standards of farmers can also be increased.

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QUIET AND BLESSED: RURAL TOURISM EXPERIENCE AND VISITOR SATISFACTION IN THE SHADOW OF COVID-19 AND BEYOND

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Abstract

Rural tourism has an increasing share of the country's tourism income and significantly contributes to the rural economy. Intensive research has been conducted on how Covid-19 affects the tourism industry and the challenges and opportunities the sector face. Although the rise of rural tourism is frequently highlighted post-Covid-19, research examining the satisfaction levels of visitors involved in rural tourism is almost nonexistent. The study's main aim is to determine customers' satisfaction levels from rural activities in and around the İznik District of Bursa province and to recommend improvement. We obtained data from a structured survey conducted with 408 people who visited İznik at least once. SPSS 23 program was also used to analyze the data obtained. Results show that visitors' satisfaction with nature and the environment is above average, and their satisfaction with the services provided is below average. The most critical dissatisfaction was the increasing environmental pollution, the loss of natural beauty, the local government's inability to do the necessary cleaning and maintenance work, and the lack of introductory information in places with historical and natural characteristics. Participants wanted to stay in caravans and tents rather than hotels and suggested expanding and improving those facilities. They suggested that local textures are preserved, and more local food and beverages are offered. The suggestion shows that visitors demand integrating more with nature, local life and historical texture.

Key words: *Covid-19, new trends, rural tourism, rural development, tourist satisfaction*

INTRODUCTION

Tourism is a very fragile sector. It can be easily affected by all sorts of crises and negative situations that occur globally or locally. Terrorism, financial crises, pandemics, natural disasters, wars, political instability, etc. disrupt the tourism industry. The tourism sector is first affected in places that experience such unfavourable situations, and the number of tourists and tourism revenue falls severely.

The deadly new type of coronavirus (Covid-19), which emerged in Wuhan, China's Hubei province, in the last days of 2019 and spread rapidly due to the global transportation network, has caused unprecedented damage world economy while leaving tourism one of the most affected sectors. The Covid-19 Tourism and Accommodation Sector in Turkey Report prepared by Deloitte [14] states that industry managers are going through a tough time determining their operational strategies for the coming period and problems with booking cancellations, personnel management, and financing configuration. According to the report, this period brings new business models and opportunities. The rapid spread of the Covid-19 pandemic worldwide accelerated the return from mass tourism to individual tourism activities. In this new challenging era, rural tourism activities are rapidly becoming widespread at national and international levels, where social distance can be maintained and carried out in small groups, and it is easier to control new hygiene requirements.

Literature review

Rural tourism

Villages around coastal centres and large cities, rural settlements near ancient cities, roadside villages, and towns are no longer unfamiliar to tourism in Turkey in recent years. Country restaurants and shopping exhibitions, even fish farms and rural roads, have met tourists or day-trippers. In addition to individual trips, travel agencies organize day trips to such places or the rural areas where they are located.

Rural tourism integrates with rural culture, natural environment and agriculture and can be easily integrated with other types of tourism. Rural tourism includes a wide variety of recreational activities. It is not a type of agricultural tourism but also includes trekking, hiking, climbing, camping, caravan, rafting, paragliding, horse riding, canoeing, fishing and bird watching [25].

Rural tourism prevents seasonal fluctuations and exceeds the regional carrying capacity by spreading throughout the year [44]. It increases rural income, complements agricultural activities, creates new employment opportunities, increases welfare in the countryside, and reduces migration from rural to urban settlements [30]. Rural tourism also aligns with new trends in the tourism market. Having lower stress factors than urban areas (pollution, traffic, noise, etc.), allowing more interaction with nature and local culture, and increased interest in outdoor recreational activities increase the share of rural tourism in this market [29]. Researchers predict that rural tourism will be on a rapid upward trend worldwide, especially with the impact of Covid-19 [2, 34, 40].

Rural tourist profile

Rural tourism has a specific customer profile. Page and Getz [39] state that tourists participating in rural tourism have high educational and income levels that are environmentally sensitive, and holiday spending is higher than mass tourism spending. Lane [33] also confirms that rural tourists are well-educated and better off than most. Although Lane [33] says that rural tourists are people of all ages, other authors characterize rural tourism as adult, senior, and family tourism. Nevertheless, they also underline that in recent years, various sporting events have become increasingly common in rural areas, and young people are becoming interested in this type of tourism. Villages or farms in rural areas gain a reputation by promoting horse riding, golf sports, nature walks and extreme sports or specializing in local handcrafts or food products [44].

Rural tourists have different priorities than mainstream tourists. The issues that they are satisfied with or not will also be different. Mainstream visitors prefer destinations known as the classic trio of sea sun sand, standard-serving hotels or even package holidays. However, rural tourists prefer places where they can stay alone with nature in smaller, less known, yet undiscovered places [22].

Due to the impact of Covid-19, the profile of tourists participating in rural tourism is diversifying. The demands of more adventurous, younger and more expectant rural tourists will be added to the well-known demands of the mainstream tourist profile. Therefore, business owners in rural areas will have to offer services that meet more visitor group characteristics to a higher standard without compromising local characteristics. For rural businesses that already have infrastructure problems, relatively low education levels, usually work as small family businesses and have minimal financial means, it will be challenging to satisfy this growing variety of tourists.

Tourist Satisfaction

As in almost all areas, customer satisfaction in the tourism sector is vital in terms of the sustainability of tourism activities at both the micro (tourism region or enterprise) and macro-level (country) [31]. Therefore, it is crucial to determine the changing tourist expectations and demands and create touristic products or services to increase the service quality for tourist satisfaction and thus create customer loyalty [45]. Furthermore, tourist satisfaction also impacts tourists' repurchase of tourism products and destination selection. Chen and Tsai [8] refer to tourist satisfaction as the general pleasure or satisfaction the visitor feels when the travel experience meets the visitor's interests, wishes, expectations and needs. The critical point here is that the tourists should feel that the performance at the end of the trip meets their desires and expectations before the trip. In other words, satisfaction occurs for tourists who are sure their expectations are met [23].

Rural tourism is seen as an essential development tool in today's tourism. Rural tourism movements such as nature walks and nature photography are experienced in rural areas brought to tourism with the necessary infrastructure and superstructure improvements [13]. Therefore, it is critical to determine the satisfaction levels of visitors to İznik and Lake İznik and to evaluate them within the scope of rural tourism.

Research overview

As the coronavirus pandemic began, scholars quickly put forward research. Gössling et al. [21] analyzed the changes the tourism sector is going through globally due to Covid-19. Jones and comfort [26] discussed the pandemic in the context of tourism and sustainable development. Girish [20] examined the resilience of the tourism industry to pandemics at the macro, meso and micro-level within the Covid-19 pandemic. Chebli and Ben Said [7] evaluated the effects of Covid-19 on tourism satisfaction. At the same time, Karali [28] analyzed the threats of Covid-19 to tourism and suggested the measures to be taken from the tourism stakeholders' perspective. Farzanegan et al. [17] studied the impact of Covid-19 on international tourism in 90 countries and reported more deaths in countries with high global tourist flows. However, the number of studies on rural tourism is minimal [41, 51, 53].

As with the world literature, there has been a significant increase in academic research on Covid-19 and the tourism sector in Turkey. Özçoban [38] has underlined Covid-19's impact on Turkish tourism and stressed the potential of rural tourism. Arslan and Kendir [2] evaluated the opportunities offered by the pandemic in their study in Zile, Tokat. However, research conducted under Covid-19 and rural tourism have remained extremely limited. Bilim and Özer [5] and Şengel et al. [46] have suggested that camping and caravan tourism could be an alternative to the new social distance-based holiday. Düzgün [16] assessed glamping tourism for The Post-Covid-19 period. The only destination-focused research on rural tourism was conducted by Gürbuz and Özkan [24] and focused on the opportunities and challenges that the pandemic brought to rural tourism in Trilye, Bursa.

This research investigates visitor satisfaction in the rural tourism, which has become increasingly important in recent years but has suddenly attracted attention with Covid-19. For this purpose, İznik district, a popular tourist destination with its historical and natural beauties in Bursa province, was selected as an example. The research also aimed to put forward recommendations for raising tourist satisfaction and addressing the problem that is a source of dissatisfaction.

The primary theoretical principles of this research testing are;

How satisfied were the tourist with the destination after the Covid-19 measurements were taken?

Are satisfaction levels differing in terms of visit characteristics?

What are the recommendations of tourists to improve satisfaction?

MATERIALS AND METHODS

Study Case

İznik, known as Nicaea in ancient times, has been recognized by the Christian world as the third "holy city" after Jerusalem and the Vatican. The First Council of Nicaea was a council of Christian bishops convened in the Bithynian city of Nicaea (now İznik, Turkey) by the Roman Emperor Constantine I in AD 325. This ecumenical council was the first effort to attain consensus in the church through an assembly representing all Christendom. The city was the capital of the Anatolian Seljuk (1075-1097), Byzantine (1204-1261) and the Ottoman Empire (1331-1335).

The agriculture sector has the most prominent role in the district economy, and İznik has a high potential for agricultural tourism. The second primary sector in İznik is tourism. The city was accepted to the Unesco World Heritage Tentative List on April 15, 2014, and efforts continue to be included in the main list. One of the most critical assets of the town is Lake İznik, which also carries the town's name.

İznik Grape Festival, first held in 1964 in İznik, was changed to the international İznik Festival in 2006 and started to be organized as a more comprehensive event and is held annually in August. The İznik Fair has been organized since 1935 between October 5-9 every year. Crafts, local food and textile are introduced in the stands opened during the fair placed around Lake İznik. Recreational activities are also available. Since 2011, the İznik Ultra Marathon has been organized. It is held annually in April for two days and is the longest trail marathon in Turkey. İznik's most famous trekking route is the Evliya Çelebi Road, which follows the route Evliya Çelebi followed on his pilgrimage to Mecca in 1671. Another gem of İznik is the Sansarak Canyon. This is a 7km long canyon in the forest, located in the village of Sansarak and contains pools that can be swum in summer and a medium-level trail of 1.7 kilometres. Trekking activities and nature tours have started in recent years. Hacı Osman Village and its surroundings have also begun to host people interested in paragliding and grass skiing.

Lake İznik, the fifth largest lake in Turkey and the largest in the Marmara region, is also suitable for swimming in summer. There are olive groves, vineyards and vegetable gardens around the lake. Besides, freshwater fish such as carp, trout and catfish in the lake provide added value to commercial businesses and tourism around the lake. The Equinox Festival is held in March and September every year to view the sunset on the lake. İznik also has an untapped potential for camping and caravan tourism.

İznik district was mostly preferred for day trips until the Covid-19 pandemic. It is only one hour away from Istanbul with the new Osmangazi Bridge. Its proximity to major industrial cities such as Istanbul, Bursa, Yalova and Kocaeli, being away from the coastal crowds and offering a wide range of rural activities make İznik a trendy rural tourism destination.

Measures

The primary material of the research is the data obtained from a survey conducted with visitors to the İznik district centre and İznik Lake in Bursa province. The survey consisted of four parts. The first part included demographic characteristics of visitors, such as gender, age, education, and income status. The second part included nine questions to determine the visit profile. These are the purpose of the visit, type of lodging, length of stay, number of visits, destination information source, average daily spending per person, whom they holiday with, mode of transportation and whether they used a travel agency or individual travellers. The third part contained 11 statements to measure tourists ' satisfaction levels with the area and services they received during their stay in İznik. The final section included 9 statements that contained suggestions for increasing the satisfaction levels of tourists. We used five-point Likert scale statements that possible responses ranged from 1=*strongly disagree*; 2=*disagree;* 3=*neutral*; 4=*agree*; 5=*strongly agree*.

The survey was self-administrated and structured. The preliminary survey was appraised by academicians who are agriculture experts and tested via Google Meet with ten people. Some statements have been rephrased to make them easier to understand, and the survey has been finalized.

We have used the convenience sampling method and activated the final survey on social media between July 1 and November 30, 2020, on Twitter, Facebook pages of the provinces in the Marmara Region, and related tourism/travel/travel guides hobby and travel pages. The study's target population consists of visitors living in the Marmara Region and have visited İznik and its surroundings between June 1, and September 30 2020, when the bans on intercity travel were lifted [35]. Due to reduced flights and coach services, we only included part of the country. The Marmara Region accommodates 30% of the total country's population [36].

Cochran's [10] formula gives the minimum sample as 384. We conducted an online survey, and we had the opportunity to reach a broader sample. Survey access was terminated when the number of participants reached 700. After carelessly completed surveys were eliminated, 648 surveys suitable for use were analyzed. Besides, additional comments left on the media platforms were considered when necessary.

Data analysis

The data obtained from the survey forms were processed into the SPSS 23.0 package program. We performed the Cronbach's alpha test to measure the internal consistency coefficient of the items included in the questionnaire. We calculated Cronbach alpha as α = 0.824; therefore, our survey meets the reliability criterion. Additionally, the mean, standard deviation kurtosis and skewness values of the variables were calculated. Next, we tested the normality assumption using The Shapiro-Wilk test. The analysis showed that [D(648)= 0.982 p< 0.001] the data does not provide normal distribution. Therefore, we used the skewness and kurtosis values and found a skewness of 0.257 (SE = 0.096) and kurtosis of 0.115 (SE = 0.192). George and Mallery [19] suggest that the data show the normal distribution in cases where the corresponding variables have kurtosis and distortion values are in the range of ±2. Frequency, percentage, mean score and standard deviation values were calculated in the data analysis. Non-parametric data were analyzed by the Chi-square and Kolmogorov-Smirnov tests.

RESULTS AND DISCUSSIONS

Demographic results

Gender distribution shows that 62.7% of the participants were women, and 37.3% were men. A relatively even distribution of age: 50-64-year-olds were the highest with 31.4%, followed by 40-49-year-olds with 24%, 18-29-year-olds with 22% and 30-39-year-olds with 18.3%. Education levels show that 84.2% of the participants were university graduates, and 13.8% were high school graduates. Nevertheless, previous research has also reported that participants in online surveys are usually highly educated. The occupational distribution analysis reveals that white-collar employees in the private sector (25.2%) and civil servants (25.4%) were almost equally distributed. This was followed by retirees (19.3%). Finally, the individual income of more than half (59.8%) of the participating visitors was around ₺4,000-9,000 (₺=Turkish Lira). 17.2% were calculated to be just above the minimum monthly wage (Turkey's legal minimum monthly wage was net ₺2,324.70 in 2020).

Tourist satisfaction

Stringent measures were put in place across the country from March 2020, when the first case of Covid-19 was reported, until June 2020. Except for those in the compulsory sectors, a 'stay-at-home' order was applied for lengthy periods. Intercity movement is prohibited. Previously made reservations were cancelled, postponed or changed in destination preferences. As of June 1, with the new measures, tourism regions could start their activities. The people, who had already panicked and stressed by the stringent quarantine measures, determined their holiday preferences under the 'new normal' conditions. This study examines tourists' satisfaction with the specified destination under the new measures introduced. Hospitality scored the highest mean score (Table 1). Thus, the attitude of local people directly affects tourist satisfaction, especially in understanding more individual and experience-oriented holidays.

Table 1. Satisfaction levels of customers

Statements	M	SD
Hygiene standards and measures taken in food and beverage establishments are sufficient	2.69	1.04
Hygiene standards and measures taken in accommodation facilities are sufficient.	3.96	0.98
Hygiene standards and measures taken in entertainment and recreation facilities in the area are sufficient.	3.39	1.18
Accommodation facilities are affordable.	4.03	1.03
The Environment (City Centre, Lakeside, hiking trails) is clean.	2.56	1.14
The region's infrastructure (sewerage, road, water, etc.) is sufficient.	2.15	0.83
Local people are hospitable.	4.12	1.10
The natural beauty and animal species are protected.	3.44	1.15
The publicity of the region is sufficient.	2.45	1.14
Food and drink facilities are affordable.	3.55	0.98

M= Mean, SD= Standard Deviation
Source: Field survey, 2020.

In his work to understand the local attitude towards tourism, Doxey [15] states that local people react at various levels depending on tourism development in their region. As they encounter tourism, their perceptions of tourism also change. The enthusiasm among the locals in the early years gives way to apathy, discomfort and even hostility over time [18]. Similarly, Butler [6] states that the stage of tourism at the destination and the number of tourists arriving at the destination are the main factors affecting the local attitude towards tourism. The increasing number of tourists coming to the region will increase their income so that local people will favour tourists in the early years. However, every destination has a capacity threshold. Once this capacity is exceeded, in other words, as tourist-local people interaction increases over time, local people begin to think that tourists interfere with their daily lives, and their perception of tourism becomes less favourable [11,12]. Elimination of these negativities depends on the ability of the local people to be aware of the effects of tourism [48]. İznik and its surroundings have been open to tourism for a long time; however, it was more a transition point than the lead tourist destination. Therefore, the destination has not yet reached its saturation. In addition, with the economic contraction after Covid-19, local people saw tourism as a revival and showed maximum hospitality to the tourists. Thus, local hospitality achieved the highest satisfaction.

Participants believed that hygiene standards and measures in accommodation facilities were sufficient, and the region's prices were affordable. In 2018, 2,000 foreign tourists and around 35,000 local tourists stayed. This was equivalent to three days for the total bed capacity and 1.5 months' occupancy. Hotels were empty for the remaining ten months of the year. Due to these low occupancy rates, lodging was affordable in the pre-Covid-19 period. The Ministry of Culture and Tourism has developed a Safe Tourism Certificate program. This program aims to implement cleaning, hygiene, and distance rules and ensure compliance with all services such as transportation, accommodation, food and drink [47]. This program obliges tourism enterprises to take extra hygiene measures, use disposable materials, and accept customers up to 60% of their available capacity. The need to comply with these measures has increased the running costs of accommodation facilities. Nevertheless, with many businesses closed and money circulation reduced, locals have tried not to reflect the cost increases in accommodation prices. This sacrifice was positively received by tourists and resulted in high satisfaction with the accommodation prices (M=3.55). However, it was not possible to see the same positive picture of food and drink facilities and prices. Visitors found the current food and beverage prices in the area considerably high. Besides, the number and varieties available of these facilities were among the issues criticized by visitors. Although this is generally a problem in rural areas, visitors especially wanted to see more eateries, stalls, and cafes that sell local dishes and drinks.

Most likely, in direct proportion to the price of the service they receive, tourists were satisfied with hygiene measures in recreation and accommodation facilities but were not satisfied with restaurants and cafes. In a panic environment caused by Covid-19, everyone pays utmost attention to cleanliness and hygiene, which has raised expectations. While distance and movement can be controlled in accommodation facilities and recreation areas, the need to serve quickly in small restaurants might have created this hygiene dissatisfaction.

Visitors were satisfied with the natural beauty in and around İznik and the conservation of animal species. (M=3.44). On the other hand, they seemed to be very dissatisfied with environmental cleanliness (M=2.56). Especially the city centre picnic areas and popular walkways were not left clean by some visitors. The lack of garbage collection boxes provided and the inability to perform cleaning work effectively by local authorities played an essential role. Dissatisfaction with the region's infrastructure adequacy was high (M=2.15).

Local infrastructure services are insufficient in small settlements in Turkey. This inadequacy is more pronounced during the summer months when visitor numbers multiply. Existing municipal services that are set up for the small population cannot respond to the needs of this seasonally increasing crowd. Central governments carry out tourism plans and give priority to mainstream tourism. On the other hand, rural areas are prioritized for their problems with agricultural activities. Additionally, Covid-19 has increased the workload of the municipalities serving the countryside. The local government also had to do more social work and cleaning, with fewer employees (illness, work rotation and social distance requirements). Thus, dissatisfaction with these issues, which was also the primary complaint in pre-Covid times, has become more apparent during the pandemic.

Visit characteristics and satisfaction levels

We examined the relationship between the satisfaction levels of tourists visiting İznik and the visit characteristics. Participants were asked to comment on their overall satisfaction and the specific expressions of satisfaction given in Table 2. The relationship between tourists' satisfaction and each studied variable was tested with Chi-Square and ANOVA analysis (0.05 and 0.01 significance levels). A statistically significant association was found between all the variables studied (excluding length of stay) and tourist satisfaction at 1%. The relationship was significant at 5% for the length of stay.

Research has shown that visitors were generally satisfied with the accommodation. Over 60% of visitors were satisfied with the stay. The previous section showed that visitors were satisfied with lodging prices and hygiene measures. Those who stayed with family and relatives (75%) and those who stayed in camps and caravans (65.2%) had the highest satisfaction, indicating that people were more satisfied in places where they felt attachment and controlled cleanliness and order. As mentioned in the early literature, a high level of satisfaction with camp and caravan accommodation indicates that caravan visits will quickly become the preferred type of holiday and accommodation. The social distance requirements during the Covid-19 pandemic, unspoilt nature, and the calm and peaceful environment could be why satisfaction in campsites is high.

The satisfaction was lowest in bed and breakfast (B&B). Similarly, the satisfaction of B&B residents (27.8%) was the lowest in the study conducted by Kılıç and Pelit [31] in the coastal countryside of Akcakoca in Düzce province, and satisfaction of those staying with family and friends was the highest (38.4%).

People who went to İznik and Lake İznik to escape the city crowds and be in nature (66.7%), picnic or experience local cuisine (63.1%) had the highest satisfaction. The lowest satisfaction was seen in those who went with the hope of having fun (33.3%). Because of the pandemic, all entertainment activities were cancelled, and such places were closed. It was observed that those who visited for cultural purposes were relatively less satisfied with their visits. This dissatisfaction could be because museums closed and tour services terminated.

The tourists' satisfaction when it came to İznik and its surroundings by relying on their previous experience (60%) and recommendation (59.4%) was the highest. About half of those informed through the media and travel agencies were equally satisfied with their visit (44.4%). These findings are similar to those of Kılıç and Pelit [31]'s research. The highest level of satisfaction in the named study was achieved by those who came on advice (50.7%). Those who went with the information gained from the media scored the lowest level of satisfaction (38.3%).

Visitor numbers are directly related to their satisfaction; satisfied visitors will revisit the destination. Although the high satisfaction rate of the first visit (65%) decreased slightly on the second and third visits, the satisfaction of people who visited the region for the fourth and higher times increased (62.5%). Since previous visits were in pre-covid periods, visitors were satisfied with the measures taken in the region during the Covid-19 period.

Neal et al. [37] state that the duration of time spent on vacation will affect the tourist's satisfaction from vacation. So, the longer the tourists' vacation, the higher their satisfaction will be. Because the longer the tourists stay on vacation, the more they will benefit from the region's opportunities, interact more with the local people, and gain more experience.

Therefore, the satisfaction of those who stay more on the trip will be higher than those who do not. Contrary to mentioned research, current research has shown that the visitors with the highest satisfaction are day visitors.

Table 2. Comparison of tourist profiles and satisfaction levels

Profile	Satisfaction levels							
	N	%	SA	A	N	D	SD	
Accommodation Type								
Summer Rents	78	12	15.4	46.2	30.8	7.7	0.0	
Bed and Breakfast	156	24.1	19.2	34.6	26.9	15.4	3.8	
Hotel	30	4.6	0.0	60.0	40.0	0.0	0.0	X^2 (20) = 171.69
Family& Friends	24	3.7	25.0	50.0	25.0	0.0	0.0	$p< 0.001$
Day Trip Only	222	34.3	25.0	50.0	25.0	0.0	0.0	
Camp/Caravan	138	21.3	17.4	47.8	30.4	0.0	4.3	
Purpose of visit								
Trekking	96	14.8	31.3	18.8	25.0	18.8	6.3	
Swimming/Water Sports	68	10.5	10.3	44.1	26.5	8.8	10.3	
Restaurant//Picnic	65	10.0	26.2	36.9	27.7	9.2	0.0	
Rest / Escape to Nature	216	33.3	27.8	38.9	19.4	8.3	5.6	X^2 (28) = 108.17
Fishing/Hunting	63	9.7	17.5	38.1	25.4	9.5	9.5	$P < 0.001$
Family & Friends Visit	36	5.6	16.7	33.3	33.3	16.7	0.0	
History/Culture	50	7.7	24.0	24.0	24.0	16.0	12.0	
Entertainment	54	8.3	11.1	22.2	44.4	11.1	11.1	
Number of visits								
First	120	18.5	20.0	45.0	25.0	5.0	5.0	
Second	156	24.1	15.4	34.6	19.2	15.4	15.4	X^2 (17) = 118.87
Third	132	20.4	18.2	22.7	40.9	13.6	4.5	$p< 0.001$
Fourth and more	240	37.0	20.0	42.5	25.0	7.5	5.0	
Information Source								
Media	72	11.1	16.7	33.3	33.3	8.3	8.3	
Past Experience	330	50.9	16.4	43.6	23.6	12.7	3.6	
Recommendation	192	29.6	25.0	34.4	21.9	12.5	6.3	X^2 (12) = 125.55 $p< 0.001$
Travel Agencies	54	8.3	11.1	33.3	33.3	11.1	11.1	
Length of stay								
Day Trip	222	34.3	25.0	36.4	18.2	11.4	9.1	
Weekend Break	258	39.7	25.0	30.6	16.7	13.9	13.9	
Up to 1 week	138	21.3	13.0	34.8	34.8	13.0	4.3	X^2 (12) = 32.74 p =0.001, $p< 0.005$
Above a week	30	4.6	20.0	40.0	20.0	20.0	0.0	
Average daily spend (TL)								
0-50	156	24.1	23.1	34.6	23.1	15.4	3.8	
51-100	198	30.6	12.1	48.5	24.2	12.1	3.0	
101-250	144	22.2	25.0	37.5	16.7	12.5	8.3	X^2 (4) = 54.66 $p< 0.001$
251-500	78	12.0	7.7	30.8	38.5	15.4	7.7	
500+	72	11.1	8.3	58.3	25.0	0.0	8.3	
Arrival								
Travel Agency	48	7.4	12.5	25.0	62.5	0.0	0.0	X^2 (4) = 43.77
Individual	600	92.6	19.0	28.0	31.0	13.0	9.0	$p< 0.001$
Accompanied								
Family	291	44.9	11.7	41.9	29.6	10.3	6.5	
Friends	109	16.8	33.0	22.0	18.3	21.1	5.5	
Individually	81	12.5	29.6	33.3	22.2	14.8	0.0	X^2 (16) = 89.01 $p< 0.001$
Partner	98	15.1	14.3	29.6	24.5	19.4	12.2	
Other	69	10.6	17.4	30.4	26.1	17.4	8.7	
Transportation								
Caravan/ motorbike	72	11.1	16.7	33.3	33.3	8.3	8.3	
Private Car	335	51.7	23.3	43.0	17.6	12.5	3.6	X^2 (16) = 134.39
Public Transport	192	29.6	25.0	34.4	21.9	12.5	6.3	$p< 0.001$
Tour/Agency	49	7.6	12.2	36.7	36.7	12.2	2.0	

SA: Strongly Agree, A: Agree, N: Neutral, D: Disagree, SD: Strongly Disagree
Source: Field survey, 2020.

Interestingly, as the stay length increased, the satisfaction level somewhat decreased. Nevertheless, satisfaction levels again rose in visitors who stayed a week and above, confirming Neal et al. [37]'s thesis. Thus, as the rate of stay in the region increases, the decrease in satisfaction may be related to reducing existing activities and amenities due to Covid-19 measures. Holidaymakers have been left in situations such as constantly paying attention to distance and hygiene requirements, queueing longer, and understanding firms providing more services with fewer employees.

Being satisfied with the holiday is highly related to whom the holiday was spent. The expectations and agenda of each individual who makes the holiday are different, and it is not easy to meet and satisfy the expectations of each individual at the same time. It also concerns social structure and habits with whom the holiday will be spent. In Mediterranean origin and family-oriented countries, such as Turkey, the tradition of going on vacation alone has not yet become widespread. Instead, holidays are usually held with family members or groups of friends.

Numerous studies in the literature examine the relationship between tourists' spending levels and their satisfaction. Jurdana and Frleta [27] research showed that satisfaction increases tourists' daily expenditure. The results of Chen and Chang's [9] research confirm that higher visitor satisfaction leads to higher spending. Kim et al. [32] showed that festival satisfaction is an essential determinant of tourist spending. Serra et al. [42] agreed that satisfaction affects tourist spending, with less satisfied tourists tending to spend less. On the other hand, the results of Wang and Davidson's [49] research underlined that satisfaction with travel is not significantly associated with total tourist spending. Kim et al. [32] caution that there is a need for a better understanding of the role of visitor satisfaction in influencing individuals' spending levels.

Current research has not found a linear relationship between daily spending levels and satisfaction levels. However, the satisfaction of those with daily expenses above ₺500 was higher than those above ₺50 and below (The legal minimum daily wage was gross ₺98.10). A similar trend has been recorded in the Kılıç and Pelit [31] research. Although satisfaction at the lowest spending level (31.9%) increased at the next level, it declined rapidly, but satisfaction at the highest spending level became the highest (42.3%).

The satisfaction levels of those who came individually to the study scored highest (62.9%). Visitors who came with friends were the second most satisfied group (55%), followed by family members (53.6%). In the Kılıç and Pelit [31] survey, the lowest satisfaction was obtained from individual visitors (29,8%). The satisfaction levels of those who came with their spouses were the lowest (43.9%). It is reported that stress and disputes have increased in couples who are constantly at home since the break of Covid-19 [4, 50]. Although rural environments are designed to give people peace and relieve stress, research shows that couples cannot relax and are unhappy with their holidays. Although the lowest satisfaction in the current study came from couples, compared to similar studies, their satisfaction levels remain high [31, 36.8%].

The satisfaction of those who came with private vehicles was highest (66.3%), while the satisfaction of those who came with public transport (59.4%) and tours (48.9%) was relatively low. This may have been caused by the worry of contracting the virus and staying in crowded and closed spaces. However, visitors were happy to take a caravan holiday, but they were not happy to travel by caravan. This may have been caused by infrastructure deficiencies in transportation to the campsite.

Suggestions to increase tourist satisfaction

This section puts forward visitors' suggestions to increase their satisfaction with İznik and its surroundings. Table 3 summarises the participants' suggestions for improving visit satisfaction.

Due to the outbreak, tourism activities decreased, and hotel occupancy rates were significantly reduced. Those who wanted to get away from crowded holiday destinations such as hotels and pensions began to show interest in rental homes, villas, camping or caravans. Bungalows, caravans and tents have been heavily favoured as campsites allow for maintaining social distance [3, 46, 52]. Yetiş [52] pointed out that glamping combines luxury and camping and is an option for visitors who wish to escape to nature but do not want to compromise their comfort. Düzgün [16] likewise confirmed that interest in glamping tourism has increased depending on tourist preferences in Turkey and worldwide after the pandemic. Akpur and Zengin [1] stated that Lake İznik and its surroundings have a rich potential in camping and caravan tourism. They also emphasized that the region can be a preferred camp centre if businesses increase service standards. They raised concerns that no certified camping facility complies with international standards in and around Lake İznik. They also reported that the Provincial Directorate of Culture and Tourism office, whom they interviewed, said no planned work on camping and caravan tourism in the region. However, the authors emphasized that the destination has a compelling potential for camping and caravan tourism. The results of this research support the literature [43]. Participants mostly suggested increasing the number of caravan and tent sites and improving the facilities of these cities (M = 4.72). Having shops selling or hiring camping equipment was another point that visitors recommended increasing visitor satisfaction (M=2.88).

Table 3. Participants' suggestions to increase satisfaction levels.

Suggestions	M	SD
Tents and camping facilities should be expanded.	4.27	1.00
More local food and homemade products in stalls and shops	4.12	1.05
It would be helpful to have guided tours for visitors outside organized tours.	4.06	1.08
More food variety in restaurants and eateries should be available.	3.84	1.05
The presence of information boards related to natural/historical sites makes the visit more beneficial	3.77	1.10
Free local maps should be available on the tourism information points	3.45	1.27
Promotion of local amenities needs to be done better	3.34	1.06
Selling non-local products should be restricted	3.00	1.07
There should be shops that sell and rent tents and camping equipment.	2.88	1.36

M= Mean, SD= Standard Deviation
Source: Field survey, 2020.

Another vital aspect expressed by visitors was that instead of selling souvenirs that are now seen everywhere and believed to have been brought from China, shops sell hand-made products (mostly food) specific to the region (M=4.12). A considerable number of participants suggested a ban on selling non-local products (M=3.00). This demand was influenced by the desire to protect the local people, whom the pandemic has badly hit. Also, it is thought that the fear of disease transmission from products that will be imported from China is also compelling.

Respondents highlighted the need for small guided tours for independent visitors (4.06). Visitors also suggest placing information plates on the historical and natural sites would benefit the visit (M=3.77). In the same line, they stressed the need for free local maps (M=3.45). As stated in the previous section of the survey, visitors were dissatisfied with the area's food and beverage facilities and choices. They suggested increasing both the number of facilities and the varieties offered.

CONCLUSIONS

The Covid-19 pandemic has changed people's tourism preferences, and a general trend towards rural tourism activities has begun, where individual activities can be carried out, and social distance can be maintained. The opportunities Covid-19 brings to the tourism sector are predominantly in rural tourism. However, seizing the opportunities and sustaining rural tourism's success is only possible by satisfying the tourists.

This study evaluated tourists' satisfaction levels and determined some factors that positively and negatively impact their satisfaction. We also tried identifying the characteristics of visits where satisfaction levels were highest. Finally, we asked tourists about suggestions that could increase their satisfaction levels and listed the most critical suggestions identified by them.

The hospitality of the local people was the top reason for satisfaction. The most critical dissatisfaction highlighted by the participants was the increasing environmental pollution, the loss of natural beauty, the inability of local governments to do the necessary cleaning and maintenance work, and the lack of introductory information in places with historical and natural characteristics.

Findings related to 'visit characteristics' showed that those who stayed with family and friends or in a caravan, who wanted to escape the city's crowds and be in nature, and who travelled individually and spent 500TL and above were the highest satisfied visitors. The least satisfied visitors were those who came with the hope of entertainment, stayed in B&B and used public transport.

The survey showed a significant increase in demand for camping and caravan accommodation in İznik. An inventory study should determine areas suitable for camping and caravans. One of the most significant shortcomings in İznik is the lack of infrastructure investment. Caravan tourism participants and campers are turning to areas with available infrastructure. Especially investments such as caravan parks and campgrounds should be planned to gain a share of this new and proliferating market.

The National Camping and Caravan Federation states that caravan tourism is not included in the tourism diversity list published by the Ministry of Culture and Tourism. Caravan tourism should be included in the list immediately.

In addition, adequate signposting and local guidance should be provided.

Tourist satisfaction should not be seen only as a problem of small rural enterprises. Instead, local governments should support rural businesses. The number of non-governmental organizations such as 'Green Suitcase' supporting rural tourism should increase. Within the scope of the IPARD (Instrument for Pre-Accession Assistance on Rural Development) 2 call, farmers are given 50% to 70% of the hotel, motel or hostel investments made for rural tourism as grants until 2020. However, farmers are often unaware of these grants or do not apply because they find the application process over complicated. Rural tourism aid packages should be increased, and these should be simple enough for rural people to understand; applications should be eased.

Training programs should be developed to improve the rural tourism management and communication skills of the rural people.

In addition to the 'Tourism and Hotel Management ' departments in universities, the 'Rural Tourism Management' department should be opened. An effective rural tourism management unit should be set up within the Ministries of Tourism.

This research is limited to the District of İznik. Therefore, to better analyze the changing tourist preferences and satisfaction after Covid-19, similar studies must be repeated in different rural destinations with other characteristics. The results drawn from this study will guide local administrators, local businesses and policymakers, especially considering the scarcity of studies on the satisfaction of rural tourists.

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STUDY ON THE PERCEPTION OF EMPLOYERS FROM PUBLIC AND PRIVATE AGRIBUSINESS ENVIRONMENT TO IDENTIFY THE MAIN REQUIREMENTS REGARDING SKILLS OF STUDENTS AND GRADUATES

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Abstract

The purpose of university education in Romania is to prepare specialists in their fields of study who, through the accumulated knowledge, can contribute to the development of society, the improvement of the way of life, innovation, research, and other aspects. These specialists, in addition to the theoretical and practical curricular knowledge that they acquire during the study program, also need other skills, knowledge, trainings, relationships in order to be prepared for integration into the labour market or to start an entrepreneurial path. In a society based on knowledge, the attitude, the competences and the abilities focused on a specific context have a decisive role. Moreover, employers follow very well-defined criteria in their recruitment process. This paper aims to analyse the perception of public and private employers regarding the evaluation criteria of University of Agronomic Sciences and Veterinary Medicine from Bucharest (USAMV from Bucharest) students and graduates. The Centre for Career Counselling and Guidance (CCOC) from USAMV Bucharest aims to acknowledge, study, clarify and implement the main requirements targeted by the employers regarding career orientation process. The research methodology involves an analysis of the specialized literature regarding the tendencies of skills needed for qualified personnel. The case study is composed of a questionnaire applied to commercial companies and institutions involved in an agribusiness field that contains 10 questions. The analysis of the resulting data was processed with the help of statistical methods, and the results obtained after their interpretation give us a clear picture of the HR criteria pursued by employers. We find that 80.4% of them consider theoretical knowledge to be important in the employment of graduates, 72.5% consider that specialized practice it is a must, 58.8% consider that graduates need internships and volunteer activities, but equally important are the digital skills that are underlined by 51% of company representatives. Also, 21.6% of the companies consider that the various personal development activities have an important role in the training of graduates. The challenges regarding a better integration on the labour market, the development of personal skills and their capitalization for added value in obtaining a job based both on generic and specific competences make the collaboration between universities and institutions in the field to be particularly important.

Key words**:** *employers, requirements, skills, students, agribusiness*

INTRODUCTION

As noted by the World Bank report (2002) the role of higher education in particular, is now more influential than ever in the construction of knowledge economies, in the creation of the intellectual capacity on which knowledge production and utilization depend and to the promotion of the lifelong-learning practices necessary for updating people's knowledge and skills [2].

The perceived demand for different skills has prompted policymakers to develop frameworks to ensure that educational institutions deliver skills that will be able to meet labour market demands.

It is widely recognized that changes in the nature of work and the workplace in modern economy are transforming the types of knowledge, skills, and attitudes needed for successful employment and work performance (OECD 2011) [13].

A different paradigm of skills is emerging and new skills are becoming important to employers and the labour market.

Grouping skills in four categories is used in literature: *cognitive skills* are usually acquired through formal education (skills such as problem solving, critical thinking, ingenuity, creativity) which may be transferable to work situations; *generic skills* [3] that include things such as communication, team work which may be transferred into the work process; *technical skills* which refer to specific skills required to perform a targeted occupation or job; *soft skills* that are hard to conceptualize, define and are not as easily measured such as time management, emotional intelligence, leadership, critical thinking [12]. In the 21st century soft skills are called “applied” skills or “21st-century skills”. They are considered an important factor for achieving job position and life success.Two different studies, one conducted by Harvard University which notes that 80% of career achievements have been impacted by soft skills, while the second study conducted by Stanford Research Institute cojoined with Carnegie Melon Foundation among the Fortune 500 CEOs certifies that their solid career in work is based 75% on soft skills and 25% on hard skills [15]. Thus, it becomes more obvious that high education institutions should aim to prepare qualified professionals but as well to improve and grow their personal abilities. According to Cambridge Dictionary “soft skills” represents people abilities to communicate with each other and work together. It is highlighted that soft skills are becoming more important in companies` recruitment decisions while the tags are workplace and HR [4]. Soft skills, such as friendliness and team work, and feature such as emotional intelligence have been highlighted as the skills that have the biggest importance in the current labour market [1, 7]

Human capital can be broadly defined as the stock of knowledge, skills and other personal characteristics embodied in people that helps them to be productive (OECD) [14].

From the perspective of labour supply, human capital theories refer to skills of persons as a specific form of assets in which individuals make investments and may capitalize on them. From this perspective, human capital includes not only tuition, but also a variety of work-related individual abilities and attributes [11, 16, 17].

In order to achieve a quality guidance services in the European Union, the Council of EU has adopted in 2008 a resolution regarding improving the purpose of lifelong guidance throughout lifelong learning strategies [6].

One of the aspects considered in a growing trade globalisation and lengthening of period of active employment is that individuals need to adapt their skills in order to assure the safety of a career path. Another aspect refers to the increased mobility in education, training and in the labour market. The transitions` in citizens lives like from school to vocational education and training (VET), higher education or employment, from employment to unemployment is to be consider.

According to ***Council Resolution on better integrating lifelong guidance into lifelong learning strategies***, Brussels, 21 November 2008, the state members of EU are invited to strengthen the role of lifelong guidance within national lifelong learning strategies in line with the Lisbon Strategy and with the strategic framework for European cooperation in education and training. The Council of the European Union by prioritising the areas of application recommends to encourage, facilitate, develop and cooperate in the field of lifelong acquisition of career management skills, guidance services and provide guidance to the population. (pupils, university entrants, job-seekers, those in vocational training and those in employment) [5].

Taking into consideration the EU Council recommendations Romania regulates lifelong career counselling and guidance services through Romanian Government order no. 1.804/4.469/2012 [18]. The order sets the general, institutional and conceptual framework through which lifelong career counselling and guidance services are carried out. In addition to this order the Ministry of National Education from Romania issued the order no. 650 from 19 of November 2014 which states the framework methodology regarding the organization and operation of the centres of career counselling and guidance in the Romanian higher education system.

The order defines career counselling and guidance as a sum of all services and activities which helps people of any age and at any moment of their existence to make choices in the sphere of education, training or work in order to manage their career. The services refer to counselling, guidance, reducing university dropout, facilitate the relationship between students and the labour market and increasing the employability of students in the fields of graduated studies. Furthermore, the activities cover educational, vocational, career, psychological counselling and evaluation. The aspect of labour market integration of students and graduates covers activities as preparing on employment portfolio, job interview simulations, companies' presentations, training sessions for the development of transversal skills of students, participation in alumni activities [8, 9, 10]. To be in harmony with acting legislation University of Agricultural Sciences and Veterinary Medicine Bucharest (USAMV from Bucharest) issued Regulation on Organization and Operation of Centre for Counselling and Career Orientation (CCOC) [19]. The CCOC main mission is to provide employment opportunities, to facilitate and to consolidate the relationship between students and the labour market environment, through soft skills development, self-knowledge, self-image, adaptation, social integration, school success, acquisition of effective learning techniques.

MATERIALS AND METHODS

Research methods applied in this study are the analysis of specialised literature relating to the skills of students and graduates who can make the difference in successfully integrate into the labour market and a quantitative survey by applying a 10 question to the targeted group.

The target group was represented by commercial companies and institutions involved in the agribusiness field. The questionnaire was developed and completed online by the subjects.

It was applied between March and October 2022, and the number of respondents was 51.

The evaluative questions on which the study was based on were as follows:

Please indicate the form of financing of your company or institution. Please indicate the number of employees of your company. Please indicate the turn over achieved in 2021. Which of the following criteria do you consider to be important when a student/graduate of higher education (USAMV from Bucharest) is evaluated, with the purpose of hiring a specialist? What kind of services should benefit the students of USAMV from Bucharest, in order to integrate more easily into the labour market? How much do you rate a student/graduate on the way they have prepared their curriculum vitae? Currently, within your institution, do you have employees students/graduates from USAMV Bucharest? To what extent do you estimate that the skills and knowledge acquired during studies by USAMV Bucharest students /graduates match the job description requirements in your company? Would you be willing to conclude a partnership agreement with USAMV from Bucharest with purpose of improve student skills by offering internship programs and workshops within your company? What recommendations do you have for the Centre for Counselling and Career Orientation (CCOC) in order to increase employability among USAMV Bucharest students/graduates?

The questionnaire covered the following aspects:

-the mix of cognitive, generic, technical and soft skills;

-services and activities result for smoother integration in the labour market;

-specific workplace skills and abilities.

The assessment limits were given by:

-the collected information was both perception and technical level;

-the questionnaire was applied to commercial companies and institutions involved in the agribusiness field;

-data analysis was interpreted through descriptive statistical methods.

Characteristics of the respondents' group

43 small and medium size enterprises (SME`s) and large enterprises, 2 non-governmental organisation (NGO), 6 public institutions. The data processing was done

using statistical methods and the results were presented in tables, graphs and throughout interpretation.

RESULTS AND DISCUSSIONS

The current study was conducted with the assistance of a 10-question questionnaire and the data collected is related with the perception of public and private employers regarding the assessment criteria of USAMV Bucharest students and graduates from the perspective of the attributions, which have been empowered to CCOC by USAMV Bucharest Senate.

The information gathered indicates the type of financing form the target group benefits.

It results that 84% of the respondents relay on private budget, 12% on public budget, 4% both on private and public budget (Table 1).

Table 1. Type of financing

No. of Employers	Type of financing	%
43	private	84%
6	public budget	12%
2	private & public budget	4%

Source: own processing.

For 35 commercial enterprises we have the requested data. For 8 enterprises the data is not eloquent as they are part of offshore companies, groups or not available to the public. From a total of 14,356 employees, 12,553 are enrolled in *large enterprises*, 1,506 in *medium-sized* enterprises, 259 in *small enterprises* and 38 in *micro enterprises*. For public institutions and NGO`s the financial data are not relevant to this study because of the source of financing (Figure 1).

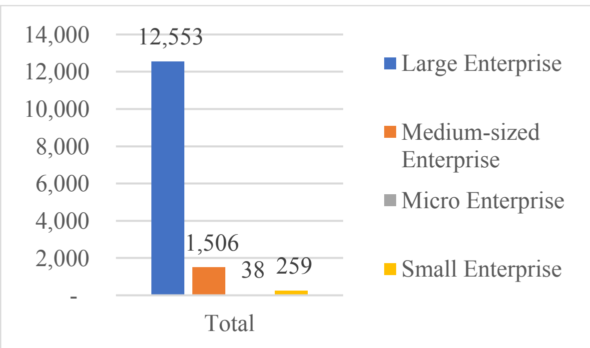

Fig. 1. No. of employees by enterprise size (2021)
Source: own processing.

In Figure 2 we note that from the total number of 14,356 employees, 87% are represented by *large enterprises*, 11% in *medium-sized enterprises*, 259 in *small enterprises* and 38 in *micro enterprises*.

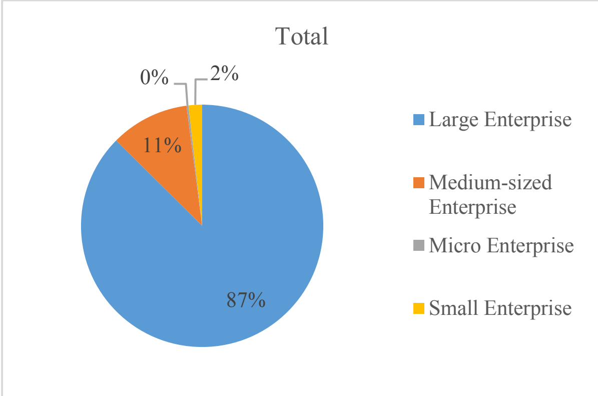

Fig. 2. Share of no. of employees by enterprise size (2021)
Source: own processing.

The third indicator is 2021 turnover. We find a total turnover for *large enterprises* of 5,405,259 thousand Ron which represents 80% of total turnover of 6,757,153 thousand Ron.

Medium-sized enterprises share is 1,079,711 thousand Ron representing 16% of the total, while small enterprises share is 241,348 thousand meaning 4% and micro enterprises represents 0.46% with 30,834 thousand Ron (Figure 3).

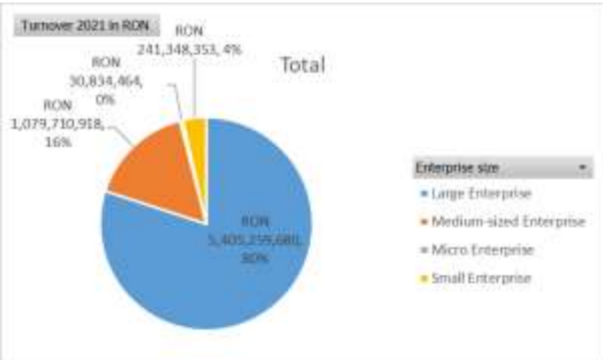

Fig. 3. Share of turnover by enterprise size in 2021 (thousand Ron)
Source: own processing.

For questions 4 to 10, all the answers of enterprises and institutions were taken into consideration. (51 respondents)

Question no. 4: *Which of the following criteria do you consider to be important when* *a student/graduate of higher education (USAMV from Bucharest) is evaluated, with the purpose of hiring a specialist?* It is a question with a multiple-choice answer.

We find that 41 (80.4%) of the respondents consider theoretical knowledge important as being on in first place, 37 (72.5%) specialized practice as 2nd place,30 (58.8%) internship and volunteering activities as 3rd, 26 (51%) digital competences as 4th, 11 (21.6%) self-improvement courses as 5th. A notable result comes from 3rd place with almost 60% of the respondent choice. The internships and volunteering activities are very likely to improve and develop students' soft skills (Figure 4).

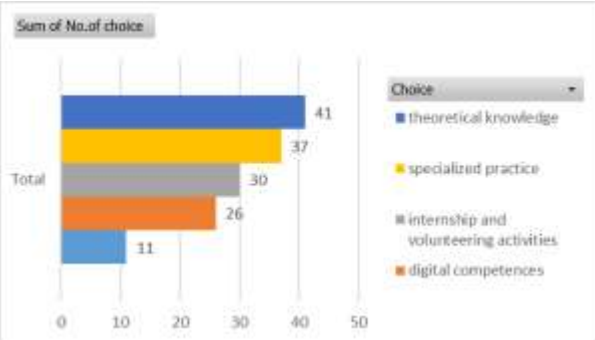

Fig. 4. Specialist hiring criteria choice
Source: own processing.

Question no. 5: *What kind of services should benefit of the students of USAMV from Bucharest, in order to integrate more easily into the labour market?* It is a question with multiple choice answer.

From the answers collected 36 (70.6%) of respondents suggested counselling and career guidance services, 27 (52.9%) employability workshop, 18 (35.3) improvement courses and 12 (23.5%) vocational counselling. The answers received show that different type of services should be provided (Figure 5).

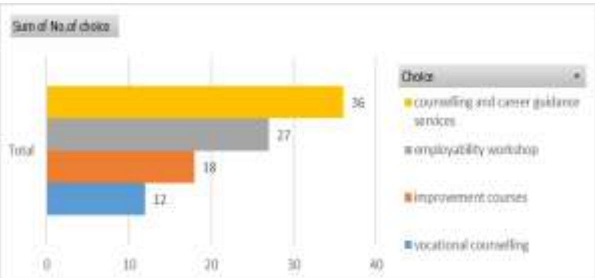

Fig. 5. Type of services to provide
Source: own processing.

To question no. 6 which refers to how much the enterprise/institution rate a student/graduate way of preparing their curriculum vitae from 51 respondents, 30 consider important, 19 very important and 2 it is not relevant. We note a determined result regarding the preparation of curriculum vitae as Figure 6 is showing below.

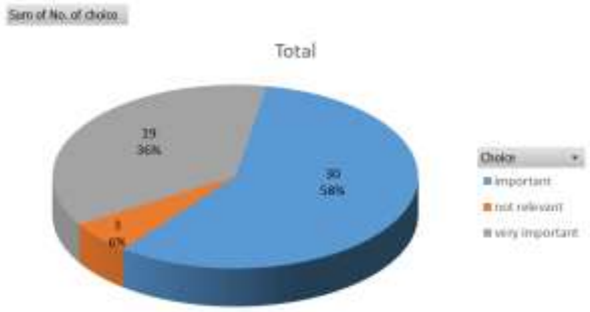

Fig. 6. Curriculum vitae preparation importance
Source: own processing.

Question no. 7: *Currently, within your institution, do you have employees students/graduates from USAMV Bucharest?*

33 (64.7%) of the respondents currently have USAMV from Bucharest graduates employed, 6 (11.8%) students and 12 (23.5%) neither of them employed. We note that the percentage of both graduated and students employed in the target group companies represents a total 76.5% (Figure 7).

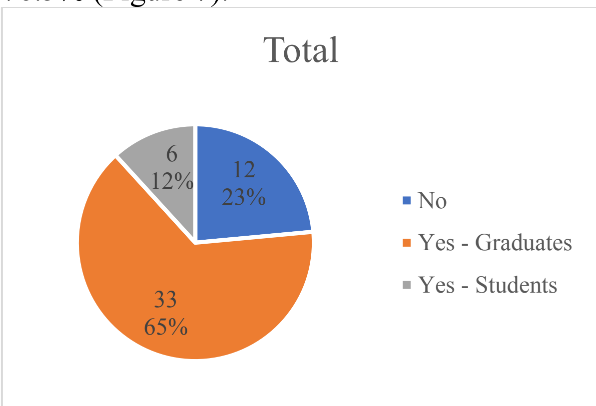

Fig. 7. Students/graduates employed by respondents
Source: own processing.

Question no.8: *To what extent do you estimate that the skills and knowledge acquired during studies by USAMV Bucharest students /graduates match the job description requirements in your company?*

22 (45.8%) of respondents consider that the skills/knowledge fits well, 18 (37.5%) matches to a great extent, 6 (12.5%) not sufficient and 2 (4.1%) cannot tell. 3 of the answers were invalidated as for choosing multiple variants. We note that over 83% of the 48 that validated on answer found the skills as a match. The key figures are represented in Figure 8.

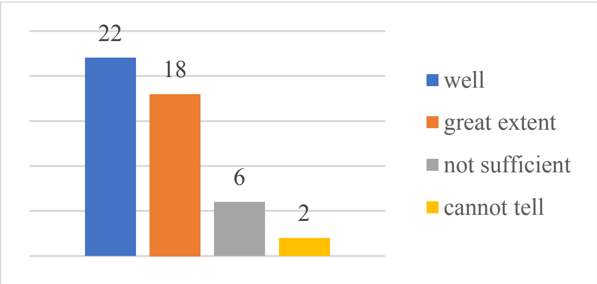

Fig. 8. Skill/knowledge match with job description
Source: own processing.

Question no. 9: *Would you be willing to conclude a partnership agreement with USAMV from Bucharest with purpose of improve student skills by offering internship programs and workshops within your company?* The question intends to conclude if enterprises are willing to participate to the student self-improvement and moreover through the internship programs their intent regarding self-growing specialised personnel. We note that 43 (84.3%) of the respondents answered affirmatively while 9 (17.6%) said no (Figure 9).

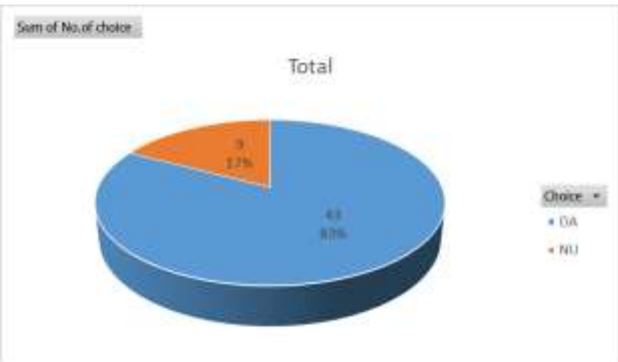

Fig. 9. Partnership with USAMVB option
Source: own processing.

Question no. 10: *What recommendations do you have for the Centre for Counselling and Career Orientation (CCOC) in order to increase employability among USAMV Bucharest students/graduates?* This is an open question and it was addressed in order that the enterprises representants to mark their point of view with aspects that is capital for the students self-development. To summarize the most important aspects raised by respondents: the experience accumulated during workshops, volunteering activities, internships contribute to the assembly of a student profile which will be attractive for the employer; guidance to short-term courses that help professional development; organising periodic meetings between students and employers representatives; developing students skill; identifying opportunities for their personal and professional development; increasing the degree of visibility of the parties: students and employers.

CONCLUSIONS

The analysis of the specialized literature in conjunction with the legislation in the field, to which the present study is added, shows that in a global, dynamic market in perpetual change, the adaptability is one of the major aspects that can influence a better integration on the labour market, a consolidation as continuous development in career and implicitly the increase of self-respect and confidence. The results show that, in addition to the specialized curriculum, students and graduates must also possess the so-called essential soft skills in order for them to be integrated into a system of knowledge accumulation throughout life. All these soft skills as knowledge will contribute to a dynamism of learning and will create a causal link between theoretical knowledge and its application in order to bring added value to society. These are acquired and developed following experiences that are targeted for this aspect. The companies in the field make a special effort to ensure that these skills are included in the curriculum vitae of the student/graduate. Moreover, the companies show a great openness in concluding lasting and sustainable partnerships with the precise aim of improving students' skills and in this way facilitating their inclusion on the labour market. Throughout the study, we show that both employers, commercial companies, public institutions or NGOs and specially created university organizations have the common purpose to increase their visibility in order to identify new opportunities for the personal development of students.

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This article is a part of individual programme of research for the doctoral thesis entitled: *Research on students' perception of content digitization in relation to the business environment in the agri-business field.*
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STUDY REGARDING THE IMPORTANCE OF PARTICIPATION IN EXTRACURRICULAR ACTIVITIES ORGANIZED BY CENTRE FOR CAREER COUNSELLING AND GUIDANCE WITHIN UNIVERSITY OF AGRONOMIC SCIENCES AND VETERINARY MEDICINE FROM BUCHAREST WITH THE AIM OF CONSOLIDATING CAREER DEVELOPMENT IN THE AGRIBUSINESS FIELD

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Abstract

Mobility is one of the aspects that define the current era, where distances are no longer a barrier both in terms of university studies and the possibilities of integration into the labour market or entrepreneurship. The skills acquired through extracurricular activities and digital skills are essential to have an easy path in professional development and access to a job focused on the field of university studies. The awareness of students and graduates regarding the accumulation of experiences from activities adjacent to the field of study and their sedimentation can bring them more personal and professional value. This paper aims to analyse the student perception and the importance of participation in extracurricular activities organized by The Centre for Career Counselling and Guidance (CCOC) for students and graduates of University of Agronomic Sciences and Veterinary Medicine (USAMV) from Bucharest in accordance with the rigors of the labour market. The research methodology involves the analysis of specialized literature regarding the extracurricular training activities that must be considered for the consolidation of a career in the studied field. The case study is composed of a questionnaire that contains 13 questions applied to USAMV Bucharest students and graduates. The resulting data were processed and analysed by statistical methods and the results obtained after interpretation give us an overall picture regarding the students/graduate's awareness of the importance of extracurricular activities. However, the adaptation of activities must be a continuous process and the link between the university environment and the field companies should be strengthen for mutual benefits. Placing graduates in jobs that coincide with professional training remains a challenge. For this reason, a better understanding and application of the process of gaining professional experience during the higher education cycle is a key factor towards a successful career.

Key words**:** *extracurricular, competences, activities, students, agribusiness, education*

INTRODUCTION

According to EU Charter of Fundamental Rights in Title II "Freedoms" access to education, vocational and continuing training is a human right [9]. Education is a powerful tool of development, and an element that could make the difference in health improvement, stability and reducing poverty. Education can be correlated with earnings, health, economic growth, innovation, stability and a strong society cohesion [21].

As Jacob Mincer demonstrates in his research, there is a connexion between the income as wages, years of schooling and years of labour market experience. Summarising the single equation earnings function of Mincer, the more years in education and the more experience in labour market results in higher wages [13].

The Mincer equation explains the return of investment in schooling which is presented in a simple format and allow people to use the results for decision making. As a conclusion, education is a substantial investment for people. As the countries' economies vary, as well as the income returns based on gender, some studies concluded that on average the return of investment for each year of schooling is between 5-8% meaning that investment in education in one of the best an individual may achieve [11,16].

Recent studies based on Mincer equation, shows that globally the biggest returns are 17% from university education, followed by primary education with 10% [14].

Higher education as investment has been linked in human resources theories with benefits mostly in a social and private context [3].

On the other hand, employability is one of the most important outcome as result of higher education. According to researchers the employability is a combination of four factors regarding high education: 'understanding of subject matter' (cognitive skills and technical skills which are obtain through education which are meant to successfully perform a specific job), 'skilful practices' (the generic and soft skills which are meant to bridge the theoretical and practical knowledge, 'efficacy beliefs'(cognitive processing from the perspective of possible threats, 'metacognition' (skills that implies individuals self-assessment as what a person knows, want and can do) [2, 12, 19].

Soft skills may be developed throughout both formal and informal activities. In Europe the formal activities are recognize by the universities through ECTS credits. On the other hand, the informal activities are not regulated through academic curricula. The informal activities may generate soft skills by extracurricular activities such as formation courses, internships, volunteering, leisure activities [8, 20].

From the companies approach the students' informal activities attendance may result in cost reduction in case of internships, because the employer can train the employee for their future job and the student accumulates the training content which is relevant to the future job assignment [15].

Studies confirm that for universities it is an effective strategy to offer to their students the possibility to attend to internships to enhance the employability of their graduates [4, 18].

In terms of volunteering although it is not proved yet that it has a major impact towards employability the results being subjective and empirical [10] from the student/graduate perspective it helps for self-developing skills. The array of impact of volunteering activities for students/graduates may reflect in personal development, transferable skills, academic life, employability process self-confidence, culture and social. Studies have shown that volunteering activities have benefits upon the volunteers. Also, it brings enjoyment and rewards in terms of social networking, new skill acquisition and self-esteem [5].

Another approach referring volunteering activities as direction to employment is that individuals may be helped to identify their motivation, targets and goals.

The connexion between volunteering and employment is a complex one. Volunteering can help improving individual employability but the effect directly to employment is not determinant [15].

Digital skills and digital comprehension is a must have for students/graduates as they become vital for economic growth, innovation and day to day job related operations. From the employers approach the future employees must be 'digitally ready' [6]. The digitally readiness presumes knowledge of computer fundamentals, key applications and the online environment. Digital skills combined with other soft skills may positively affect and facilitate the insertion into the labour market.

In order to obtain a good job in the studied related field the students/graduates must be concerned of shifting between education environment and work environment. A person who achieved significant academic results will be more successful if they have soft skills and they can reveal to the potential employer both the aspects above throughout a letter of intention and a curriculum vitae. These instruments may be the first interface between the candidate and the employer human resource department. An organised and well-structured CV and a well-drafted letter of intention may give the candidate the possibility of attending to first interview for the job applied.

Studies confirmed that the recruiter's perception on the candidates is a mix between academic qualifications, work background and other activities [7].

Students and graduates must understand as well the industry's requirements and expectations when selecting possible candidates. The candidates should have to take proactive measures to take the opportunities they have been providing during their studies. They should focus both on academic and non-academic acquired skills even during the period of their academic formation [1].

As for students/graduates' revenue needs and expectations there are many factors which may be involved. The government policies of minimum wage, the productivity in the targeted sector, the country standard of living, the GDP, lifestyle, social welfare, international mobility possibilities, are the main macro factors that influence the starting wage and time of initial insertion into the labour market. The empirical researches underlined the difference of wage expectations between first year students and final year ones, the expectations being lower for the students in the last year as they are supposed to be more connected with the labour market. Thus, the educational institutions have a determinant role to properly form and prepare the students attitude towards labour market integration [17].

In this context, the goal of this research is to analyse the student perception and the importance of participation in extracurricular activities organized by The Centre for Career Counselling and Guidance (CCOC) for students and graduates of USAMV from Bucharest in accordance with the rigors of the labour market.

MATERIALS AND METHODS

The research methods of the study combine the analysis of specialised literature related to the benefits of higher education studies, additional skills and abilities acquired during the formation curricula and the student/graduate expectations and awareness towards the integration in labour field. The quantitative survey method consists in 13 questions applied to the targeted group. The target group was represented by students and graduates of University of Agronomic Sciences and Veterinary Medicine from Bucharest (USAMV from Bucharest). The questionnaire was developed and applied in an online form on the subjects. The time range of gathering the responses was October 2021 and had 129 responders.

The evaluative questions of the survey were as follows:

Please indicate the faculty you attend to. Please indicate the level of studies. To what extent do you consider the knowledge and skills acquired during the bachelor's / master's / doctorate program are useful in finding a job in the studied field? During the study program did you participate in training courses organized by USAMV from Bucharest? Do you consider that participating in these training courses will or has helped you to find a job or in your personal development? Have you participated in an Erasmus+ mobility program facilitated by USAMV from Bucharest? Did you participate in any internship program during your years of study? Did you participate in volunteer activities during your study years? Do you consider that doing an internship program or volunteer activities is beneficial for professional development and the facilitation of obtaining a job? To what extent do you think it is necessary to prepare a CV already during college? Do you think that accessing recruitment platforms, such as www.usamvjobs.ro, help you find the job you want? Please indicate the degree of importance from your point of view regarding career counselling and guidance support since college. Please indicate if during studies or after graduation you were employed.

The survey covered the following aspects:

-the perception from self-evaluating point of view of students/graduates regarding skills acquired during the formation period;

-the extra academic activities provided by university participation and perception;

-labour market integration taking into consideration the studied field

The evaluation limits were given by:

-the data collected was at technical and perception level;

-the survey was applied to students and graduates of the 7 faculties of USAMV from Bucharest;

-data processing was interpreted throughout descriptive statistical methods.

Respondent group characteristics:

129 respondents of which 84 students, 16 students at master, 27 graduates, 2 PhD students. The information was processed using descriptive statistical methods and the results were presented in graphs, tables and interpretation.

RESULTS AND DISCUSSIONS

The present study contains a 11-questions questionnaire and the input data is related with the students/graduates participation in activities for soft skills acquisition and their perception whether these activities may influence in a positive way the access to labour market insertion in the studied field.

The distribution of respondents covers the 7 faculties of USAMV from Bucharest, observing a larger number of participants within the faculties of Management and Rural Development with 41 and Agriculture with 38 corresponding to the number of students registered in the study programs. All 7 faculties respondents are represented in a share pie Figure 1.

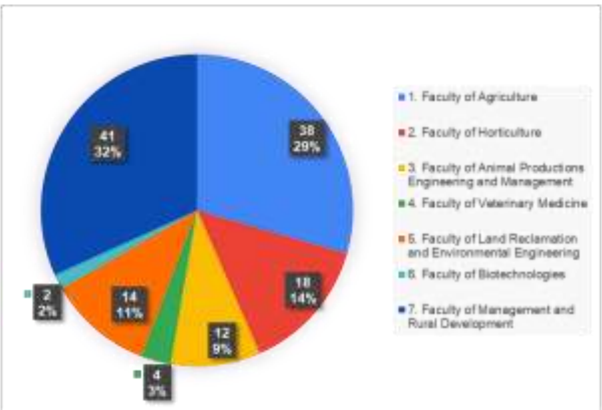

Fig. 1. Share of participants of the 7 faculties
Source: own processing

Figure 2 share pie represents the level of studies of the respondents. We note that from a total of 129 respondents most of participants are students 84 (65%), followed by graduated students 27 (21%), master programs students 16 (12%) and 2 PhD students.

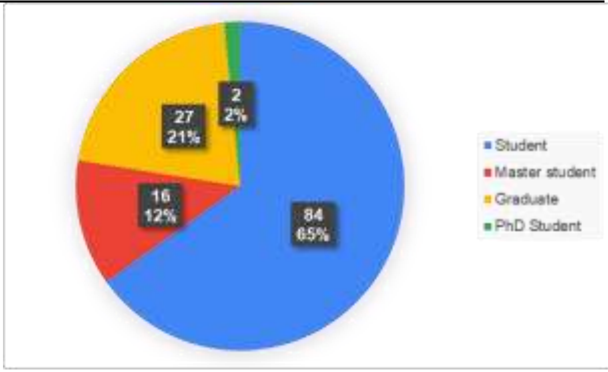

Fig. 2. Share of participants by level of studies
Source: own processing.

The question no. 3 measures the perception level of the respondents considering if the knowledge and skills acquired during their formation studies are useful in order to achieve a field related job. It can be observed that together "very useful" 59(46%) and "useful" 53(41) answers represents a % of 87% while "not useful" 12(9%) and "I don't know" 5(4%) represents 13%. The figurative results are presented in Figure 3.

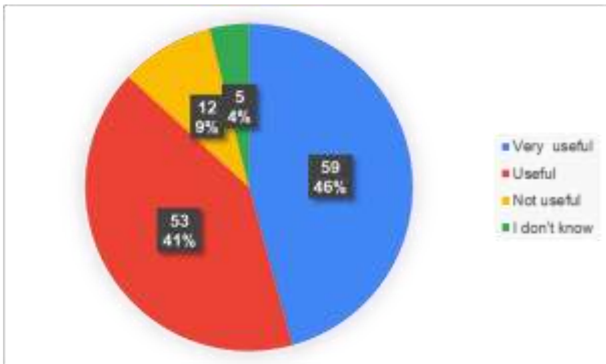

Fig. 3. Share of perception level
Source: own processing.

Question no. 4: *During the study program did you participate to training courses organized by USAMV from Bucharest?*

75 (58%) of the respondents have not participate during the study programs to training courses organised by USAMV from Bucharest through the Centre for Counselling and Career Orientation (CCOC) while 54 (42%) have participate. The results are showing moderate results in student participation but still motivating to be increased. The participation is represented in graph below (Figure 4).

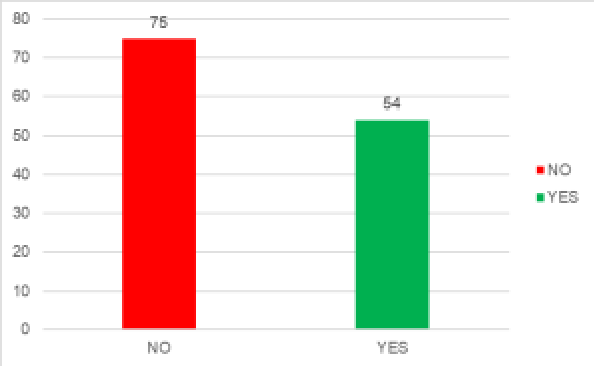

Fig. 4. Student participation to training courses
Source: own processing.

Question no. 5: *Do you think that participating in these training courses will/has helped you in finding a job or in your personal development?*
The question combines the aspects of technical participation with the perception of usefulness of participation. The results show that 106 (82%) answers were positive while 23 (18%) where negative (Figure 5).

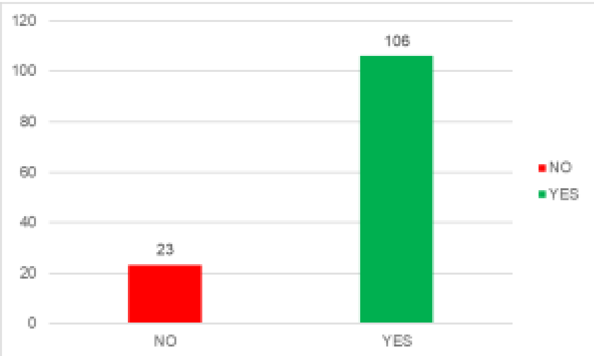

Fig. 5. Student perception towards training courses
Source: own processing.

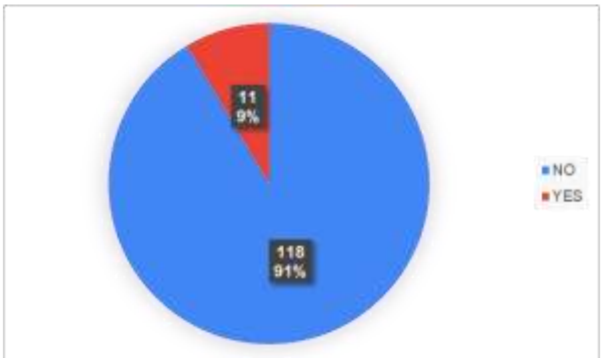

Fig. 6. Student participation to Erasmus + programs
Source: own processing.

To question no. 6 which refers weather students have participated in an Erasmus + mobility program 118 respondents which represents 91% of the total of 129 have not participated and 11(9%) participated (Figure 6).

Question no. 7: *During your study formation did you participate in any internship program?*
We note that the participation to an internship program facilitated by USAMV from Bucharest through Centre for Counselling and Career Orientation in partnership with agribusiness field companies shows that 27(21%) of the respondents did participate while 102(79%) did not participate (Figure 7).

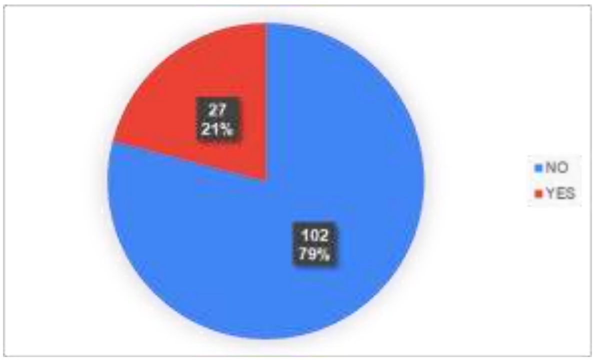

Fig. 7. Student participation in internship programs
Source: own processing.

Question no. 8: *During your study formation did you participate in any volunteering activities?*
Taking into consideration the wide range of volunteering activities which may imply organization of sports and cultural events, entertainment events, fairs, exhibitions, conferences, study visits and more the student participation is increased versus Erasmus + and internship programs. 42(33%) students have already participated in volunteering activities while 87(67%) have not. The share pie Figure 8 presents the results.

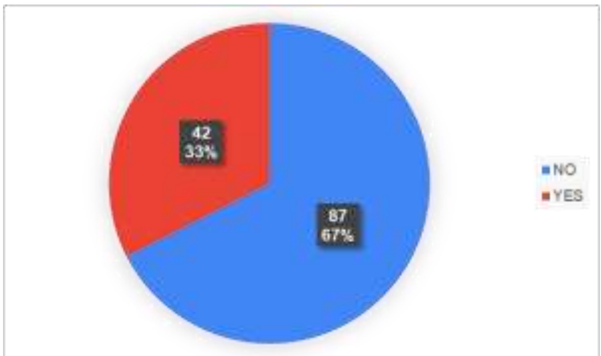

Fig. 8. Student participation in volunteering activities
Source: own processing.

Question no. 9: *Do you consider that participating in an internship program/volunteer activities is beneficial for professional development and the facilitation of obtaining a job?*

The question is targeted to reach both perception level and technical level. We note that 108 (84%) respondents consider that to participate to an internship program and to volunteering activities do have benefits for professional self-development and may facilitate the insertion on labour market. 9(7%) respondents consider doesn't benefit while for 12 (9%) does not apply as in Figure 9.

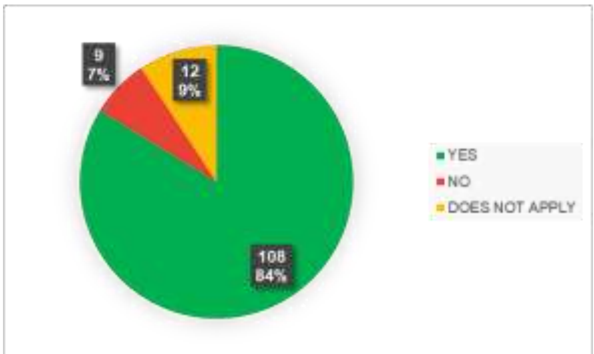

Fig. 9. Student perception towards benefits of internship programs and volunteering activities
Source: own processing.

Question no. 10 *To what extent do you think it is necessary to prepare a CV already during college?*

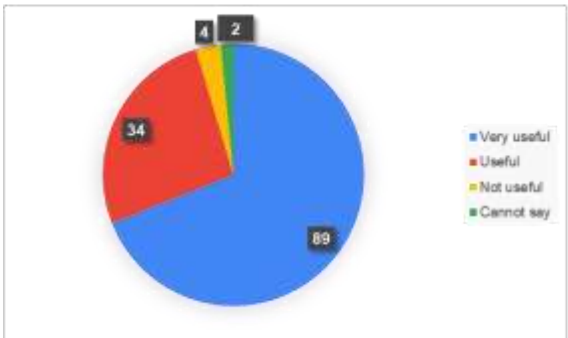

Fig. 10. Student perception towards building a CV during the studies
Source: own processing.

This question purpose is intended to measure the students/graduate's awareness of Curriculum vitae importance as a tool for a smoother access to labour market. The results show that 89 (69%) of the respondents consider "very useful", 34 (26%) "useful", 4 (3%) "not useful" and 2 (1.55%) "cannot say". Graph 10 presents the results.

Question no. 11: *Do you think that accessing recruitment platforms, such as www.usamvjobs.ro, help you find the job you want?*

www.usamvjobs.ro is an official job platform own by USAMV from Bucharest which purpose is to facilitate the relationship between employers and USAMV students and graduates. It is and controlled environment which reflects the partnership between university and agribusiness field companies. The respondents' interest in the platform is significant as per results shown in Figure 11. 112(87%) of the respondents consider accessing the platform being helpful and 17 (13%) not being helpful.

Fig. 11. Student/graduates perception towards accessing field targeted job platform
Source: own processing.

Question no. 12: *Please indicate the degree of importance from your point of view regarding career counselling and guidance support since college:*

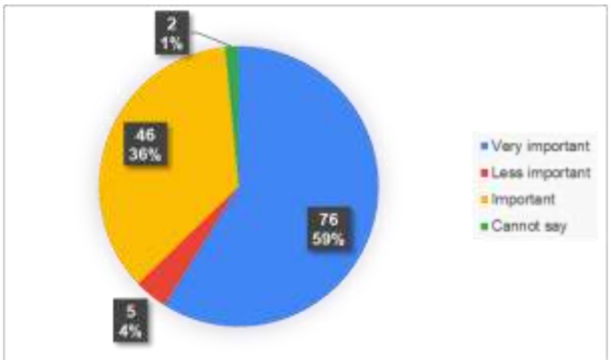

Fig. 12. Importance of career counselling and guidance
Source: own processing

Centre for Counselling and Career Orientation within USAMV from Bucharest provides services for the student/graduates and alumni. Among the services, the career counselling and guidance is one the most relevant. Thus "very important" and important answer together represent a total of 122(95%) while "less important" 5(4%) and "cannot say" 2(1.55%). The figures are presented in graph 12.

Question no 13: *Please indicate if during studies or after graduation you were employed.*

We found that 68 (52.7%) of the respondents have worked or working in other field than the studied one wile 61 (47.3%) work in the studied field (graph 13).

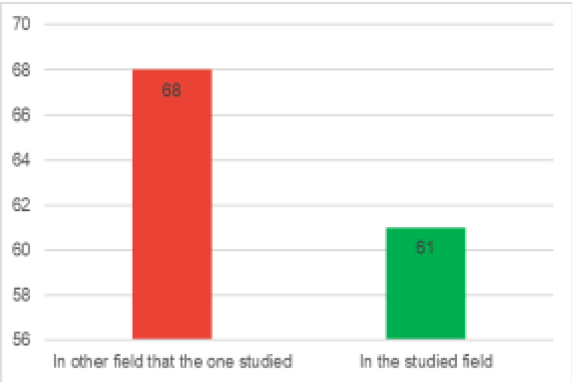

Fig. 13. Student/graduates working field distribution
Source: own processing.

CONCLUSIONS

Comparing and analysing the literature and specialized studies, to which we add the present study, the conclusions are that adaptability in terms of the competences acquired over the years of studies, corroborated with other experiences are defining for a successful insertion on the labour market for graduates. Universities in general have adapted study programs and extracurricular activities to support students and graduates. However, studying the obtained results, their interpretation and the corrective measures that must be taken should be considered as priority.

Digital skills, but also the other skills acquired through participation in internship programs, volunteering, workshops, conferences and other activities based on skills acquisition and capitalization, can be a strong differentiator upon graduation together with the bachelor's degree. Completing a study program from university education can bring significant benefits both personally and socially. In addition, the awareness of the need to develop skills already during the years of study exists among students, and the present study confirms this aspect, at least at the level of perception. At the same time, taking into account the dynamics of the market economy in terms of the qualified manpower circulation, the geopolitical situation, climate changes, government strategies in the medium and long term, but also the adaptability of companies in terms of the above aspects, we suggest strengthening the ties between the university environment and the companies which acts in the field. The adaptation of training programs according to the inputs obtained from companies which carries out their activities in the agribusiness field can facilitate a better insertion into the labour market and can give an added value to students and graduates that can materialize in better salary packages and in the return of their knowledge and innovation to society.

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MANAGEMENT OF CONFLICTS IN AGRARIAN NATURE USE OF TERRITORIAL COMMUNITIES

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Abstract

The purpose of this study is to develop recommendations for the conflict in agrarian nature use management on the basis of assessment, analysis and mapping (on the example of the community of Velyka Andrusivka of the Kirovohrad region of Ukraine). To achieve the goal, the methods were used: analytical, SWOT analysis, interviewing, cartography, chemical analysis. The article includes the results of the chemical analysis of water from the wells of the Velyka Andrusivka community and the results of the SWOT analysis of the conflict in nature use between the community of Velyka Andrusivka and the “VKiK” pig farming complex. The existence of a conflict within the community was confirmed and recommendations for its resolution were formed. A number of ecological and social recommendations for this specific community have been developed on the basis of existing methods of resolving conflicts in nature use. The data and recommendations obtained during the research can be used to resolve the conflict in the community of Velyka Andrusivka and similar conflicts in agrarian nature management.

Key words: *conflicts in the field of agrarian nature use, community, pig farm, pollution, well, waste management*

INTRODUCTION

Conflicts in the field of nature management are quite widespread in Eastern Europe. They are often caused by contradictions between different household subjects. They can cause a huge negative impact on household structure, environment and common health. In most cases, conflicts in the field of nature management can be described as consequences of controversy, occurred within social-economic territorial system, or between several systems, caused by limited amount of natural resource or it’s quality decreasing [9]. The reasons and conditions, which may cause such conflicts are as varied, as are social-economic formations, natural conditions, and features of public mentality. These conflicts become imminent because of increasing of sphere of influence of mankind itself and it`s increasing impact on natural environment. Therefore, they involve not only nature and mankind, but also different subjects of nature use, which begin confrontation between each other for right to use said environment and it`s resources. In other words, conflicts in the field of nature management may occur, when one of nature users has a concern about planning or current providing of other nature user’s project, which does not submit to the principals of rational nature using, or just does not fit the conception of it’s using of one of the users [8; 11]. These conflicts may have local or global interstate nature [13]. In such a conditions timely distinction and searching of optimal methods of solution of these conflicts as well as methods of optimization of affected natural systems is crucial.

There are different ways of solving of such conflicts in different countries, based on cultural and mentality features of particular society. As good example of such a variety can be astonishingly different methods of solving of the same type of conflicts in the field of nature management (between nature users and environmental institutions) in Finland and Kazakhstan. In both countries there is a problem of local seal population decreasing because of unregulated fishing and intentional or unintentional actions, that can be classified as poaching. In case of Finland, the active society was the main actor of conflict solving. Volunteers and petitions to government allowed to restrain and minimize interactions between men and seal population of lake Saimaa by establishing zones of the lake, forbidden for men to visit, and providing measures to increase number of seals. It was environmental and volunteer organizations, who took the initiative and provided necessary measures, which can be determined as result of high level of personal responsibility of each citizen. Kazakhstan acts marginally differently: the main actor here is a state itself, to be specific, it`s enforcers, because of low initiative level of each particular individual, as well as of citizenry society and particular traditional features of interactions of individuals between each other and of institutions between each other. The main method is resolving a mass ambushes on unregulated fishers, to take their catch from them, frequent armed skirmishes between enforcers and poachers, which cause injuries and deaths of people. These actions have a low level of efficiency.

Methods and effectiveness of conflict resolution in the field of nature management depend primarily on the cultural, legal and economic features of the territory in which it occurred. Therefore, it is crucial to understand conflict`s history, duration, former attempts to resolve it, main stakeholders, their motives and positions in the conflict before providing the methods of it`s solving. Based on these data, it is possible to understand which part of stakeholders can initiate a compromise or a final solution to the problem, or what kind of external force must be involved to change the balance of power in the conflict.

The purpose of the research is applying recommendations on solving the conflict in agrarian nature use of territorial community, based on methods of conflict mapping and conflict analysis (on example of territorial community (TC) of Velyka Andrusivka of Kirovohrad region of Ukraine.

MATERIALS AND METHODS

In this research next methods were used: analytical, SWOT-analysis, interviewing, conflict mapping, chemical analysis.

Empiric hypothesis is based on assumption, that wastes of the local pig farm enterprise increase water hardness; the white precipitate on plastic tools, that had a direct contact with well water – are sulfates, nitrates and other salts, mixed with water from the enterprise.

In June, 2020 the field research was provided, to investigate the current state of the conflict between government, enterprisers and citizens. The research included several stages:

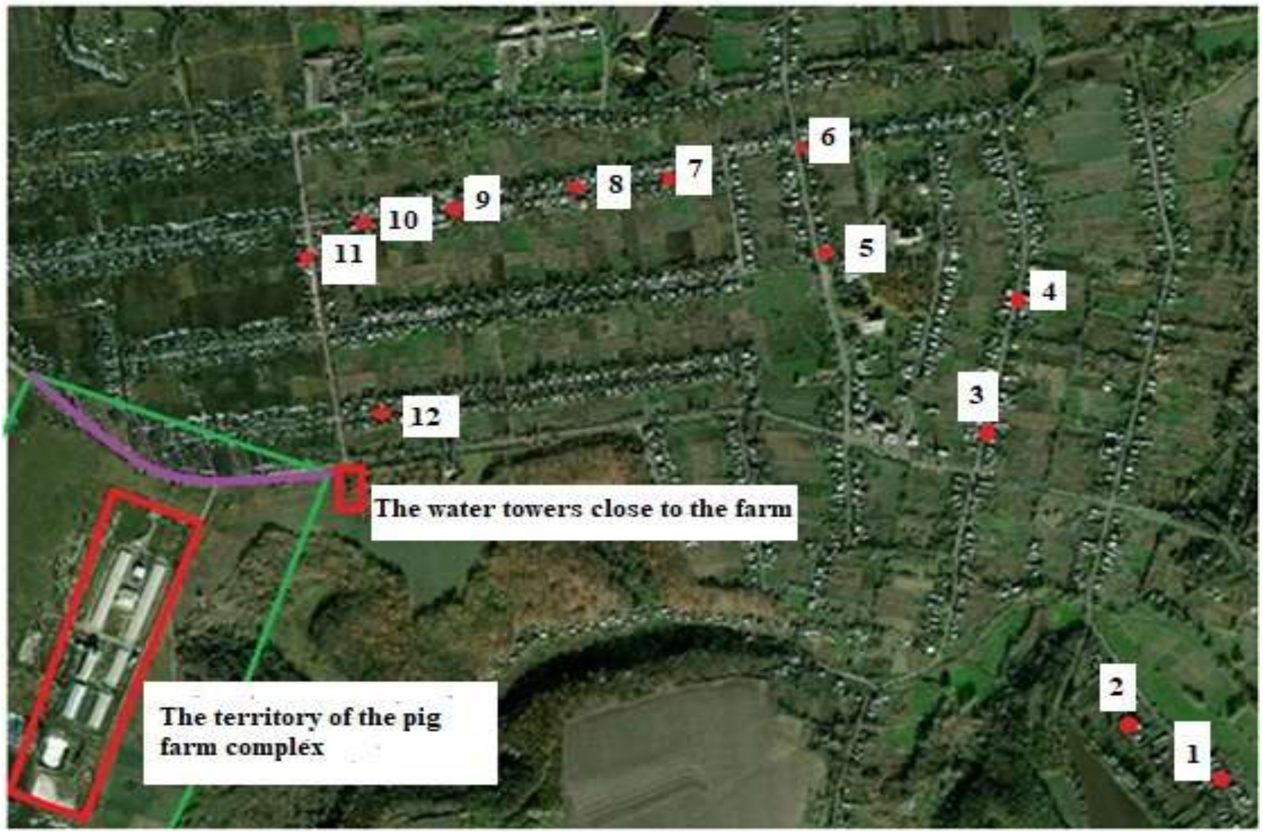
(1) interviewing citizens of Velyka Andrusivka in order to determine their attitude to the conflict, and to identify possible sources of the problem, or its new aspects that were not taken into account before;

(2) collecting water samples from wells of Velyka Andrusivka, for further analysis;

(3) analysis of the collected samples for compliance with sanitary standards.

The expedition was held on July 4, 2020, during which 12 water samples was collected. Samples were taken in different parts of the village located at different distances from the pig farm. This will allow to investigate the dependence of water pollution on proximity to it. This will also be helped by an increase in the number of complaints from citizens as they approach the pig farm. Interviewing was spontaneous, due to the fact that not everyone who provided their water for testing agreed to provide information, possibly due to the pressure exerted by local authorities on people raising the issue of conflict.

Map 1 shows the sampling map during the expedition. The places where water samples were taken are shown with red dots, the serial number of the sample is in white squares. Also on this map, the territory of the pig complex, which is quite close to the village, and the water towers are marked. The sanitary zone that was meant to be is marked in green (500 m against the real 372 m). The area of violation is marked in purple. Due to the small distance of its location from the village, residents complain about the unpleasant smell coming from the complex. It is possible to raise the issue of payment of compensation from the management of the complex. The main indicators that will be analyzed are pH, total hardness and total salinity, or mineralization. The indicator of mineralization is crucial in proving the fact that waste from the pig farm entered the groundwater.



Map. 1. Water sample collection map of Velyka Andrusivka
Source: authors' scheme based on data of Google Maps.

RESULTS AND DISCUSSIONS

The most common conflicts in the field of nature management within TC

Considering the fact that society interacts with the natural resource complex on a large number of different levels, it is quite logical that in order to cover the entire spectrum of possible conflicts in field of nature management, there is a system of their classification and description according to the work by V. V. Sabadash [9]: "According to the basic component of the ecosystem, due to which a conflict may arise, regarding its involvement in production, consumption or exchange, they are divided into land, water, forest, mineral, food, assimilation and complex. All of them are possible within the boundaries of territorial communities, especially in cases where the unification of settlements of different sizes and levels of influence took place. The dominant settlement, which has the majority of representatives in the community council, and also has, thanks to a larger share of the population in the overall structure, a larger share of votes during public meetings and voting, can, if desired, implement its own priorities in matters of the use of natural resources".

The most common are conflicts related to the distribution of resources between internal communities. This type of conflict includes both contradictions between internal communities and between separate settlements of the TC regarding the distribution of funds or other resources between them, infrastructure, to be specific. Mostly, they are related to the fact that some internal communities consider this distribution to be unfair and such that it satisfies the interests of some at the expense of the interests of others. Such conflicts can unfold both between the administrative center and the periphery, and between peripheral settlements [8].

Description, features, participants and classification of the conflict in nature management in TC of Velyka Andrusivka

TC of Velyka Andrusivka is located in the northeast of the Kirovohrad region. To the south of it is the city of Svitlovodsk, and to the east it is washed by the Dnieper river. Both of these factors create favorable conditions for the potential economic development of TG, both economically and recreationally.

General information about the pig farm given in Table 1.

Table 1. General information about the pig farm

Title	FARM “VKiK”
Short title	FG “VKiK”
Code	34141366
CEO	Kozyarchuk V. V.
Status	Registered
Location	Ukraine, 27520, Kirovohrad region, Svitlovodsk district, Velyka Andrusivka, complex No. 1
Type of the enterprise (according to KVED)	1.46 Pig farming
Use of water for industrial needs from underground sources, thousand m^3/year	76.515
Place of discharge (within/outside the settlement)	The cesspool, located in the village Velyka Andrusivka of the Svitlovodsk district of the Kirovohrad region, the basin of the Dnipro River; Accumulator, located in the village. Velyka Andrusivka, Svitlovodsk district, Kirovohrad region, Dnipro river basin
Waste water category	tap, industrial
Main waste or indicators for measuring water quality	BOD5, BOD2, ammonium nitrogen, phosphates, chlorides, SPAR (synthetic surfactants), nitrates

Source: formed by the authors according to the data of the Ukrainian inspection portal [7; 10].

By 2019, the State Environmental Inspection has recorded a number of violations, the main of which are listed below using data from the inspection portal from the report on a routine inspection dated May 29, 2019: “measures have not been taken to control compliance with the approved standards of maximum allowable emissions of pollutants; Instrumental measurements were not carried out on the border of the sanitary protection zone and the Program for conducting production laboratory control of emissions approved by the Main Department of the State Production and Consumer Service in Kirovohrad region was not followed” [7]. “The enterprise is not on the state register as an object that causes or may cause a negative impact on public health and the state of an atmosphere” [7]. “The inventory of waste sources does not include waste containers from pesticides and agrochemicals; the journal of accounting for waste and packaging materials and containers according to the standard form No. 1-VT is not kept in full (accounting for waste of worn overalls, waste from welding works, metal shavings, paper and cardboard waste, containers from pesticides and agrochemicals, damaged needles is not kept or used and others); the indicator of the total generation of waste needs to be adjusted; no changes have been made to the Registration card; no contracts have been concluded for the transfer of waste containers from pesticides and agrochemicals, used needles, liquid sewage (sewage)” [7]. In general, a number of violations were recorded in relation to atmospheric air pollution and waste management. Also, as of May 29, 2019, the company did not have a permit for the special use of a well in Velyka Andrusivka, but received it on July 8, 2019 [10]. The following information was obtained after interviewing one of the deputies of Svitlovodsk council. In the village of Velyka Andrusivka, water from the local water supply supplied by KP “Gospodar” corrodes zinc buckets and makes holes in them with frequent use. There is a very high probability of damage to the pipes. There is an assumption that waste from a pig farm located on the territory of the village and owned by the Svitlovodsk private enterprise "VKiK" gets into the aquifers from which water is pumped by local entrepreneurs. This farm was founded by the former mayor of Svitlovodsk, known for his corruption scandals and political intrigues and persecution of opponents during his tenure as mayor. There are also complaints from residents that the water in many village wells below the level of the main streets suddenly disappeared, despite the fact that this had never happened before. This phenomenon is also associated with the penetration of waste from the pig farm into groundwater. It is also known that at the request of local farmers, the pig complex supplies them with waste as fertilizer for the fields. This may be the main cause of waste entering groundwater. In 2014, they tried to resolve the conflict through inspections and the involvement of the Svoboda party, experts found a violation of the sanitary zone (328 meters from the village instead of 500) and the absence of a permit for handling waste of 1–3 hazard class [1]. Features of the conflict. Resonance in local media, active discussion of the problem in social networks.

Problem context:

(1) lack of dialogue between local authorities and citizens, which leads to inactivity of the former;

(2) the scandalous personality of the founder of the pig complex, which complicates the process of finding the optimal solution;

(3) lack of dialogue between the villages of the TG, which is a consequence of the conflict situations of the past years.

Participants and parties:

(1) supports the termination of pig farm activities related to the deterioration of water quality – the community and some deputies;

(2) supports the continuation of activities – representatives of the pig farm;

(3) the authorities of the TG do not want disclosure and deterioration of the image.

Conflict classification

According to current methods of conflict classification, the studied conflict can be classified.

1) According to the basic component of the ecosystem, due to which a conflict can arise, this conflict is based on water;

2) According to the territorial feature, it should be considered local, because its boundaries are determined by a defect in the village water supply system, and it does not go beyond them;

3) According to the hierarchy of participants, this conflict is intergroup, because in this case there are two clearly defined interest groups: the village community and the management of the pig farm together with the authorities. The latter can be separated into a separate group, because they have interests that coincide, but partially, with the interests of the management.

4) According to the affiliation of the participants, this is a conflict between users and intermediaries, because in this case water is public property. In this case, administrative bodies and representatives of the government act as mediators.

5) It seems difficult to classify this conflict according to the duration of the conflict, because its duration has already reached more than half a year, that is, it no longer fully fits the term of a short-term conflict, but it has not yet turned into a long-term conflict. It should be noted that with the nature of the authorities of the TG, such a course of events does not seem impossible, because it is in the interests of the authorities not to publicize it, which will lead to its freezing, with the intimidation of representatives of the active community in order to save money that could be spent on examinations, measures with cleaning and monetary compensation to the population. But for now, this conflict is closer to the short-term class in terms of time frame, but could potentially become long-term.

6) By role of the ecological component in the mechanism, this conflict should be considered real, because in this case we are talking about the unmediated direct role of the resource in the conflict. Its poor quality is a problem in itself. It is also not fictional, which is confirmed by the analyzes conducted by two different authorities. Also, it is not used intentionally by any political forces to discredit the existing authorities, and therefore there is no increased forcing and problem exaduration within TC.

7) According to the measure of uncertainty, it is fashionable to consider this conflict as a conflict in conditions of certainty, because all parties to the conflict are sufficiently well informed about the prerequisites, course and manifestations of the conflict situation. This increases the probability of finding the optimal solution, but cannot guarantee it due to the subjective characteristics of the owner of the pig farm.

8) In terms of the direction of action, this conflict is characterized by pronounced verticality, because it cannot cover new territories or participants, locked within the boundaries of the village water supply. But it worsens over time due to deterioration of mood among the population.

9) According to the degree of manifestation, this is currently an open conflict, because the parties have openly expressed their goals and brought them to the media.

10) According to the results of the resolution, the conflict is constructive, because its solution does not necessarily involve the destruction of one of the participating parties and can be achieved through dialogue and consensus.

11) It is not yet possible to classify this conflict according to methods of resolution, since in these conditions it is not known what methods will be used to resolve the conflict despite the recommendations provided below.

12) According to the factors of occurrence, this conflict can be characterized as a conflict caused by a scarcity of resources, caused by the low quality of the mentioned resource.

Results of field research, mapping and SWOT analysis of the conflict

According to the testimonies of proactive villagers, water problems started in the year of 2019. Then the pig complex had to drill a new well to replace the old one, during the operation of which an incident occurred, and a foreign object was dropped into it, which, according to the assumptions made, was the engine of some unit. After that, a new well was drilled, probably without due consideration of the effect on groundwater circulation, around the same time many village wells downstream of the plant dried up.

Table 2. Indicators of total mineralization, total hardness and pH for collected water samples

No	Tot. min., mg/dm^3	Characteristic (Total mineralization)	pH	Characteristic (pH)	Total hardness	Characteristic (Tot. hardness)
1	520	Very high hardness index, use is dangerous for health	8.730	Meets standards for tap water	12.8	Very hard water
2	511	Very high hardness index, use is dangerous for health	9.197	Alkaline environment. Does not meet standards for tap water	12.8	Very hard water
3	377	High hardness index, use without a filter is not recommended	9.066	Alkaline environment. Does not meet standards for tap water	12.2	Very hard water
4	383	High hardness index, use without a filter is not recommended	9.537	Alkaline environment. Does not meet standards for tap water	8.0	Hard water
5	376	High hardness index, use without a filter is not recommended	9.542	Alkaline environment. Does not meet standards	10.0	Hard water
6	322	High hardness index, use without a filter is not recommended	9.043	Alkaline environment. Does not meet standards for tap water	6.4	Medium hardness
7	384	High hardness index, use without a filter is not recommended	9.454	Alkaline environment. Does not meet standards for tap water	8.8	Hard water
8	386	High hardness index, use without a filter is not recommended	9.493	Alkaline environment. Does not meet standards for tap water	8.0	Hard water
9	294	Classified as a tap water	9.303	Alkaline environment. Does not meet standards for tap water	8.8	Hard water
10	322	High hardness index, use without a filter is not recommended	9.091	Alkaline environment. Does not meet standards for tap water	6.2	Medium hardness
11	389	High hardness index, use without a filter is not recommended	9.473	Alkaline environment. Does not meet standards for tap water	8.0	Hard water
12	319	High hardness index, use without a filter is not recommended	9.473	Alkaline environment	6.4	Medium hardness

Source: results of authors' research based on the data of the SanPiN 2.2.4-171-10 "Hygienic requirements for drinking water intended for human consumption".

The water level in some has only significantly decreased, and residents of the rural outskirts continue to take water there. But it would be incorrect to immediately associate this phenomenon with the drilling of a well, due to the fact that in recent years the summer was very dry and characterized by a small amount of precipitation, which could cause a decrease in the groundwater level. The results of the analysis of the collected water samples are shown in Table 2.

The results of the analysis show that in all cases the water does not meet the standards for well water in terms of pH and total mineralization, and in 9 out of 12 cases it does not meet the requirements for total hardness, according to SanPiN 2.2.4-171-10 "Hygienic requirements for drinking water intended for human consumption". In all mentioned cases, we are talking about a high level of water hardness and high water alkalinity. The highest indicators of mineralization and hardness can be observed in samples 1 and 2 – these samples were taken from wells that people use for drinking water and for domestic purposes. Long-term use of water with a high level of hardness has a negative effect on the digestive and cardiovascular systems, leads to the formation of calculi in the body. Regular use of alkaline water, in turn, leads to stomach ulcers and gastritis, and also negatively affects the cardiovascular system.

Table 3. Indicators of nitrates in selected water samples

№	Nitrate content, mg/dm^3	Maximum permissible concentration (MPC), mg/dm^3	Characteristic
1	417.9	50	The indicator significantly exceeds the MPC
2	427.0	50	The indicator significantly exceeds the MPC

Source: results of authors' research based on the data of the SanPiN 2.2.4-171-10 "Hygienic requirements for drinking water intended for human consumption".

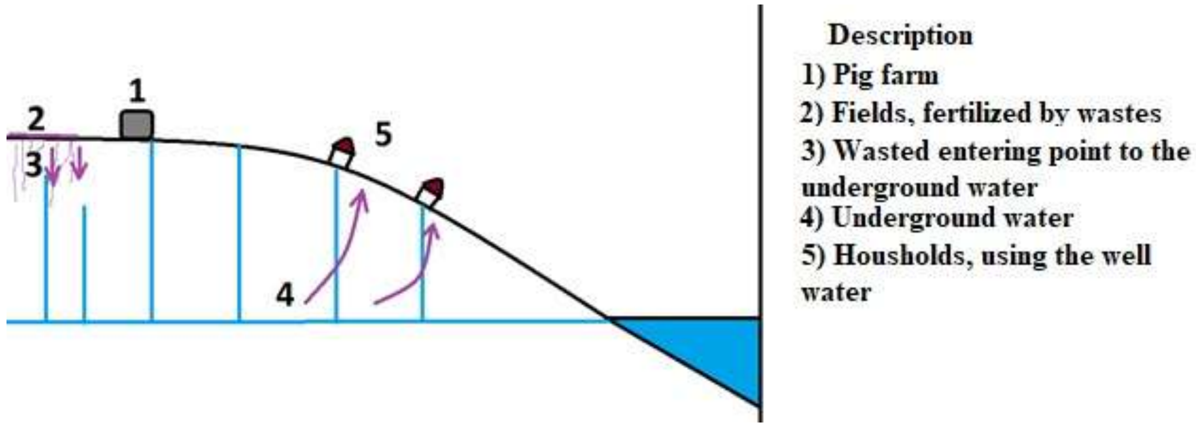


Fig. 1. Schematic representation of waste entering groundwater
Source: authors' scheme.

In both cases, the indicator of nitrate concentration is significantly higher than the norm. The approximate calculation of the amount of compensation for damages caused to the state due to groundwater pollution was carried out in accordance with the methods approved in Order No. 389 dated 07.20.2009 "On approval of the Methodology for calculating the amount of damages caused to the state due to violations of the legislation on the protection and rational use of natural resources". The indicator of nitrates was taken as a basis. According to the results of the calculations, the estimated damage from pollution is UAH 237750. It is known that in addition to the incident with the well, the pig complex supplies its waste as fertilizer to neighboring entrepreneurs who irrigate their fields with it. There is a high probability that these fields are above aquifers, and the waste gets into them by being absorbed through the soil, washed away by rains, and the nature of the terrain and the fact that the village is on a slope, and the complex and fields are on top, only intensify this process. Then this water goes to the village water supply. Figure 1 shows a schematic representation of this phenomenon.

In order to develop effective recommendations in the situation that developed in the TC of Velyko Andrusivka it is necessary to characterize the external and internal environment of the conflict, which can be done in two ways at least:

(1) Conflict mapping;

(2) Providing a SWOT analysis.

The mapping of this conflict was carried out according to the method of identifying the main sides of the conflict, namely: the community, as the victims; the management of the pig complex as the culprits; the authorities of the TC as mediators. The complete scheme is presented in Figure 2.

Fig. 2. Mapping of the conflict surrounding the contamination of water from wells by the pig complex
Source: authors' scheme.

Table 4. Strengths and weaknesses, opportunities and threats of this conflict

Strengths 1) The presence of an active layer of the community 2) The possibility of communication and disclosure in the mass media and social networks 3) The conditions and the source of the conflict are known. 4) A relatively high level of awareness of the community about its rights and the ability to use the available legal tools	*Opportunities* 1) Providing examinations 2) Involvement of public organizations 3) International attention 4) Modernization of the complex
Weaknesses 1) Odious personality of the head of the pig complex, which hinders the resolution of the conflict 2) Low level of civic activity 3) Silence of the head of the community about the fact of the conflict 4) Reluctance to modernize production and disposal technologies, guided by the save funds priorities	*Threats* 1) New accidents at the enterprise 2) Increasing pressure on the community 3) Conflict freezing

Source: results of authors' research.

In order to develop effective and comprehensive recommendations for resolving the conflict between the pig farm and the community of Veliko Andrusivka, from the very beginning it is necessary identify its strengths and weaknesses, which show the state of the internal environment, as well as opportunities and threats, which characterize possible factors that can affect the course of the conflict. The results are shown in Table 4. Based on the results of the analysis, legal methods with the involvement of additional parties in the form of groups of experts and public or political organizations with their legal tools should become the main tools for resolving the conflict. Based on the results of the SWOT analysis matrix, it is possible to apply recommendations for conflict resolution. So, the main cause of the conflict is the fact that the management of the complex did not take into account the location of groundwater when drilling a well, which led to waste from the pig complex entering the village aqueduct, which leads to the deterioration of water quality in general, that is, we can say that the conflict has already led to the loss of ecosystem services [6; 14]. Unfortunately, in Eastern post-Soviet Europe, the level of civil society and understanding of one's own civil and property rights does not allow the full implementation of self-regulatory practices common in the West [2]. These circumstances are worsened by the authoritarian nature of the enterprise management, which leads to the actual freezing of the conflict in a phase disadvantageous for both sides, due to the impossibility of reaching a consensus [4]. Also, the political nature of the owner of the enterprise (former mayor) can be an obstacle on the way to resolving the conflict [5]. Therefore, it is important to involve public organizations and democratic parties in solving the problem in order to attract public attention in neighboring cities and the region as a whole, in order to prevent framing of information about the conflict [3]. It is also important to implement environmental risk management systems [12] that will ensure a reduction in the conflict of interests between agricultural enterprises and society and promote sustainable development.

CONCLUSIONS

The investigated conflict is characterized as follows: it is an open water vertical local constructive intergroup real conflict of users and mediators in conditions of certainty, caused by resource scarcity. This deficit, in turn, is caused by the low quality of the considered resource. So far, this conflict is closer to the short-term time frame, but could potentially become long-term. In order to resolve the conflict, using the methods of expert assessments and external environmental audits, the involvement of public and political organizations, and settlement by judicial procedure are necessary:

1) organization of protests and forming of public organizations to protect citizens from possible force, legal and psychological methods of pressure and information campaign among the population. Disclosure of information about each case of pressure or threats from management or authorities;
2) involvement of public organizations and democratic parties in solving the problem to attract public attention in neighboring cities and the region as a whole;
3) conducting an external environmental audit at the enterprise and looking for opportunities to attract subsidy funds for the modernization of pig keeping conditions and waste disposal, raising the issue of material compensation for environmental damage;
4) filing a lawsuit against the management of the complex in order to stop operating the existing well and drill a new one taking into account the groundwater regime to prevent waste from getting there and organizing a forensic environmental examination;
5) demand modernization, transfer or termination of activities;
6) constant “informational pressure” on social networks, photo reports with images that can attract the attention of the community: yellowed flowers that have been watered with water from a well or buckets that have been run over by water, unfit for further exploitation;
7) attracting the attention of international human rights organizations to the problem;
8) conducting a hydrological analysis of local groundwater, determining the boundary of aquifers and the area of their recharge, on its basis, creating a protection zone. A study of

the experience of the United States in this matter;

9) cessation of fertilization of fields located within these limits, carrying out environmental control of land use;

10) reorientation of local farms to the greening of agriculture, making a markup on the final product for its environmental friendliness.

Among the promising areas of research are the following: development of a standardized methodology for the study of conflicts in the use of nature in territorial communities; preparation of practical recommendations on conflict management in the field of nature use of territorial communities. This study was carried out before the full-scale Russian invasion of Ukraine, it does not take into account the consequences of the war unleashed by Russia on the environment, agriculture, other industries and the new challenges that society as a whole faced. Therefore, issues of post-war restore of the environment, agrarian sector and the economy of Ukraine as a whole, guaranteeing global, national and regional food security are among the priority areas of future research.

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STUDY ON THE USE OF COMPUTER BASED INFORMATION SYSTEMS IN PRODUCTION MANAGEMENT

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Abstract

The aim of this paper is to highlight the role of computer based information systems in managing the resources of agricultural companies in order to forecast agricultural production and to study, from several points of view, the impact of climate change, respectively the changes brought by them. The Internet of Things involves the use of the Internet to connect different devices, services, and automated systems, thus forming a network of objects. Internet of Things devices will be integrated, connected to computer based information systems to increase the efficiency of agricultural production, by remotely monitoring sensors that can detect soil moisture and crop growth, ensuring (for example) remote management of smart combine harvesters and equipment of irrigation. The data provided by different sensors will be collected and the operational data obtained will be analyzed. The analysis will be performed using artificial intelligence methods that, through specific algorithms, allow the learning of new processing procedures, using data and previous knowledge collected, correlated with information obtained from meteorological services, to improve the making process. of decisions. Climate change is affecting agriculture by decreasing agricultural areas and reducing crops in the affected areas. These changes ultimately lead to a reduction in the amount of food available to humans and animals, to starvation, a phenomenon that still affects millions of people today.

Key words: *information systems, climate change, production*

INTRODUCTION

Agriculture is an essential branch of economic activity in our country, contributing decisively to ensuring the consumption requirements of the population [17].

The share of this activity sector is 4.2% of the Gross Domestic Product at the level of 2015. [14, 15].

After Romania's accession to the European Union (2007), the integration of national agriculture into the community systems continued [20], as well as the adaptation to the requirements of the European Union market. At the same time, compliance with the Common Agricultural Policy (CAP) made Romanian agriculture adopt modern measures to respond to market needs [2].

In parallel with this stage, other challenges arise over time, such as the need to respond to increasing climate change and to consider in any development analysis the existence of a production environment where uncertainty becomes an important factor to address. Environmental protection measures, conservation of natural heritage, pollution prevention currently form the core of strategies for sustainable development of agricultural holdings, and their implementation is closely related to changes in agricultural practices and environmental legislation [6, 8, 9, 20].

Integration into the European model of agriculture requires adaptation to a competitive sector, which must incorporate, in a constant trend, the newest methods and discoveries from other spheres of economic activity both in the field of production and logistics, but also in management [10].

The research seeks to identify the importance of information systems in resource management and in making forecasts regarding the production obtained within agricultural holdings, but also in managing financial results and finding viable solutions that contribute to reducing the impact of climate change.

MATERIALS AND METHODS

This paper is a bibliographic documentation study on the use of different computer based information systems in improving production management.
In this sense, various specialized scientific works, as well as national or international websites, were analyzed.

RESULTS AND DISCUSSIONS

Production management within a company includes: knowing, planning, organizing, recording, tracking and controlling the entire production activity within that company [19].
The degree of application of computer systems has been influenced by their evolution, which in recent years has experienced an accentuated and accelerated development, it is about the use of elements of nanotechnology, about the increase of their processing power, about the cheapening of computers and computing techniques in general, and it is also worth mentioning the interconnection of computers in networks on a planetary scale, which makes possible instantaneous communication, the collection and dissemination of information from all sectors of production, the sharing of knowledge and the analysis of a very large volume of data. From all production sectors, knowledge sharing and analysis of a very large volume of data.
All this progress thus facilitates timely operational decisions, on a much larger scale than before, helps to substantiate strategic decisions in all areas of human activity. Nowadays, information systems can manage an impressive amount of data, allowing the management of complex phenomena, macro-level planning of activities, forecasting of agricultural production, as well as tracking climate phenomena with major impact on crops and crops. For these reasons, it is natural for the development of information systems to help the evolution of macro systems for forecasting agricultural production and to allow the study, from several points of view, of the impact of climate change and the changes brought by them, taking into account the new economic paradigm, increasing the level of uncertainty in systems in general and in systems used in agricultural production management in particular.
These transformations have been analyzed by experts and researchers and have led to the adoption of strategic development directives or directions at country level or within the european union, they have also broadened the area of knowledge and analysis in the fields of agricultural production forecasting and climate change.
Macro-level computer based information systems for forecasting agricultural production fall into the category of those systems that allow automatic data entry, storage, processing and extraction of results. They have been studied and used for the last 25 years in agriculture, and in the last decade they have undergone an upward development, managing increasingly complex information and an increasing amount of data. These systems have become more robust and efficient by incorporating the latest developments in computing technology.
We consider that it is necessary to create tools in the online environment for the business environment in Romanian agriculture [18].
With the increase in bandwidth - by switching to 4G technology (and even 5G), which is the new generation of data transfer on mobile phones and can reach data transmission at a speed of 100 Megabits/second) used for internet connection and communication, as well as by spreading innovative networking solutions in the near future, the use of these information systems has become more widespread in agriculture.
[16] involves the use of the Internet to connect different devices, services and automated systems, thus forming a network of objects - objects that are providing data and are ensuring information exchange for better and timely management decisions.
From the perspective of a system architecture designed for the interaction between the citizen and the business environment, [3] describes as a platform architecture solution an integrated portal type system. The benefit of the spread of the Internet of Things will

address issues such as: rising water shortages, low land availability, difficulties in managing management costs, intensified trends against estimates of global population growth, which, according to FAO [3, 11], is projected to increase by 70% by 2050. These devices (specific to the Internet of Things) will be integrated, connected to computer based information systems to increase the efficiency of agricultural production, by remotely monitoring sensors that can detect soil moisture and increase crops, ensuring (for example) the remote management of smart combines and irrigation equipment. The data provided by different sensors will be collected and the operational data obtained will be analyzed. The analysis will be performed using artificial intelligence methods that, through specific algorithms, allow the learning of new processing processes, using data and previous knowledge collected - correlated with information obtained from meteorological services, to improve the making process. Of decisions.

The use of these devices also involves challenges related to the need to ensure the security of the data communicated at a headquarters, in order to maintain the confidentiality, integrity and availability at all times of the information thus obtained and processed. Last but not least: a challenge related to the large amount of data to be analyzed.

Another current feature of computer based information systems is the progressive migration of data and computer based information systems in cloud computing - the concept is graphically represented in Figure 1 and represents the distributed set of computing services, applications, access to information and data storage, in which the user does not need to know the location and physical configuration of the systems that provide these services, which are owned and operated - via the Internet, through a web browser - by other providers of computing technology. Below is the diagram illustrating the concept of cloud computing [7, 15, 12].

Due to the consolidation and management of computer based information systems in a service available to several beneficiaries this means (from the point of view of centralization) the return to the concept of "computing centers" - the characteristic of a previous approach, typical of another cycle of using computing techniques - units that meet in Romanian before the advent of personal computers (PCs), with the mention that access to these services is now possible via the Internet, due to the continuous savings of data transmission costs.

Not only computer systems have developed a lot in recent years, but also some miniaturized equipment that has become common, which has led to a decrease in their price. Likewise, the automation or remote control systems that can control certain processes are elements that have contributed, in parallel with the evolution of computing techniques, to the development of high-performance computer systems, which have allowed the improvement of the way of tracking and analyzing efficiency the production activity within the agricultural holdings.

The computer based information systems used in the management of agricultural production manage, in a unitary approach, the resources of the company and of the group to which it belongs, integrating financial, human and material information, as well as those of plant production and zootechnical production. One of the most relevant functionalities for the plant production activity is the internal reporting, for the monitoring and control of the activity in order to initiate the corrective activities in case of exceeding some efficiency parameters.

At the same time, reporting plays an important role in transmitting information to national and European authorities, for the preparation of reports and substantiation of decisions with a wide impact. An example of such an information system is the INOVAGRIA Meteo application dedicated to the management of meteorological and agrometeorological phenomena in Romania [1].

With the help of INOVAGRIA Meteo, farmers will be able to access “agro-meteo data that will help them to efficiently plan the agricultural production activity and to make the right decisions for the growth and protection of agricultural production. Farmers will have the opportunity to know at any time the weather, atmospheric pressure, air and soil humidity, wind speed or soil water reserve at the locality level. With this up-to-date information farmers will know when to take the machinery out into the field, when to irrigate, when to protect crops from heat or frost and when to plan their sowing work so as to avoid freezing plants. In the context of current and predictable climate change, the best way to find specific adaptation measures for agriculture and beyond is based on forecasting and warning of dangerous weather events, as well as on specialized information on evolution, intensity and range.

Substantiating the process of adaptation to climate change on climate data and specialized studies will allow decision makers and practitioners to take the best measures to prevent and reduce climate risks. Therefore, "the INOVAGRIA Meteo support application responds to the challenges generated by increasing the frequency and intensity of weather phenomena in correlation with the need to improve resource management in production", says Dr. Elena Mateescu, General Manager of the National Meteorological Administration [13].

Users will have access, from anywhere and anytime, to a number of important weather and agro-weather data, such as:

1. weather conditions for any place in Romania;
2. specialized weather forecast for the next 24 hours and for 3 days, for any location in Romania;
3. air and soil temperature, but also the minimum and maximum of the day;
4. amount of precipitation, air humidity and soil moisture;
5. atmospheric pressure, wind speed and maximum wind gust;
6. soil water reserve for wheat and corn cultivation and agro-meteorological bulletin;
7. immediate warnings of severe weather at locality level;
8. risk phenomena;
9. weather history for each weather station.

"The current weather raises special problems for crops, and farmers must be constantly informed of the advice, recommendations and warnings of meteorological experts. The innovation of our application is that farmers will have direct access to the latest weather data on the phone, receive notifications with severe weather warnings, and the three-day forecast will help them take the necessary steps to be avoid possible dangers for agricultural production", says Gabriel Lospa, director of the eAgriculture department of SIVECO Romania [13].

Another example in this sense is the Charisma application for Agriculture, which “supports in a single computer system the resources of the company and the group (financial, human, material, but also the specific ones, of vegetal production and zootechnical production).

For the plant production activity, the most important functionality was the graphical interface, for internal reporting and to the authorities, with the terrain map controls.” [4].

At the macroeconomic level, there is the European Simulation Model (ESIM). The evolution of the production, consumption and trade of the considered agricultural products can be simulated by creating scenarios using the ESIM model [5].

The obtained results can contribute to the better organization and management of the agricultural markets in Romania, being used to substantiate the agricultural policy decisions.

The model includes macroeconomic variables, called exogenous, variables for agricultural plant and animal production, processed products and intermediate consumption.

The products as variables, presented in Table 1 are significant products for the agriculture of our country [5].

SICASA or the computer system for the conservation and improvement of agricultural animal species in Romania is the computer system used by the National Agency for Animal Husbandry “Prof. Dr. G. K. Constantinescu ”(ANZ). It is used for the registration and centralized management of all breeds of zootechnical animals (sheep, goats, cows, etc.) except for equidae (horses, donkeys, etc.), which have their own management and record system, in which the civictechRO team is already working in parallel [5].

SICASA is a central electronic system for internal use used both by the National Agency for Animal Husbandry and by animal breeders' associations accredited/authorized by the Agency throughout the country. Unfortunately, SICASA is an old computer system that does not work properly and has many errors and blockages, which significantly complicate the work of animal husbandry specialists [20].

In the research study, decision support computer based information systems occupy an important place, because they come to the aid of companies that have achieved over time a significant accumulation of data in heterogeneous information systems.

The new technologies of data storage and processing, being oriented towards the intelligent exploitation of this potential, are imposed through three main directions:

a) Data Warehouse - technology for centralization, consolidation, reorganization and storage of large volumes of data accumulated over time, data taken from heterogeneous computer based information systems, which will form the basis of analytical processing necessary for decision-making processes;

b) OLAP (On-line Analytical Processing) - technology for aggregating data stored in warehouses in a multidimensional approach, which provides quick access to the information needed by analysts and managers in a consistent, interactive and very flexible manner;

c) Data Mining - technology for exploring data stored in warehouses in an attempt to discover new aspects of the activity, aspects normally overlooked: correlations between events, associations between certain facts, sequences, patterns of behavior [21].

CONCLUSIONS

Currently, the use of computer systems based on artificial intelligence not only allows the management of a large volume of information, but also contributes to the control of increasingly complex phenomena or to the planning of macro-level activities. In terms of agricultural production, they allow the making of forecasts or the effective monitoring and management of some climatic phenomena that influence the level of production and the profitability of agricultural holdings. Finding solutions based on the use of information systems has an important role in agriculture because they are meant to help the evolution of macro systems for forecasting agricultural production and to allow the study, from several points of view, of the impact of climate change and the changes brought by them, taking into account the new economic paradigm. Increasing the level of uncertainty in systems in general and in systems used in agricultural production management in particular.

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TOURISM CAPACITY IN IALOMITA COUNTY, ROMANIA IN THE PERIOD 2008-2020 - WHAT ABOUT ITS FUTURE?

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Abstract

Capitalizing on the tourist potential of a region together with the presence of roads and means of transport to areas with potential generates numerous tourist flows that will contribute to the tourist development of that geographical part of the country. The tourist technical-material base adapted to the needs and standards of tourists will contribute to a high number of overnight stays in the tourist region. The data processed in the work come from National Institute of Statistics-NIS. The qualitative aspects in this research were studied based on current scientific literature, official documents and observation method, and the quantitative research was carried out using statistical analysis of the processed data, graphic and cartographic method, the method of observation and interpretation. The results were presented in tables, graphs and then interpreted and examined. Data used in this study are part of the textbook on the desk. Tourist reception structures are the most important part of the technical-material base of tourism. The tourist accommodation units include public utility spaces classified and arranged in such a way as to allow the accommodation of tourists and the provision of specific services according to the location. Despite that the most numerous accommodation units are represented by hotels, their number declined from 2,100 in 2008 to 1,526 in 2020 (-17.4%). The number of overnight stays is also high in hotels, but they also decreased from 52,481 in 2008 to 22,368 in 2020 meaning by - 67.4% less. A number of 304,068 tourists visited Ialomita county in 2008 and 73,697 in 2020, which reveals 24.2% because the county is visited especially for spa treatment in Amara Resort. The more active involvement of the authorities and the population for competitive activities and the increased degree of responsibility for everyone will generate a sustainable development of the region.

Key words: *tourists, tourist flow, tourist capacity, tourism, profit*

INTRODUCTION

Tourism is one of the most dynamic branch of the economy of any country with tourist resources and brings an important contribution to GDP [19, 22].

Between demand in terms of tourist arrivals and overnight stays and the number of accommodation units and number of places (beds) it is a strong correlation destined to assure the balance in tourism market [17, 20].

„Within the technical-material basis of tourism, accommodation facilities, public food, entertainment, by their number and structure, reflect, to a greater extent, the degree of touristic equipment and development in its ensemble and levels" [3].

The need to maintain health has contributed to the development of spa tourism in Romania which has a lot of natural resources in this respect and many balneary resorts within Amara, in Ialomita County, occupies an important place for treatments based on mud and not only [6, 25].

Among the categories of accommodation units, hotels come on the top position having a higher capacity and comfort, closely related to tariffs for their services and facilities [26].

Also, other types of accommodation units like hostels, motels and agri-tourist guesthouses have become more attractive.

For the safety of tourists and their stay, especially during the Covid 19 pandemic, agro-tourist guesthouses were preferred by tourists [23, 24].

In Ialomita county, there is an important number of guest houses, the majority of them two pearls pensions and hotels.

However, none of the existing pensions use the local specification (architecture, interior design, traditional food).
Their degree of opposition is compared to the area's potential, demonstrating that the tourist traffic in the region is quite low, or that the tourists rarely stay during the nights in local accommodation units, preferring other accommodation.
The restaurants are few in number, they do not use the local specificity in the menus or in the interior and exterior decoration [1].
However this situation could be considered an exception, as in many regions of Romania tourism offer has started to modernize and develop to better satisfy visitors' desires of accommodation, facilities an entertainment [10].
There are well known regions [12, 13, 18] and counties 11, 16, 21] where tourism is flourishing benefiting of more visitors, overnights stays and income [Tourism agencies play an important role in promoting the tourist offers [14, 15].
The objectives of the current study are to analyze the accommodation capacity of the region, the number of accommodation units, the number of overnight stays and the net capacity rate in Ialomita County.

MATERIALS AND METHODS

For a more concrete documentation, we analyzed and interpreted tourism data from Ialomita in the period 2008-2020 [30]. The statistical data provided by NIS regarding the tourist infrastructure were also utilized.
For the qualitative research, there were applied the following methods: documentation based on the consultation of current literature that could be accessed and official documents, and observation method.
The quantitative research used the following research methods: analysis method and data processing, graphic and cartographic method, the method of observation and interpretation.
The data were processed and converted into tables, graphs and then interpreted and analyzed. Data used in this study are part of the textbook on the desk.

RESULTS AND DISCUSSIONS

Number of places in accommodation units and their structure by unit category in Ialomita tourism

Tourist reception structures are the most important part of the technical-material base of tourism.
The tourist accommodation units include public utility spaces classified and arranged in such a way as to allow the accommodation of tourists and the provision of specific services according to the location.
The accommodation facilities include all the facilities and services for overnight stays for tourists, such as: hotels, motels, inns, inns, villas, bungalows, cottages, campgrounds, youth camps, sanatoriums, etc., with permanent or seasonal occupancy [4].
The number of places existing in housing units in Ialomiţa county was 2,473 in 2020, approximately 0.69% of the total number of places housing units in Romania.
The number of places in housing units registered a fluctuating trend, thus, from 2,528 units in 2008, 2,807 in 2010, to 2,473 in 2020 (-55 places versus 2008) (Table 1).
The most numerous places are in hotels, with a share of 83.06% in 2008, but with 61.7% in 2020.
On the 2nd position are campgrounds preferred by tourists with lower incomes and especially for one night. The share of their places increased from 1.34% in 2008 to 13.82% in 2020.
On the 3rd place are the motels, whose percentage increased from 4.58% in 2008 to 8.16% in 2020. In general, they are frequented by people who stay for one night and are in transit.
Tourist cottages are ranked the 4th, with a share of the number of places of 4.15% in 2008 and a slight growth to 4.24% in 2020.
Tourist villas are ranked the 5th with a lower share ranging between 1.02 % in 2008 to 2.91% in 2020, but being preferred mainly by families desiring to spend a few nights in a comfortable place.

Table 1. Existing tourist accommodation capacity by type of tourist accommodation facilities in Ialomiţa County (number of places)

No. places in accom. units	2008	2009	2010	2018	2019	2020	2020/ 2008%
Total	2,528	2,612	2,807	2,469	2,477	2,473	97.82
Hotels	2,100	2,156	2,193	1,522	1,530	1,526	72.66
Hostels	15	15	15	69	69	69	460.00
Motels	116	120	145	202	202	202	174.13
Tourist Villas	26	26	50	72	72	72	276.92
Tourist small Cottages			18	14	14	14	-
Campgrounds	34	44	44	342	342	342	1,005.88
Tourist larger cottages	105	105	105	105	105	105	100.00
Student and preschool camps	120	120	122	90	90	90	75.00
Tourist guesthouses				27	27	27	-
Agrotourism guesthouses	12	26	26	26	26	26	216.66
Share of hotels in total units (%)	83.06	82.54	78.12	61.64	61.76	61.70	-
Share of campgrounds (%)	1.34	1.68	1.57	13.85	13.80	13.82	-
Share of motels (%)	4.58	4.59	5.16	8.18	8.15	8.16	-
Share of tourist cottages (%)	4.15	4.01	3.74	4.25	4.23	4.24	-
Share of tourist villas (%)	1.02	0.99	1.78	2.91	2.90	2.91	-

Source: Own calculation based on NIS data [10].

The accommodation capacity recorded fluctuations.

In Ialomita county, the accommodation capacity decreased from 2,473 places in 2020 compared to 2,528 places in 2008, while in Romania, between 2008-2020, the accommodation capacity had an upward trend. Thus, the share regarding the tourist capacity experienced a decrease. Thus, compared to Romania, in Ialomita county, it declined from 0.85% in 2008 to 0.69% in 2020.

This situation could be explain by the fact that in the year 2020 it has emerged the Covid-19 pandemic which paralyzed many fields of activities among which tourism was the most affected.

People has to respect the measures imposed by authorities, and the period of relaxation started in June when most of the tourists had to take last minute decisions where to spend their vacation.

Many tourism units with role in tourist accommodation were closed in the first part of the year and the personnel had to look for jobs in other fields than tourism.

Tourist accommodation capacity in operation in Ialomita county in terms of the number of places-days

The number of days in tourist accommodation units in Ialomiţa county decreased by 42.33% during the analyzed period, 2008-2020. Thus, from 596,683 days in 2008, they recorded a decrease to 345,307 days in 2020 (- 42.13%).

In the same interval, 2008-2020, at the national level, the number of places-days increased by 8.19% from 59,187,968 places-days in 2008 to 64,040,595 places-days in 2020 (Table 2).

Table 2. Tourist accommodation capacity in Ialomiţa County in terms of the number of places-days, 2008-2020

Number of places-days	2008	2009	2010	2018	2019	2020	2020/ 2008%
Romania	59,187,968	51,104,435	63,808,286	89,075,891	88,789,656	64,040,595	108.19
Ialomita county	596,683	577,621	573,151	511,156	506,494	345,307	57.87
Share of Ialomita county in Romania's places-days (%)	1.01	0.95	0.90	0.57	0.57	0.54	-

Source: Own calculations based on NIS data [10].

Number of dining units

Along with the dining units, an important part in the structure of the technical-material base is held by the food units, designed to ensure both dining and entertainment facilities.

The food facilities offered by tourism represent the entire food and catering system for serving tourists meals for the duration of their temporary stay at tourist destinations. The same is true of the facilities offered by the food establishments, other than those intended for tourist food: breweries, taverns, daytime and night-time bars, chefs, pastry chefs [5].

The most famous restaurants are: Sohodol, Semluna, M Somimas, lexi Star, Brancusi, Laguna Albastra, La Scala.

In Ialomiţa county, the food network has approximately 23,000 places to eat, the structure of the units varying from casual or special restaurants, to brasseries, bars, buffets, cafeterias.

Regarding the level of comfort, most of the losses at the table are taken in the units of the first and second categories (about 87% of the total).

It results in an average of 2.5 places per table for one place.

Leisure units

Leisure represents a basic component of the tourist product, although it is designed to ensure the active rest of the tourists, contributing greatly to a new health of life.

In the county of Ialomiţa, leisure takes various forms such as: parties, dance halls, billiard tables, but their number is quite small.

The only leisure complex is located on the territory of the city of Amara, in the immediate vicinity of the lake with the same name, at a distance of only 7 km from the Municipality of Slobozia.

The favorable climate contributes to relaxation together with the steppe vegetation and landscaped parks.

Treatment units

The treatment centers are located in Amara Resort. They offer a large range of treatments for various diseases like: articular rheumatism; polyarthrosis; degenerative rheumatism; peripheral neurological disorders; gynecological disorders; post-trauma syndrome; recovery after operations on joints, muscles, bones; dermatological disorders; endocrine disorders; occupational diseases.

The main natural healing agent is the Amara lake. The total degree of mineralization of Amara Lake is 9.88g/l, with a high content of sulfate, sodium chloride and magnesium.

The silt of the lake is sapropelis, which contains 40% organic substances and 41% mineral substances.

Among the main facilities available at the resort, there are: baths and wraps with salt mud, mud poultices, internal salt of mineral water, hydrotherapy, electrotherapy, air therapy.

Analysis of tourist traffic

For a better understanding of the tourist phenomenon in Ialomiţa county, the internal tourist circulation is being studied.

The arrivals of tourists (established tourists), the number of overnight stays, the average length of stay, the tourist density and the coefficient of use of accommodation capacities are the main indicators according to which we analyze the tourist flow [7].

Tourist arrivals

The structural changes of the main indicators, the number of tourists staying and overnight stays generate fluctuations in tourist traffic in Ialomita county. Tourist traffic in Ialomiţa county is reduced, given the socio-economic conditions unfavorable to mass tourism, as well as the technical condition and the low level of comfort [30]. This is also due to the constant reduction, from year to year, of the number of tourists arriving in accommodation units [8]. Other reasons that could have caused this reduction in the number of arrivals are: the quality of the services offered to tourists, the tourist potential of the county, the rates charged in these accommodation units, tourist offices, etc. [28].

From Table 3, one can very well observe the evolution of the number of tourists arriving in the tourist reception facilities.

Table 3. Tourist arrivals in tourist reception structures with tourist accommodation function by unit category and type of tourists in Ialomita County, 2008-2020

Type of accom. unit	Type of tourist	2008	2009	2010	2018	2019	2020	2020/ 2008%
TOTAL	Total	52,481	42,839	36,480	42,154	43,567	22,368	42.62
	Romanians	48,177	39,776	34,417	39,101	40,387	21,785	45.21
	Foreigners	4,304	3,036	2,063	3,053	3,180	583	13.54
Hotels	Total	43,009	38,382	30,732	30,865	32,242	15,572	36.02
	Romanians	38,863	35,514	28,895	28,334	29,567	15,027	38.66
	Foreigners	4,146	2,868	1,837	2,531	2675	545	13.14
Hostels	Total	548	171	69	3,200	4,263	2,283	416.60
	Romanians	546	169	66	2,981	4,049	2,263	414.46
	Foreigners	2	2	3	219	214	20	1,000.0
Motels	Total	4,008	2,906	3,871	6,354	5,184	3,690	92.06
	Romanians	3,860	2,782	3,713	6,062	4,912	3,674	95.18
	Foreigners	148	124	158	292	272	16	10.81
Tourist villas	Total	3,480	189	554	756	932	789	22.67
	Romanians	3,480	128	508	751	917	787	31.73
	Foreigners		61	46	5	15	2	-
Tourist cottages	Total			22	28	27		-
	Romanians			17	23	27		-
	Foreigners			5	5			-
Campgrounds	Total	180	183	265	-	-	-	-
	Romanians	180	183	265				-
Camps for students and preschoolers	Total	894	470	735	587	499		-
	Foreigners	894	470	735	587	499		-
Agritourism guts houses	Total	362	538	232	205	20	34	9.39
	Romanians	354	530	218	205	20	34	9.60
	Foreigners	8	8	14				-

Source: Own calculations based on NIS data [10].

In the year 2020, most of the tourists, more exactly 74%, preferred to stay in hotels, then in motels 11.89%, in hostels 9.78%, at a very long distance there are villas 2.13% and camps for students and preschoolers 1.14%.

All the other accommodation types have less visitors. In 2020, the highest share is represented by Romanians, 92.7% of the total tourist arrivals in tourist reception structures. However, even in this case, their number in 2020 decreased by 54.38% compared to their number in the year 2008.

The highest decline of Romania tourists was noticed in hotels (-61.34%), tourist villas 60.27%. But in hostels, the number of domestic tourists increased more than 4 times. This is a reflection of the lack of attention paid by managers of tourist units to modernize accommodation conditions and facilities, including leisure alternatives. Also, the lack of correlation between the tariffs per night and services quality is also a cause which explains the reduction in the tourist' number in Ialomita county. The reduction in tourist flow generates a very low coefficient of capacity utilization in Ialomiţa county.

This is a result of an irresponsible survey, not adapted to the new market trends, or of the almost permanent changes involved in the organization of resorts or commercial tourism companies in the Ialomita county [29].

Number of overnight stays in the existing facilities

Table 4. Overnight stays in tourist accommodation facilities by types of facilities, types of tourists in Ialomiţa County, 2008-2020

Type of accom. unit	Type of tourist	2008	2009	2010	2018	2019	2020	2020/ 2008%
TOTAL	Total	304,068	273,843	199,574	170,308	184,076	73,697	24.23
	Romanians	296,193	266,588	195,600	164,913	177,911	72,195	24.37
	Foreigners	7,875	7,255	3,974	5,395	6,165	1,502	19.07
Hotels	Total	233,552	259,456	183,858	151,739	163,086	62,062	26.57
	Romanians	225,960	252,632	180,245	147,066	158,577	60,667	26.84
	Foreigners	7,592	6,824	3,613	4,673	4,509	1,395	18.37
Hostels	Total	2,122	485	357	4,939	7,747	4,418	208.19
	Romanians	2,120	482	296	4,612	7,260	4,337	204.57
	Foreigners	2	3	61	327	487	81	4,050.0
Motels	Total	5,635	6,009	7,141	8,013	8,616	6,394	113.46
	Romanians	5,378	5,742	6,967	7,634	7,479	6,370	118.44
	Foreigners	257	267	174	379	1,137	24	9.33
Tourist villas	Total	56,956	336	659	1,463	1,642	789	1.38
	Romanians	56,956	275	613	1,458	1,616	787	1.38
	Foreigners	:	61	46	5	26	2	-
Tourist cottages	Total	:	:	37	48	46	:	-
	Romanians	:	:	21	38	46	:	-
	Foreigners	:	:	16	10	:	:	-
Campgrounds	Total	2,340	2,580	3,325	:	:	:	-
	Romanians	2,340	2,580	3,325	:	:	:	-
Camps for students and preschoolers	Total	2,764	3,960	3,774	3,522	2,370	:	-
	Romanians	2,764	3,960	3,774	3,522	2,370	:	-
Agritourism guts houses	Total	699	1,017	423	392	20	34	4.86
	Romanians	675	917	359	392	20	34	5.03
	Foreigners	24	100	64	:	:	:	-

Source: Own calculations based on NIS data [10].

Approximately 90% of the number of tourists from Ialomita county stay in hotels, followed by motels, student hostels and campsites, as shown in Table 4.

The number of overnight stays by tourists in hotels also decreased significantly from 304,068 overnight stays in 2008 to 73,697 overnight stays in 2020 (-75.77%).

In 2020 versus 2008, the results from Table 5 show that the highest declined was recorded in hotels (-73.43%), in agri-tourism guest-houses (-95.14%) and tourist villas (-98.62%).

Motels are an exception, where the number of overnight stays increased by 13.46%, but also hostels, where they increased by 108.19%, due to practical the low prices.

In 2020, the number of overnight stays in Ialomita county accounted for 73,697 compared to 304,068 in the year 2008, meaning a reduction of 58.12%. As a result, the share of the number of overnight stays in Ialomita country in the total overnight stays in Romania declined from 1.46% in 2008 to 0.5% in 2020.

The degree of use of the tourist resource

This indicator is expressed in percentages and used in the evaluation of the degree of exploitation of tourist capacities.

The calculation formula is as follows:

GUGT = number of nights/number of accommodation places x number of working days x 100 [9].

The results presented in Table 5 reflects a low capacity of using the available resources in the tourism of Ialomita county, as in the period 2008-2020, the number of overnight stays declined by -75.77% and the number of places by -2.18%. In consequence, the degree of use of the tourist resources decreased from 32.96% in 2008 to 8.16% in 2020.

Table 5. The degree of utilization of the tourist resource in Ialomiţa County

	2008	2009	2010	2018	2019	2020	2020/ 2008 %
Overnight stays	304,068	273,843	199,574	170,308	184,076	73,697	24.23
Number of places	2,528	2,612	2,807	2,469	2,477	2,473	97.82
Degree of use (%)	32.95	28.72	19.48	18.90	20.36	8.16	-

Source: Own calculations based on NIS data [10].

The net capacity rate of utilization

The index of tourist net capacity rate of utilization has varied in Ialomita county from a month to another sometimes being higher than the national average, other times being smaller in the year 2020 as shown in Fig. 1. In Ialomita county, the index of net capacity rate in the tourism is higher than the average index in Romania's tourism in January, February, March, April and June, but in the summer months it is below. However, in the month of August, it recorded a peak value, as at the national level, August being the month when most of people is in summer holidays.

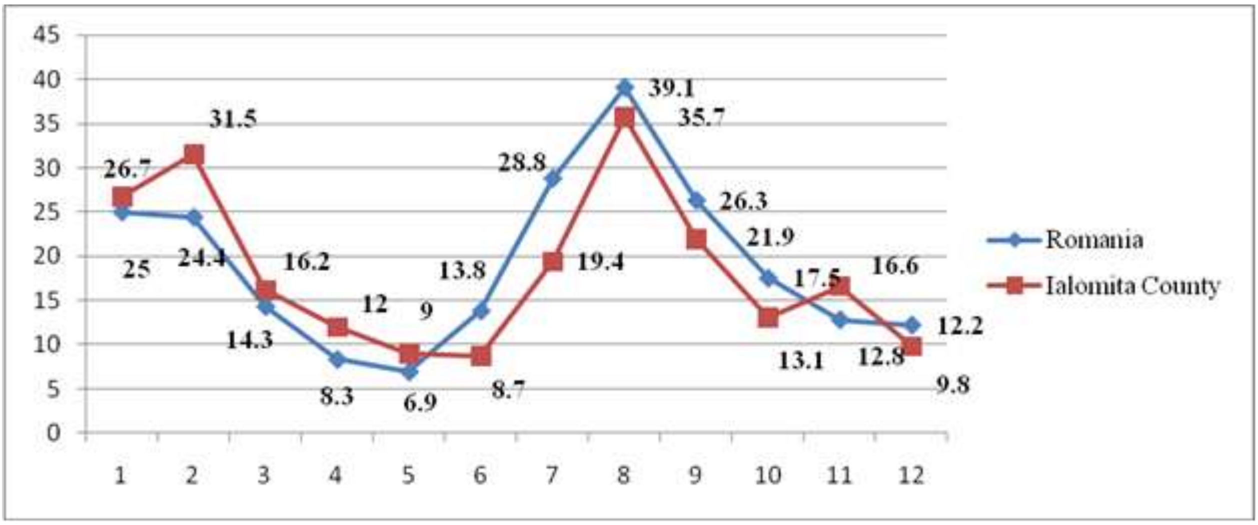

Fig. 1. The dynamics of the index of net capacity rate in the tourism of Ialomita County compared to the average rate in Romania in the year 2020

Source: Own design based on the data from National Institute of Statistics.

In September, October and December, in Ialomita tourism the net capacity rate is below the national index, but in November is higher.

Therefore, this could be explained by the key attraction which is in Ialomita county, the Amara spa resort, where many people go for getting a corresponding treatment for various diseases. In the first months of the year and in November, the main category of tourists in Amara resort are the pensioners.

This confirms again that tourism resources are not enough valorised in this county and for this reason the tourist flow and number of overnight stays are not satisfactory in comparison with the accommodation capacity. If we compare with other counties of where the local authorities and business people are very much involved in the development of the localities and the region by means of tourism, we cannot be satisfied about how tourist resources are valorised in Ialomita county.

CONCLUSIONS

Ialomiţa County, thanks to its natural elements, offers elements of beauty and novelty, the hunting and fishing area of the Ialomiţa and Danube rivers, historical and cultural values, creates the proper framework for the development of tourism.

The most important tourist destination of Ialomiţa County are Băile Amara, located 7 km from Slobozia and 126 km from Busureşti, famous for its sapropelis mud and medicinal mineral water, which are popular in the countryside.

The county is visited especially for spa treatment in Amara Resort and not for other tourist objectives.

Therefore, Ialomita County has numerous tourist resources, but they must be kept alive and not excessively exploited in order to preserve them.

The most numerous accommodation units are represented by hotels, and the number of overnight stays is also high in hotels.

However, hostels and motels look to be the most attractive unit of accommodation and Romanians are the main visitors, even though their number has substantially declined in the analyzed period.

However, tourist flow declined in this county of Romania due to a weak management of tourist resources and low service quality connected to tariffs.

A higher involvement of the local authorities and new opportunities for business could be encouraged as Ialomita country to have a flourishing competitive tourism.

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CLIMATE CHANGE AND ITS IMPACT ON WHEAT, MAIZE AND SUNFLOWER YIELD IN ROMANIA IN THE PERIOD 2017-2021

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Abstract

The paper purpose was to assess the impact of climate change on wheat, maize and sunflower yield in the period 2017-2021, using statistical data from National Institute of Statistics (NIS) and National Administration of Meteorology (NAM) and other sources. Comparison method was used to evaluate the deviations between the registered air temperatures and precipitations and the 1981-2010 climatological norm. Graphic method reflected the dynamics of monthly air temperatures and rainfalls in each year. Descriptive statistics for mean, standard deviation and coefficient of variation reflected an more comprehensive image upon air temperature, precipitations and yield. Correlations and regression equations were used to establish the intensity of the kinks between climate factors and yield. The highest average air temperature In Romania was 12.13^{0}C in 2019. In the period 2017-2020, the average annual temperatures exceeded the climatological norm 1981-2010 accounting for 9.1^{0}C. The lowest rainfalls, 614.2 mm, were recorded in 2019, being below of 633.1 mm the norm for the period 1981-2010. The high temperatures associated with drought and low precipitations have deeply affected yield of many agricultural crops, including maize, wheat and sunflower. The highest wheat yield 4,888 kg/ha was achieved in 2017, and the lowest one, 2,966 kg/ha in 2020. Maize registered the highest performance of 7,644 kg/ha in 2018, and the lowest one, 3,977 kg/ha in 2020. Sunflower carried out the high performance 3,041 kg/ha in 2018, and the lowest one, 1,858 kg/ha in 2020. The worst agricultural years for these three crops was 2020, but 2017 favored wheat, while 2018 favored maize and sunflower. The correlation coefficient had in general small values between average temperature and yield, but a higher link with precipitations level. The multiple correlation between yield, air temperatures and precipitations was: r= 0.817 for wheat, r = 0.116 for maize and r = 0.504 for sunflower. In the South Eastern Dobrogea, the driest area in Romania, the rainfalls declined by 65% in the period 2018-2020 having a deep negative impact on sunflower seeds yield, which decreased from 4,282 kg/ha in 2018, to 1,503 kg/ha in 2020. The correlation between precipitations and sunflower yield positive and very strong (r = 0.737). As a conclusion, the climate conditions should be analyzed in each farm and farmers have to take measure to adapt the technologies for sustaining production.

Key words: *climate change features, wheat, maize, sunflower, yield, Romania*

INTRODUCTION

Romania is an important country in the EU agriculture, both as producer and exporter of agricultural products and food.
Of the 8.3 million cultivated area, the highest share is kept by three crops: maize 30.8% and wheat 26.3%, summing 57.1% and sunflower 13.6%, all together accounting for 70.7% [24, 33, 36, 37].
In 2020, of the 18.1 million tonnes cereals carried out in Romania, wheat represented 6.4 million tonnes and maize 10.9 million tonnes, all together 17.3 million tonnes (95.5%) [32, 34, 38, 40].
Since 2015, Romania's sunflower production of seeds is on the top position in the EU. In 2020, Romania contributed to the EU sunflower output by 2.1 million tonnes (34%) [33, 35, 41, 42, 44].
The exports raised both quantitatively and as values. In 2020, Romania exported 4.4 million tonnes wheat and rye, 5.8 million tonnes maize and 1.6 million tonnes sunflower seeds,

at the same time assuring the availabilities for internal consumption which accounted for 3.9 million tonnes, 6.6 million tonnes and, respectively for 1.3 million tonnes [33, 39, 41, 46].

During the last decade, the yield and production performance were due to the efforts made by farmers to modernize production technologies and increase economic efficiency in wheat, maize and sunflower cropping. However, this performance would have been higher if the climate change has not been intensified during the last decade, climate factors being the main environmental items influencing the evolution of the development of agricultural crops and productivity.

Climate factors are considered of high risk for agriculture, taking into account the monthly, annual and multiannual deviations of temperature and precipitations from the climatological norms [3].

Any deviation from the optimal requirements in thermal, rainfalls regime, wind and air humidity along each phenological stage could affect yield and harvest, farmers' income and profit [8].

Despite that the effects of climate change are more and more visible, there are still not enough studies which approach the climate impact on yield.

In Europe, in the last decade, it was noticed a higher temperature, an elevated CO_2 concentration in the atmosphere, low rainfalls and extreme hazards. In consequence, sunflower was deeply affected by heat stress and drought during its growing cycle leading to a loss of yield, oil content and fatty acids [7].

In the EU, it was noticed a relevant progress in wheat and barley, and it was affirmed that a temperature growth by 1^0C could increase yield by +0.33 T ha^{-1}. At the global level, in the recent years, warming has led to a stagnation yield progress.

To adapt to higher temperatures, a mix between genetic performance, crop cycle duration, drought tolerance, sowing moment and smart irrigation could be a useful recommendation [15].

In France, maize and wheat yield is highly challenging due to climate change in the opinion of [4].

In Spain, the impact of climate change on wheat and barley was studied using regression models like EURO-CORDEX regional climate model RCM simulation combining maximum and minimum air temperature with monthly precipitations [2].

Rain fed and irrigated sunflower yield was studied in connection with climate change in Turkey and it was found that an increase of temperature will cause a shortening of plant growth cycles [13].

In Serbia, there were found positive correlations between precipitations in July and August sand maize and sunflower yield, and also that the temperatures registered in March, August and September are the most responsive of crop yield level [25].

[50] used regression models and correlations, and found that wheat yield is strongly influenced by rainfall in January-March.

In Hungary, 75% of the area cultivated with sunflower is affected by drought and as a result it is was noticed a loss of yield [14].

In Romania, during the last decade, climate is characterized by the following aspects:

-the shift of the seasons;

-mild winters with a thin snow layer or even missing in some parts of the country; late frosts; low precipitations and even absent across the year in the period of vegetation of the plants;

-an increased air temperature, heat waves and a scorching heat for a longer period of time, severe drought in many regions and pedological drought on the surfaces situated in the South, East and South-Eastern part of the country;

-the appearance of desertification in the traditional zones for cultivating wheat, maize, barley, sunflower and also other crops and plants;

-extreme phenomena like: huge rainfalls, floods, storms, hail [1].

The largest agricultural surfaces have a moderate regime of precipitations, a moderate and dried regime. In the period 1961-2010 it was noticed a general decreasing trends in precipitations, especially in the South, South East and Eastern part of the country.

In the period 2001-2010, the average annual temperature increased by + 0.4...+0.6 degrees compared to each decade since 1961 till present when it reached 9.3^{0}C [49].

In the last 40 years, the average annual temperature increased by +2^{0}C in Romania [5].

All these aspects have had a deep impact on crop development, production level per surface unit, seeds quality and their destinations, selling price at the farm gate, farmers' income and profit, especially in South and South-East Muntenia, Dobrogea, South West Oltenia, West, North-West Transilvania and Moldova regions.

Also, demand/supply ratio on the domestic market, price volatility, seeds trade on the domestic market and Romania's external trade were also disturbed due to lower yields and productions in wheat, maize and sunflower and other crops [37, 47, 48].

Theses aspects were studied by researchers who pointed out the impact of climate change on agricultural crops in Romania.

In this respect, it was attested that wheat cultivated in the West part of Romania is extremely vulnerable to meteorological hazards [21].

Studying the physiological feed-back of winter wheat and maize to climate change, using CERES simulation crop models, it was concluded that "interaction between double CO_2 concentrations and higher temperatures, under irrigated maize in South of Romania had a negative response to climate change" and it was suggested the use of a longer maturity hybrid, sown in the last week of April, for diminishing the impact of climate change on maize yield [6].

In Transilvania, it was found that using an optimal combination between fertilization and crop protection in conservation agriculture system could be an alternative for maize [9] and also for wheat yield compared to conventional agriculture [11].

The No-tillage system and fertilization could increase wheat production and also protein and gluten content in grains [10, 12].

The extreme meteorological phenomena obliged the farmers to adapt crop technologies to diminish the negative impact of climate change on yield [22, 23].

Dobrogea, South East Romania, is the region with the lowest precipitations accounting for less than 200 l/year during the last years and combined with higher and higher temperatures, heat waves and pedological drought, production per surface unit in many crops, and especially in sunflower was diminished [43, 45].

In such a situation, to sustain yield, farmers proceeded to adapt sunflower technology selecting the hybrids with high yield performance and resistant to drought and also changed the sowing moment and plant protection scheme [16, 17, 18].

In this context, the aim of the paper was to analyze the impact of climate change in Romania, in terms of temperatures and precipitations, on wheat, maize and sunflower yield in the period 2017-2021, using correlations and regression models between yield and climate factors.

MATERIALS AND METHODS

The research work is based on a large source of information, including empirical data from National Institute of Statistics- NIS, National Administration of Meteorology-NAM and other sources [18, 19, 20].

The main climate indicators used in this study were:

-air temperatures, maximum, minimum, average at the level of each year and also by month in Romania;

-rainfalls, maximum, minimum, average per year and also per month in Romania.

Wheat, maize and sunflower yields were studied in the period 2017-2021;

Correlation coefficients were calculated between yield and temperatures and rainfalls.

Regression equations were used to evaluate the dependence of yield on the level of temperatures and precipitations.

A study case regarding the impact of the decrease in precipitations in South Eastern Dobrogea on sunflower yield was included to point out that climate factors have to be studied locally and in consequence farmers have to adapt the technology to sustain production.

Tables and graphics were used to synthesize the results.

Finally, the conclusions presented the main ideas drawn from this research work.

RESULTS AND DISCUSSIONS

Climate characteristics in the period 2017-2021

The last decade 2012-2021 has reflected more than ever an alarming climate change with a negative economic, social and environmental impact.

The temperatures proved a warming process year by year, exceeding the value of 9.1^{0}C, representing the climatological norm in the period 1981-2010 (Fig. 1) [27].

The figures show that the years 2019 and 2020 are the warmest years in the history, and the experts consider that ”the decade 2012-2021 is the warmest interval of 10 consecutive years with positive thermal deviations since the meteorological measurements have been made in Romania" [1]. The analyzed period is characterized by extreme meteorological phenomena like: high air temperatures, heats waves, scorching heat, low precipitations and unevenly distributed in the territory of the country, strong and prolonged drought, pedological drought, torrential rains followed by devastating floods, storms and hail, which caused damages to the households and agricultural crops.

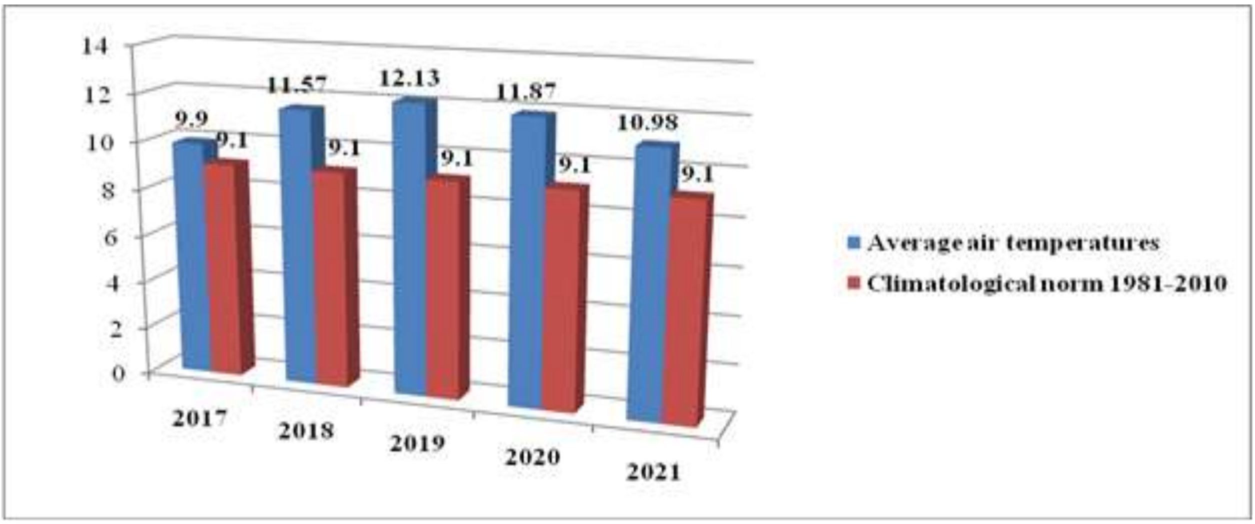

Fig. 1. Air temperatures in Romania, 2017-2021 compared to climatological norm 1981-2010 (^{0}C)
Source: Own design based on the data from [27, 28, 29, 30, 31].

Annual precipitations varied from a year to another with a general decreasing trend in Romania from 791.5 mm in the year 2016 to 648.2 mm in the year 2021, meaning a reduction by -143.3 mm.

Taking into account the climatological norm 1981-2021 of 633.1 mm, it is obviously that in the years 2017, 2018, 2020, 2021, precipitation level was higher, but in the year 2019 it was registered 614.2 mm, by -18.9 mm less (-3%) (Fig. 2).

The year 2017 recorded 9.9^{0}C average air temperature by +0.8^{0}C more than the climatological norm of 9.1^{0}C. The deviations of temperatures varied between 0.3^{0}C in the month of May and 3.9^{0}C in January, but in the other 9 months between 0.1^{0}C in October and 3.4^{0}C in March [31].

The annual precipitations accounted for 673.5 mm, with a deviation of 40.4 mm (+6.1%) compared to the multiannual norm 1981-2010 whose value was 633.1 mm [31].

The average monthly precipitations in 2017 were 56.1 mm, with variations between the maximum level 84.7 mm in the month of May and 27 mm in January.

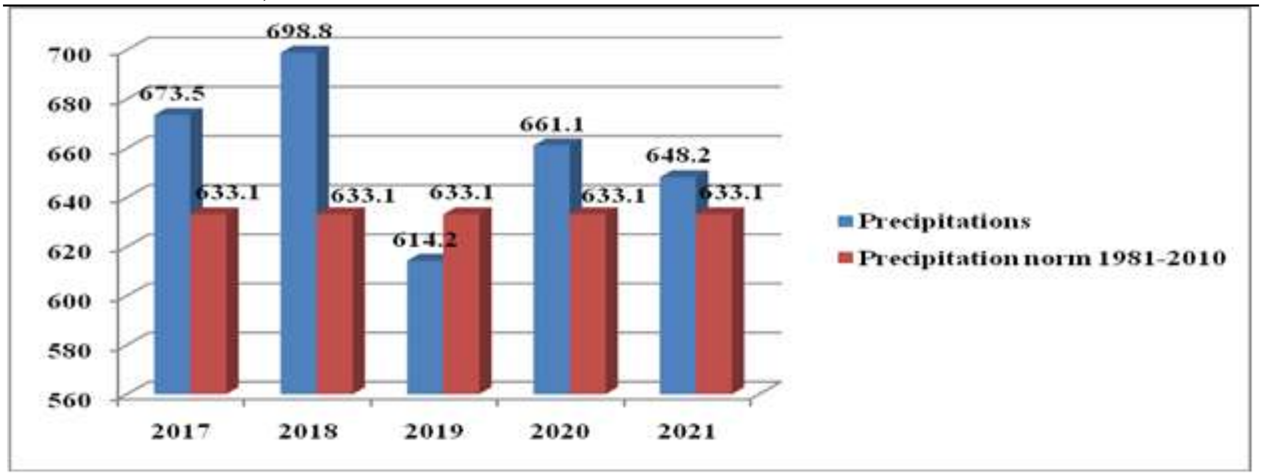

Fig. 2. Annual precipitations in Romania, 2017-2021 compared to climatological norm 1981-2010 (mm)
Source: Own design based on the data from [27, 28, 29, 30, 31].

Compared to the climatological norm 1981-2010, the deviations were positive in most of the months except June (-15.9), August (-28.1) and September (-0.4).

The year 2018 registered 11.57^{0}C average air temperature, being by +2.47^{0}C higher than the climatological norm (9.1^{0}C), and for this reason, "this year was considered the 3rd year with the highest temperature since the year 1901 till present" [26].

The annual precipitations accounted for 698.8 mm, being by +65.7 (10.3%) higher than the climatological norm (633.1) [30].

The precipitations varied between 20 mm in October, the minimum and 159 in June, the maximum, the monthly average being 58.2.

Compared to the multiannual norm 1981-2010, negative deviations were registered in: April (-31.6), May (-7.5), August (-33.7), September (-27), October (-23.5), November (-1.5), in the other months the deviations being positive.

The year 2019 was in the top of the warmest years, reaching the record of 12.13^{0}C average air temperature, exceeding by +3.03^{0}C the climatological norm 1981-2010 (9.1^{0}C). This year was characterized by long and severe drought periods and even pedological drought in some regions of Romania, affecting the normal phenological development of the agricultural crops [29].

The annual precipitations accounted for 614.2 mm, being by -18.9 (-3%) smaller than the multiannual norm 1981-2010 (633.1).

The maximum amount of precipitations was 120, registered in May, and the minimum level was 20 recorded in February and March, the average monthly level being 51.1.

Compared to the climatological norm, there were noticed negative deviations in February (-11.6), March (-18.3), July(-20.8), August (-22.7), September (-27), October (-11.5) and December (-14.8) which had a negative impact on the production performance per surface unit in agriculture for various crops [29].

The year 2020 was considered by experts as being "an atypically meteorological year, coming on the 2nd position in the top of the warmest years in the period 1961-2020, after the year 2019".

In fact, starting from November 2019 till March 2020, the period was characterized by cold, then, the first months of 2020 were lacked of precipitations, and suddenly in June higher temperatures than the climatological norm 1981-2010 were registered.

The average temperature in 2020 was 11.87^{0}C, being by +2.7^{0}C higher than 9.1^{0}C, the climatological norm.

The average monthly temperatures varied between 23^{0}C, the maximum level in August and 3.5^{0}C, the minimum level in December.

High deviations from the multiannual norm were noticed on large surfaces in Moldova, Dobrogea, Muntenia and Oltenia, which resulted in lower performances in agricultural productions.

Their persistence led to a hot summer season, as the precipitations were below 200 l/s. m. in June, July and August, leading to an water deficit into the soil mainly in Muntenia, Moldova and Dobrogea regions.

In addition, in some parts of Romania, the fast and huge rains, accompanied by hail and storms produced important damages.

After September 1st, in most of the regions, the precipitation level was reduced, except the North West of the country [28].

The amount of precipitations in 2020 was 661.1, by +28 higher (+4.4%) than the climatological norm 1981-2010.

The monthly precipitations varied between the minimum 10.3 in January and the maximum 131.4 in June, with a monthly average of 55.

Negative deviations from the norm 1981-2010 were registered in January (-23.30, April (-38.1), August (-18.8) and November (-23.2) [28].

The year 2021 recorded 10.98^{0}C average air temperature, exceeding the 1981-2010 norm by +1.88^{0}C, and for this reason, it was included among the warmest years of the decade 2012-2021 (which in the decreasing order are: 2019, 2020, 2015, 2018, 2014, 2013, 2012, 2021).

Taking into account, the period 1900-2022, the experts consider that 2021 is the 15th warmest year.

After the record of temperature 39^{0}C achieved in the west part of the country on June 24-25, at the end of July the temperatures reached 40^{0}C. More than this, the first part of August was the warmest period in the last 60 years. The records of over 40^{0}C were registered in the South-Western part of Romania.

The prolonged heat waves of July and August affected the South, East and West of Romania.

Besides the high temperatures and low precipitations, in 2021, there were registered extreme meteorological phenomena like huge rains, floods, storms and hail [27].

In 2021, the quantity of precipitations accounted for 648.2 mm, being by +15.1 higher than the climatological norm 1981-2010, meaning +2.3%.

In this year, the average monthly precipitations level was 54 mm, with variations between 28.8, the minimum in September and 96.8, the maximum in June.

Negative deviations from the multiannual norm were registered in February (-1), April (-1.7), July (-8.9), September 9-26.2), October (-10), November (-4.2), in the rest of the months positive deviations being noticed [27].

Precipitations recorded by agricultural years

As the purpose of this research work is to assess the impact of climate change in terms of temperatures and precipitations on the yield of three major crops cultivated in Romania, it was considered necessary to calculate the total amount of precipitations characteristic for the agricultural years specific to each crop.

In consequence, for wheat it was taken into consideration the period September till June, next year, for maize it was considered the period January-October and for sunflower, it was considered January-August.

Table 1. Annual precipitations by agricultural years, related to each agricultural crop: wheat, maize and sunflower compared to the climatological norm 1981-2010 (633.1 mm)

	WHEAT September-June		**MAIZE January-October**		**SUNFLOWER January -August**	
	Absolute values	Deviations	Absolute values	Deviations	Absolute values	Deviations
2017	550.4	+59.8	575.4	+28.6	441.2	**-7.1**
2018	632.9	+142.3	599.5	+52.7	551.5	+103.2
2019	529.0	+38.4	540	**-6.8**	480.0	+31.7
2020	460.1	**-30.5**	580.8	+34	454.6	+6.3
2021	598.0	+107.4	527.3	**-19.5**	465.0	+16.7

Source: Own calculations based on the data from [27, 28, 29, 30, 31].

The results regarding the amount of precipitations by each agricultural year an also the deviations from the climatological norm 1981-2010 are shown in Table 1.

The average monthly precipitations and their deviations from the climatological norm 1981-2010 by agricultural year connected to each crop: wheat, maize and sunflower are presented in the Figures 3, 4 and 5.

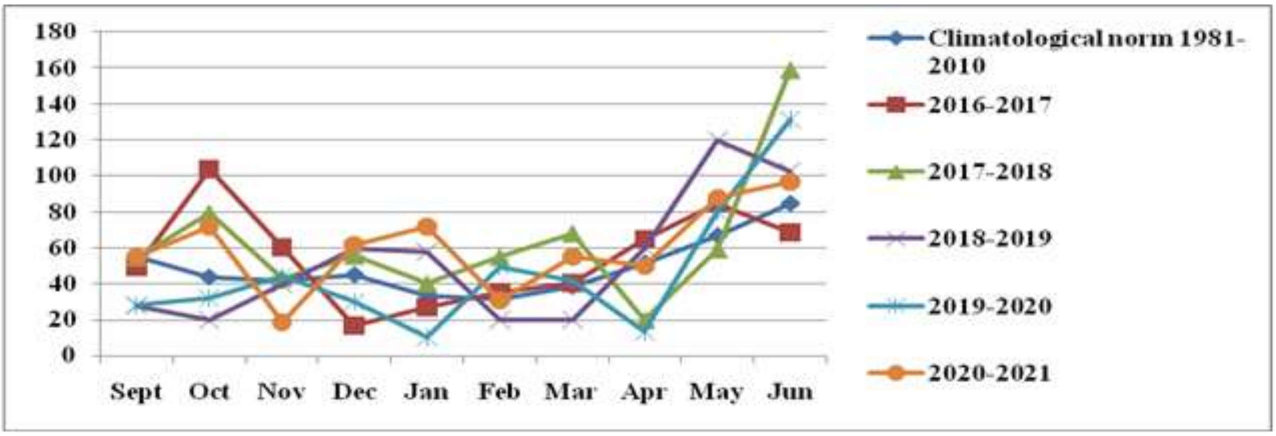

Fig. 3. Distribution of average monthly precipitations by agricultural year connected to Winter Wheat compared to climatological norm 1981-2010 (mm)
Source: Own design and calculations based on the data from [27, 28, 29, 30, 31, 32].

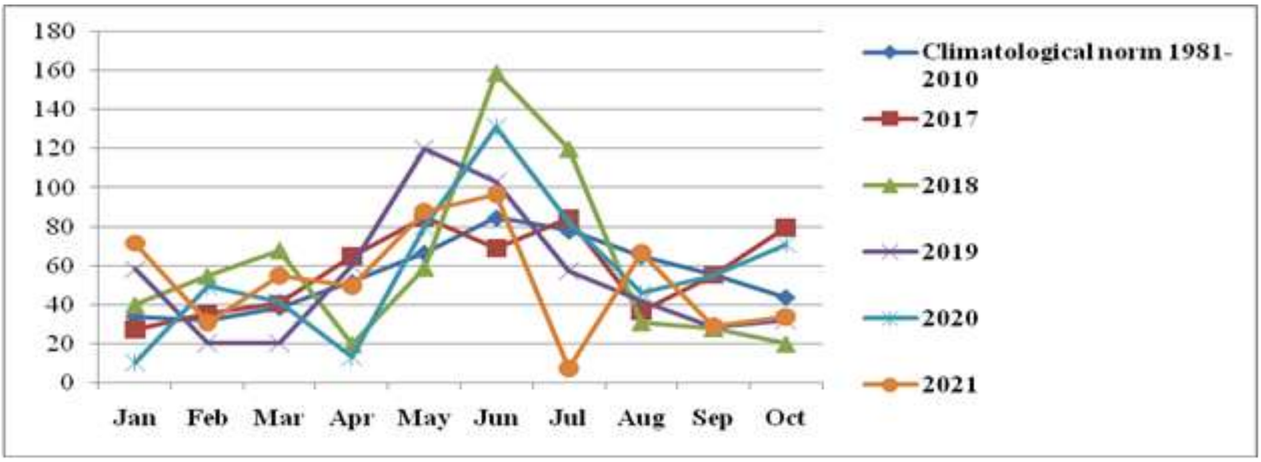

Fig. 4. Distribution of average monthly precipitations by agricultural year connected to Maize and their deviations compared to climatological norm 1981-2010 (mm)
Source: Own design and calculations based on the data from [27, 28, 29, 30, 31].

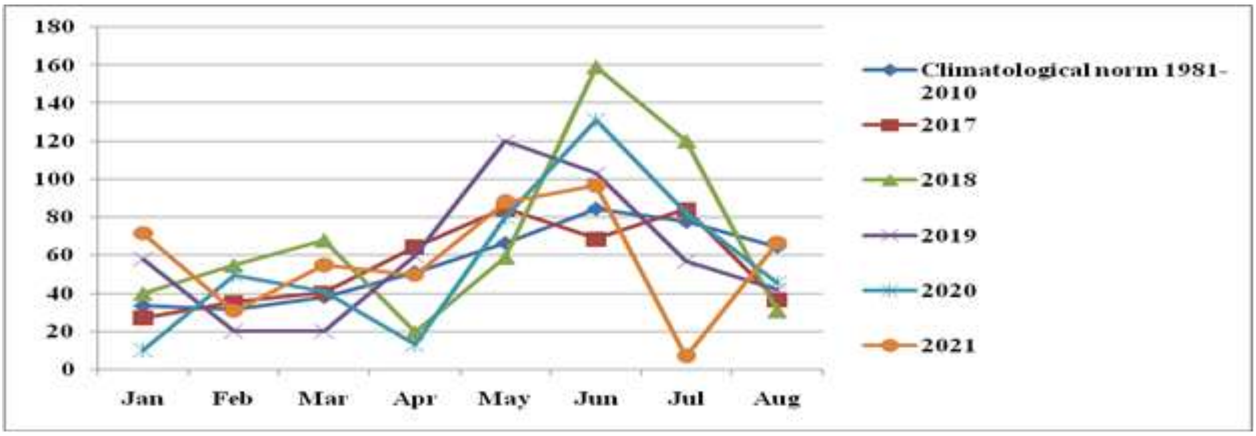

Fig. 5. Distribution of average monthly precipitations by agricultural year connected to Sunflower and their deviations compared to climatological norm 1981-2010 (mm)
Source: Own design and calculations based on the data from [27, 28, 29, 30, 31].

The months with negative deviations from the climatological norm 1981-2020 by each agricultural year and crop are presented in Table 2.

Table 2. The months with negative deviations from the climatological norm 1981-2010 by each agricultural year and crop in the period 2017-2021 in Romania

Agric. year	WHEAT	MAIZE	SUNFLOWER
2017	2016 (Sept., Dec)	2017 (Jan., June, Aug., Sept.)	2017 (Jan., June, Aug.)
2018	2017 (Sept), 2018 (April, May)	2019 (April, May, Aug., Sept., Oct.)	2018 (April, May, Aug.)
2019	2018 (Sept., Oct., Nov.), 2019 (Feb., March)	2019 (Feb., March, July, Aug., Sept, Oct.)	2019 (Feb., March, July, Aug.)
2020	2019 (Sept., Oct., Dec.), 2020 (April)	2020(Jan., April, Aug.)	2020 (Jan., April, Aug.)
2021	2020 (Nov.), 2021 (Feb., April)	2021 (Feb., April, July, Sept. Oct.)	2021 (Feb., April, July)

Source: Own conception based on the data from [27, 28, 29, 30, 31, 32].

In the years 2019 and 2020, the most affected region by thermal stress and unsufficient precipitation was Dobrogea [1].

Wheat, Maize and Sunflower yield by agricultural years

Wheat yield registered the highest performance of 4,888 kg/ha in the year 2017, and the lowest one, accounting for 2,966 kg/ha in the year 2020 (Fig. 6).

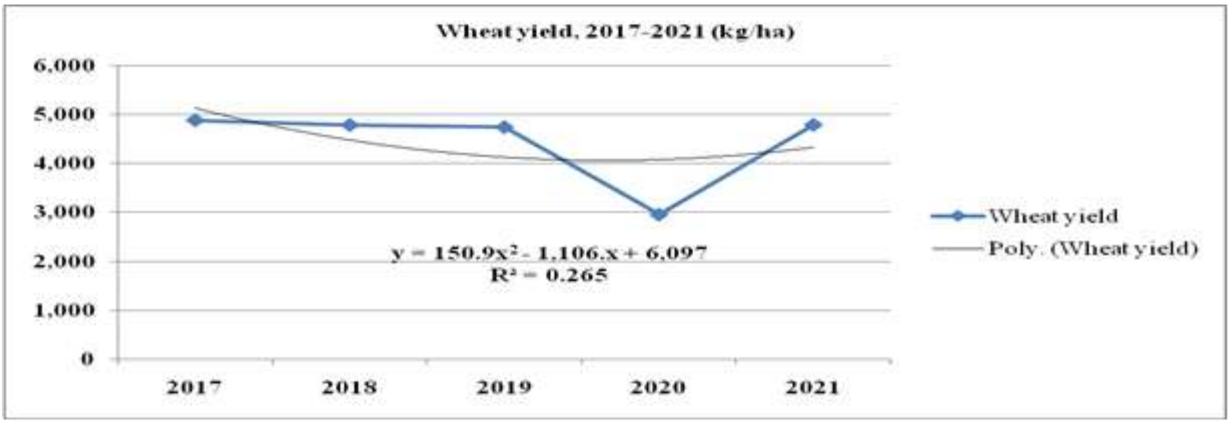

Fig. 6. Dynamics of wheat yield, 2017-2021, Romania (kg/ha)
Source: Own design and calculation based on the data from [33].

Maize yield registered the highest performance of 7,644 kg/ha in the year 2018, and the lowest one, accounting for 3,977 kg/ha in the year 2020 (Fig. 7).

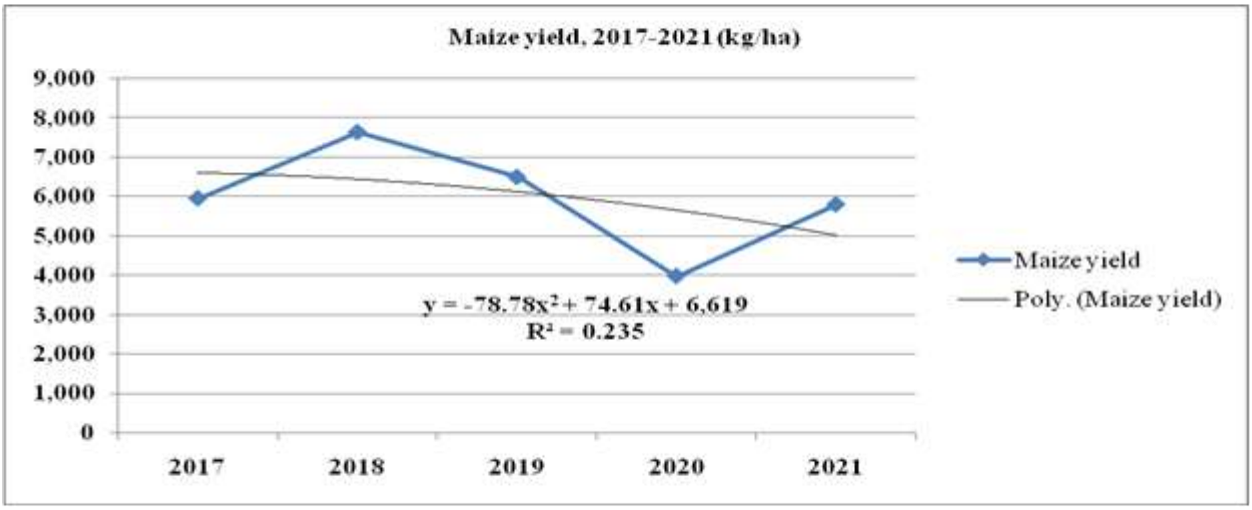

Fig. 7. Dynamics of maize yield, 2017-2021, Romania (kg/ha)
Source: Own design and calculation based on the data from [33].

Sunflower yield registered the highest performance of 3,041 kg/ha in the year 2018, and the lowest one, accounting for 1,858 kg/ha in the year 2020 (Fig. 8).

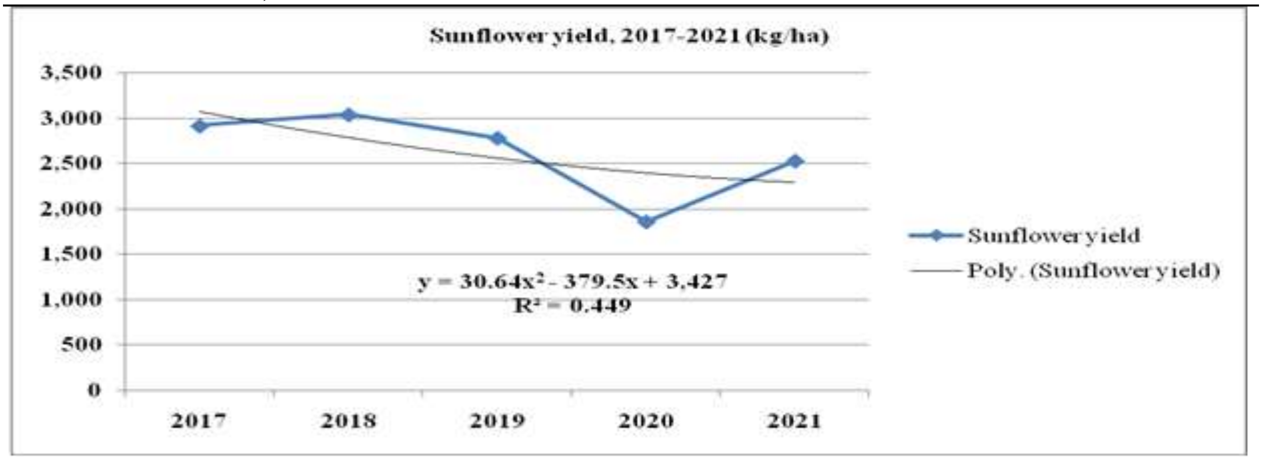

Fig. 8. Dynamics of sunflower yield, 2017-2021, Romania (kg/ha)
Source: Own design and calculation based on the data from [33].

The descriptive statistics in terms of mean, standard deviation and coefficient of variation for yield performance of wheat, maize and sunflower and also average annual temperature and total amount of precipitations by agricultural year in the interval 2017-2021 in Romania is presented in Table 3.

It worth to mention that the coefficient of variations was low in case of annual precipitations and average annual temperatures, but in case of yields it reflected a higher variability, ranging between 17.9% for sunflower, 18.5% for wheat and 22.2% for maize (Table 3).

Table 3. Descriptive statistics: Mean, Standard deviation and variation coefficient for wheat, maize and sunflower yield and also for average annual temperature and precipitations, by agricultural years for the whole period 2017-2021, Romania

Crop	Statistical parameter	Yield 2017-2021 (kg/ha)	Average annual temperature 2017-2021 (^{0}C)	Annual precipitations 2017-2021 (mm)
Wheat	Mean	4,438.6	11.29	554.08
	Stand. Deviation	824.75	0.88	66.36
	Variation Coeff. (%)	18.5	7.8	11.9
Maize	Mean	5,976.8	11.29	564.6
	Stand. Deviation	1,330.92	0.88	29.97
	Variation Coeff. (%)	22.2	7.8	5.3
Sunflower	Mean	2,625.8	11.29	478.46
	Stand. Deviation	469.2	0.88	43.23
	Variation Coeff. (%)	17.9	7.8	9.0

Source: Own calculations based on the data from [27, 28, 29, 30, 31, 32, 33].

Correlations between yield, average annual temperature and annual amount of precipitations

Starting from the reality that yield level is influenced by temperatures and precipitations, there were calculated the correlations between each pair of variables, considering that all the other factors determining yield are at optimum level and also as a constant factor.

Correlations between pairs of variables

In case of wheat, the correlation coefficient reflects the existence of a positive and relatively moderate connection between average production per ha and the average annual temperature (r=0.420) and a strong relationship between yield and annual precipitations. In case of maize, the correlation coefficient shows a weak and positive link between yield and the two climate factors: temperature (r=0.036) and precipitations (r=0.113), and also between temperature and precipitations (r=0.046).

In case of sunflower, the coefficient of correlation reflected a relatively moderate connection between yield and temperature (r=0.343), between yield and precipitations (r=0.479) and between temperature and precipitations (r=416) (Table 4).

Table 4. Coefficients of correlation between yield and average annual temperature and annual amount of precipitations by crops

	Wheat	Maize	Sunflower
Correlation coefficient between yield and average annual temperature	0.420	0.036	0.343
Correlation coefficient between yield and annual amount of precipitations	0.787*	0.113	0.479
Correlation coefficient between average annual temperature and annual amount of precipitations	0.263	0.046	0.416

Source: Own calculations.

The t Test of the correlation coefficient reflected the existence of a significant relationship between wheat yield and annual precipitations. In the other cases, the test results proved that the correlations are not significant.

Correlation between all the three variables: yield, temperature and precipitations

Using multiple total correlation formula, it was found that in case of wheat crop, there is a high connection (r=0.817) between the three variables, for sunflower the multiple correlation showed a positive a moderate relationship (r=0.504) and in case of maize, the multiple correlation was positive but very weak (r=0.116) (Table 5).

Table 5. Multiple correlation between yield, temperature and precipitations by crop

	Wheat	Maize	Sunflower
$r_{z.xy}$	0.817	0.116	0.504

Source: Own calculations.
r= correlation coefficient; z= yield, x= temperature, y = precipitations

Regression equations and coefficient of determination

In case of wheat, the regression equation between yield and average annual temperature could be interpreted that a reduction by one unit of temperature, could induce an average production of 8,458 kg/ha. R square reflects that only 17.65 % of the yield variation is caused by the variation of temperature.

Also, the increase of precipitations by one unit could diminish wheat yield by 0.96 kg/ha. In this case, R square shows that 62% of yield variation is determined by precipitations.

In case of maize, a reduction by one unit of the average annual temperature could assure 6,542 kg maize grains per ha. R square shows that practically, average temperature has almost zero influence of maize yield and other factors are more important in production performance.

An increase in precipitations could grow maize yield by 3.13 kg/ha. R square shows a weak determination of yield variation caused by precipitations. Also, in case of maize, other factors are more important for achieving a production performance.

In case of sunflower, the regression equation tells us that a reduction of temperature by 1^0C could assure a yield of 4,495 kg/ha. R square reflects that an increase of precipitation by one unit could grow sunflower seeds yield by 0.1263 kg/ha. R square shows a weak variation of yield caused by the variation of precipitations (Table 6).

Table 6. Regression equations and coefficient of determination reflecting the dependence of yield (y) on average annual temperature (x_1) and annual precipitations (x_2)

Crop	Pair of variables	Regression equation Y= bx +a	R^2
Wheat	Yield y x Average annual temperature x_1	Y= -390.62x +8,848.71	0.1765
	Yield y x Annual precipitations x_2	Y= 0.00978x -0.09788	0.620
Maize	Yield y x Average annual temperature x_1	Y= -54.93x+6,597.02	0.0013
	Yield y x Annual precipitations x_2	Y=0.005x+3.134	0.0128
Sunflower	Yield y x Average annual temperature x_1	Y= -181.69x+4,677.15	0.1180
	Yield y x Annual precipitations x_2	Y= 0.0052x +0.1211	0.2303

Source: Own calculations.

yield depending on precipitations in an agricultural holding, in South East Dobrogea in the period 2018-2020

As sunflower proved a high and positive coefficient of correlation between yield and precipitations, r= 0.479 at the national level, we considered to continue the analysis at the local conditions in the most dried area of Romania, in South Eastern Dobrogea, where the rainfalls are below 200 mm per year and the drought was very strong and for a longer period in the studied interval.

Using the data from [18, 19, 20], the deviations of rainfalls calculated by us in the agricultural years 2018, 2019 and 2020 from the 1991-1990 climatological norm, accounted for: +297.4 mm (+107.8%) in the year 2018, -95.2 mm (-35%) in the year 2019 and -140.7 mm (-52%) in the year 2020 (Figure 9).

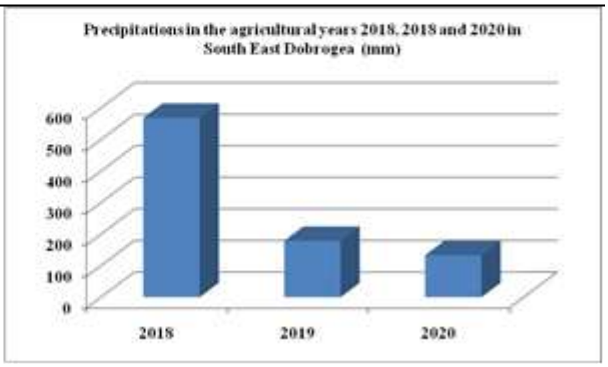

Fig. 9. Dynamics of precipitations in the agricultural years suitable to sunflower (January-August) in the period 2018-2020 in South East Dobrogea
Source: Own design based on the data from [18, 19, 20].

The comparison between the rainfalls registered in the studied period and 1961-1990 climatological norm for each month of the agricultural year suitable to sunflower is shown in Figure 10.

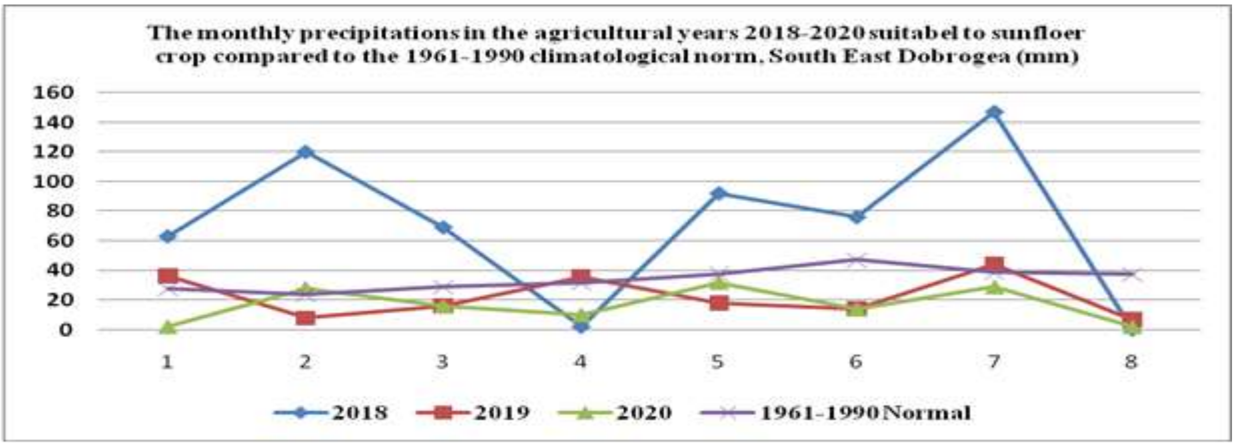

Fig. 10. The monthly precipitations in the agricultural years 2018, 2019 and 2020 compared to the 1961-1990 climatological norm
Source: Own design based on the data from [18, 19, 20].

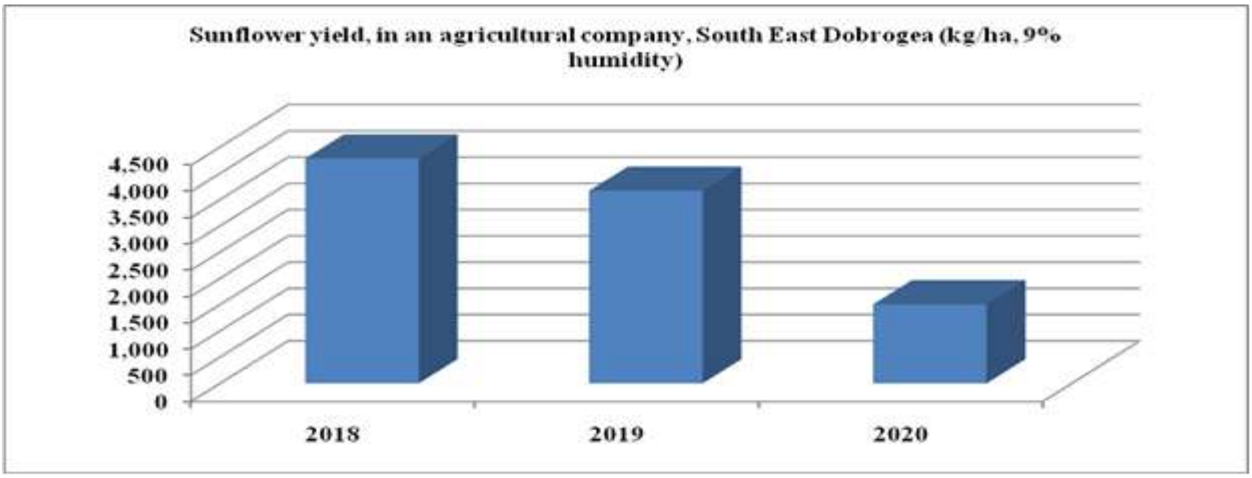

Fig. 11. Dynamics of sunflower yield, in an agricultural company, South East Dobrogea, 2018-2020 (kg/ha, 9% humidity)
Source: Own design based on the data from [18, 19, 20].

Sunflower yield declined from 4,282 kg/ha at 5% humidity in the year 2018, the best agricultural year for this crop, to 1,503 kg/ha in 2020, when it was by 65% smaller than in the year 2018 (Figure 11)

The correlation between precipitations and sunflower yield in the studied period was positive and very strong, r = 0.737.

Also, an increase in rainfalls by one unit could grow sunflower yield by 4.49 kg/ha as shown by the regression equation and the coefficient of determination R^2 = 0.544 reflects that 54.4% of the variation in sunflower seeds yield is determined by the variation of rainfalls (Figure 12).

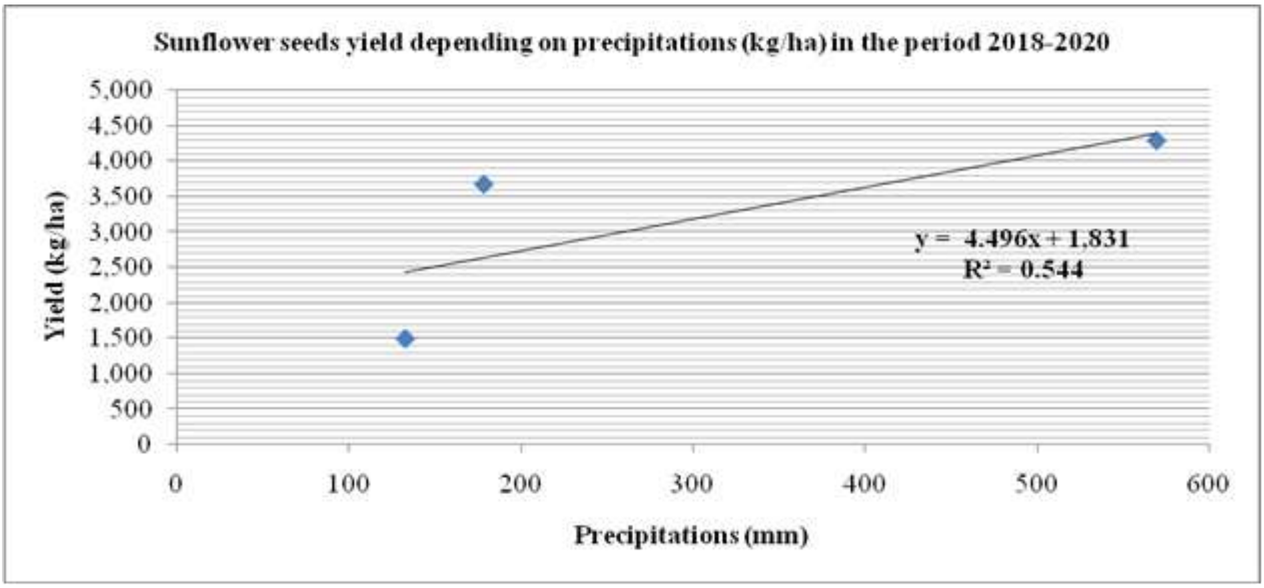

Fig. 12. The dependence of sunflower yield on precipitations, 2018-2020
Source: Own design and calculations based on the data from [18, 19, 20].

CONCLUSIONS

This research study reflects the evolution of temperatures and precipitations levels as well as their impact on three important agricultural crops in Romania; wheat, maize and sunflower.

At the national level, the average air temperature increased reaching the highest level of 12.13^{0}C in 2019. However, in the period 2017-2020, the average annual temperatures exceeded the climatological norm 1981-2010 accounting for 9.1^{0}C.

The precipitations level registered a variation from a year to another, but the lowest rainfalls 614.2 mm were recorded in the year 2019, being below of 633.1 mm the climatological norm for the period 1981-2010.

The results showed large the variations regarding both the monthly air temperatures as well as the monthly precipitations from the climatological norms.

The high temperatures associated with drought and also the low precipitations have deeply affected yield of many agricultural crops, including maize, wheat and sunflower.

Wheat yield registered the highest performance of 4,888 kg/ha in the year 2017, and the lowest one, accounting for 2,966 kg/ha in the year 2020.

Maize yield registered the highest performance of 7,644 kg/ha in the year 2018, and the lowest one, accounting for 3,977 kg/ha in the year 2020.

Sunflower yield registered the highest performance of 3,041 kg/ha in the year 2018, and the lowest one, accounting for 1,858 kg/ha in the year 2020.

Therefore, the worst agricultural years for these three crops was 2020. The year 2017 favored wheat, while the year 2018 favored maize and sunflower yield.

In case of wheat, the values of the correlation coefficient (r=0.420) proved a positive and relatively moderate relationship between yield and average annual temperature and a strong relationship between yield and annual precipitations (r= 0.787).

In case of maize, the correlation coefficient reflected a weak and positive link between yield and the two climate factors: temperature (r=0.036) and precipitations (r=0.113).

In case of sunflower, the coefficient of variation reflected a relatively moderate connection between yield and temperature (r=0.343) and yield and precipitations (r=0.479).

The multiple correlation between yield, air temperatures and precipitations was: r= 0.817 for wheat, r = 0.116 for maize and r = 0.504 for sunflower.

The regression equations reflecting the dependence of yield on temperatures and precipitations have shown differences from a crop to another.

The study case run in South Eastern Dobrogea, the driest area in Romania, showed that the decline in rainfalls in the agricultural year 2018, 2019, 2020 had a deep negative impact on sunflower seeds yield, which decreased from 4,282 kg/ha at 9% humidity in the year 2018, to 1,503 kg/ha in 2020, when it was by 65% smaller than in the year 2018. In this part of the country, the correlation between precipitations and sunflower yield in the studied period was positive and very strong (r = 0.737).

This statistical analysis of yield level in close connection with two main climate factors: temperature and precipitations is not comprehensive, as yield depends on the combined effect of a large range of factors: soil type, its structure, quality (humus content and other nutrients), fertility level, water content, pollution degree, crop technology, the moment of application and quality of the agricultural works, varieties and hybrids and their production potential, the degree of resistance to drought, diseases and pests, work force training level, technical endowment, environment in terms of geographical area, climate factors and their evolution across the years (temperature and precipitations level, other weather conditions) in connection to the specific phenological development of each crop etc.

For this reason, the analysis at the national level has just indicative results which do not reflect a precise image of climate change impact on yield.

The influence of these factors should be analyzed under the local conditions of each farm and to represent a starting point to adapt the production technologies to climate change.

Farmers have to be aware that important measures have to be taken in order to sustain production and diminish the negative impact of climate change.

In this respect, a few recommendations are given below:

- to keep under control soil fertility, air temperature and water content for choosing the best moment for sowing, so that the seeds to germinate in good conditions;
- to use certificated seeds which are of the best quality for assuring a high germination rate and yield;
-to diminish the amount of chemical fertilizers and pesticides and to pass to organic agriculture;
-to chose varieties and hybrids of high value, well adapted to local conditions, resistant to drought, diseases and pests;
-to change the zone of crop farming to favorable areas;
-to establish an optimal crop structure including leguminous plants which are able to fix the nitrogen and plants which are able to achieve Carbon sequestration into the soil;
- to apply the agricultural works at the optimal moment and of high quality;
-to install protective forest curtains;
-to enlarge the surfaces covered by irrigation systems and utilize them in a more efficient way; to assure a high quality irrigation water.

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FARM STRUCTURE AND FARMLAND CONCENTRATION IN ROMANIA AND IN OTHER SELECTED EU'S COUNTRIES WITH LARGE UTILIZED AGRICULTURAL AREA

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Abstract

The present paper aimed to analyze utilized agricultural area (UAA), number of agricultural holdings (NAH), average holding size (AHS), standard output per holding (SOH) in Romania and other EU countries with large UAA in the period 2005-2020 using the data from Eurostat and National Institute of Statistics in order to identify the trends and actual situation. Fixed basis indices, regression equations, R square, Herfindahl-Hirschman Index (HHI), Gini Struck Coefficient(GSC), structural indices, comparisons with the EU average and among the selected EU countries: Romania, Poland, Italy, Spain, France, Germany, United Kingdom were used as processing methods for reflecting the changes farmland and farm structures. In 2020, Romania had 12,763 thousand ha UAA, representing 7.6% of the EU's UAA and coming on the 6th position, after France, Spain, Germany, Poland and Italy. In 2020, Romania had 2.88 million AH and together with Poland, Italy, Spain, France and Germany, had 6.89 million AH (75.7% of the EU's 9.1 million NAH). The farms smaller than 5 ha represent: 90.3% in Romania, 64.1% in Italy, 52.3% in Poland, 51.6% in Spain, 19.6% in France and 8.2% in Germany, while the farms with 50 ha and over account for 7.5% at the EU level, 1% in Romania, 3.1% in Poland, 4.5% in Italy, 11.6% in Spain, 31.5% in Germany and 45.9% in France. To the EU's SO, all these six countries contribute by 71% to the EU's SO. In the EU, less than Euro 2,000 SO was produced by 35.7% farms, while Euro 50,000 and over was achieved by 12.9% farms. In Romania, 71.5% farms produce less than Euro2,000, while 0.9% achieve Euro 50,000 and over. Regarding the concentration of farms by SO size class, HHI and GSC reflected a high concentration in Romania, relatively moderate at the EU level, moderate in Poland and Italy, and a lack of concentration in Spain, France and Germany. The SO/AH in Romania was Euro 4,029, compared to Euro 38,703 at the EU level, Euro 19,680 in Poland, Euro 57,681 in Italy, Euro 44,124 in Spain, Euro 158,430 in France and Euro 167,631 in Germany. As a final conclusion, the gaps among these countries are caused by the unbalanced farm structure with the highest share belonging to the farms with less than 2 ha. Farms with 50 ha and over could assure a higher SO/farm. To diminish NAH and grow AHS has to continue for increasing the economic power in terms of standard output. Small and medium-sized farms have to be sustained to join their efforts for a higher concentration of land, production and economic efficiency.

Key words: *utilized agricultural area, agricultural holdings, standard output, concentration, Romania, European Union*

INTRODUCTION

Global agriculture is sustained by small farms, reflecting their role in human life, poverty reduction, biodiversity and environment conservation.
However, small agribusiness is facing various barriers which affect profitability and future development, as long as the financial support is mainly oriented to commercial large farms. That is why, small farmers should be encouraged and sustained to become more involved in the economic and social development, as well as in environment preservation [20, 21, 26].
It is unanimously recognized that the EU agriculture is also characterized by small farming, as long as in 2020, the average farm size was 17.4/ha per farm, and this highlights the role of small farmers in the EU food

system, in rural development assuring jobs and income for local population, producing healthier products and preserving regional specificity by using traditional technologies, contributing to environment quality, biodiversity and landscape maintenance [6, 40].

The general trend across the time, and mainly in the last two decades, was the disappearance of millions of small farms in the EU due to the market pressure, the negative effects of climate change, lack of financial resources to improve technologies and invest in innovation, farmers' aging and migration of young people to cities [1].

These aspects have been noticed in many EU countries, including Romania [34].

A new reform in the EU CAP recently adopted pays more attention to small farmers and provides important measures for sustaining small agribusiness.

Farm structure is very diverse from a country to another and in each member state from a region to another [3, 7, 8, 27].

Farm size is a key indicator which reflects resources, inputs, output and profitability. The size of a farm depends on land ownership, technical endowment, applied technologies, farmer's age and training level, and opportunities to sustain agribusiness [27].

The growth in farm size is closely connected to the decline rate in the number of farms and the capacity of larger farms to acquire the remaining farm land [2, 23].

Farm size could be expressed in terms of land area per farm or in livestock units (LU/farm), labour force, farm inputs and products sales, but the key measure is "land surface" considered an universal tool which allows the comparison between farms, regions and countries all over the world [22].

However, the EU established a new indicator which allows to assess the agricultural economic output, named "standard output-SO", considered more effective for expressing the economic power of a farm.

Standard output is "the average monetary value of the agricultural output at farm gate price, in Euro/ha or per head LU." For each regional product, the EU established a "regional SO coefficient, as a mean value over a reference period of five years. The sum of all the SO per ha or LU in a farm is at present a measure of its overall economic size in Euro".

At present, agricultural holdings are classified by SO and also by type of farming in the EU [16, 19].

Farm size is linked to agriculture profitability and to increase farm size is a goal to grow farmer's profit, but also the economic, social and environmental effects [38].

Farm size and productivity vary at the global level and has a high importance for economic development, poverty reduction, food production and environment protection [39].

The EU has a large variety of countries regarding utilized agricultural land (UAA), number of agricultural holdings (NAH) and their size in ha/farm and in SO/farm, and of course, a diverse contribution of its member states to the EU agricultural economic output.

In the EU, there are a few countries working large surfaces of agricultural land, which in the decreasing order are: France, Spain, Germany, Poland, Italy and Romania, all together using 68.6% of the EU UAA, which in the year 2020 was 157.4 million ha [17,18]. These countries cultivate relatively similar agricultural crops, and this was the reason why Greece is not included to this group despite it has a large UAA.

Regarding NAH, Romania is on the top position with 2.88 million farms, being followed by Poland and Italy, all these three countries summing 5.32 million farms, accounting for 59.% of the EU 9.1 million farms in the year 2020. The other member states Spain, France and Germany with a large UAA have a smaller NAH.

Romania is an important country of the EU and agriculture in this country has an important contribution to GDP [29, 32].

The variability of land policy applied in the EU member states produced important changes in farm structure, both inside each country and at the EU level.

At present, the EU has a large range of farm types, sizes, endowment, productivity, and efficiency [30, 31, 33, 35, 36, 37].

Most of the farms are family subsistence or semi-subsistence small farms [4].

Despite that during the last decades, millions of farms have disappeared, the merge process is running slowly [5].

The EU agriculture is dominated by family farms which in the year 2020 accounted for 94%. In this farms, 50% of labor force is represented by family members. In all the EU member states, family farms are the most numerous of the total NAH [17].

The average farm size at the EU level was 17.4 ha in the year 2020. In the countries mentioned, farms have a different average area, as follows: 69.7 ha/farm in France, 63.17 ha in Germany, 26.12 ha in Spain, 11.36 ha in Poland, 11.06 ha in Italy and 4.42 ha in Romania. But, Czechia and Slovakia occupy the top position in the EU for this indicator.

The average economic size of a farm in the EU is Euro 38.7 thousand, but it varies from a country to another. Regarding the six countries with the largest UAA, SO/NAH in the decreasing order is: Euro 167,631 in Germany, Euro 158,430 in France, Euro 57,681 in Italy, Euro 44,124 in Spain, Euro 19,680 in Poland and Euro 4,029 in Romania [17].

In this context, the purpose of this research was to identify the trends in the dynamics of UAA, NAH, average farm size in terms of UAA/farm and average economic size in terms of Euro SO/farm in the period 2005-2020 in Romania in comparison with the EU average and in the selected EU member states with the large utilized agricultural area, emphasizing the situation in the year 2020, after the recent agricultural census in Romania and the EU.

MATERIALS AND METHODS

In order to set up this paper, the data were collected for the period 2003-2020 from Eurostat Database and National Institute of Statistics.

The following indicators were taken into consideration to characterize farm and agricultural land concentration:

(i)Utilized agricultural area (UAA) which was analyzed in its dynamics in Romania, both at the country level and in the territory by the 8 micro-regions of development and also in the EU, pointing out the share of Romania's UAA in the EU's UAA and in the selected member states with the largest UAA: France, Spain, Germany, United Kingdom, Poland, Italy.

(ii)Number of agricultural holdings (NAH) which was analyzed in its dynamics in Romania and also by micro-region of development and also in the EU, pointing out the share of Romania's NAH in the EU's NAH and in the selected member states with the largest UAA.

(iii)Average holding size (AHS) was analyzed in its dynamics in Romania and by micro-region in the territory, and at the EU level and in the selected member states.

(iv)Farm structure by UAA size class in Romania and the EU selected member states, pointing out the share of the farms and their share in UAA by UAA size class;

(v)Farm structure by standard output class in Romania and the EU selected member states, pointing out the share of the farms by each SO size class;

(vi) Standard output in Romania and EU and also in the selected member states by SO size class.

(vii)Standard output per agricultural holding (SO/AH) in its dynamics in Romania and EU and in 2020 in the selected member states, and also by SO size class.

As methodological tools to process the data, there were used the following ones:

-Fixed basis indices, whose formula is:

$I_{FB}=(y_t/y_0)*100$ .... (1)

-Average growth rate, having the formula:

$\bar{R}_a = (\sqrt[n-1]{\frac{y_n}{y_0}} - 1)*100$ ....(2)

- Trend method using the linear regression function according to the formula:

$\widehat{yt}= bt + a$ .... (3)

-Herfindahl-Hirschman Index, HHI, for reflecting the degree of concentration regarding UAA, NAH, and SO/AH and SO size class, using the formula:

$HHI_j= \sum_{i=1}^{n} g_i^2$ ....(4)

-Gini-Struck Coefficient, also for assessing the concentration degree, using the formula:

$GSC= \sqrt{\frac{n\sum_{i=1}^{n} g_i^2-1}{n-1}}$ .... (5)

-The graphical method to illustrate the results for a better understanding.
-Comparison method to show the differences between the analyzed indicators in Romania versus EU level and also in the other selected member states.

RESULTS AND DISCUSSIONS

Utilized agricultural area (UAA)

Of Romania's total area of 23,839,071 ha, 61.29% represents agricultural surface. However, only 53% of the whole territory, that is 12,763 thousand ha is utilized for agriculture as reflected by the statistical data [24].
During the period 2003-2020, the utilized agricultural area (UAA) registered a decreasing trend from 13.93 million ha in 2003 to 12.08 million ha in the year 2020, when it was by -13.3% smaller than at the beginning of the interval [25].
As a result, the share of UAA in Romania's surface also decreased from 58.43% in 2003 to 53.53% in 2020.
The tendency is similar with the one observed at the EU level, where UAA declined by 17.3 million ha (9.9%) from 174.7 million ha in 2003 to 157.4 million ha in the year 2020 [17].
In this case, Romania's UAA share in the EU UAA decreased from 7.97% in 2003 to 7.67% in 2020, meaning by -0.3 percentage points less (Figure 1).

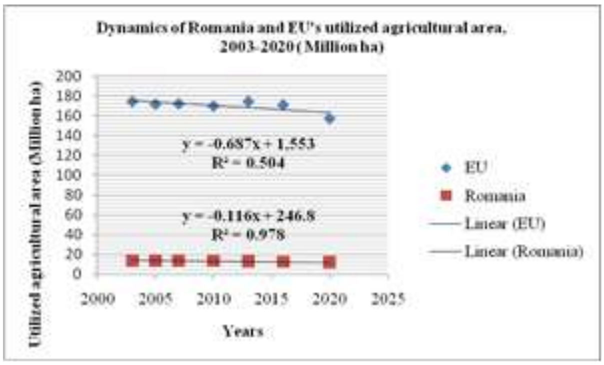

Fig. 1. Dynamics of utilized agricultural area in Romania and in the EU, 2003-2020 (Million ha)
Source: Own design based on the data from [5, 10, 17, 25].

The dispersion of UAA by micro-region of development in Romania is different from a region to another. In 2020, the largest UAA meaning 17.89% of the total UAA belonged to South Muntenia region, followed by South East region with 17.03%. The lowest weight, that is 0.62% is kept by Bucharest Ilfov area (Figure 2).

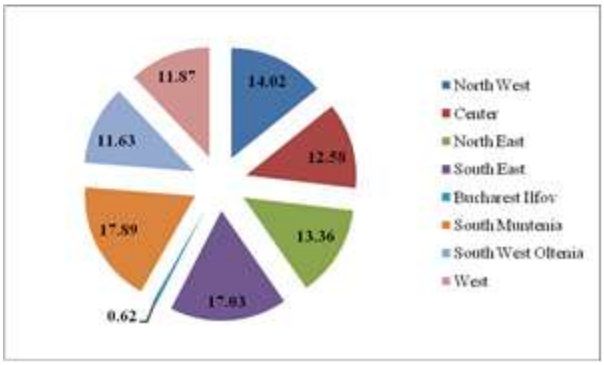

Fig. 2. Dispersion of UAA in Romania's territory by micro region in 2020 (%)
Source: Own design based on the data from [24].

The degree of UAA concentration, expressed as Herfindahl-Hirschman Index, HHI = 0.1447 and Gini-Struck Coefficient, GSC = 0.1500 reflects an unconcentrated surface or, in other words, that there are no significant differences from a region to another.
The UAA is not equally distributed among farms. About 97 % represents the smallest farms with less than 10 ha.
The largest farms with over 50 ha represent less than 0.9 % of the total number of farms, but they are working about 58 % UAA and practice intensive agriculture, producing high quality products and deeply market oriented [35].

Table 1. Dynamics of UAA in Romania compared to the EU' selected countries, 2010-2020 (Million ha)

	2010	2013	2016	2020	2020/2010 %
EU	170.02	174.6	171.28	157.4	92.50
France	27.09	27.74	27.81	27.4	101.14
Spain	23.75	23.30	23.22	23.9	200.63
Germany	16.70	16.70	15.16	16.6	99.40
United Kingdom	15.92	17.32	16.67	-	-
Poland	14.38	14.41	14.40	14.80	102.92
Romania	**13.30**	**13.05**	**12.50**	**12.08**	**90.82**
Italy	12.88	12.09	12.09	12.50	97.04
Total	124.02	124.61	121.85	108.0	87.08
Share in the EU (%)	72.94	71.30	71.14	68.60	

Source: Own calculations based on the data from [17].

Regarding Romani's position in the EU, taking into account the UAA dynamics, the country has maintained its 6th rank after France, Spain, Germany, United Kingdom, and Poland, being followed by Italy till 2019, and in 2020, after Brexit, it had the same 6th position after France, Spain, Germany, Poland and Italy [28].

If in 2010, the seven selected countries with the largest UAA summed 124.02 million ha, representing 72.94% of the EU's UAA, in the year 2020, the six countries totalled 108 million ha, accounting for 68.6% of the EU's UAA (Table 1).

The number of agricultural holdings (NAH) in Romania followed a continuous decline from 4.5 million in 2003 to 2.88 million in the year 2020, meaning a loss of 1.62 million farms (36%).

This descending trend is similar with the one in the EU where the number of farms decreased from 15.1 million in 2003 to 9.1 million in 2020, showing a loss of 6 million (-59.74%).

In consequence, the share of Romania's farms in the EU's agricultural holdings increased from 29.7% in 2003 to 31.7% in 2020. However, in 2020, the number of Romanian farms was by 0.54 million smaller (-15.8%) from 3.42 million in 2016 to 2.88 million in 2020 (Figure 3).

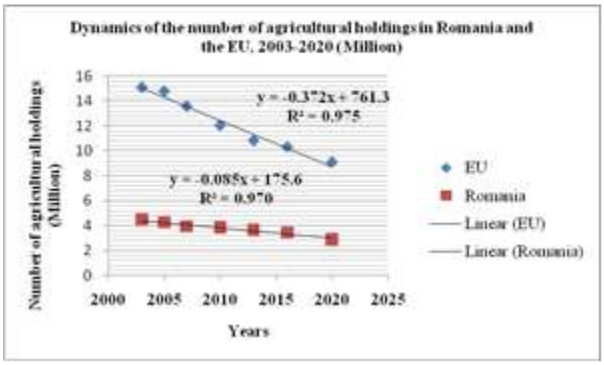

Fig. 3. Dynamics of agricultural holdings in Romania and EU in the period 2003-2020 (Million)
Source: Own design based on the data from [10, 17, 25].

Figure 3 reflects a faster decline rate in the number of agricultural holdings at the EU level than in Romania, where the reduction is still a slow process. The distribution of NAH in Romania's territory, in terms of HHI = 0.1542 and GSC = 0.1826 reflects a moderate concentration of farms. The micro-regions of development with the highest NAH are: North East (20.54%), South Muntenia (18.08%), South West Oltenia (16.18%) and North West (15.34%)/ The lowest share of NAH is in Bucharest-Ilfov (0.59%) (Figure 4).

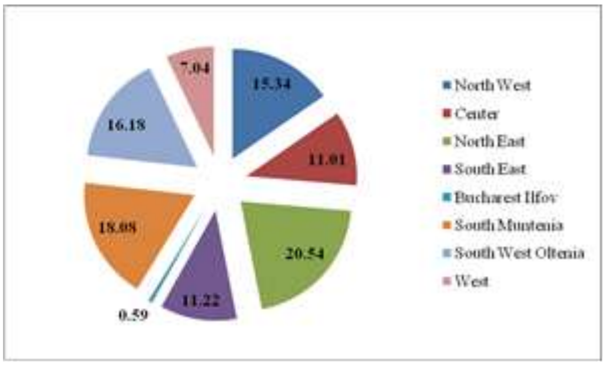

Fig. 4. Fig. 2. Dispersion of the number of agricultural holdings in Romania's territory by micro region in 2020 (%)
Source: Own design based on the data from [24].

After Romania's access into the EU on January 1st, 2007, the country is in the top position for NAH, next to other EU member states with the largest UAA: France, Spain, United Kingdom, Germany, Poland, and Italy. In Romania, the farms are subsistence and semi-subsistence farms, most of them having below 2 ha, and commercial farms have a very low percentage. The majority of farms have a large variety of scarce resources, mainly agricultural surface, technical endowment, and the results in terms of production performance, productivity and Standard Output as an efficiency barometer are very low [33, 35]. In 2005, Romania, Poland, Italy, Spain, France, Germany and United Kingdom had all together 10.77 agricultural holdings, which represented 74.94% of the EU's NAH. In the year 2020, after Brexit, Romania, Poland, Italy, Spain, France and Germany accounted for 6.89 million agricultural holdings, representing 75.75% of the EU's NAH.

In the period 2005-2020, the number of farms declined in all the selected EU countries, the highest decrease being registered in Poland (-47%), followed by Italy (-34.31%), Germany (-32.65%), France (-30.69%), Romania (-32.4%) and Spain (-15%). At the EU level, the decline in NAH accounted for -36.68% in the interval 2005-2020 (Table 2).

Table 2. Dynamics of the number of agricultural holdings in Romania and in the selected EU countries with the largest utilized agricultural area in the period 2005-2020 (Million)

	2005	2007	2010	2013	2016	2020	2020/2005 %
EU	14.37	13.58	12.05	10.84	10.32	9.1	63.32
Romania	**4.26**	**3.93**	**3.86**	**3.63**	**3.42**	**2.88**	**67.60**
Poland	2.47	2.39	1.50	1.43	1.41	1.31	53.03
Italy	1.72	1.68	1.62	1.01	1.11	1.13	65.69
Spain	1.08	1.04	0.989	0.965	0.945	0.919	85.09
France	0.567	0.527	0.516	0.472	0.456	0.393	69.31
Germany	0.389	0.370	0.299	0.285	0.276	0.262	67.35
United Kingdom	0.285	0.300	0.202	0.185	0.185	-	-
Total	10.77	10.24	8.986	7.975	7.802	6.894	64.01
Share in the EU (%)	74.94	75.40	74.50	73.97	75.60	75.75	-

Source: Own calculations based on the data from: [9, 10, 11, 13, 14, 15, 17].

Average holding size (AHS)

As a result of the decline in UAA and NAH, average holding size (AHS) increased in Romania from 3.1 ha/farm in 2003 to 4.42 ha/farm in 2020, meaning by +42% (Figure 5).

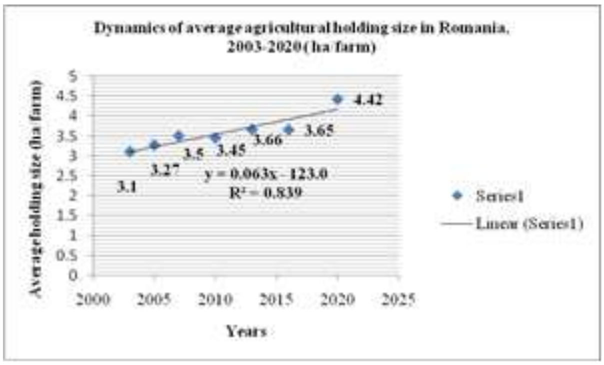

Fig. 5. Dynamics od average agricultural holding size in Romania, 2003-2020 (ha per farm)
Source: Own design based on the data from [25].

The average farm size in Romania is far away from the EU average farm size and in other EU member states.

In the EU, taking into consideration the decline of the UAA and the loss of farms in different countries, the average agricultural holding size increased in the decade 2010-2020 from 14.1 ha/farm to 17.4 ha/farm.

Therefore, if in 2010, AHS in Romania was 3.45 ha/farm, that is 4 times smaller than the EU average, in the year 2020, its size was 4.42 ha, being 3.93 times smaller [17].

In the territory of Romania, the average farm size is enough different from a micro-region to another. The highest AHS is in West region, 7.46 ha/farm and Center, 5.05 ha/farm, while in North East is the smallest AHS, accounting for 3.09 ha and in South West Oltenia, 3.18 ha (Figure 6).

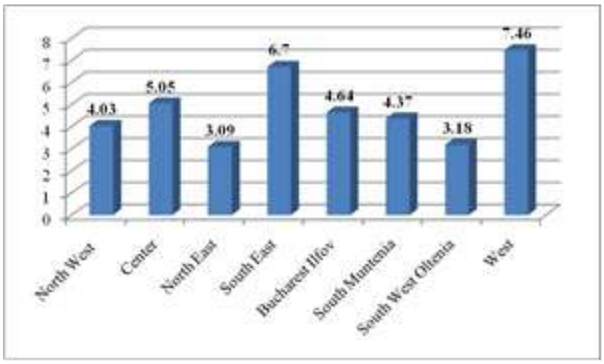

Fig. 6. Dispersion of average agricultural holding size in Romania by microregion in the year 2020 (ha)
Source: Own design based on the data from [25].

At the EU level, the dynamics of AHS reflected a growth rate of 48.71% from 11.7 ha/farm in the year 2003 to 17.4 ha in 2020.

Important growth rates were noticed in the selected EU countries: Poland (+72.12%), Italy (+65.07%), France (+53.86%), Germany (+53.32%) and Spain (+18.19%).

Comparing AHS with the EU average and also in these selected countries, it is easy to notice that AHS in Romania is much smaller than the EU average and in the other countries considered in this study (Table 3).

Romania comes on the penultimate position in the EU, being followed by Cyprus and Malta.

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Table 3. Dynamics of average agricultural holding size in Romania compared to the one in the EU and the selected countries in the period 2003-2020 (ha/farm)

Country	2003	2010	2013	2016	2020	2020/2010 %
EU	11.7	14.1	16.1	16.66	17.4	148.71
United Kingdom	57.4	78.6	93.6	99.07	-	-
France	45.3	52.6	58.7	60.9	69.7	153.86
Germany	41.2	55.8	58.6	57.2	63.17	153.32
Spain	22.1	24.0	24.1	24.5	26.12	118.19
Italy	6.7	7.9	12.0	11.97	11.06	165.07
Poland	6.6	9.6	10.1	10.2	11.36	172,12
....						
Romania	**3.1**	**3.4**	**3.6**	**3.66**	**4.42**	**130.00**

Source: Own calculations based on the data from [10, 17].

Farm structure by UAA size class

In the EU, the farm structure by UAA size is very different from a country to another.

Comparing the share of the farms with an UAA smaller than 5 ha and the ones having an UAA of 50 ha and over, we may easily notice that, in 2016, in the EU, the number of farms smaller than 5 ha accounted for 65.4% in the total NAH and 6,1% in the EU total UAA.

The farms with 50 ha and more represented 7% of NAH and 68.1% of EU total UAA.

In 2016, Romania had the most numerous farms smaller than 5 ha in the EU, they accounting for 3.1 million farms, representing 91.8% of NAH in the country and working 28.75 of the country UAA.

The larger farms than 50 ha represented only 0.5% of the total NAH and worked 51.15 of the total UAA.

This is a peculiar situation in Romania and completely different than in all the other EU selected countries as shown in Table 4.

In 2020, Romania had 2.88 milion farms accounting for 31.7% of the EU NAH.

The highest share of 70.76% in Romania's NAH was kept by the farms having less than 2 ha.

The farms between 2 and 4.9 ha represented 18%, the ones with 50 ha and over 0.95%, and the farms with 100 ha and more accounted for only 0.56%.

Therefore, in the EU NAH, Romanian farms below 2 ha accounts for 54.7%, the ones between 2-4.99 ha accounts for 26.97% and the ones for 5-9.99 ha for 14.35%.

Table 4. The share of the smallest farms smaller than 5 ha and of the larger farms than 50 ha in Romania compared to the other EU selected countries in the year 2016 (%)

Country	Share (%) in:	The smaller farms with less than 5 ha	The larger farms with 50 ha and over
EU	NAH	65.4	7
	UAA	6.1	68
Romania	NAH	91.8	0.5
	UAA	28.7	51.1
Poland	NAH	54.3	2.4
	UAA	13.2	31.6
Italy	NAH	58.7	4.5
	UAA	11.4	44.0
Spain	NAH	51.6	10.8
	UAA	4.3	70.8
France	NAH	24.3	41.3
	UAA	0.8	86.9
Germany	NAH	8.7	30.5
	UAA	0.3	78.3
United Kingdom	NAH	10.2	38.6
	UAA	0.3	88.2

Source: [17].

The larger farms with 50 ha and over in Romania represented 8.1% of the EU NAH belonging to this UAA size class.

The larger Romanian farms with 100 ha and over, accounting for 16.010 farms represented only 4.9% in the EU farms of this size class (Table 5).

In the yaer 2020, at the EU level, the farms smaller than 2 ha represented 42.55%, while the farms with 50 ha and more accounted for 7.50%.

In Italy, the highest share is also kept by the smaller farms than 2 ha (39.7%) and the farns with 50 ha and over represented 4.57%.

In Spain, 29.59% were smaller farns than 2 ha, while 11.65% were farms with 50 ha and more. In France, 10.86 % are smaller farms than 2 ha and 45.99% are larger farms than 50 ha. In Germany, the larger farms than 2 ha accounted for 31.57%, while the smaller farms than 2 ha were representde by 5.13%.

In Poland, the highest share is kept by the farns whose size varies between 2 and 4.9 ha (33.35%), the smaller farms than 2 ha accounts for 18.93% abd the lagest farms than 50 ha for 3.13% (Table 6).

Table 5. Romania's number of agricultural holdings by UAA size class, compared to the EU number of farms in the year 2020

UAA size class (ha)	EU		Romania		Share of the Romanian farms in the EU NAH by UAA size class (%)
	Number of agricultural holdings	Share in EU total NAH (%)	Number of agricultural holdings	Share in Romania's total NAH (%)	
	9,070,970	100.00	**2,887,070**	100.00	-
Zero	126,500	1.39	45,570	1.57	36.00
Less than 2	3,733,840	41.16	2,042,630	70.76	54.70
2 to 4.9	1,925,860	21.23	519,440	17.99	26.97
5-9.9	1,121,810	12.36	161,020	5.58	14.35
10-19.9	789,450	8.70	56,200	1.96	7.11
20-29.9	341,920	3.76	18,160	0.63	5.3
30-49.9	353,860	3.90	16,890	0.58	4.7
50.99.9	350,110	3.85	11,150	0.38	3.2
100 and over	327,620	3.65	16,010	0.55	4.9

Source: Own calculations based on the data from [17].

Table 6. Farm structure by UAA size class in Romania compared to the EU selected countries in 2020 (%)

Farms size class UAA (ha)	**EU**	**Romania**	**Poland**	**Italy**	**Spain**	**France**	**Germany**
Total farms	9,070,970	2,887,070	1,302,330	1,133,020	914,870	393,030	262,780
Share of farms by UAA size class							
Zero	1.39	1.57	0.32	1.10	0.87	1.14	1.49
Less than 2	41.16	70.76	18.61	38.60	28.72	9.72	3.64
2 to 4.9	21.23	17.99	33.35	24.33	21.95	8.77	3.04
5-9.9	12.36	5.58	21.69	14.13	14.41	8.72	17.03
10-19.9	8.70	1.96	14.79	9.66	11.32	9.41	20.00
20-29.9	3.76	0.63	4.71	3.98	5.51	6.14	9.53
30-49.9	3.90	0.58	3.40	3.63	5.57	10.11	13.70
50.99.9	3.85	0.38	2.02	2.86	5.52	19.81	17.02
100 and over	3.65	0.55	1.11	1.71	6.13	26.18	14.55

Source: Own calculations based on the data from [17].

At the EU level, of the total NAH, the smallest farms below 5 ha represent: 90.3% in Romania, 64.1% in Italy, 52.3% in Poland, 51.6% in Spain, 19.6% in France and 8.2% in Germany.

The farms with 50 ha and over accounted for 7.5% at the EU level, 1% in Romania, 3.1% in Poland, 4.5% in Italy, 11.6% in Spain, 31.5% in Germany and 45.9% in France.

The largest farms with 100 ha and more accounted for 3.6% at the EU level and for: 26.1% in France, 14.5% in Germany, 6.1% in Spain, 1.6% in Italy, 1.1% in Poland and 0.6% in Romania. The concentration degree of the farms by UAA size class in terms of the calculated values of Herfindahl-Hirschman Index and Gini-Struck Coefficient could be interpreted as follows:

- At the EU level and also in Poland and Italy, it is a relatively moderate concentration of the farms;
-In Romania it is high concentration of farms, as confirmed by the dominance of the ones with less than 2 ha;
-In Spain it is a moderate concentration, as the farms are relatively uniformly distributed by UAA size class;
-In France and Germany, it is a lack of concentration as the farms are the farms are almost equally distributed by UAA size class (Table 7).

Table 7. The degree of concentration of the farms by UAA size class in terms of HHI and GSC in Romania and the other EU selected countries in the year 2020

	EU	Romania	Poland	Italy	Spain	France	Germany
HHI	0.2432	0.5648	0.2187	0.2416	0.1771	0.1555	0.1495
GSC	0.3844	0.6984	0.3479	0.3831	0.2724	0.2234	0.2078

Source: Own calculations.

Table 8. Share of farms in NAH and UAA in each EU selected country by UAA size class in 2020 (%)

UAA size class (ha)		EU	Romania	Poland	Italy	France	Germany	Spain
0-4.9	%Farms	63.8	90.3	52.3	64.1	19.6	8.2	51.6
	%UAA	5.8	22.8	11.7	10.3	0.5	0.22	3.8
5-9.9	%Farms	12.4	5.6	21.7	14.1	9.7	17.0	14.4
	%UAA	5.8	8.5	13.6	8.9	0.9	1.95	3.9
10.19.9	%Farms	8.7	1.9	14.8	9.7	9.4	20.0	11.3
	%UAA	7.0	6.0	18.0	12.1	1.9	4.71	6.1
20-29.9	%Farms	3.8	0.6	4.7	4.0	6.1	9.5	5.5
	%UAA	5.3	3.5	10.0	8.7	2.2	3.75	5.2
30-49.9	%Farms	3.9	0.6	3.4	3.6	10.1	13.7	5.6
	%UAA	8.7	5.2	11.4	12.5	5.8	8.51	8.2
50-99.9	%Farms	1.9	0.4	2.0	2.9	19.8	17.0	5.5
	%UAA	15.7	6.1	12.1	17.8	20.9	19.11	14.9
100 and over	%Farms	3.6	0.6	1.1	1.6	26.1	14.5	6.1
	%UAA	52.5	47.8	23.2	29.7	67.8	61.75	57.8
Farms with 50 and over	%Farms	5.5	0.9	3.1	4.5	46.0	31.5	11.6
	%UAA	68.2	54.0	35.3	47.4	88.7	80.86	72.7

Source: [17].

Table 8 presents the share of farms in NAH and UAA in each EU selected country by UAA size class.

Farm structure by standard output size class

Standard output (SO) in Romania registered a relatively slight increase by 14.94% in the period 2007-2020, from Euro 10,120 million to Euro 11,632 million. In the EU, the growth rate was +22.92% in the same interval when standard output went op from Euro 285,587 in 2007 to Euro 351,079 in the year 2020.
As a result, Romania's contribution to the EU standard output declined a little from 3.54% in 2007 to 3.31% in 2020 (Table 9).
Compared to the other selected EU countries, Romania's contribution to the EU's standard output is very small (Table 10).

Table 9. Dynamics of Standard output in Romania compared to the trend in the EU, 2007-2020 (Euro million)

	2007	2010	2013	2020	2020/2007 %
EU	285,597	308,062	331,568	351,079	122.92
Romania	10,120	10,420	11,990	11,632	114.94
Share of Romania in the EU (%)	3.54	3.38	3.62	3.31	-

Source: Own calculations based on the data from [9, 10, 11, 12, 14, 15, 17].

Table 10. Share of the NAH and SO of Romania into the EU NAH and SO compared to the other selected countries in the year 2020 (%)

	Share in the EU's NAH (%)	Share in the EU's SO (%)
Romania	31.8	3.31
Poland	14.4	7.3
Italy	12.5	18.6
Spain	10.1	11.5
France	4.3	17.7
Germany	2.9	12.5

Source: [17].

Distribution of agricultural holdings by standard output size class

In the EU, the dispersion of farms by standard output size classes varies from a country to another.

At the EU level, the highest share accounting for 35.71% belongs to the farms producing less than Euro 2,000, being followed by 14.19% farms which carry out between Euro 2,000 and 3,999 and then by 12.94% farms achieving between Euro 4,000-7,999.

Only 1.96% farms are able to produce between Euro 250,000-499,999 and 1.33% farms between Euro 500,000 and over.

Romania is an important contributor to the EU agricultural output, and also to EU standard output and GDP coming from agriculture [29, 32].

However, in Romania 71.5% of the farms produced less than Euro 2,000, being followed by 13.74% farms carrying out Euro 2,000-3,999. Then, 7.48% farms produced between Euro 4,000-7,999. Just 0.09% farms are able to produce between Euro 250,000-499,999 and 0.07% farms achieve Euro 500,000 and more.

In terms of Standard Output, reflecting the farm economic size, the Romanian holdings achieve much less compared to the EU average and the other EU member states, aspect which reflects the consequence of the dominance of the semi-subsistence farms lacked of competitiveness and efficiency existing in Romania [1].

In France, 25.71% farms produce Euro 100,000-249,999, 13.52% farms achieve Euro 250,000-499,000 and 6.17% farms carry out Euro 500,000 and over. Only 5.5% farms produce less than Euro 2,000.

In Germany, just 0.54% farms produce below Euro 2,000, and the highest share of 17.58% belongs to the farms achieving Euro 100,000-249,999. About 7.67% farms produce the highest standard output, Euro 500,000 and more.

In Italy, the highest weight of 17.57% belongs to the farms able to carry out Euro 8,000-14,999, also 16.27% farms produce Euro 4,000-7,999 and 13.35% farms achieve between Euro 25,000-49,999. Only 1.54% farms produce Euro 500,000 and over.

In Spain, 17.16% farms produce less than Euro 2,000, but 16.64% farms produce Euro 4,00-7,999, 14.73% achieve between Euro 2,000- 3,999 and 13.91% carry out between Euro 8,000-14,999. Only 3.43% farms are able to produce Euro 250,000 and more standard output.

In Poland, The highest share of 26% farms produce less than Euro 2,000, being followed by 19.65% farms producing Euro 2,000-3,999, then other 12.32% farms carry out Euro 8,000-14,999. Only 0.92% farms produce Euro 250,000 and more SO (Table 11).

The concentration degree of the farms by standard output size class in terms of the values of Herfindahl-Hirschman Index and Gini-Struck Coefficient reflects the situation presented below (Table 12).

- At the EU level, the farm concentration is relatively moderate;

-In Romania, it is a high concentration of the farms, as proved by the dominance of the farms producing less than Euro 2,000;

-In Poland and Italy, it is a moderate concentration;

-In Spain, France and Germany, it is a lack of concentration, as the farms are uniformly distributed by standard output size class (Table 12).

Table 11. The dispersion of farms in Romania and the selected EU countries by standard output size class in the year 2020 (%)

SO size class (Euro)	**EU**	**Romania**	**Poland**	**Italy**	**Spain**	**France**	**Germany**
Total number of farms	9,070,970	2,887,070	1,302,340	1,133,020	914,870	393,030	262,780
Zero	0.83	0.85	0.66	1.44	0.59	0.17	0.04
Less than 2,000	35.71	71.50	26.00	8.46	17.16	5.50	0.54
2,000-3,999	14.19	13.74	19.65	10.56	14.73	3.40	4.67
4,000-7,999	12.84	7.48	17.59	16.27	16.64	5.14	10.55
8,000-14,9999	9.92	3.14	12.32	17.57	13.91	6.94	12.73
15,000-24,999	6.52	1.36	7.82	12.56	9.29	6.74	10.00
25,000-49,999	6.95	1.03	7.90	13.36	10.14	11.36	12.44
50,000-99,999	5.12	0.45	4.81	9.26	8.09	15.35	12.52
100,000-249,999	4.53	0.28	2.33	6.85	6.02	25.71	17.58
250,000-499,999	1.96	0.09	0.58	2.13	1.93	13.52	11.26
500,000 and over	1.33	0.07	0.34	1.54	1.50	6.17	7.67

Source: Own calculation based on the data from [17].

Table 12. The degree of concentration of the farms by SO size class in terms of Herfindahl-Hirschman Index and Gini-Struck Coefficient in Romania and the other EU selected countries in the year 2020

	EU	**Romania**	**Poland**	**Italy**	**Spain**	**France**	**Germany**
HHI	0.2266	0.5370	0.1676	0.1520	0.1278	0.1408	0.1202
GSC	0.3863	0.7004	0.2904	0.2592	0.2014	0.2342	0.1794

Source: Own calculations.

Distribution of Standard output by SO size class

-*At the EU level*, the superior SO size classes produce the most SO, as we may notice that, starting from the SO size class Euro 50,000 and over, it is produced 83.92% of the EU SO.

-*In Romania*, 45% of SO is achieved by the SO size class Euro 50,000 and over and 32.06% SO is carried out by the SO size class below Euro 8,000.

-*In France*, 95.79% SO is produced by the SO size classes Euro 50,000 and more;

-*In Italy*, 81.97% SO is carried out by the SO size classes Euro 50,000 and more;

-*In Germany*, 94.87% SO is produced by the superior classes of Euro 50,000 and over;

- *In Spain*, 80.74% SO is achieved by the high SO size classes with Euro 50,000 and over.

-*In Poland*, 61.86% SO is carried out by the high SO size classes with Euro 50,000 and over (Table 13).

Table 13. Dispersion of Standard output in Romania and in the EU selected countries by SO size class in the year 2020 (%)

SO size class (Euro)	**EU**	**Romania**	**Poland**	**Italy**	**Spain**	**France**	**Germany**
Total standard output (Euro Million)	351,079	11,632	25,631	65,353	40,368	62,268	44,368
Share by SO size class (%)							
Less than 2,000	0.77	12.50	1.54	0.16	0.41	0.03	0.004
2,000-3,999	1.05	9.44	2.88	0.53	0.97	0.06	0.088
4,000-7,999	1.90	10.12	5.08	1.64	2.17	0.19	0.375
8,000-14,9999	2.80	8.20	6.85	3.35	3.47	0.49	0.848
15,000-24,999	3.24	6.24	7.67	4.20	4.08	0.83	1.156
25,000-49,999	6.32	0.51	14.12	8.15	8.16	2.60	2.646
50,000-99,999	9.29	7.56	16.82	11.25	12.88	7.08	5.368
100,000-249,999	18.18	9.80	17.25	18.09	20.28	26.33	16.902
250,000-499,999	17.13	7.47	9.27	12.63	13.72	29.03	22.840
500,000 and over	39.32	20.15	18.52	40.00	33.86	33.36	49.776

Source: Own calculation based on the data from [17].

Regarding the degree of concentration of standard output by SO size class in Romania and the EU selected countries in the year 2020, it was found the following situation:
-*At the EU level*, it is a moderate concentration of the standard output;
- *In Romania and Poland*, it is a lack of concentration, as SO is relatively uniformly distributed by SO size class;
- *In Italy and Spain*, it is a moderate concentration of SO by SO size class;
-*In France,* it is a relatively moderate concentration of SO among SO size classes;
- *In Germany*, it is a high concentration of SO, as reflected by the high share in SO of the superiors SO size class Euro 500,000 and over (Table 14).

Table 14. Degree of concentration of SO by SO size class in terms of Herfindahl-Hirschman Index and Gini-Struck Coefficient in Romania and the EU selected countries in the year 2020

	EU	Romania	Poland	Italy	Spain	France	Germany
HHI	0.2319	0.1141	0.1348	0.2311	0.2012	0.2711	0.3323
GSC	0.3828	0.1251	0.1966	0.3816	0.3352	0.4360	0.5080

Source: Own calculations.

Standard output per agricultural holding
In the EU, the value of SO/AH increased from Euro 20.9 thousand in the year 2007 to Euro 38.7 thousand in the year 2020, meaning by +85.16%, *In Romania*, it also increased, but from Euro 2.42 thousand in 2007 to Euro 4.03 in 2020, that is by +66.52%. In consequence, the share of SO per agricultural holding produced in Romania in the EU SO/AH decreased from 11.5% in 2007 to 10.4% in 2020, that is by -1.1 percentage points (Table 15).

Table 15. Dynamics of Standard output per agricultural holding in Romania compared to the EU, 2007-2020 (Euro 1,000/holding)

	2007	2010	2013	2020	2020/2007 %
EU	20.9	25.6	30.65	38.8	185.16
Romania	2.42	2.80	3.30	4.03	166.52
Share of Romania in the EU (%)	11.5	10.9	10.76	10.4	-

Source: Own calculations based on the data from [9, 10, 11, 12, 14, 15, 17].

Average standard output per agricultural holding by SO size class in Romania and the EU selected countries in the year 2020 (Euro/AH)
In the year 2020, the average SO/AH accounted for Euro 38,703/farm.
In Romania, it was very small, accounting for Euro 4,029/farm that is it was 9.6 times smaller than the EU average.
In Poland, it was achieved Euro 19,680 SO/AH, being 1.98 times smaller than the EU average.
In Italy, it was carried out Euro 57,681 SO/AH, meaning 1.5 times higher than the EU average SO/AH.
In Spain, it was produced Euro 44,124 SO/AH, a level which is 1.14 times higher than the EU average.
In France, it was obtained Euro 158,430 SO/AH, being 4.09 times higher than the EU average.
In Germany, it was registered the highest SO/AH accounting for Euro 167,631/AH, being 4.33 times higher than the EU average (Table 16).
In all the studied countries it was normally as SO/AH to increase from the SO size class less than Euro 2,000 to the superior SO size class Euro 500,000 and over.
But, if we compare the average SO/AH in each country with the EU average SO/AH, we may easily notice large deviations as follows:
- *In case of Romania*, the average SO/AH for almost all the SO size classes does not exceed the EU average SO/AH, except the superior SO size class with Euro 250,000 and over SO.
Also, we have to specify, that the average SO/AH produced by the superior SO size

class Euro 500,000 and over in Romania, accounting for Euro 1,263,878 is by +16.22% higher than in Germany.
Also, this figure is by + 26.22% higher than in Spain, by +47.49 higher than in France and by +61.42% higher than in Poland.
But, is also by - 15.72% lower than the one achieved by Italy.
-*In France*, the EU average SO/AH is exceeded by the SO size classes ranging between Euro 2,000 and Euro 499,999.
A smaller average SO/AH was recorded in case of the SO size class less than Euro 2,000, and also in case of the SO size class Euro 500,000 and over.
-*In Germany*, almost all the SO size classes exceeds the EU average SO/AH, except the SO size class Euro 500,000 and over.
-*In Italy*, the EU average SO/AH is exceeded only by the SO size classes ranging between less Euro 2,000 and Euro 24,999, and also between Euro 250,000 and over.
Therefore, the SO size classes between Euro 25,000 and 249,999 registered a smaller SO/AH than the EU average.
-*In Spain*, The EU average SO/AH is exceeded only in case of the SO size classes varying between Euro 2,000 and Euro 49,999. Therefore, the SO size classes ranging between Euro 50,000 and over recorded a smaller average SO/AH than the EU average.
-*In Poland*, we noticed a similar situation like in Spain, that is, the SO in smaller size classes had an average SO/AH higher than the EU average.
The superior SO size classes with Euro 50,000 and over achieved a smaller average SO/AH than the EU average (Table 16).
Table 16 presents average Standard output per agricultural holding by SO size classes in Romania and the EU selected countries in the year 2020 (Euro/AH).

Table 16. Average Standard output per agricultural holding by SO size classes in Romania and the EU selected countries in the year 2020 (Euro/AH)

SO size class (Euro)	**EU**	**Romania**	**Poland**	**Italy**	**Spain**	**France**	**Germany**
Average SO/AH	38,703	4,029	19,680	57,681	44,124	158,430	167,631
Average SO/AH by SO size class (Euro/AH)							
Less than 2,000	833	707	1,169	1,087	1,048	799	1,454
2,000-3,999	2,854	2,786	2,886	2,905	2,914	2,921	3,082
4,000-7,999	5,669	5,482	5,679	5,815	5,760	5,818	5,921
8,000-14,9999	10,926	10,650	10,948	11,024	11,012	11,280	11,139
15,000-24,999	19,252	18,949	19,289	19,306	19,351	19,532	19,378
25,000-49,999	35,187	34,040	35,388	35,180	35,481	36,287	35,584
50,000-99,999	70,239	68,629	68,826	70,092	70,224	72,062	71,882
100,000-249,999	155,403	152,464	145,350	152,246	148,697	162,265	161,134
250,000-499,999	336,987	341,016	320,335	342,017	313,278	340,125	340,118
500,000 and over	1,141,919	1,253,978	108,830	1,499,593	1,001,360	856,873	1,087,571

Source: Own calculation based on the data from [17].

CONCLUSIONS

In 2020, Romania had 12,763 thousand ha UAA, by -13.3% smaller than in 2003 and representing 7.67% of the EU's UAA.
The values of HHI and GSC smaller than 15% reflects that there are no significant differences regarding UAA from a region to another.
Taking into account its UAA, Romania is ranked the 6th after France, Spain, Germany, United Kingdom, and Poland, being followed by Italy till 2019, and after Brexit, in 2020, it preserved its 6th position, but after France, Spain, Germany, Poland and Italy.
In 2020, Romania had 2.88 million farms, by about 60% less than in 2003. The share of its farms in the EU's NAH was 7.67%.
In 2020, Romania, Poland, Italy, Spain, France and Germany, all together had 6.89 million agricultural holdings, meaning 75.75% of the EU's NAH. In the interval 2005-2020, the EU lost 36.7% farms.
The average farm size is one of the smallest in the EU, that is 4.42 ha/AH being 3.93 times smaller than the EU's average accounting for

17.4 ha/farm and also compared to the other EU countries selected in this study.

At the EU level, the farms with less than 2 ha account for 70.7% in Romania, 42.55%, in Spain for 29.5%, in Poland for 18.9%, in Italy for 11.6%, in France for 10.8%, in Germany for 5.1%.

Of the total EU's NAH, the smallest farms below 5 ha represent: 90.3% in Romania, 64.1% in Italy, 52.3% in Poland, 51.6% in Spain, 19.6% in France and 8.2% in Germany.

The farms with 50 ha and over accounted for 7.5% at the EU level, 1% in Romania, 3.1% in Poland, 4.5% in Italy, 11.6% in Spain, 31.5% in Germany and 45.9% in France.

The values of HHI and GSC for the average UAA/farm the following concentration type: high concentration in Romania, relatively moderate Poland, Italy and Spain, and lacked of concentration in Germany.

In 2020, Romania produced Euro 11,632 million standard output, accounting for 3.3% of the EU's SO. The other EU countries contribute by much more: Poland 7.3%, Spain 11.5%, Germany 12.5%, France 17.7% and Italy 18.6%.

In the EU, the dispersion of farms by standard output size classes varies from a country to another.

In 2020, the farms producing less than Euro 2,000 per farm and year represent: 35.7% at the EU level, 71.5% in Romania, 26% in Poland, 17.1% in Spain, 8.4% in Italy, 5.5% in France and 0.54% in Germany.

The farms producing Euro 250,000 and over accounted for: 3.29% at the EU level, 0.16% in Romania, 0.92% in Poland, 3.43% in Spain, 3.67% in Italy, 18.93% in Germany and 19.69% in France.

The farms producing Euro 50,000 and over represented for: 12.9% at the EU level, 0.9% in Romania, 8.1% in Poland, 17.5% in Spain, 19.8% in Italy, 49% in Germany and 60.7% in France.

The values of HHI and GSC reflected the following degree of concentration of the farms by SO size class: high concentration in Romania, relatively moderate at the EU level, moderate in Poland and Italy, lack of concentration in Spain, France and Germany.

The SO size class Euro 50,000 and over contribute by 83.92% to the EU's SO, in Romania by 45%, in France by 95.7%, in Germany by 94.8%, in Italy by 81.9%, In Spain by 80.7% and in Poland by 61.8%.

The values of HHI and GSC reflected the following degree of concentration of SO by SO size class: High concentration in Germany, relatively moderate in France, moderate concentration at the EU level, Italy and Spain, lack of concentration in Romania and Poland.

In 2020, the standard output per holding accounted for: Euro 38,703 at the EU level, Euro 4,029 in Romania, Euro 19,680 in Poland, Euro 57,681 in Italy, Euro 44,124 in Spain, Euro 158,430 in France and Euro 167,631 in Germany.

As a final conclusion, while the UAA and NAH declined, the average UAA/farm and SO/farm increased at the EU level, in Romania and in all the selected EU countries analyzed in this study.

However, Romania has still the highest number of farms compared to the other EU countries, but its average farms size is very small 4.43 ha/farm and in terms of SO/farm as well, recording just Euro 4,029/farm and year.

Poland has a better situation from all these points of view, but a middle one compared to the performance recorded by the other EU member states.

France and Germany are definitely on the top positions regarding average farm size in ha/farm and mainly SO/farm.

These discrepancies among these countries are caused by the unbalanced farm structure with the highest share belonging to the farms with less than 2 ha.

Farms with 50 ha and over could be considered of a corresponding size which could also assure a higher SO/farm.

The decline in the number of farms has to continue stimulating the growth of farm size and economic power of the farms.

For Romania, it is still a long-term process to diminish the number of agricultural holdings, and assure a higher economic efficiency in terms of standard output.

Small and medium-sized farms have to be encouraged and supported to merge their efforts for a higher concentration of land, production and economic efficiency.

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CONCENTRATION OF STANDARD OUTPUT AND NUMBER OF FARMS IN THE EUROPEAN UNION BASED ON THE ECONOMIC DIMENSION

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Abstract

The paper aimed to analyze the concentration degree of standard output (SO) and number of agricultural holdings (AH) in the EU countries in the year 2020 by economic dimension in terms of standard output size class. The data collected from Eurostat were used to calculate Gini-Struck coefficient according to which the countries were classified. The EU has a moderate concentration both concerning SO (GSC = 0.3938) and AH (GSC = 0.3276) by SO class. Discrepancies were noticed referred to these two indicators in the member states. Regarding SO, GSC varied between 0.7941 in Denmark and 0.1597 in Romania. Six countries (22.3%) have a low concentration, 12 countries (44.4%) have a moderate concentration and 9 countries 9933.3%) have a high level. 13 countries: Bulgaria, Cyprus, France, Luxemburg, Sweden, Estonia, Hungary, Germany, Belgium, Slovakia, Netherlands, Czechia and Denmark exceeds the EU GSC= = 0.3938. Regarding AH, GSC values ranged from 0.1204 in Denmark and 0.7004 in Romania. A number of 17 countries (63%) registered a low concentration level of the number of farms by SO class, other 9 countries (33.3%) recorded a moderate concentration and one country, Romania (2.7%) had the top position with the highest concentration of the number of farms. Taking into *consideration GSC values both for Standard output and number of farms by SO class, it was found that 8 countries (29.3%) have a high concentration of SO and a low concentration of AH; 7 countries (25.9%) have a moderate concentration of SO and a low concentration of AH; 5 countries (18.5%) have a moderate concentration of SO and a moderate concentration of AH, all these three categories summing 73.7%. As a final conclusion, the concentration of standard output by SO class is a moderate one in 44.4% of the EU countries and in 33% is a high.*

Key words: *concentration degree, standard output, number of farms, Gini-Struck coefficient, European Union*

INTRODUCTION

European Union's is characterized by a large agricultural potential which varies from a country to another regarding the performance in production, productivity and efficiency of land use [1, 13].

The variety of farms regarding the aspects related to the type of the farms, most of them being family subsistence and semi-subsistence holdings, with a small physical size in UAA, low technical endowment, productivity, and efficiency [2, 3, 4, 6]. Family farms represented 94% of the EU agricultural holdings in the year 2020 [5, 7, 8].

Compared to the year 2013, when the EU had 10.84 million farms, in 2020 it had 9.1 million. Their number is in a continuous decline, which favours the increase of average farm size, which in the year 2020 reached present is 17.4 ha/farm, compared to 16.1 ha in 2013 [10, 13, 18].

Farm structure, applied technologies, environmental conditions in terms of soil quality and fertilization level, climate in terms of temperatures and humidity, technical endowment and labor and capital inputs, labor's training level and skills, land productivity per UAA are important factors with a deep impact on agricultural output intensity [11, 15, 16].

About 50% of labor used in agriculture is represented by family members [12].

Qualification level and input of labour force in agriculture have an important impact on productivity and quality of products [14, 17].

The dispersion of labor force and the connection between farmers income and minimum salary confirm this feature of the EU agriculture [11].

EU countries could be easily analized regarding output intensity from the perspective of the assumptions of the concept of sustainable development [19].

The economic size of the farms is expressed in their standard output, which is a measure of the monetary value of agricultural output at farm-gate prices for crops and livestock. In contrast, the physical size of farms is expressed in utilized agricultural area.

In 2013, about 69% of the EU farms were very small and small farms, subsistence households with a standard output less than 2,000 Euro and, respectively between 2,000 and 8,000 Euro.

At the other pole, there were about 680,000 very large farms (6.3% of the total number of farms) producing at least 100,000 Euro standard output, that is 71.4% of the EU standard output in the year 2013 [9].

In the year 2020, the EU standard output accounted for 350 billion Euro, compared to 331.5 Billion in 2013.

At present, 74 % of the farms produce a standard output higher than 100,000 Euro and 39.3$ holdings produce 39.3 % of the EU total standard output [8].

Structural analysis of the distribution of standard output (SO) and number of agricultural holdings (AH) could contribute to the creation of an image on the actual situation of the EU agriculture in terms of economic power and dimension.

More than this, it may reflects the dispersion of SO and AH by SO size classes which allows to assess the disparities existing in the agriculture of each EU member state.

The dynamic analysis is always useful to quantify the progress achieved for different tome series and in what measures it covers the expectations concerning the decrease of AH and the growth in SO.

The structural analysis also could emphasize the changes of the shares of different SO classes in total SO in the agriculture of each EU member state and also at the EU level, reflecting the trends of the economic dimension of AH.

In this context, the paper aimed to assess the degree of concentration/diversification of SO and AH in the EU in the year 2020, for which there are available data on Eurostat, using Gini-Struck Coefficient.

MATERIALS AND METHODS

The research study is based on the statistical data collected from Eurostat regarding SO and AH by SO classes as established by the EU.

The data were processed using Gini-Struck Coefficient (GSC), calculated using the well-known formula:

$$GSC=\sqrt{\frac{n\sum_{i=1}^{n} g_i^2-1}{n-1}} \quad ....(1)$$

where:

n= number of SO classes

g_i = the share of each SO class in total SO.

According to GSC values, the countries were classified into three groups as follows:

(a) Countries with a low concentration degree of SO (LCSO), where GSC < 0.3;

(b) Countries with a moderate concentration of SO (MCSO), where 0.3 >GSC < 0.5;

(c) Countries with a high concentration degree of SO, where GSC > 0.5.

GSC values closer to zero reflects the equal dispersion of SO by classes, that is a balanced share of SO by class.

The distribution of AH by SO class was analyzed using the same formula, where:

n= number of SO class

g_i = the share of AH by each SO class.

Based on GSC calculated values, for the concentration degree of AH by SO class, the EU member states were divided on three groups as follows:

(a) Countries with a low concentration degree of AH(LCAH), where GSC < 0.3;
(b) Countries with a moderate concentration of AH (MCAH), where 0.3 >GSC < 0.5;
(c) Countries with a high concentration degree of AH, where GSC > 0.5.
GSC values closer to zero reflects the equal dispersion of SO by classes, that is a balanced share of SO by class.
Also, the countries were again divided into nine groups based on the combination of GSC value for SO and AH.
The results were graphically represented and also displayed in tables.
Comparison method was used to establish the hierarchy of the countries and to select them and include in each group according to the GSC value.
Also, the differences between countries where emphasized.

RESULTS AND DISCUSSIONS

Concentration degree of standard output (SO) in the EU countries by SO size class

At the EU level, GSC had the value of 0.3938 reflecting a moderate concentration of SO among classes.
However, GSC values varies from a country to another, more exactly from GSC =0.7941 in Denmark, the highest value, to GSC = 0.1597 in Romania, the lowest value (Fig. 1).

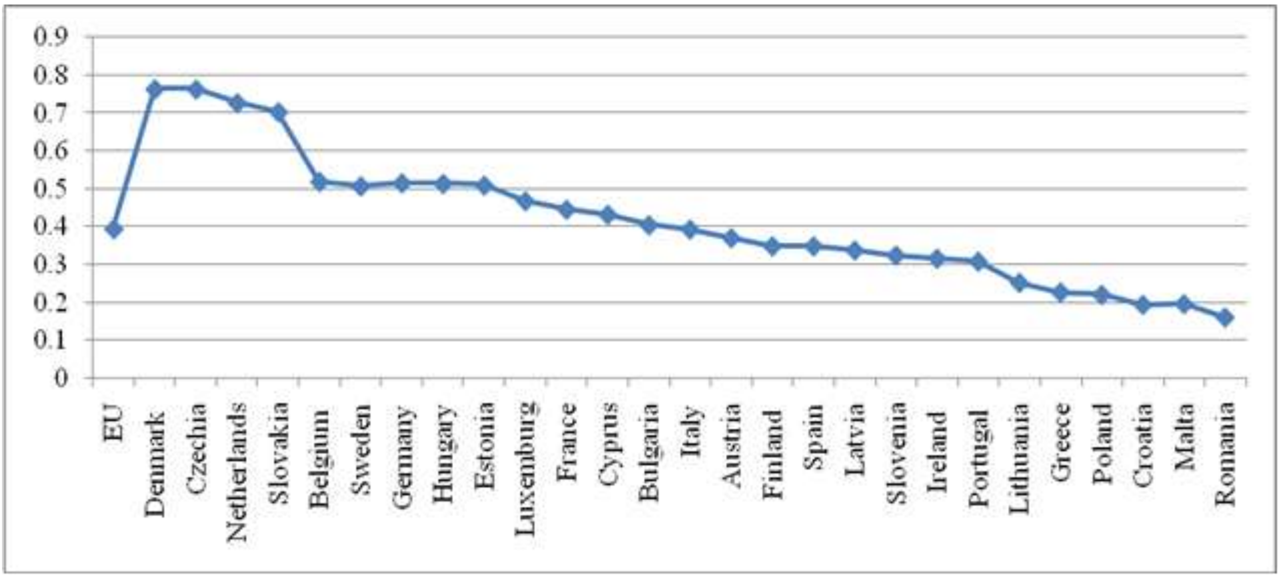

Fig.1. Gini-Struck Coefficient (GSC) reflecting the concentration of standard output (SO) by SO class and by EU member state in the year 2020
Source: Own calculation and design based on Eurostat data [8].

Table 1. EU countries grouped based on GSC for SO concentration by SO class

Group (a) LCSO GSC < 0.3		Group (b) MCSO 0.3<GSC < 0.5		Group (c) HCSO GSC > 0.5	
1. Lithuania	0.2514	1.Luxemburg	0.4647	1.Denmark	0.7911
2.Greece	0.2263	2.France	0.4452	2.Czechia	0.7633
3.Poland	0.2197	3,Cyprus	0.4320	3.Netherlands	0.7274
4.Croatia	0.1933	4.Bulgaria	0.4041	4.Slovakia	0.7034
5.Malta	0.1852	5.Italy	0.3826	5.Belgium	0.5188
6.Romania	0.1597	6.Austria	0.3700	6.Germany	0.5152
		7.Spain	0.3483	7.Hungary	0.5137
		8.Finland	0.3483	8.Estonia	0.5093
		9.Latvia	0.3374	9. Sweden	0.5070
		10.Slovenia	0.3239		
		11.Ireland	0.3158		
		12.Portugal	0.3077		

Source: Own calculation based on Eurostat data [8].
Note: LCSO = low concentration, MCSO= Moderate concentration, HCSO= High concentration

Based on GSC values, the EU countries were included in the following groups:

(a) Countries with a low concentration of SO, [GSC < 0.3], which in the decreasing order were: Lithuania, Greece, Poland, Croatia, Malta and Romania, the GSC varying between 0.2514 in Lithuania and 0.1597 in Romania.

This reflects a relative uniformity of dispersion of SO in these countries with small differences among SO classes.

(b) Countries with a moderate concentration of SO, [0.3<GSC < 0.5], including a number of 12 member states, whose descending order based on GSC was: Luxembourg, France, Cyprus, Bulgaria, Italy, Austria, Spain, Finland, Latvia, Slovenia, Ireland and Portugal.

(c) Countries with a high concentration of SO, [GSC > 0.5], the group including 9 member states: Denmark, Czechia, Netherlands Slovakia, Belgium, Germany, Hungary, Estonia and Sweden (Table 1).

The structured image of the EU countries in these three groups for SO concentration is shown in Fig, 2.

The shares reflect a moderate diversity regarding the distrubution of the EU countries based on GSC value for SO by SO size class.

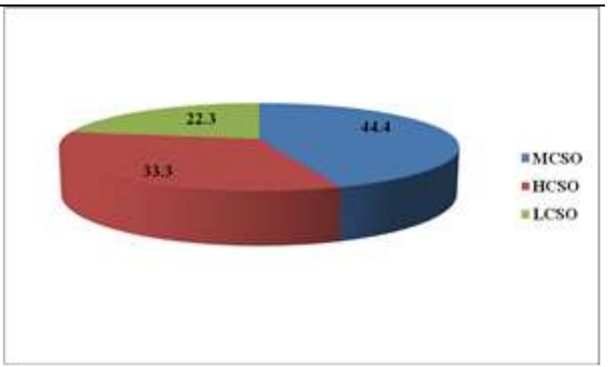

Fig. 2. The EU strcutured SO concentration
Source: Own calculation based on the GSC results.

The increase of SO is directly conditiones by the agricultural development in each EU country, production and quality og agricultural products, offer diversification and farm structures.

Concentration of the number of farms (AH) by standard output (SO) classes

At the EU level, in the year 2020, the concentration degree of AH in terms of GSC accounted for 0.3276, reflecting a moderate concentration and diversity among the member states.

Taking into account GSC values calculated by country, we may easily notice the discrepancies existing from a member state to another.

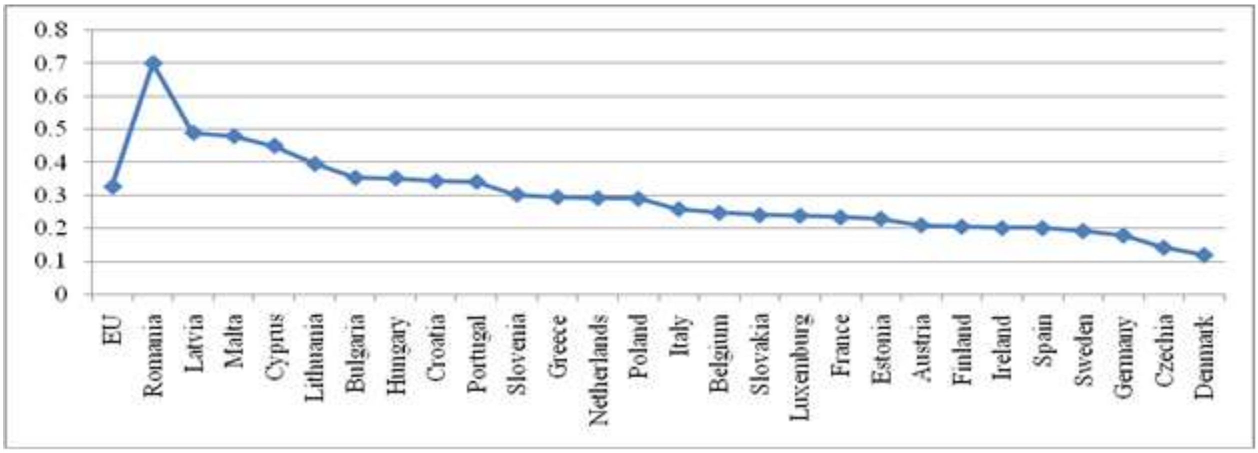

Fig. 3. GSC values reflecting the concentration of agricultural holdings by SO class and EU member state in the year 2020
Source: Own calculation an design based on Eurostat data [8].

Romania comes on the top position for GSC =7004 reflecting a high concentration of number of farms, in other words, the large differences among the agricultural holdings by SO economic dimension class.

At the other pole, it is Denmark with GSC =0.1204, the lowest concentration level of farms by SO class, reflecting that their distribution is uniform assuring a balanced economic power (Fig.3).

A number of 17 member states recorded a GSC < 0.3, their range in the decreasing order being: Greece, Netherlands, Poland, Italy, Belgium, Slovakia, Luxemburg, France, Estonia, Austria, Finland, Ireland, Spain, Sweden, Germany, Czechia and Denmark.

In these countries, the concentration degree of AH by SO class is low, reflecting a uniform distribution.

Other 9 countries had a moderate concentration of AH by SO class, as their GSC value ranged between 0.3 and 0.5, more exactly between 0.4899 in Latvia and 0.3032 in case of Slovenia. The situation of these countries in the decreasing order is: Latvia, Malta, Cyprus, Lithuania, Bulgaria, Hungary, Croatia, Portugal and Slovenia.

Finally, Romania is the only country which registered the highest GSC value higher than 0.5, more exactly 0.7004, reflecting a high concentration of AH by SO class and, obviously, large discrepancies (Table 2).

Table 2. EU countries grouped on GSC values for the number of agricultural holdings (AH) by SO class

Group (a) LCAH GSC < 0.3		**Group (b) MCAH 0.3<GSC < 0.5**		**Group (c) HCAH GSC > 0.5**	
1. Greece	0.2955	1.Latvia	0.4899	1.Romania	0.7004
2.Netherlands	0.2923	2.Malta	0.4802		
3.Poland	0.2904	3,Cyprus	0.4509		
4.Italy	0.2592	4.Lithuania	0.3960		
5.Belgium	0.2479	5.Bulgaria	0.3541		
6.Slovakia	0.2407	6.Hungary	0.3527		
7.Luxemburg	0.2393	7.Croatia	0.3441		
8.France	0.2342	8.Portugal	0.3419		
9.Estonia	0.2300	9.Slovenia	0.3032		
10.Austria	0.2105				
11.Finland	0.2060				
12.Ireland	0.2019				
13. Spain	0.2014				
14. Sweden	0.1930				
15.Germany	0.1794				
16.Czechia	0.1426				
17.Denmark	0.1204				

Source: Own calculation based on Eurostat data [8].

Note: LCAH= low concentration, MCAH= Moderate concentration, HCAH= High concentration

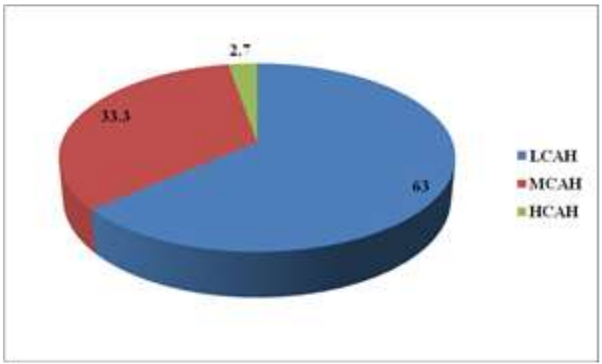

Fig. 4. The EU structure of the number of farms concentration by SO class and group of countries

Source: Own results and design.

Figure 4 shows the weight of the concentration degree of the number of agricultural holdings (AH) by SO class.

The shares reflect a large diversity and discrepancy among the groups of countries regarding the concentration level of the farms by SO class.

The group of countries with LCAH dominates the EU agriculture (63%), one third of the countries has a moderate concentration of farms and 3.7% have a high concentration of AH, it is the case of Romania.

Classification of the EU countries based on the concentration degree both of SO and AH

The EU countries were again divided into groups taking into account the GSC values both for SO and for AH. Therefore, 9 groups were established as follows:

-LCSO+ LCAH= low concentration for SO and low concentration for AH

-LCSO+MCAH= low concentration for SO and moderate concentration for AH

-LCSO+HCAH= low concentration for SO and high concentration for AH
-MCSO+LCAH= moderate concentration for SO and low concentration for AH
-MCSO+MCAH= moderate concentration for SO and moderate concentration for AH
-MCSO+HCAH= moderate concentration for SO and high concentration for AH
-HCSO+LCAHA= high concentration for SO and low concentration for AH
-HCSO+MCAH= high concentration for SO and moderate concentration for AH
-HCSO+HCAH= high concentration for SO and high concentration for AH

The distribution of the countries by group based on these combinations of GSC is shown in Table 3, which reflects the following aspects:

- 8 countries have a high concentration of SO and low concentration of AH;
- 7 countries have a moderate concentration of SO and a low concentration of AH;
- 5 countries have a moderate concentration of SO and a moderate concentration of AH;
-3 countries have a low concentration of SO and a moderate concentration of AH;
- 2 countries have a low concentration of SO and also a low concentration of AH;
-1 country has a low concentration for SO and a high concentration for AH;
- 1 country has a high concentration of SO and a high concentration for AH.

Table 3. Distribution of the EU countries by group of concentration degree for combined two criteria SO and AH by SO class

LCSO + LCAH	LCSO + MCAH	LCSO + HCAH	MCSO + LCAH	MCSO + MCAH	MCSO + HCAH	HCSO + LCAH	HCSO + MCAH	HCSO + HCAH
1.Greece	1.Croatia	1.Romania	1.Ireland	1.Bulgaria	-	1.Belgium	1.Hungary	-
2. Poland	2.Lithuania		2.Spain	2.Cyprus		2.Czechia		
	3.Malta		3.France	3,Latvia		3.Denmark		
			4.Italy	4.Portugal		4.Germany		
			5.Luxemburg	5.Slovenia		5.Estonia		
			6.Austria			6.Netherlands		
			7.Finland			7.Slovakia		
						8.Sweden		

Source: Own determination based on the obtained results

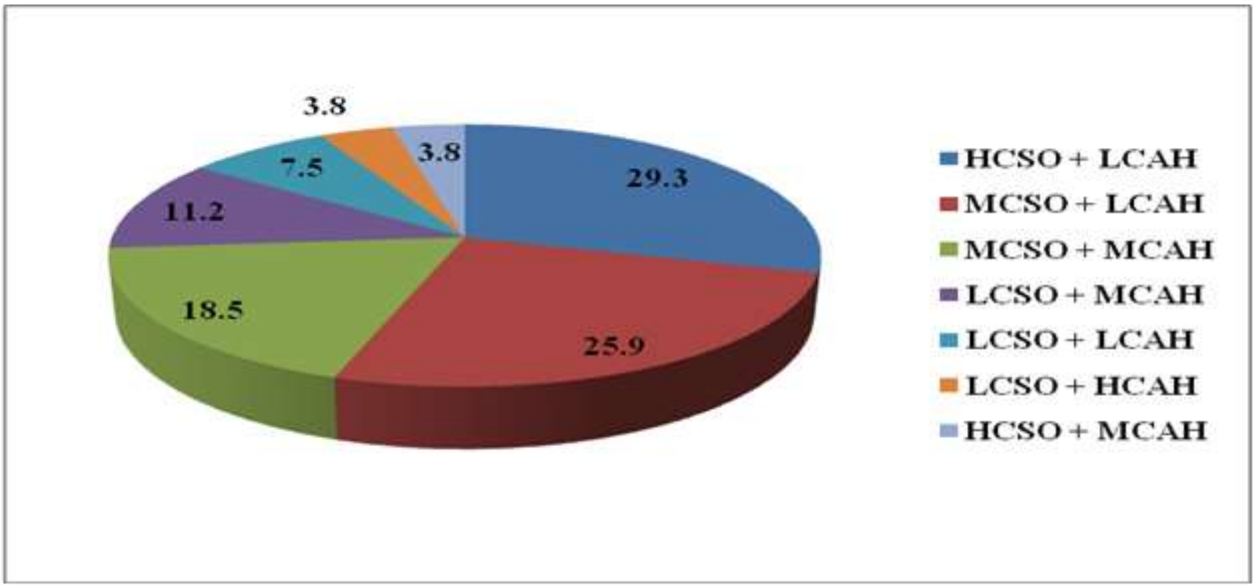

Fig. 5.The EU structure by group of member states based on GSC value combined for the two criteria SO and AH by SO class.
Source: Own results and design.

Figure 5 reflects the EU structure of the concentration level of Standard output (SO) and number of agricultural holdings (AH), two criteria expressed in various combinations according to Gini-Struck Coefficient value for each criterion.

Looking at the shares, we may consider that 12 countries have a moderate concentration of standard output accounting for 44.4%, and 12 countries have a high concentration of standard output meaning 33%.

The low concentration of standard output is found in 22.5% of the countries.

Exceptions regard Romania, which has a low concentration of standard output, but the highest concentration of agricultural holdings, and Hungary which has a high concentration of standard output and a moderate concentration of agricultural holdings.

Looking at Table 3, we may see that there is none country in the EU with a moderate standard output and high concentration of agricultural holdings, and also there none country with a high concentration of standard output and high concentration of agricultural holdings.

CONCLUSIONS

The paper analyzed the degree of concentration and diversity regarding Standard output and number of agricultural holdings in the EU in the year 2020, using as econometric tool Gini-Struck Coefficient method, whose values were calculated based on the primary empirical data provided by Eurostat.

In the year 2020, the results reflected that at the EU level it is a moderate concentration both concerning standard output and number of farms by SO class, more exactly GSC = 0.3938, and respectively, GSC = 0.3276.

But, there discrepancies regarding the concentration of these two indicators in the member states as proved by Gini-struck Coefficient values.

For standard output, GSC values varied between 0.7941 in Denmark, the highest value and 0.1597 in Romania, the lowest value.

A number of 6 countries (22.3%) have a low concentration of standard output, 12 countries (44.4%) have a moderate concentration and 9 countries have a high level (33.3%).

Over the EU Gini Struck Coefficient accounting for 0.3938, there were 13 countries, in the increasing order of their GSC being: Bulgaria, Cyprus, France, Luxemburg, Sweden, Estonia, Hungary, Germany, Belgium, Slovakia, Netherlands, Czechia and Denmark.

For the number of agricultural holdings, GSC values ranged from 0.1204 in Denmark and 0.7004 in Romania.

A number of 17 countries (63%) registered a low concentration level of the number of farms by SO class, other 9 countries (33.3%) recorded a moderate concentration and one country, Romania (2.7%) had the top position with the highest concentration of the number of farms.

Taking into consideration GSC values both for Standard output and number of farms by SO class, it was found the following situation:

-8 countries (29.3%) have a high concentration of SO and a low concentration of AH;

- 7 countries (25.9%) have a moderate concentration of SO and a low concentration of AH;

- 5 countries (18.5%) have a moderate concentration of SO and a moderate concentration of AH, all these three categories summing 73.7%.

A few number of countries, more exactly 6 have a low concentration of SO, but 3 countries (11.2%) have a moderate concentration of AH, 2 countries (7.5%) have a low concentration of AH and 1 country (3.8%) has a high concentration of AH.

Only one country (3.8%) has a high concentration of SO and a moderate concentration for AH.

As a final conclusion, the concentration of standard output by SO class is a moderate one in 44.4% of the EU countries and in 33% is a high.

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ROMANIA'S VEGETAL PRODUCTION IN THE POST ACCESS PERIOD TO THE EUROPEAN UNION

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Abstract

The paper analyzed the dynamics of cultivated area, production and yield in vegetal sector of Romania's agriculture in the period 2007-2020 and also in the decade 2014-2020 versus 2007-2013 in order to quantify the effects of the implemented agricultural strategy aligned to the EU CAP. The data from National Institute of Statistics were processed using fixed basis indices, structural indices, growth rate, mean, regression models, R square and comparisons between the two decades. In 2020, Romania had 8,263,672 ha cultivated by +6.25% more than in 2007. Crop structure included: cereals 64.6%, oil plants 20.3%, vegetables 2.4%, leguminous plants 1.3% and 1% potatoes. The area cultivated with cereals raised by +4.07% reaching 5,338,067 ha in 2020, of which maize and wheat 87.9%. In the decade 2014-2020 versus 2007-2013, it was registered a larger total cultivated area and also with cereals (wheat and maize), leguminous crops, oil crops (sunflower), but a reduced area with vegetables and potatoes. Cereals production increased by +132.29% accounting for 18,153,714 tons in 2020, of which maize 55.61% and wheat 35.2%. In the period 2007-2020, important production gains were carried out in leguminous grains, oil seeds, fruits and vegetables, but potatoes production declined by -49.63%. In the period 2014-2020 versus 2007-2013, production gains were registered in cereals, wheat, maize, leguminous grains, in oil seeds, sunflower seeds and fruits, but losses by -4.14% in vegetables and -21.26% in potatoes. In 2020 versus 2007, yield level was accounted for 3,400 kg/ha cereals (+123.24%), 2,966 kg/ha wheat (+92.47%), 3,977 kg/ha maize (+160.61%), 1,858 kg/ha sunflower seeds (+184.09%), 15,843 kg/ha potatoes (+15.95%), 21,858 kg/ha tomatoes (+57.07%). In the period 2014-2020 versus 2007-2013, yield gain accounted for: +50.08% cereals grains,+44.7% wheat,+54.18% maize,+61.5% sunflower seeds, +13.13% potatoes and +12.83% tomatoes. In conclusion, the implementation of Romania's strategy of agriculture development in the vegetal sector aligned to CAP has resulted in higher productions and yields of the analyzed groups of crops, except potatoes production which declined by about 50% in 2020 compared to 2007, and also, in the 2nd decade 2024-2020 versus 2007-2013, it was registered a decrease by -4.14% in vegetables and by -21.26% in potatoes, which is justified by the decline in cultivated area. This performance is due to the efforts made by farmers to obtain better results in their business and to the financial support given by the EU and Romanian Government.

Key words: *vegetal sector, cultivated area, production, yield, main agricultural crops, Romania*

INTRODUCTION

In Romania's economy, agriculture one of the most important sectors as it plays a unique role to provide food for nourishing the population, raw materials for industry and forages for animal rearing.
With 2.88 million farms, most of them family semi subsistence farms with about 4.2 ha average farm size, four times smaller than the EU average accounting for 17.4 ha and about

20% of the population employed in agriculture, Romania is able to produce about 10% of the EU grains and oil seeds production [4].

Its production potential is favoured by its geographical position, soil fertility, long tradition in vegetal production mainly in cereals and oil seeds plants cultivation.

There is no doubt that cereals, vegetables and fruits continue to be special components in human diet grace to the rich content in a large variety of bio-active substances like carbohydrates, fats, protein, vitamins, minerals and fibers [5, 31].

Besides France, Germany, Italy, Spain, Poland, Greece, Romania is an important producing country able to contribute by about 10% to the EU grain and oil seeds output [14].

The access of Romania into the EU in January 1st, 2007 has been in the benefit of the both sides:

-for Romania to align its strategy for the development of agriculture according to the EU Common Agricultural Policy and benefit of financial support for farmers and of the advantages of an open unique market without barriers stimulating the trade exchange and the competitiveness among the market players [3];

- for the EU to extend its market of material and human resources and of agro-food products.

Cereals are produced on large surfaces in Romania. Maize and wheat are the main cereals produced in the country, but also barley, oats and sorghum [12].

Their favorable zones are situated in South Muntenia, South Eastern Romania, South West Oltenia, and West [17, 18].

Maize and wheat are cultivated both in family farms but also in commercial farms, the last ones being deeply market oriented [21]. For its high performance, Romania is situated among the top maize producers in the EU [8].

When the internal requirements are covered, the surplus is destined to export and maize and wheat are the top exported agricultural products [9, 23].

When the domestic market is facing an insufficient production, imports are required to cover the deficit, and this leads to a negative trade balance, reflecting a low efficiency in agro-food commerce [26, 27].

Climate change has become more visible in Romania during the last decades with a deep negative impact on the performance in agriculture due to the extreme meteorological phenomena like drought, low precipitations and high temperatures which also influence market price [16, 29, 30].

Oil seeds crops are also a well developed subsector of vegetal agriculture as their seeds are more and more called in edible oil industry, in energy industry and also for producing meals for animal feeding [5]. Larger surfaces are cultivated with sunflower and smaller areas with rape and soybean [13, 25].

Production performance is high and oil seeds are subject of export, Romania being among the top producing and exporting countries in the EU [24, 28].

A large range of vegetables are grown in Romania: tomatoes, cucumbers, green peppers, egg plants, pumpkins and roots (carrots, parsley, parsnip, celery, onion, garlic etc). However, the field production is of high risk for the farms where irrigation systems are missing or not enough, and for this reason cultivation in protected spaces like green houses has been intensified [7, 1].

The highest share in vegetables production belongs to tomatoes [15].

However, the domestic market needs have to be also covered by imports mainly in extra season [20].

Potatoes are a basic food in Romania but the cultivation areas declined and production as well due to the expensive farm inputs, climate change and invasion of imported potatoes at lower prices which disadvantaged local producers who carried out higher production costs [10, 11],

Fruit offer in internal market is not sufficient as production declined taking into account the reduction in the number of fruit trees and the surface of orchards. Romania could produce many types of fruits like: apples, plums, apricots, peaches, nuts, and also strawberry, raspberry, blueberry and black berry. But internal demand is not covered by domestic output and imports are compulsory to complete the offer [2, 19].

Also, fruit production structure changed, plums passing on the top position and apples on the second one, as Romanians are accustomed to use plums not only as such or for preparing jams and canned fruit, but also for producing the traditional "plum brandy" [19, 22].

In this context, the purpose of this research paper was to analyze the dynamics of cultivated areas, production and yield for the main groups of crops: cereals, oil seeds plants, leguminous plants, vegetables, potatoes and fruits. The study was done separately for two periods of time after Romania's access into the EU: 1st decade 2007-2013 and 2nd decade 2014-2020 in order to identify the differences and find out if the adopted strategies for the development of the vegetal sector of agriculture aligned to the EU CAP reforms have been successful.

MATERIALS AND METHODS

The paper is based on the data provided by National Institute of Statistics for the period 2007-2020 regarding cultivated areas, agricultural production and yields for the main groups of crops: cereals, leguminous plants, oil seeds plants, vegetables and potatoes. Also, there were picked up data for production of fruits and tomatoes.

The main methods and procedures for processing the data were: the calculation of mean, using the formula: $\overline{X} = \frac{\sum xi}{n}$, where xi are the values of the cultivated areas/productions/yields across the time series 2007-2020 (i); n = number of years considered (n= 20); Fixed basis indices, $I_{FB} = (X_n/X_1) \times 100$; $S_{\%}$ = structural indices, reflecting the share of each crop in the cultivated area or production; Growth rate $\overline{R} = (\overline{I} \times 100) - 100$; Regression models based on polynomial equations of second degree, $y = ax^2 + bx + c$, and coefficient of determination R^2.

Comparisons were made along the considered period as a whole and also divided into two decades: 2007-2013 and 2014-2020 in order to identify in what measure cultivated areas, productions and yields progressed after Romania's access into the EU when different CAPs were applied.

The results were illustrated in suggestive graphics and also in tables where the absolute and percentage differences between the 2nd decade 2014-2020 and the 1st decade 2007-2013 were emphasized.

RESULTS AND DISCUSSIONS

Cultivated area with agricultural main crops

Romania is one of the EU countries with a large cultivated area after Poland, Italy, Spain, France and Germany.

In the period 2007-2020, the two decades after Romania's access into the EU on January 1st, 2007, the cultivated area increased from 7,777,174 ha in 2007 to 8,263,672 ha in 2020, meaning +6.25% (Fig. 1).

In 2007, the crop structure in the cultivated area was the following one: 65.9% cereals, 17.25 oil plants, 3.4% potatoes, 3.2% vegetables, 0.5% leguminous plants and 9.8% other crops.

In the year 2020, in the total cultivated area, the cereals maintained their top position with a share of 64.6%, followed by oil plants with 20.3%, vegetables were ranked the 3rd with 2.4%, leguminous plants with 1.3% and 1% for potatoes. In the analyzed period, these changes in crop structure was caused by:

(a) the increased cultivated area with cereals by +4.07% from 5,129,183 ha in 2007 to 5,338,067 in 2020, by +25.35% growth in cultivated area with oil plants from 1,340,374 ha in 2007 to 1,678,832 ha in 2020, by + 13.5% in cultivated surface with vegetables from 228,124 ha in 2007 to 259,029 ha in 2020 and by +146% increased cultivated area with leguminous crops for grains from 43,659 ha in 2007 to 107,443 ha in 2020;

(b) the decreased cultivated area with potatoes by -63.26% from 268,091 ha in 2007 to 98,498 ha in 2020 (Fig. 2).

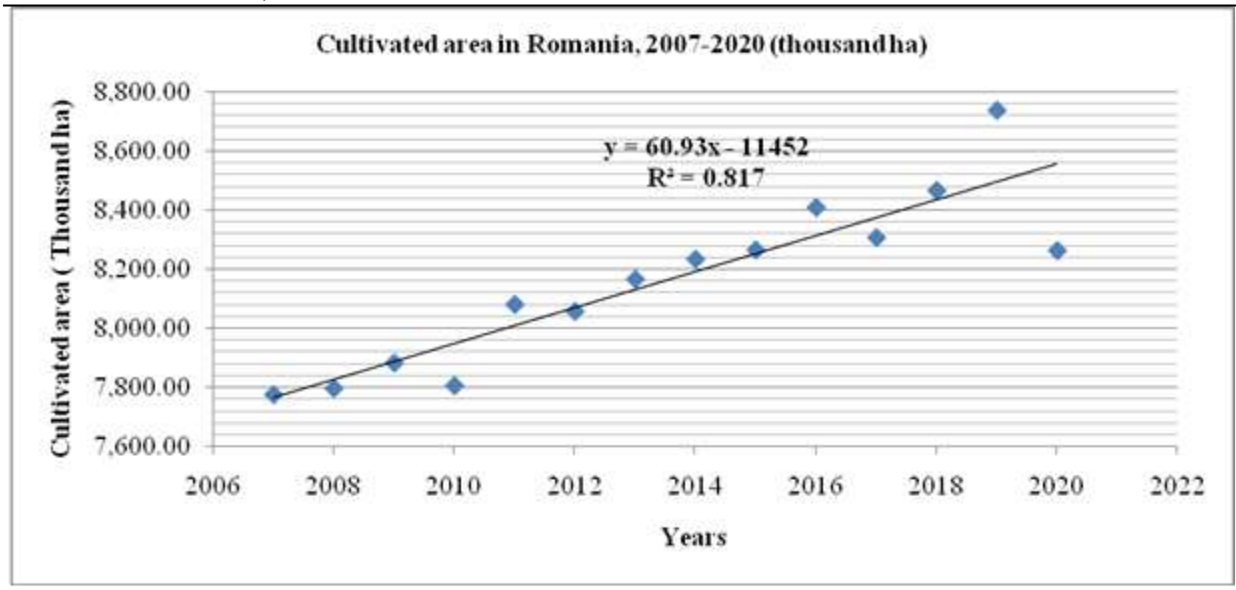

Fig. 1. Dynamics of the cultivated area in Romania in the period 2007-2020 (Thousand ha)
Source: Own calculation and design based on the data from National Institute of Statistics.

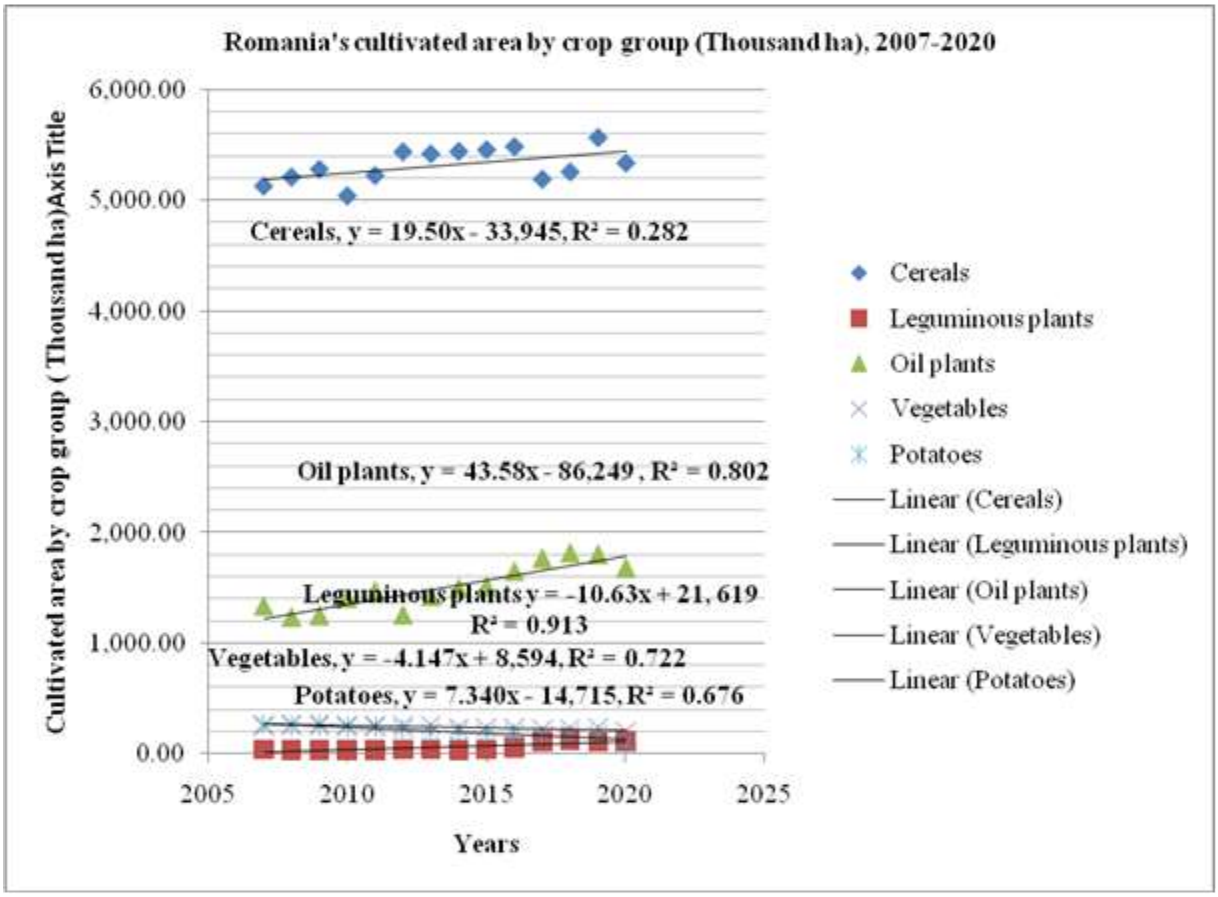

Fig. 2. Dynamics of the cultivated area by crops group in Romania in the period 2007-2020 (Thousand ha)
Source: Own calculation and design based on the data from National Institute of Statistics.

Within cereals crops, maize and wheat are cultivated on the largest surface, whose dynamics in the studied period was the following one:

- in case of maize, the cultivated area increased by +0.49% from 2,524,706 ha in 2007 to 2,537,104 ha in 2020;
- in case of wheat, the cultivated surface increased by +9.12% from 1,975,022 ha in 2007 to 2,155,254 ha in 2020.

Therefore, maize and wheat keep together 4,499,728 ha, that is 87.7% in the cultivated area with cereals in 2007 and 4,692,358 ha, that is 87.9% in the year 2020 (Fig. 3). The difference is covered by barley, oats and sorghum which are cropped on smaller surfaces.

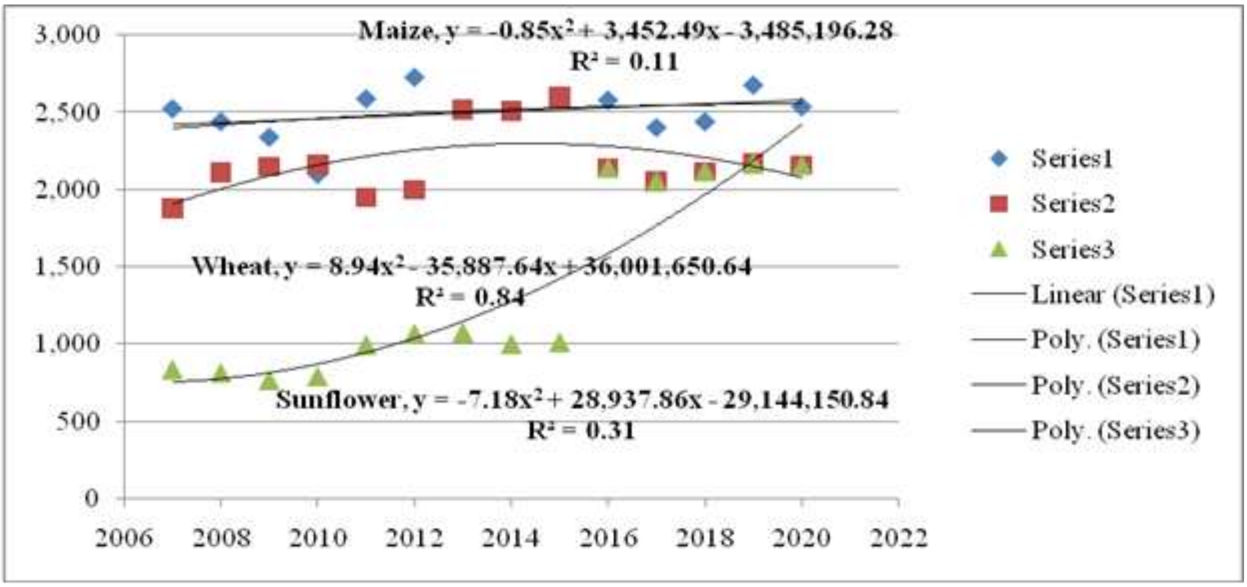

Fig. 3. Dynamics of the cultivated area with the main three crops: maize, wheat and sunflower in Romania in the period 2007-2020 (Thousand ha)
Source: Own calculation and design based on the data from National Institute of Statistics.

Comparing the average cultivated area in the decade 2014-2020 with the one in the decade 2007-2013, we may easily notice important increases as follows: +5.59% in total cultivated area, + 2.73% in cereals areas, +2.8% in wheat area, +2.98% in maize area, +115.64% in the area covered by leguminous plants, +24.42% in the area cropped with oil plants, +17.97% in sunflower area, but a decline by -13.47% in the cultivated area with vegetables and also by -30.29% in the cultivated area with potatoes (Table 1).

Table 1. Dynamics of the average cultivated area with the main agricultural crops in the decade 2014-2020 versus the decade 2007-2013 (ha)

Crop	Average 2007-2013 1sr decade	Average 2014-2020 2nd decade	Differences 2nd decade - 1st decade	
			Absolute differences, ha	% differences
Total cultivated area	7,939,071	8,383,425	+444,354	105.59
Cereals	5,249,883	5,393,588	+143,705	102.73
Wheat	2,063,590	2,121,412	+57,822	102.80
Maize	2,463,060	2,536,640	+73,580	102.98
Leguminous plants for grains	41,086	88,601	+47,515	215.64
Oil plants	1,343,394	1,671,571	+328,177	124.42
Vegetables	261,872	226,602	-35,270	86.53
Potatoes	241,363	168,263	-73,100	68.71

Source: Own calculation based in the data from National Institute of Statistics.

These changes will have a deep impact on total productions and could justify the increase in export amounts of cereals and oil seeds grains and the imported quantities in vegetables and potatoes.

Production for the main agricultural crops

Cereals production increased from 7,814,825 tons in 2007 to 18,153,714 tons in 2020, meaning by +132.29%.

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This was determined by the raised production in maize from 3,853,918 tons in 2007 to 10,096,689 tons in 2020, that is by 161.96% more and in wheat from 3,044,465 tons to 6,392,369, meaning a surplus of +109.96%.
In consequence, the share of maize in total cereals production increased from 49.3% in 2007 to 55.61% in 2020, while the share of wheat declined from 38.95% to 35.2%.
However, these two cereals crops have together the highest share in cereals production, as in 2007 they produced 6,898,383 tons grains, accounting for 88.27% and 16,489,058 tons in 2020, accounting for 90.83% (Fig. 4).

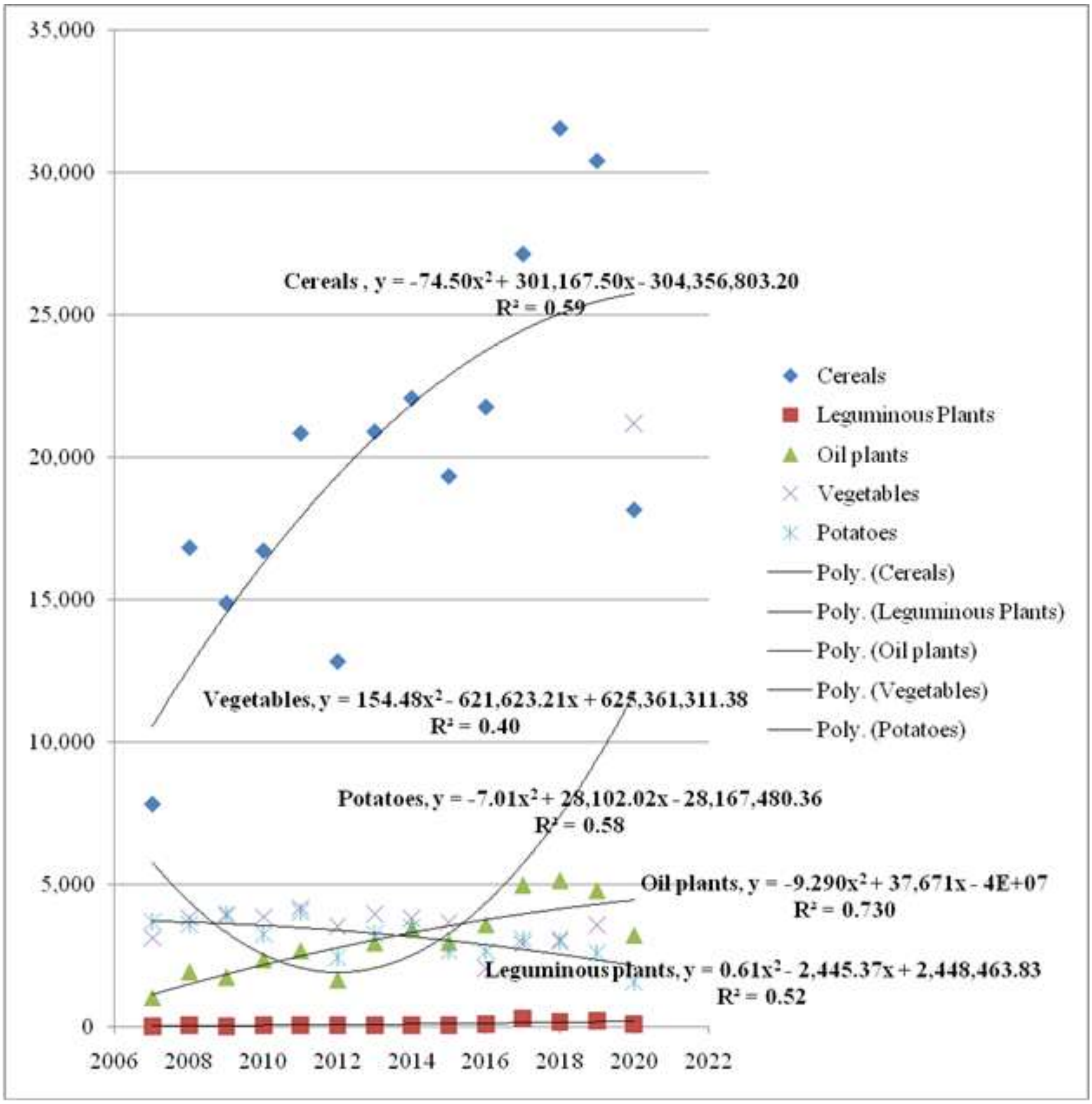

Fig. 4. Dynamics of the agricultural production for cereals, leguminous plants, oil plants, vegetables and potatoes in Romania in the period 2007-2020 (Tons)
Source: Own calculation and design based on the data from National Institute of Statistics.

Leguminous grains production also had an ascending trend from 36,185 tons in 2007 to 121,978 tons in 2020, meaning by +237.09% more.

Oil seeds production increased by 208.51 % from 1,046,558 tons in 2007 to 3,228,766 tons in 2020.

Sunflower is the main crop with the highest contribution to oil seeds production and in a low measure rape and soybean.

Sunflower seeds production raised by 288,14% from 546,922 tons in 2007 to 2,122,865 tons in 2020. As a result, the contribution of sunflower to oil seeds output is the highest, accounting for 52.25% in 2007 and for 65.74% in 2020, due to the importance given to this crop not only in oil industry but also in energy industry for producing diesel.

Vegetable production also recorded an ascending trend from 3,116,801 tons in 2007 to 3,483,035 tons in 2020, reflecting a surplus of +11.75%. The main contribution to vegetable production is given by tomatoes and in a lower measure by other vegetables like cucumbers, pumpkins, onion, green peppers, carrots, celery, parsnip, garlic etc.

Potatoes production registered a decline from 3,116,801 tons in 2007 to 1,601,239 tons in 2020, meaning a loss of 48.63%. This was caused by many factors such as: climate change with high temperatures and low precipitations in the specific zones where potatoes are cultivated, the lack of irrigation systems and high tariff for irrigation water, the high price for other farm inputs (certified seeds, fertilizers, pesticides etc) which resulted in a decline in the cultivated area and yield.

In consequence, the domestic market requirements had to be covered by imports which came mainly from Poland, being commercialized at lower prices affecting Romanian producers (Fig. 4).

Fruit production registered an ascending trend from 1,085,756 tons in 2007 to 1,590,795 tons in 2020, meaning +46.51% (Fig. 5).

This happened despite that the number of fruit trees declined by -23.66% from 96,384,568 in 2007 to 73,586,476 in 2020. But, the extend of new intensive plantations and use of varieties of high production potential favoured the growth of fruit production. However, it is still below the needs in the internal market and that is why imports are required not only for exotic fruits, but also for apples, pears, cherries, apricots, peaches etc.

The main contribution to fruit production is given by plum and apple trees and in a lower measure by cherry, apricot, peach, nuts trees and also by strawberry, raspberry, blueberry and blackberry plantations.

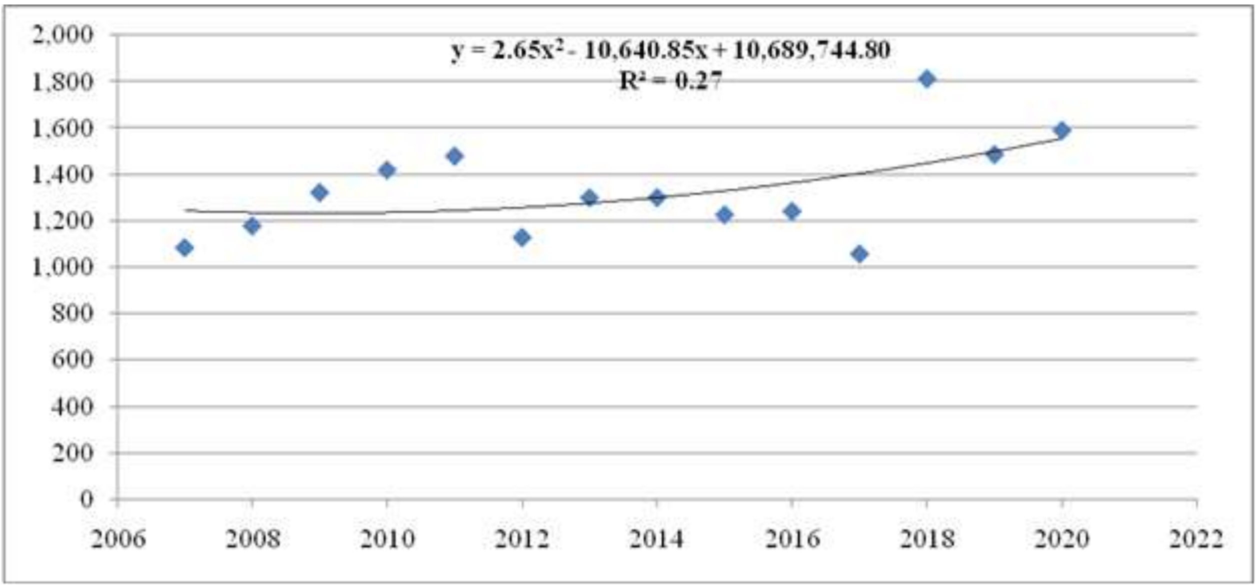

Fig. 5. Dynamics of the fruit production in Romania in the period 2007-2020 (Tons)
Source: Own calculation and design based on the data from National Institute of Statistics.

While in 2007, apples accounted for 43.78% and plums for 34.31% in total fruit production, in the year 2020, on the top position there are plums with 48.39% and on the second position came apples with 34.32%. This change is explained by the fact that in Romania it is prepared a traditional "plum brandy" named "tzuica" which requires more plums.

Making the comparison between vegetal production carried out in the 2nd decade 2024-2020 with the one obtained in the 1st decade 2007-2013, we may identify the following aspects:

- the growth of production for cereals by +53.82%, for wheat by +48.53%, for maize by +59.93, for leguminous grains by +157.21%, for oil seeds by +95.03%, for sunflower seeds by + 87.88% and for fruit production by +5.64%;
- a lower production for vegetables accounting for -4.14% and for potatoes by -21.26% (Table 2).

Table 2. Dynamics of vegetal production by main crops in the decade 2014-2020 versus the decade 2007-2013 (Tons)

Crop		2007-2013 1st decade	2014-2020 2nd decade	Differences 2nd decade - 1st decade	
				Absolute differences	% differences
Cereals	Mean	15,827,211	24,346,668	+8,519,457	153.82
	Total	110,790,477	170,426,676	+59,636,199	153.82
Wheat	Mean	5,852,214	8,692,353	+2,840,139	148.53
	Total	40,965,498	60,846,471	+19,880,973	148.53
Maize	Mean	8,242,047	13,182,184	+4,940,137	159.93
	Total	57,694,329	92,275,288	+34,580,957	159.93
Leguminous grains	Mean	60,983	156,860	+95,877	257.21
	Total	426,881	1,098,020	+671,139	257.21
Oil seeds	Mean	2,064,518	4,026,555	+1,962,039	195.03
	Total	14,451,626	28,185,885	+13,734,259	195.03
Sunflower seeds	Mean	1,343,921	2,524,981	+1,161,060	187.88
	Total	9,407,447	17,674,867	+8,267,420	187.88
Potatoes	Mean	3,497,245	2,753,777	- 743,468	78.74
	Total	24,480,715	19,276,439	-5,204,276	78.74
Vegetables	Mean	3,767,825	3,611,850	-155,975	95.86
	Total	26,374,775	25,282,950	-1,091,825	95.86
Fruits	Mean	1,273,721	1,388,410	+114,689	109.00
	Total	8,916,046	9,718,873	+802,827	109.00

Source: Own calculation based in the data from National Institute of Statistics.

Average production for the main agricultural crops

Yield performance is a result of many factors among which could be mentioned: geographical position of the farm, soil and climate conditions, farm size, technical endowment, technology applied, crop varieties and hybrids and their production potential, resistance to drought, diseases and pests, farm inputs in terms of seed quality, fertilizers and pesticides, farmers training level and his management skills and capacity and experience, and also the allotted subsidies by Government and the EU.

In Romania, after its access into the EU, the dynamics of yield for the main crops has performed as described below:

-*In case of cereals*, yield increased from 1,523 kg/ha in 2007 to 3,400 kg/ha in 2020 (+123.24%). The peak of average production was 5,999 kg/ha achieved in the year 2018 which was the most favourable agricultural year for cereals in Romania.

-*Wheat yield* increased from 1,541 kg/ha in 2007 to 2,966 kg in 2020, meaning by + 92.47%, but the peak of average production was 4,888 kg recorded in the year 2017. The worst years with droughts for wheat were 2007, 2009, 2012 and 2020.

-*Maize yield* went up from 1,526 kg/ha in 2007 to 3,977 kg in the year 2020, when it was by +160.61% higher. The peak of average production per surface unit accounted for 6,502 kg in the year 2019, the most favourable year for this crop. However, in the years 2007, 2012 and 2020, maize yield was deeply influenced by extreme meteorological phenomena, drought being on the top position.

- *Sunflower seeds yield* increased from 654 kg/ha in 2007, the lowest level in the analyzed interval to 1,858 kg/ha in the year 2020, which means by +184.09% more. The peak of yield was 3,041 kg per surface unit recorded in the year 2018. The unfavourable years for sunflower crop which diminished drastically the yield were 2007, 2012, 2015 and 2020.

-*Potatoes yield* increased from 13,663 kg/ha in 2007 to 15,843 kg/ha in 2020, meaning by +15.95% more. The unfavourable years for potatoes crop were 2007, 2010, 2012 and 2015.

-*Tomatoes yield* raised from 13,916 kg/ha in 2007 to 21,858 kg/ha in 2020, which means a surplus of +57.07%. The peak of the average production accounted for 21,858 kg/ha in the year 2020 and the lowest level for 13,761 kg was registered in the year 2012 (Fig. 6).

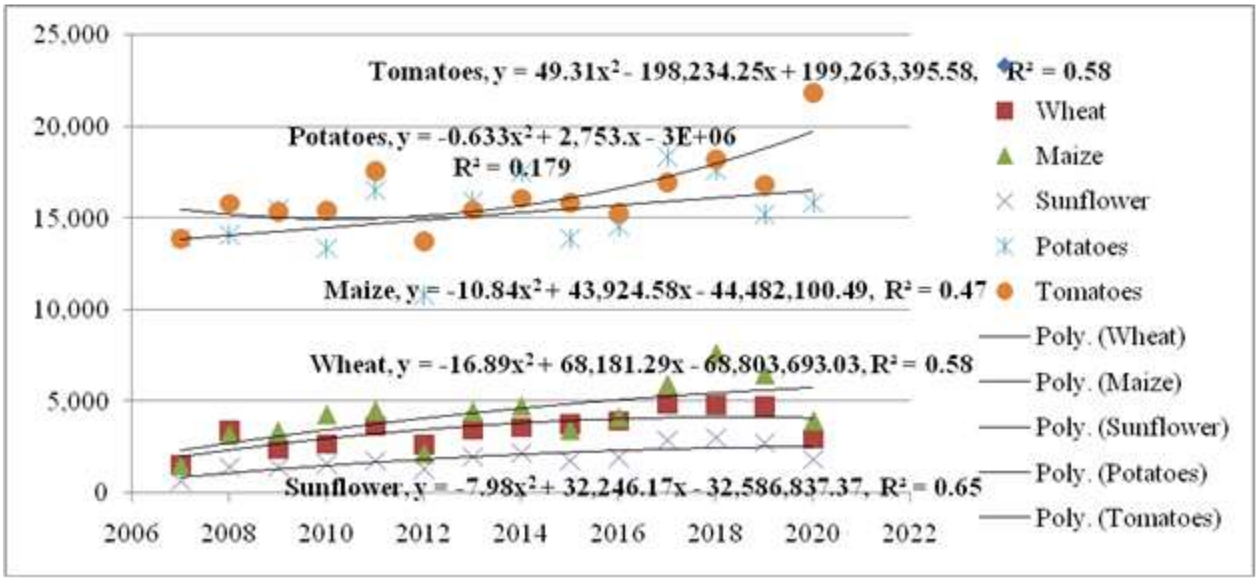

Fig. 6. Dynamics of the agricultural yield for wheat, maize, sunflower, potatoes and tomatoes in Romania in the period 2007-2020 (kg/ha)
Source: Own calculation and design based on the data from National Institute of Statistics.

Table 3. Yields by main crops and decades (kg/ha)

Crops	Average 2007-2013 1st decade	Average 2014-2020 2nd decade	Differences	
			Absolute differences	% differences
Cereals	3,011	4,519	+1,508	+150.08
Wheat	2,834	4,101	+1,267	+144.70
Maize	3,379	5,210	+1,831	+154.18
Sunflower	1,460	2,358	+898	+161.50
Potatoes	14,172	16,147	+1,875	+113.13
Tomatoes	15,345	17,315	+1,970	+112.83

Source: Own calculation based on the data from National Institute of Statistics.

Taking into account the average production performance in the 2nd decade 2014-2020 compared to yields level recorded in the 1st decade, we may notice important increases as follows: +50.08% for cereals grains, +44.7% for wheat, +54.18% for maize, +61.5% for sunflower seeds, +13.13% for potatoes and + 12.83% for tomatoes (Table 3).

CONCLUSIONS

In the period 2007-2020, the cultivated area increased +6.25%, accounting for 8,263,672 ha in 2020. In 2020, in the total cropped area, cereals have a share of 64.6%, oil plants 20.3%, vegetables 2.4%, leguminous plants 1.3% and 1% potatoes.

The cultivated area with cereals raised by +4.07% from 5,129,183 ha in 2007 to 5,338,067 in 2020.

Maize and wheat are cropped on 4,499,728 ha, accounting for 87.9% of the cultivated area with cereals in the year 2020.

Compared to the decade 2007-2013, in the decade 2014-2020, the cultivated area increased by +5.59%, by + 2.73% in cereals areas, by +2.8% in wheat area, by +2.98% in maize area, by +115.64% in the area with leguminous plants, by +24.42% in the area with oil plants, by +17.97% in sunflower area, but it decreased by -13.47% in the area with vegetables and also by -30.29% in the cultivated area with potatoes.

Cereals production increased by +132.29% accounting for 18,153,714 tons in 2020, of which maize 55.61% and wheat 35.2%.

Leguminous grains production also increased by +237.09% and reached 121,978 tons in 2020.

Oil seeds production raised by 208.51 % and accounted for 3,228,766 tons in 2020, of which 65.74% sunflower seeds.

Vegetable production recorded a lower growth of +11.75% so that in 2020 it accounted for 3,483,035 tons in 2020.

Potatoes registered a decline of 49.63% of production and reached 1,601,239 tons in 2020.

Fruit production had an ascending and accounted for 1,590,795 tons in 2020, meaning by +46.51% more than in 2007.

Compared to the 1st decade 2007-2013, in the 2nd decade 2024-2020 it was carried out a higher production by +53.82% in cereals, by +48.53% in wheat grains, by +59.93 in maize grains, by +157.21% in leguminous grains, by +95.03% in oil seeds, by + 87.88% in sunflower seeds and by +5.64% in fruit. However, production declined by -4.14% in vegetables and by -21.26% in potatoes.

Yield level increased in the last 20 years by +123.24% in cereals, reaching 3,400 kg/ha in 2020, by + 92.47% in case of wheat which performed 2,966 kg in 2020, by +160.61% in case of maize which achieved 3,977 kg/ha in 2020, by +184.09% in case of sunflower which reached 1,858 kg/ha in 2020, by +15.95% in potatoes which achieved 15,843 kg/ha in 2020, by +57.07% in tomatoes which accounted for to 21,858 kg/ha in 2020.

Taking into account the average production performance in the 2nd decade 2014-2020 compared to yields level recorded in the 1st decade, the surplus of yield was: +50.08% for cereals grains, +44.7% for wheat, +54.18% for maize, +61.5% for sunflower seeds, +13.13% for potatoes and +12.83% for tomatoes.

Therefore, as final conclusion, even though we did not discuss anything about the detailed implementation of the EU CAP reforms in Romania in its own strategy of agriculture development, at the end of this study we could conclude that along the whole period of time and mainly in the 2nd decade, that is 2014-2020 it was noticed a real progress regarding productions and yields of the analyzed groups of crops in the vegetal sector.

The only exceptions are:

- the decline by about 50% in potatoes production in 2020 versus 2007;
- in the 2nd decade 2024-2020 versus 2007-2013, it was registered a decrease by -4.14% in vegetables and by -21.26% in potatoes, which is justified by the decline in cultivated area.

The efforts made by farmers to obtain better results in their business have not been in vain and the financial support given by the EU and Romanian Government have been of much help to sustain the development of agriculture in general, and especially the vegetal sector.

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TOURIST ARRIVALS AND OVERNIGHT STAYS IN ROMANIA BY TOURIST DESTINATION IN THE YEARS 2020 AND 2021 OF COVID-19 PANDEMIC COMPARED TO 2019

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Abstract

The aim of the study was to analyze the dynamics of tourist flows in terms of tourist arrivals and overnight stays by tourist destination in Romania in the years 2020 and 2021 of the Covid-19 pandemic compared to the year 2019. Graphics and fixed and variable basis and structural indices were used to show the difference of the level of these two indicators and their distribution by each destination. The year 2019 was the best for Romania's tourism when over 13.37 million arrivals and over 30.08 million overnight stays were registered. In 2020, the arrivals were by 52.16% lower than in 2019, and the overnight stays smaller by 48.45%, showing that this year was the worst, as a part of units were closed or worked at a reduced capacity, recording a lower revenue and even failed. Romanians saved tourism, being the dominant category who rediscovered the beauty of their own country both in 2020 and in 2021 when the restrictions were cancelled or limited. In 2021, the number of arrivals accounted for over 9.37 million and the number of overnight stays for over 20.83 million. The hierarchy of the tourist destinations in Romania based on the level of these two indicators is: Bucharest, the capital and the main cities, other localities and tourism itineraries, seaside resorts, mountain resorts, spa resorts and the Danube Delta and Tulcea City. The recovery of was not yet at the level of 2019, despite that in 2021, tourism managers have made special efforts to improve and diversify their offers and better satisfy their guests. This dynamics gives a hope that in coming years tourism will return to the level of 2019 or even to exceed it.

Key words: *tourist arrivals overnight stays, dynamics, tourist destination, Covid-19 pandemic, Romania*

INTRODUCTION

"The physical space where the tourist spend at least one night" and benefits of different services and attractions" is the definition given to tourism destination by [39, 32].
The destinations for which the tourists leave home and travel could be represented by a country, a region, a city or town etc that they prefer to visit and spend their money assuring a revenue flow from tourism to that destination.
To better satisfy tourists, a tourist destination must be accessible by means of travel services, must offer accommodation and board services, various attractions and high quality services [7].
The loyalty of the tourists for a specific destination depends on the relationship existing between "the destination image and value and tourist satisfaction degree [4].
The recognition of the position of a country in the world tourism is given by the number of international tourist arrivals and also by the revenue coming from tourism [12, 40].
Romania is a tourist destination grace to its geographical position, mild climate, relief variety in a shape of an amphitheater: mountains, hills, plains, the Black Sea coast for a length of about 245 km with fine sand beaches, warm sea water and the necklace of well known seaside resorts beginning with its pearl Mamaia, the Danube Delta - the paradise of fishes and birds. The sceneries are beautiful, the natural resources are rich and of a large variety, culture, history and gastronomy are mysterious, unique and attractive stimulating curiosity and delighting the eyes of the visitors, improving their

knowledge through an opened door to the people civilization in this part of Europe.

The hospitality and quality of tourism services connected to price and tariffs contribute to visitors' satisfaction and increase their desire to return and recommend Romania as a charming destination.

Taking into account the life cycle of a tourist area, business management has to be permanently kept under control to maintain tourism destinations in the visitors' preferences [1, 34, 38].

Romania has become more and more known for its special attractions like: Transilvanian medieval towns, castles and fortresses, Bran Castle, the Royal Peles Castle in Sinaia, the Prahova Valley, the painted monasteries from the Northern-Eastern part of the country, Sarmisegetusa Regia, Sighisoara - the only medieval inhabited city in Europe, the Danube Delta - the most beautiful natural reservation of this type in Europe, the charming cities like Bucharest, the capital, Brasov, Sibiu, Cluj-Napoca, Timisoara, Transfagarasan and Transalpina roads crossing the Southern Carpathians [3, 12], traditional villages, arts, crafts, local architectural style, traditions and customs, folklore, events and festivals, delicious and tasty food and flavoured wines [33].

Wild Carpathia serials which promote the beauty of Romania by the well known journalist Charlie Ottley and the visits of King Charles III mainly in Transilvania [41] have increased the fame of Romania as a paradise garden where nature is preserved and offer a peaceful and healthy life to its inhabitants.

Tourism is sustained by its human resources working in the field in accommodation, restaurants and catering, transportation, entertainment and management and improving their attitude, behaviour, knowledge and skills to offer best conditions and higher and higher quality services to their visitors, and to ensure a sustainable and profitable business and protect environment [2, 10].

Tourism stakeholders make high efforts to assure the balance between offer and demand, by increasing the number and comfort in the accommodation units and the number of places [15, 16].

Tourism is among the most dynamic branches of the economy contributing to GDP and economic growth [20, 22].

Also, tourism is a field were efficiency could be high, as in the year 2019, when it attained over Lei 5 Billion turnover, even though in the years of the Covid-19 pandemic, 2020 and 2021, it decreased below that level [14].

The Covid-19 pandemic has disturbed the ascending trend of tourism all over the world [5], and in Romania as well, regarding tourist flows [18, 25], tourism seasonality in the seaside and mountain resorts [19], tourism offer and demand [31], and concentration of tourist arrivals in tourist and agro-tourist guesthouses [29], and stimulated agro-tourism [36], and ecotourism [35].

However, the tourist destination image has been the reason why tourists decided to travel during the risky conditions in the Covid-19 pandemic [37].

The main tourist destinations in Romania are classified into balneary resorts, seashore resorts without Constanta City, mountain resorts, Bucharest and other municipalities, the Danube Delta and Tulcea City and other localities and tours [8].

In this context, the purpose of the paper was to comparatively analyze the dynamics of tourist arrivals and overnight stays in Romania by tourist destination in the years: 2019, the top year in Romania's tourism, in the year 2020, the 1st year of the pandemic, which was the worst year which deeply affected this branch of the economy, and 2021, when tourism started its recovery.

MATERIALS AND METHODS

The study is based on the data provided by National Institute of Statistics [8] regarding the number of tourist arrivals an overnight stays both at the country level and also by destination: balneary resorts, seashore resorts without Constanta City, mountain resorts, Bucharest and other municipalities, the Danube Delta and Tulcea City and other localities and tourism itineraries.

The dynamics was represented by graphics to enable the readers to better understand the evolution of the two indicators in three years:

2019, as a reference year when Romania recorded the highest numbers of tourist arrivals and overnight stays, 2020, when tourism was very much affected by the pandemic and the imposed restrictions till June and 2021, when the measures of restrictions were much earlier relaxed starting from the month of March.

In the calculation, the fixed and variable basis index was used to show in what measure the level of each indicator changed from a year to another.

Also, the structural index was used for reflecting the share of tourist arrivals, and, respectively, the weight of overnight stays in their total number by destination.

Suitable comments have accompanied the results and finally, the conclusions emphasized the main ideas resulting from this research.

RESULTS AND DISCUSSIONS

Tourist arrivals

Tourism arrivals had a large variation from a year to another in the studied short interval and proved how the Covid-19 pandemic decreased the number of arrivals for the peak performance of 13,374,943 carried out in the year 2019, to the low level of 6,398,642 arrivals in 2020, meaning by 52.16% less and then, in 2021, in the 2nd year of the pandemic how tourism has started to recover and tourist arrivals raised to 9,370,232 being by 46.44% higher than in 2020 by 30% lower than in 2019 (Fig. 1).

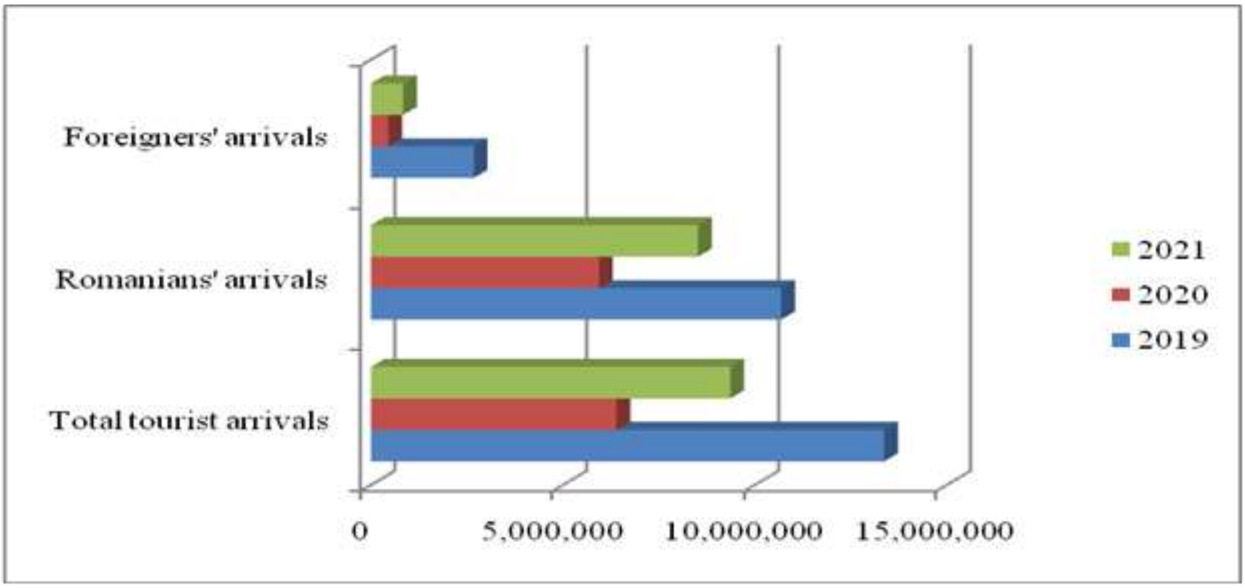

Fig. 1. Dynamics of tourist arrivals in Romania, 2019-2021 (Number)
Source: Own design based on the data from NIS [8].

The share of foreign arrivals in the total number is in general small as Romanians are dominant. However, if in 2019, the arrivals of the foreign visitors reached 20%, in 2019 it declined to 7% and in 2021 it climbed to 9%, but it did not yet achieve the peak from the best year for Romania's tourism. Travels abroad were really a critical aspect in the two years of pandemic due to the different restriction measures imposed by each country authorities (Fig. 2). The decline in the number of arrivals was determined by the type, duration and severity of the restrictions imposed by authorities to stop the spread of the corona virus, the people's fear to travel and not to get the virus, variation of income per family in relation to job situation (employed, unemployed, hired, home work etc), vacation duration and other conditions).

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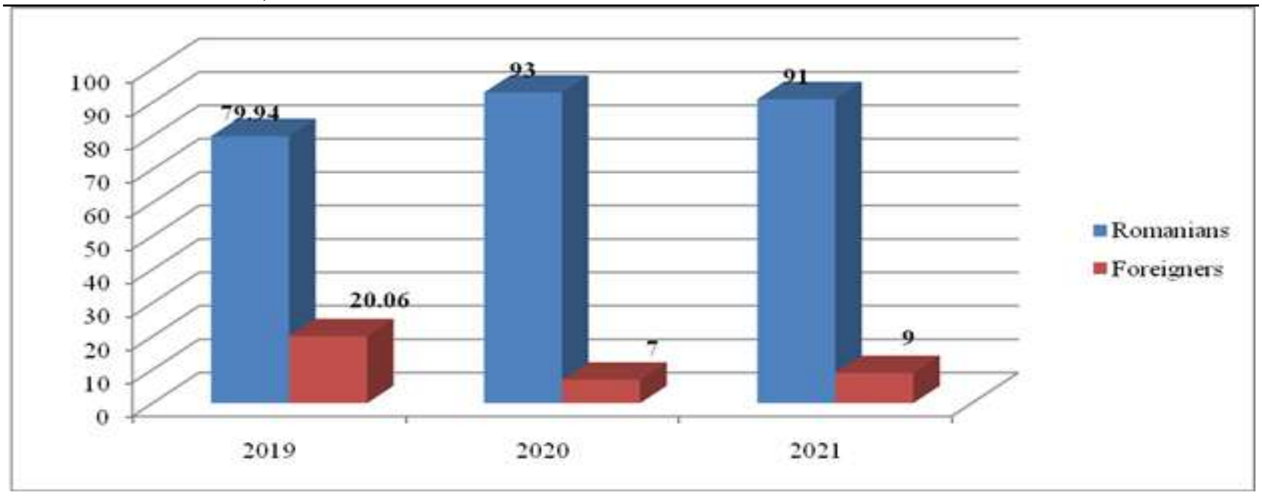

Fig. 2. Share of Romanians and foreigners in total arrivals in Romania, 2019-2021 (%).
Source: Own calculation and design based on NIS data [8].

Foreigners have many reasons and interests to visit Romania such as: to visit their relatives, to meet their friends, to learn about the capital and other cities, cultural and historical places, gastronomy, for treatment, leisure and entertainment, looking for a job opportunity, to enjoy admiring the beauty of the landscapes, wild life etc.

The main tourist destinations in Romania are classified into: balneary resorts, seashore resorts, mountain resorts, the Danube Delta and Tulcea City, Bucharest and the main cities residence of the counties, and other localities and tourism routes.

The dispersion of tourist arrivals by destinations in Romania is presented in Fig. 3.

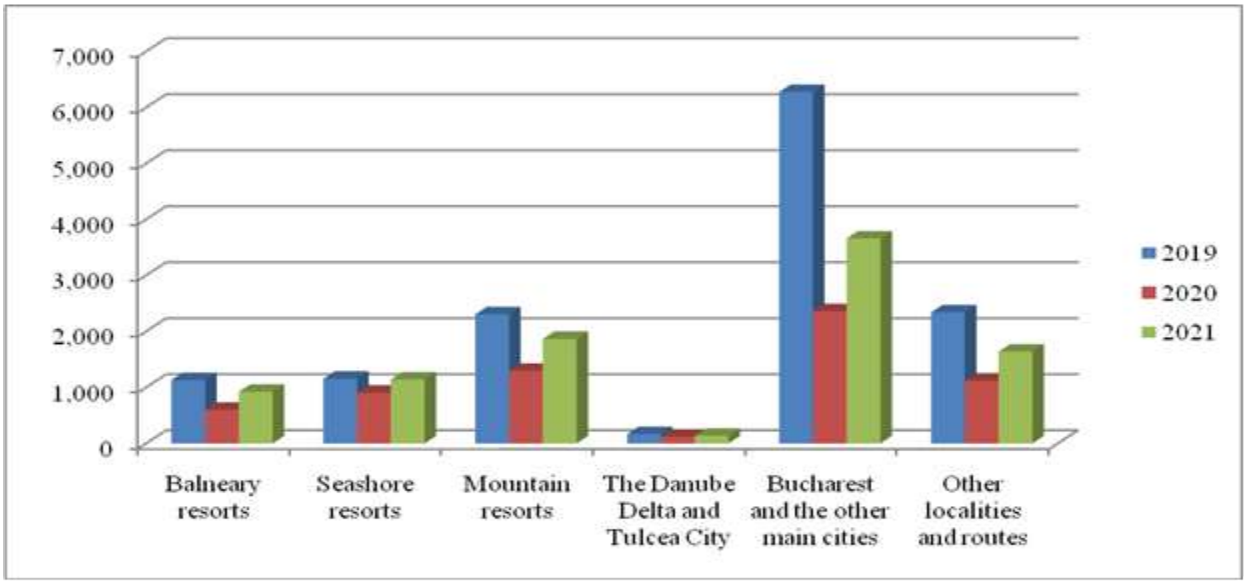

Fig. 3. The number of tourist arrivals by destination in Romania, 2019-2021 (Thousands)
Source: Own design based on the data from NIS[8].

From Fig. 3, it is easily to notice that the highest number of tourist arrivals in registered in Bucharest, the capital of Romania, and also in other cities like: Cluj-Napoca, Brasov, Sibiu, Timisoara, Iasi.

Among these cities, Cluj-Napoca and Sibiu look to be more and more visited especially by foreigners on the occasion of various festivals and events [21].

In 2019, it was the peak of visitors in the cities accounting for 6,276 thousands. In the 1st year of the covid-19 pandemic, this destination remained on the top position with 2,359 thousands visitors, but this number was by 62.42% smaller than in 2019. In 2021, when tourism activity restarted earlier and in relatively normal conditions, the arrivals in Bucharest and other municipalities went up to

3,661 thousands, being by 55.19% higher than in 2020 and by 41.67% lower than in 2019.

The tourists interest to Romania's destinations in their decreasing order established based on the number of arrivals in the following one: Bucharest and the other municipalities, mountain resorts, other localities and tourism itineraries, seashore resorts, balneary resorts and the Danube Delta and Tulcea City.

The mountain resorts come on the 2nd position and are of a high attractiveness along the whole year, but especially in the winter season when the snow layer covers the mountains and offer opportunities for practicing winter sports mainly for ski lovers in the well know resorts like: Poiana Brasov, in Predeal and Sinaia and other localities in the Prahova Valley, Balea Lake, Vidra/Voineasa, Paltinis- Sibiu, Ranca-Gorj, Straja-Hunedoara, Madarasi-Harghita, Olimpica-Borsa etc.

Poiana Brasov is one of the pearls of the mountain resorts of Romania with wonderful ski slopes endowed with modern equipments, like of the other ski resorts, but in addition it is situate at 14 km from the City of Brasov with its well known cultural objectives [9].

More than this, in the Prahova Valley it is also a necklace of well known mountain resorts, Sinaia being the pearl of this valley, being followed by Predeal, Azuga, Busteni [10].

Mountain areas are visited along the year in many seasons, the seasonality reflecting a top of tourists in summer and also in winter season. In this periods of high number of tourists, the accommodation units are full and sometimes it could appear a difference between the need of rooms and beds and the offer [28].

In 2019, the mountain resorts were visited by over 2,305 thousand tourists, but in 2020, the 1st year of the pandemic the arrivals declined to 1,295 thousand, being by 44% smaller than in the previous year. In 2021, a number of over 1,866 thousand arrivals were registered in the mountain resorts.

On the 3rd position come the seashore resorts, which are a real necklace of beautiful resorts like Mamaia, Eforie North and South, Costinesti, Olimp, Venus, Saturn, Mangalia and Vama Veche with fine sand beaches, warm and pleasant Black Sea water in summer time, elegant hotels and villas, divers restaurants with large range of menus, many of them specialized in fish and sea fruit dishes, and of lot of opportunities for entertainment during late in the night, tariffs being accessible for all the pockets [26].

The seashore resorts came on the 1nd position based on the number of visitors and preserved their position from a year to another. In 2019, over 1,154 thousand tourists spent their vacations on the seashore of Romania, in 2020 their number of a little higher than 905 thousands, meaning by 22% less than in the previous year. But, in 2021, the seashore resorts received 1,142 tourist arrivals, by 26% more than in 2020 and by only 1.1 % less than in 2019. Therefore, we may conclude that 2021 was really a mouth of "fresh air" for the seashore tourism.

However, in summer season, seaside resorts are full of visitors and sometimes it is an unbalance between tourist demand and offer, a few visitors looking for accommodation in private houses [23].

Balneary resorts are very attractive during the year, being suitable in general to elder people who have health problems and needs treatments and various procedures, but also young tourist who are keen to keep their body in good condition. And the spa units make huge efforts to diversify their services and the service quality for satisfying better their clients and increase their income [6].

In the year 2019, over 1,133 thousand tourists benefited of spa services, but in 2020 their number decreased to 601 thousands, meaning by 47% less. In 2021, their number increased reaching 924 thousands, being by 53.7% higher than in 2020 and by 18.5% smaller than in 2018.

However, even in the spa resorts, it is not always a correlation between the demand and offer of accommodation services, and some people apply for private houses and tourist guesthouses instead of staying in hotels [27].

The Danube Delta and Tulcea City are a special attraction mainly for people interested to the Danube Delta natural reservation which is very rich in thousands of birds and fish species, and also for the people who like fishing and fish meals.

In 2019, about 166 thousand tourists visited the Danube Delta, but in 2020, their number decreased to 118 thousands, being by 29 % lower than in the previous year. In 2021, the Danube Delta and Tulcea were visited by 137 thousand tourists, meaning 16% more than in 2020 and by 18% less than in 2019.

Taking into account the number of foreign tourist arrivals and its dispersion by destination, it was calculated the share of the arrivals of foreign visitors in total arrivals of foreigners and the results are presented in Fig. 4.

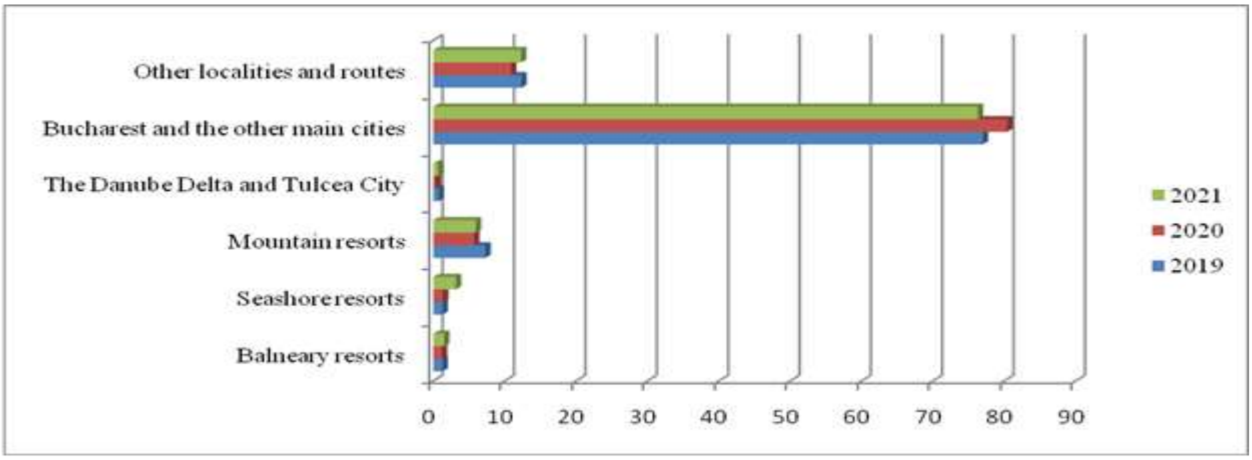

Fig. 4. The share of the arrivals of foreign visitors by destination in total arrivals of foreigners in Romania, 2019-2021 (%)
Source: Own calculation and design based on the data from NIS[8].

The results showed in Fig. 4 inform us that that 76% in 2019, 80.42% in 2020 and 76.31% of the number of tourist visiting Bucharest and the main municipalities were of foreign origin. Foreign visitors accounted in the other destinations for the following shares: 12% in other localities and routes, 5-6% in the mountain resorts, 1-2% in the seashore resorts, and 1.2-1.5% in balneary resorts. In the Danube Delta, in 2019, foreigners represented 0.76% in total number of visitors, but in 2020, it was only 0.33% and in 2021 0.71 % Figure 5 presents the share of foreign tourist arrivals in total arrivals of tourists by destination (%). From Fig. 5 we may notice that foreigners have an important share in the number of tourists who visit the capital and the main municipalities. Its level was 32.93% in the year 2019, 15.47% in 2020 and then 17.57% in 2021. In other localities and itineraries, foreign tourists represented 14.18% in 2019, by only 4.42% in 2020 and 6.33% in 2021. In the mountain resorts, 8.5% of visitors were foreigners in 2019, then in 2020 their share declined to 2% and in 2021 it was only 2.68%.

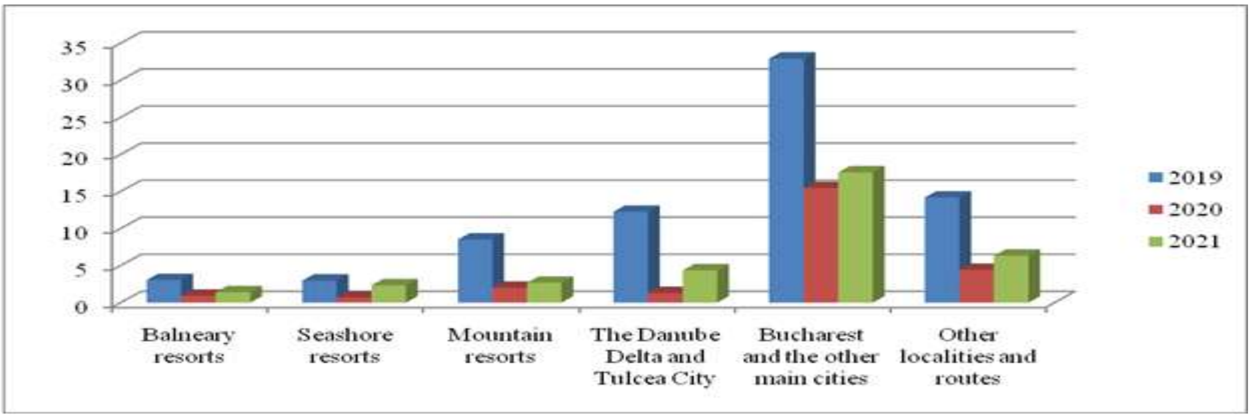

Fig. 5. The share of foreign tourists arrivals in total arrivals of visitors by destination (%)
Source: Own calculation and design based on the data from NIS.

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In the seashore resorts, foreigners represented 2.97 % in 2019, 0.68% in 2020 and then 2.33 % in 2021, while in balneary tourism their weight varied between 3% in 2019 and 1.4 % in 2021, but in the 1st year of the pandemic declined to 0.92%.

Tourist overnight stays

In Romania, the number of overnight stays reached the top level in the year 2021, where they accounted for 30,086,091, but during the year 2020, the 1st year of the pandemic, they decreased by 48.45%, accounting for only 14,579,140. In 2021, the situation started to recover in relation to the increased number of arrivals. In this year, the total number of overnight stays was 20,835,814, by 42.91% higher than in 2020, but still by 30.75% lower than in the year 2019 (Fig. 6).

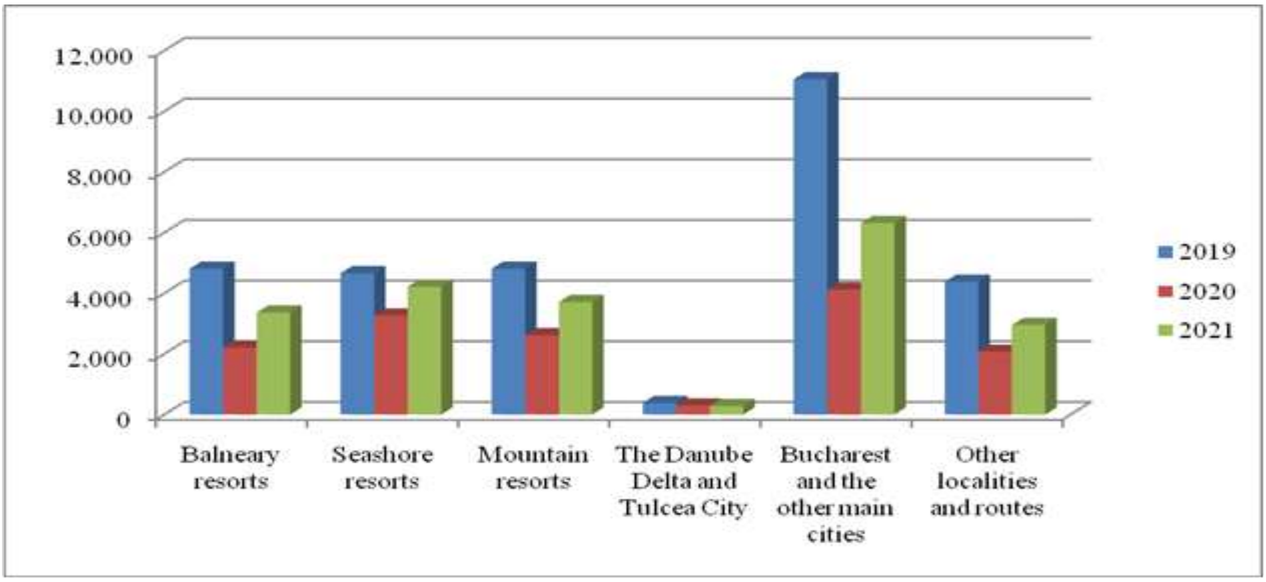

Fig. 6. The number of tourists' overnight stays by destination in Romania, 2019-2021 (Thousands)
Source: Own design based on the data from NIS [8].

The overnight stays belonging to the Romanians were dominant with a share of 82.41% in 2019, 93.15% in 2020 and 91.20% in 2021. Therefore, they followed the evolution of the number of tourists' arrivals.

The share of Romanians by tourist destination ranged as follows:

-In the year 2019: 63.58% in Bucharest and other municipalities, 86.57% in other localities and tourism itineraries, 87.78% in the Danube Delta and Tulcea, 91.92% in the mountain resorts, 97.35% in the seaside resorts and 97.67% in the balneary resorts.

-In the year 2020, Romanians had the highest share in all the destinations varying from 80.95% in Bucharest and main cities and 99.37% in the seaside resorts, the last destination being the most desired by tourists in the first year of the pandemic when the restrictions were relaxed starting from the month of June.

-In the year, 2021, the weight of the overnight stays in the capital and the main cities accounted for 77.8%, being smaller than in 2020 by 3.15 percentage points, but by 14.22 higher than in 2019. The highest share of overnight stays accounting for 98.81% was recorded also by the seaside resorts which continue to be on a top position as a summer destination.

Regarding the preference of tourists for accommodation, it was noticed a special attention given to hotels [30] where it was possible to assure a safe stay and also to tourist and agro-tourist guesthouses, as suitable for spending a safe vacation for a family of a group of friends [17, 24].

CONCLUSIONS

The year 2019 was the best for Romania's tourism when the number of tourist arrivals and overnight stays reached the top level in the last decade.

In this year, a peak of over 13.37 million arrivals and over 30.08 million overnight stays in Romania were registered.

The year 2020 was the worst year for Romania's tourism as many units from tourism sector were obliged to close or to work at a reduced capacity, hiring a part of the personnel and registering a low revenue and even failed.

Romanians saved Romanian tourism, being the dominant category who rediscovered the beauty of their own country in the 1st year of the covid-19 pandemic, where the restrictions were cancelled or limited.

In 2020, the number of arrivals was by 52.16% lower than in 2019, and the overnight stays were smaller by 48.45%.

In 2021, it was noticed a recover in tourism due to the relaxed restrictions starting from March compared to June in 2020. The number of arrivals accounted for over 9.37 million and the number of overnight stays for over 20.83 million.

The recovery of was not yet at the level of the year 2019, despite that in 2021, tourism managers had more time to prepare their offers and receive guests and also to people to plan their vacations and excursions in a longer period of the year.

Based on the obtained results for the number of arrivals and overnight stays by tourism destination, the following classification was established: Bucharest, the capital and the main cities, other localities and tourism itineraries, seaside resorts, mountain resorts, spa resorts and the Danube Delta and Tulcea City.

The interest of foreign visitors to discover Romania is increasing due to the intensified promotion on media (internet, youtube, facebook, twitter, instagram, blogs etc), and also grace to its beautiful landscapes, cultural-historical places, large variety of tourism forms (mountain, seashore, spa and medical, cultural, historical, musical, religious, gastronomic, sport, adventure, rural, ecotourism, fishing, wild etc).

Tourism is one of the main reasons why the people leave home and spend vacations to charge their "batteries" by leisure and entertainment, to enrich their knowledge and cultural horizon, meeting new people and civilizations or enjoying life in its various splendors.

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PRODUCTIVITY OF SOWS, GROWTH OF PIGLETS AND FATTENING QUALITIES OF PIGS AT DIFFERENT DURATIONS OF THE SUCKLING PERIOD

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Abstract

The article describes the results of studying the interdependence between indicators of reproductive qualities of sows, indicators of growth of pigs, during fattening. In addition, the results of the experiment determined the dependence of the level of fatness of piglets on the term of their suckling period. It was proven that when the duration of lactation is reduced by 7 days, their preservation improves, due to which their number in the nest before weaning increases. At the same time, in the case of premature weaning of piglets, no difference was found with sows with the traditional duration of the suckling period in terms of the total number of piglets born, multifertility, high fertility and litter weight of piglets at birth. While the shorter period of lactation of sows led to a decrease in the growth intensity of piglets in the post-weaning period and to a decrease in the absolute growth and individual weight of piglets and the weight of their nests at weaning. When piglets were weaned earlier from sows, they exhibited lower growth intensity during rearing, consumed relatively less feed, and had poorer payment for feed in the form of gain and consequently lower weight at the end of the rearing period compared to counterparts with a traditional duration of the suckling period. At the same time, no significant difference was found between piglets of the control groups in the parameters of piglet survival and absolute growth. The fattening qualities of pigs did not depend on the length of their suckling period. A 7-day reduction in the lactation period contributed to a reduction in the duration of the reproductive cycle from 150 to 143 days. This made it possible to obtain 0.12 more farrowings from each sow per year and to use each pen for farrowing sows 25.3% more often. What made it possible due to the intensification of the use of farrowing space, the intensification of the use of the sow and the reduction of the feed cost of her maintenance to obtain additional cost savings per sow during the year.

Key words: *sow, piglet, suckling period, rearing, fattening, cost savings*

INTRODUCTION

The importance of all the processes of the suckling period in piglets, during which the foundations of the future development of the pigs' organism are laid, is clearly very high. The technology of keeping suckling piglets should form a healthy and adapted herd of pigs for intensive rearing at the stages of rearing and fattening. One of the most important elements in the technological process of pork production is the weaning period of piglets [29]. By managing the duration of the stay of new born piglets near the sow, pork producers influence both the litter itself and the sow at the farrowing stage, as well as the entire course of subsequent technological periods of the production cycle of the pig industry complex. This allows for the application of various management options in the process of raising pigs in order to obtain maximum profit [16].

World practice regarding the management of piglet holding periods in the group of suckling sows includes both the use of a shorter period of 14-21 days and longer periods of 28 days and more indifferent countries [23]. The trend of changes in the length of the suckling period in the previous decade tended to decrease it first from 60 to 35 days [10, 13], and then to 28 and finally to 21 days before weaning. Reducing or increasing the length of time piglets stay with the sow has various consequences. The short duration of lactation reduces the average feed intake before weaning, which is why there is a trend in the US pig industry to increase the length of the suckling period [14] to improve the growth performance of piglets at rearing and fattening. In addition, it is prohibited in the EU countries to wean piglets from the sow under the age of 28 days [6]. Among the positive consequences of shortening the suckling period directly for piglets is the early preparation of piglets for the consumption of vegetable feed due to the adaptation and development of their digestive system and the increase in the intensity of their growth [17, 19]. At the same time, a shorter piglets stay in the farrowing group has a positive effect on sows, namely: the number of piglets born to a sow during the year increases [11], the number of udder diseases of the sow decreases [25], the intensity of use of the sow increases, the exhaustion of the sow's body decreases and its mass did not decrease [31]. As a general positive effect of shortening the duration of the suckling period, there was an increase in the efficiency of the use of the farm's production premises area. The consequence of more efficient use of the piggery working space was the increase in the overall profitability of the pigs enterprise's production [37].

In addition to the positive impact of a shortened suckling period, scientists also highlight some of its negative consequences for pork production. In particular, it was established that piglets that were weaned earlier were under severe stress [9, 36], and as a result, for sometime during rearing, they refused to consume feed, slowed down growth [4] and were pro neto diarrhea [7]. In addition, the initial weight of piglets weaned earlier (3 weeks) was lower compared to counterparts weaned at the age of 4 weeks, which subsequently led to lower growth intensity during rearing. Greater weight of piglets at weaning guarantees effective adaptation after transferring them to rearing [24, 38]. According to published data, piglets that were kept in the farrowing group 28 days, during this additional week, gained more strength, energy and acquired a higher physiological adaptation of the body for better adaptation and growth at the stage of rearing [12]. And the piglets with a shortened suckling period, which at weaning were less prepared for new housing conditions, feeding conditions and hierarchical struggle, had a lower ability to adapt and, as a result, during the first week of rearing showed a deterioration in growth [35] and higher morbidity [5, 30]. Also, according to some scientists, sows from which piglets were weaned at the age of 3 weeks, due to more intensive use of their body, were earlier eliminated from the herd, which required the availability of additional resources of repair young [3, 15]. It should be taken into account that when piglets are weaned too early, the involution of the sow's reproductive system is delayed, and as a result, the length of the service period increases [34].

In general, scientists claim that increasing the duration of the suckling period up to 4 weeks is a method of increasing the productivity of piglets both before weaning [2] and after weaning in rearing [33]. However, a number of scientists hold the opposite opinion [18, 20, 28] that shortening the suckling period to 3 weeks will lead to improved reproductive characteristics of sows and increase the intensity of their growth piglets.

Considering that the term of weaning piglets from the sow has a fundamental impact on both the efficiency of rearing and the efficiency of fattening and the quality of pig carcasses, and most scientists show the opposite vision of approaches to its application, the study of this is sure remains relevant.

The aim of our work was to establish the influence of the duration of the suckling period of piglets on the reproductive qualities of sows, the intensity of growth of pigs during rearing and their fattening qualities.

MATERIALS AND METHODS

In order to carry out research on the basis of LLC "NVP "Globinsky Pig Complex", Poltava region, Ukraine by the method of pairs of analogs, two groups of sows were formed, which came from Great White sows and boars of the Landrace breed of English selection (genetic company PIC), which were inseminated with boars of the synthetic line PIC 337. Each group included 60 sows identical in age, weight and fatness (Table 1).

Table 1. Scheme of the experiment on the study of the dependence of the reproductive and fattening qualities of pigs for different durations of the suckling period

Indicator	**Group I**	**Group II**
Breed combinations of sows	♀LW×♂L	
Genotype of boars	PIC-337	
The duration of the sucking period	28 days	21 days
Number of sows, heads	60	60
Number of piglets in rearing, heads	140	140
Number of fattening pigs, heads	110	110

Source: own calculations.

In 3-5 days, the animals of both groups were transferred to the farrowing room, where they were kept in individual pens with fixation.

Feeding of sows was carried out with dry complete feed for suckling sows. Feeding was ad libitum using the Sov Max feed do sing system from Hog Slat (USA). Feeding of piglets started from the $seven^{th}$ day of their life with granular starter feed. All veterinary and technological procedures throughout the experiment were conducted out according to the same protocol for both experimental groups.

During the weaning period, the total number of piglets at birth, multiple fertility, weight at birth, weight of the piglets nest at birth, survival of piglets until weaning, individual piglets live weight and weight of the piglets nest at weaning were studied. For identification, a clip with an individual number for the control group was put on the right ear of the piglets on the 3rd day after birth, and green for the piglets of the experimental group. When the piglets were weaned and weighed individually, an additional 140 piglets from 10 sows with average productivity from both experimental groups were given labels of the same color and with the same numbers.

Weaning of piglets of the experimental group was carried out on 21 day of the third week of lactation with an average age of piglets of 21.3 days. After that, the piglets were transferred to rearing, where they were kept in pens on a completely slotted floor measuring 18 m^2, including 55 heads in each.

Feeding piglets during this period was carried out with liquid full-ration kibbles using the Schauer feed kitchen (Switzerland) in the ratio of 2.7 liters of water per 1 kg of feed. Feed was supplied to the feeder 12 times a day. Feed accounting in each of the pens was carried out automatically using the feed kitchen management program.

All growing piglets were fed full-rational balanced compound feed of their own production, according to the scheme adopted in the farm, from the 7^{th} to the 41^{st} day, pre-starter compound feed and from the 42^{nd} day to the 77^{th} day, starter feed.

After 7 days, animals of the control group, whose age at the time of weaning was 28.3 days, were transferred to the same rearing section. Piglets of both experimental groups were kept in this section until they reached the age of 77 days. Thus, the duration of rearing piglets of the control group was traditionally 49 days, and the experimental group was 56 days. In growing farms, the growth intensity of piglets was studied according to such indicators as absolute, average daily and relative live weight gains. The preservation of their piglets was also investigated. Based on the data on the amount of feed fed in each pens and the weight of the piglets when they were placed and transferred to fattening and based on the number of feeding days of the piglets in each pen, daily feed consumption and their costs per kilogram of growth were calculated. At the age of 77 days, at the end of rearing, the piglets of both experimental groups were transferred to the fattening pig complex after individual weighing. For fattening, they were kept 50 heads in identical adjacent pens on a completely slotted floor with a size of 4.1 by 10.0 m.

The pigs of the experimental groups were fed with liquid feeding, using Weda equipment (Austria). Liquid feed in the ratio of 2.8 kg of water per 1 kg of dry feed was delivered to the feeders in equal portions 12 times a day. Data from the feed kitchen management program were used to record the eaten feed.

Upon completion of fattening, the animals of both experimental groups were individually weighed, and, the fattening qualities of the experimental animals were calculated according to generally accepted methods. The age of reaching 100 kg live weight, absolute, average daily and relative growth, average daily feed consumption and its consumption per 1 kg of growth were calculated.

A comprehensive, multifaceted assessment of the maternal qualities of sows was determined using the evaluation index of reproductive qualities (I) [22]:

$$I = B + 2W + 35G \text{......................} (1)$$

where:

B–number of piglets at birth, heads;

W–number of weaned piglets, heads;

G–average daily growth of piglets before weaning, kg.

The selection index of reproductive qualities of sows (SIRQS) was used to study the breeding value [32]:

$$(SIRQS) = 6X_1 + 9.34\left(\frac{X_2}{X_3}\right) \text{........} (2)$$

where:

SIRQS is the selection index of reproductive qualities of sows;

X_1–multifertility, heads;

X_2–weight of the piglet nest at weaning, kg;

X_3–duration of weaning period, days;

6 and *9.34* are clarifying coefficients.

According to the results of the study, the index of fattening qualities was calculated [1]:

$$I = (A * A) : (B * C) \text{......................} (3)$$

where:

A - total weight gain, kg;

B - duration of the fattening period, days;

C - the amount of feed spent on gaining 1 kg of weight, kg.

The results of the experiment were calculated in the Microsoft Office Excel environment. The statistical reliability of the difference in indicators was recognized for the significance levels $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$.

RESULTS AND DISCUSSIONS

As shown in Table 2, no statistically valid differences in the indicators of the number of piglets born alive and multifertility were observed between sows at different times of the suckling period in the experiment. On the contrary, the weight of piglets at birth was 1.7% higher in sows with a traditional lactation period than in sows with a lactation period shorter by seven days.

There was also no significant difference in litter weight of piglets at birth between sows of group I and group II. At the same time, a 1.7% higher survival rate of piglets was observed in the sows of the experimental group ($p<0.05$). This resulted in a higher number of piglets at weaning. With a shortened duration of lactation, it was 0.3 heads or 2.7% ($p<0.05$) higher compared to analogues with a traditional duration of lactation.

Considering the longer time the piglets stayed with the sows and the greater amount of milk they received, the piglets with the traditional lactation period had an average daily gain 32.3 g or 14.5% ($p<0.001$) higher than the piglets that had a lactation period seven days shorter.

This factor and the lower number of days in the suckling period also resulted in a significantly lower absolute gain of the animals at early weaning by 2.2 kg or 35.8% ($p<0.001$).

Also, piglets that were weaned later differed from their counterparts by 29.6% (2.3 kg) ($p<0.001$) lower live weight of one head and 27.7% (26.0 kg) ($p<0.001$) lower weight of the nest of piglets at the time of weaning.

Table 2. Reproductive indicators of sows and growth dynamics of their piglets (n = 60)

Indicator	Group I	Group II
The number of piglets were born, heads	15.4±0.09	15.5±0.08
Multifertility, heads	14.4±0.08	14.5±0.08
Nest weight of piglets at birth, kg	19.9±0.11	19.7±0.10
Piglet weight at birth, kg	1.38±0.03	1.36±0.02
Number of piglets at weaning, heads	12.3±0.06	12.6±0.05***
Preservation of piglets, %	85.5±0.33	87.2±0.29***
Weight of weaned piglet, kg	7.6±0.11***	5.4±0.09
Weight of the nest of piglets at weaning, kg	93.9±1.54***	67.9±0.96
Absolute growth, kg	6.3±0.09***	4.0±0.07
Average daily increase, g	223.0±0.27***	191.5±0.23
Relative growth, %	141.3±1.13***	119.70±1.06
Index of reproductive qualities (I), points	46.5	46.1
Selection index of reproductive qualities of sows(SIRQS), points	114.2	113.4

*** – $p<0.001$
Source: own calculations.

Evaluation of the results showed the relative growth in piglets weaned at the age of 28 days was by 21.6% ($p<0.001$) higher than in their counter parts from the experimental group. This pattern is explained by the 7-day longer stay of piglets of the control group under sows and, accordingly, longer consumption of mother's milk.

But regardless of the difference in the length of the suckling period, the comprehensive indicators of reproductive capacity calculated using the selection index of reproductive qualities (SIRQS) and the evaluation index of reproductive qualities (I), no significant difference between sows of the control and experimental groups was found. The difference between the animals of these groups according to the index (I) was only 0.9%, while according to the index (SIRQS) the difference was only 0.7%.

Thus, it was found that when the duration of lactation was shortened to 7 days, no difference was observed between the sows in the I and II groups in terms of total number of piglets born, multiple fertility, piglet weight at birth, and litter weight of piglets at birth. In contrast, during early weaning of piglets, their maintenance improved, increasing their number in the nest before weaning. The shorter duration of the suckling period resulted in a decrease in the growth intensity of the piglets during the suckling period and a decrease in the absolute growth and individual weight of the piglets and in the weight of their nests at weaning.

The process of weaning piglets and their rearing is a very important stage of rearing, where they are exposed to a large number of stressful factors, such as the weaning process itself, the formation of new hierarchical relationships in the group, a change of location, etc.

These questions are especially relevant for prematurely weaned piglets. Therefore, we investigated the intensity of growth and the payment of feed by increments of piglets weaned from sows with different durations of lactation during their rearing for different durations.

As shown in Table 3, despite the extension of the rearing period by seven days, the weight of piglets at early weaning at the end of this period was 2.2 kg or 7.14% ($p<0.01$) lower than in animals with traditional duration of the suckling period.

In our opinion, this is due to the lower growth intensity of the animals in the II group during the growing period. Thus, the average daily growth of piglets in II group was 63.0 g or 133.25% lower than in the I group ($p<0.01$). The relative growth rates of the animals in this group were 8.6% lower.

At the same time, the absolute gains of the animals of both groups were almost equal due to the longer duration of the growing period. The preservation of piglets in both groups was practically equal, despite the different duration of the rearing period itself.

Piglets that were weaned early from sows consumed 7.4% less feed during rearing, but due to lower growth intensity during the rearing period, they showed 0.11 kg (6.75%) worse feed payment in increments.

Table 3. Growth, preservation and payment of feed by increments of young pigs during the traditional and shortened suckling period (n=110)

Indicator	Group I	Group II
Average live weight at the beginning of rearing, kg	7.5±0.05	5.5±0.17
Average weight at the end of rearing, kg	30.8±0.85	28.6±1.35**
Preservation of piglets, %	98.2	97.9
Duration of rearing, days	49	56
Absolute growth, kg	23.3±0.88	23.1±1.18
Average daily increase, g	476±6.2	413±10.2**
Relative growth, %	122.0	113.4
Feed conversion, kg	1.63	1.74
Feed consumption per head, kg	0.78	0.72

** – $p < 0.01$
Source: own calculations.

Thus, piglets with earlier weaning from sows and reared piglets had a lower growth intensity, relatively consumed less feed and had a worse pay for feed in increments and, as a result, a lower weight at the end of the rearing period compared to their counter parts with a traditional duration of the suckling period. In addition, no statistically confirmed difference was found in terms of indicators of piglet survival and absolute growth.

The feeding qualities of pigs depend not only on their genotype, but also significantly on par atypical conditions
in the previous stages of their breeding. Therefore, we investigated the dependence of fattening indicators of pigs on different durations of their suckling period.

As follows from Table 4 different terms of weaning of piglets and different duration of their rearing did not significantly affect the realization of the genetic potential of productivity during fattening.

Thus, no significant difference was found between the animals of the control and experimental groups in terms of live weight when placed on fattening, the duration of fattening, and the weight of animals when removed from fattening.

Table 4. Feeding parameters of young pigs raised for different lengths of suckling period, (n=100)

Indicator	Group I	Group II
Average live weight at the beginning of fattening, kg	29.8±0.50	29.3±1.23
Average weight at the end of fattening, kg	115.1±1.10	114.6±2.1
Duration of fattening, days	102	101
Age at the end of fattening, days	179	178
Preservation of piglets, %	98.4	97.9
Absolute growth, kg	85.3±1.23	85.3±2.16
Average daily increase, g	836±13.2	845±8.0
Relative growth, %	117.7	118.6
Feed conversion, kg	2.89	2.86
Feed consumption per head, kg	2.42	2.42
Age of reaching 100 kg live weight, days	160.9	160.7
Comprehensive index of fattening qualities, points	19.3	19.9

Source: own calculations.

There were also no differences in the indicator of preservation of pigs during fattening perion. In terms of growth intensity, pigs weaned 7 days earlier had a advantage of 9.0 g, or 0.7%, over those with the 28-length of suckling period. Whereas, the absolute increase in animals of both groups was the same, and the relative increase was slightly higher by 0.8% in the animals of the experimental group.

Every day, during fattening, pigs of both groups consumed the same amount of feed, while feed conversion was 0.03 kg or 1.0% better in pigs with a shortened suckling period.

The age at which a weight of 100 kg was reached was almost the same in pigs of both groups, as was the comprehensive indicator of fattening qualities.

Thus, the fattening performance of pigs did not depend on the duration of the suckling period in piglets.

The economic efficiency of shortening the suckling period in sows was calculated according to generally accepted methods, as the difference of indicators of feed costs, maintenance costs and productivity of sows with traditional and 7 days shortened suckling period.

Thus, the duration of the reproductive cycle decreased from 150 to 143 days in the animals of the groupII with a 7-day shorter lactation period. This made it possible to obtain 0.12 more farrowings from each sow per year. Also, due to a 7-day reduction in the lactation period, each individual pens for farrowing sows was used 25.3% more often.

From sows of the control group, 12.4 piglets were obtained for farrowing at weaning. As a result, 30.1 piglets with an average weight of 7.6 kg were obtained per year from an average sow. Thus, piglets with a live weight of 229.0 kg were obtained from one sow per year. At the same time, during the shortened suckling period, 12.6 heads were weaned from one sow per farrowing. Then, in one year, 32.13 piglets were obtained from her with an average live weight of 5.4 kg at weaning. So, the weight of piglets for the year was 173.5 kg. The market value of piglets at the age of 21 days was 4.60 EUR/kg in the farm, while at the age of 28 days it was 3.80 EUR/kg.

In this way, the cost of offspring obtained in a year from sows with reduced duration of lactation amounted to EUR 799.78. While the cost of the annual weaned offspring for the traditional duration of the suckling period amounted to EUR 872.43. That is, the cost of the obtained products at the prices of 2022 was EUR 68.26 less for the shortened term of the suction period compared to the traditional one.

At the same time, the intensity of use of the farrowing pens increased by 25.3% in sows with a shortened suckling period due to a 7-day shorter duration of lactation. For sows with reduced lactation, it was 13.03 times, while for sows with traditional lactation, it was 10.4 times. The difference was2.63 times or 25.3%. The cost of equipment for one pen for farrowing a sow for the enterprise was EUR 2,420.89 in 2022. Taking into account the planned period of its use, which is 5 years, its annual depreciation cost amounted to EUR 484.17. Increasing the efficiency of its use by 25.3% will provide additional cost savings in the amount of EUR 122.48.

Also, with a reduced duration of lactation, due to a smaller amount of feeding more expensive feed for suckling sows, the feed cost of keeping one sow per year is reduced by EUR 20.24.

In this way, the seven-day reduction in the duration of the suckling period of sows will contribute to the saving of EUR 142.73.

Hence, taking into account the lower cost of annual production from sows with a reduced lactation duration, the additional savings per head will amount to EUR 74.46. With the average annual number of commercial sows per year of 12,500 heads, the savings will amount to EUR 930.79.

Our conclusions regarding the lack of a relationship between the duration of the suckling period before weaning and the fattening quality of pigs are in contradiction with the data [8]. The data [8] demonstrated a reliable influence of the term of the suckling period on the success of fattening pigs. The correlation coefficients between the weight of piglets at birth and the growth rate of pigs during fattening did not refute the negative effects of the low weight of suckling piglets on weaning time caused by the short stay of piglets with the sow before weaning.

Similar to the results [26], we cannot claim that pigs with a shortened suckling period outweighed pigs with a shortened suckling period in litter weight of piglets at birth by 1.81 and 2.21 kg ($p<0.001$), as the author of the indicated manuscript says, because piglets in our experiment did not differ in this indicator.

We also observed the discrepancy with this work in the expression of the indicator of the number of piglets at weaning. In our study, the number of piglets at weaning increased when the lactation length of sows decreased to 21 days, while in the opposite experiment [26], the number of piglets at weaning increased when the lactation length increased to 28 days. However, we obtained some similarity of the results with the mentioned data in terms of the index of piglet survival rate, which increased both in our work and in the mentioned wdata with the shortening of the suckling period (21 days) compared to the analogues with the traditional term of the suckling period (28 days).

It is possible to agree with the data of other scientists [27], according to which the duration of the suckling period before weaning had a significant influence on the indicators litter weight of piglets at weaning (73.0%), average weight of piglets at weaning (64.4%), absolute growth of piglets in the post-weaning period (63.0%) and average daily growth during this period (8.4%). At the same time, the duration of the suckling period did not affect the total number of piglets at birth and multifertility of sows. According to the result of our experiment, a reliable difference in the mentioned indicators was confirmed.

We also obtained results that are contrary to other reports [21], which indicated that piglets at early weaning had a 2.90–11.35% lower growth intensity at the time of rearing and the beginning of fattening, worse at 0.83% retention and 0.03 kg feed payment in increments. On the contrary, we found that shortening the suckling period increased the intensity of growth of piglets during rearing and did not affect the growth of pigs during fattening.

CONCLUSIONS

It was established that when the duration of lactation was reduced by 7 days, the preservation of piglets improved and their number in the nest before weaning increased, while the absolute growth and individual weight of piglets and the weight of their nest at weaning decreased.

No difference was found between sows with the traditional duration of lactation and reduced lactation in terms of the total number of piglets born, multifertility, piglet weight at birth, and litter weight of piglets at birth.

Piglets weaned from sows and previously reared had lower growth rates, consumed proportionally less feed, and had poorer feed conversion with lower weight gain at the end of the rearing period compared to their littermates with traditional weaning periods.

At the same time, there was no statistically significant difference in piglet survival rates and absolute growth rates.

The length of the suckling period in the piglets had no effect on the fattening characteristics of the pigs.

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IMPLEMENTATION OF THE INNOVATIVE MANAGEMENT IN THE FOOD INDUSTRY ENTERPRISES IN THE REPUBLIC OF MOLDOVA - CURRENT STATE, BARRIERS, POSSIBLE SOLUTIONS

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Abstract

The basic goals of the research consisted in the elucidation of the essence and significance of the innovative management, its connection with the enterprises` performance, as well as the reflection on the implementation of innovative management in the food production sector of the Republic of Moldova. The research was carried out with the use of qualitative and quantitative methods: literature review, interview, content analysis, thematic and statistical analysis.As a result of the research, problems related to the economic efficiency of the food enterprises, as well as related to the reduced tendencies of the exports of the food products have been identified.It was also found out that the number of innovative food enterprises is continuously decreasing. Thus, even if more and more enterprises are advocating for the combination of different types of innovations (a fact positively appreciated), the reduction in the number of innovative enterprises induces the reasoning that the sector does not sufficiently capitalize on innovation as a performance factor. According to the opinion of the company representatives, the financial barriers have the greatest negative impact on the innovative activity of food enterprises, followed by the barriers related to the reduced demand for innovative products, the insufficiently capitalized human factor, deficiencies in creating partnerships, insufficient information etc. In these conditions, the amplification of efforts to promote and support innovations is required as an important direction for improving the management of food enterprises.

Key words: *efficiency, food production, innovative management, Republic of Moldova*

INTRODUCTION

The particularly flexible environment in which businesses are developing at the current stage imposes the need for innovative management as an indispensable factor of the success and sustainability. Thus, starting from highlighting it as the specific tool of entrepreneurs, as the means by which they exploit change as an opportunity for another business or a different service [6] we can state that the synergy of innovation and management is the cornerstone of the performance. In order to argue the last reasoning, we can refer to Van de Ven who emphasizes new ideas and ways to improve capabilities and the development of new products or processes as remedies against stagnation [20]. Kline and Rosenberg, in their turn, point out the role of innovation in the economic growth [9].

Countless attempts to conceptualize innovative management having been stated, we distinguish the scope of innovation as a criterion for highlighting its internal side, according to which technological and managerial innovations are highlighted. Thus, the concept of innovative management involves both focusing on the design and implementation of technological innovations, as well as the accomplishment of managerial duties at a new qualitative level, in an innovative manner.

The technological side of the innovation presupposes directing the idea and the new to a new product, process or service [7]. The role of the technological aspect of innovative management can be seen in the approaches of Van de Ven [20] and Nagîț [13], it later being developed by including the resources used to obtain new products. Thus, according to Nagiț`sopinion, all potential and all resources, be they material or human, must be used to acquire new knowledge which, once accumulated, leads to the generation of ideas that allow obtaining new products, processes and services or improving existing ones and the transfer of the best ideas to the manufacturing and commercialization phases [13]. According to Cormican et al., product innovation is the strongest pillar used by the enterprise to achieve success [2].

Separate reflections on managerial innovation can be found at authors such as Evan, Daft, Damanpor et al., Hamel. Evan, for example, referring to technological and managerial innovation (using the term administrative innovation), mentions that compared to technological innovation, new ideas in administrative innovation can be extended to wider areas, such as staff recruitment, resource allocation, structuring tasks, developing authority or reward system [7]. Daft uses the term "organizational innovation" meaning the adoption of a new idea or a new management method by a company. The author supports Evan's ideas, stating that the part of organizational innovation, which refers to the personnel and the manager's activity, must be studied differently from the technological innovation. Moreover, he highlights the important role of the manager in the development of new ideas, but especially in their implementation [3].

Damanpour et al. state that the importance of innovative management lies in its ability to make the organization work and to succeed by using its resources in an efficient way. And for this goal to be achieved, it is necessary to have managerial knowledge and skills that, once possessed, contribute to making changes in the organization's structure and processes [4].

Hamel positions innovative management focused on the organizational side as clearly superior in its importance in comparison with innovative management focused on the product. Thus, in his work "The Future of Management" the author identifies the following forms of innovation: operational innovation, product innovation, strategic innovation and management innovation. Studying the importance and impact of each type of innovation and accepting that each of them has an important role in achieving a certain level of efficiency, the author claims that management innovation must be ranked first, stating that understanding this fact is an important step in consolidating innovative practices in managerial activity [8].

By summarizing the presented above, we support the complex approach to the innovative management, by including both technological and managerial elements and, in this context, we consider it relevant to define it as the totality of new processes and practices, implemented starting with the managerial dimension up to the technological one, which aim to change the way in which the company operates by introducing new techniques and strategies, the expected result being the increase in the economic performance.

Being widely recognized the impact of the innovation on the enterprises' performance [1;11;12;21], we will especially highlight its role in improving the efficiency indicators of the activities carried out. Thus, by stimulating the entrepreneurial spirit, innovation contributes to increasing the business performance, through its role in reducing the losses, increasing the work productivity, better managing the available resources [19].

MATERIALS AND METHODS

The research methodology consisted of:

-synthesis of conceptual approaches to innovative management, of its internal side, as well as of its connection with business performance;

-analysis of the food production sector performance in the Republic of Moldova;

-performing a general incursion on the innovative activity of food industry enterprises;

-diagnosing the innovation barriers in the food industry;

-arguing the influence of innovative activity on the performance of food enterprises;

-formulating the recommendations for rationalizing the innovative activity in the food production sector.

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Research tools included: literature review, content analysis, thematic and statistical analysis, structured thematic interview carried out on a sample of 78 managers and specialists of the food enterprises between February and April 2022.

In order to achieve the research objectives, the following sources of information were used: a series of scientific publications with reference to the researched subject, statistical data related to the economic performance of food industry enterprises, as well as the data obtained by the National Bureau of Statistics of the Republic of Moldova as a result of the application of the statistical questionnaire 1 - INOV "Innovation in industry and services", the results obtained in the structured thematic interview of the food enterprises` representatives.

RESULTS AND DISCUSSIONS

Even if the exact quantification of the impact of the innovation on the performance indicators is a difficult, or even impossible task, the existence of causal relationships between the performance indicators and the innovative activities carried out is indisputable, this fact being reflected above. In order to support this reasoning, we will further evaluate the economic-financial situation of the food enterprises in the Republic of Moldova in relation to their concerns for various types of innovations.

According to the official data of the National Bureau of Statistics of the Republic of Moldova, in 2021 the food industry was represented by 977 enterprises. At the same time, by examining the trends in the number of food enterprises, the continuous increase is noted, the growth rate in 2021 compared to 2015 being 104.82% [15].

A significant aspect in the enterprises` activity is the obtained economic-financial indicators. Among them, we will initially highlight the value of the production obtained, its evolution being shown in Fig. 1.According to the data in Fig. 1, during the analyzed period, a stable but slow trend is observed in the increase of the production value obtained by food industry enterprises.

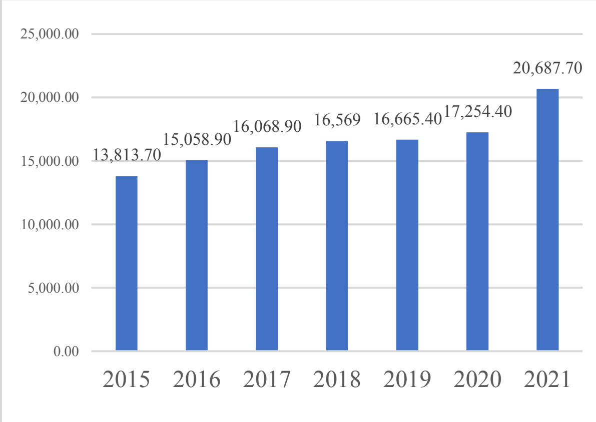

Fig. 1. Evolution of the production obtained by food industry enterprises in the period 2015-2021 (million lei)
Source: Developed by the authors based on [14].

The prosperity of each sector can be evaluated, however, by the efficiency of the activities carried out. The ability to operate profitably is an essential factor in the sustainability of each sector. By investigating the financial situation of food industry enterprises, we find out, however, the existence of an imposing number of inefficient entities (Fig.2).

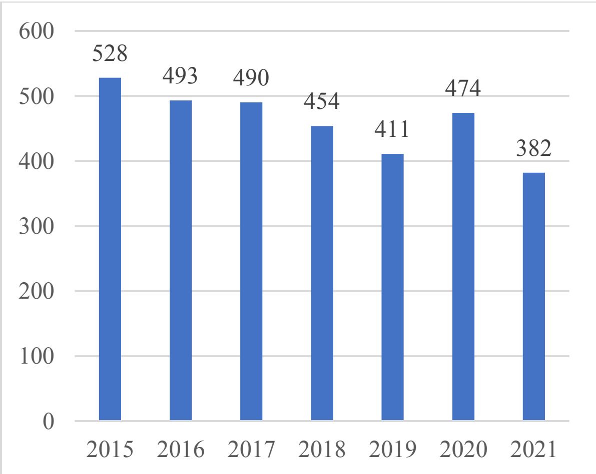

Fig. 2. Evolution of the number of enterprises of the food industry that operated with losses in the period 2015-2021 (units).
Source: Developed by the authors based on [15].

From the data in Fig.2, we infer an alarming situation resulting from the number of enterprises that operated with losses during the analyzed period. Also, a high share of inefficient enterprises in the total number of enterprises is found out (Fig. 3).

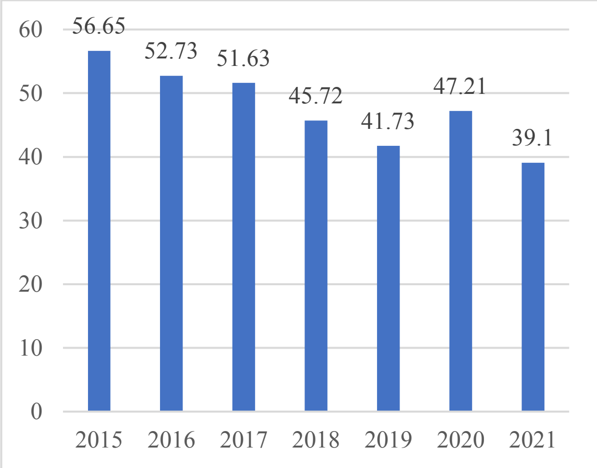

Fig. 3. The share of enterprises that operated with losses in the total number of enterprises of the food industry in the period 2015-2021 (%)
Source: Developed by the authors based on [15].

From the data in Fig. 3, it follows that, even if in the analysed period there is a slow reduction
in the share of inefficient enterprises in the food industry, 39.1% of them continue to face losses. Another important productive aspect of the food sector is its contribution to the country's exports. The data in Fig. 4 reveals the dynamics of exports of food industry products in the period 2015-2021 and shows the following: even if the value of exported food products is increasing, the growth trends are extremely slow. Thus, for example, the rate of increase in the value of exported food products in 2021 compared to the previous year was only 107%, and compared to 2015 – 136%.

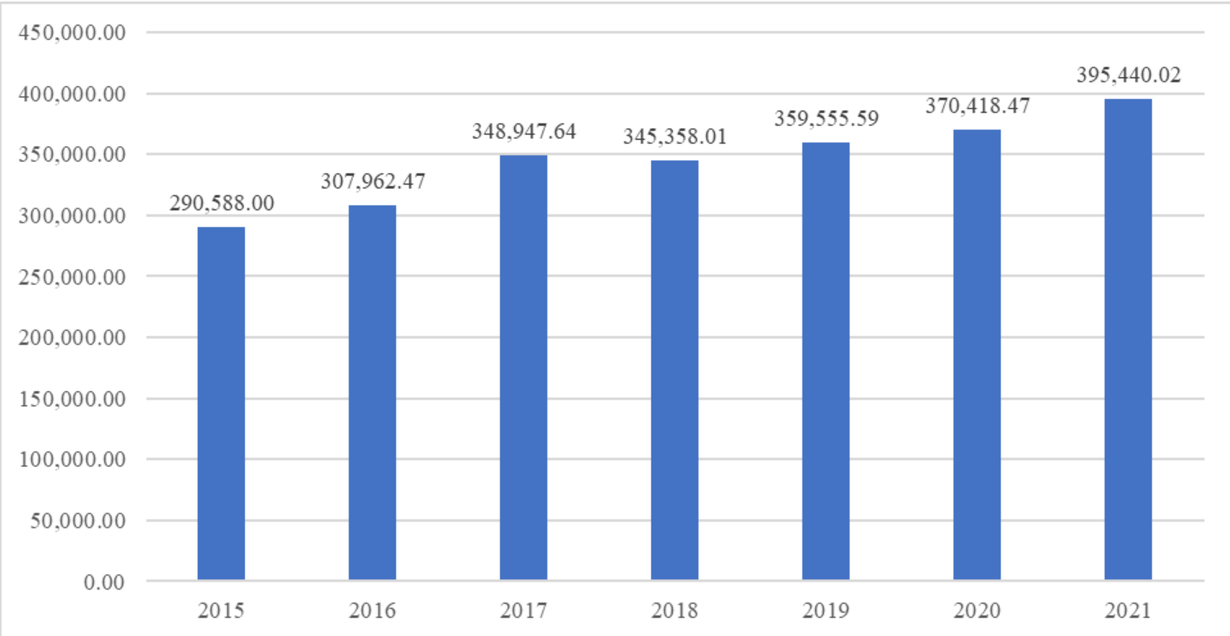

Fig. 4. Dynamics of exports of food industry products in the period 2015-2021 (thousand US $)
Source: Developed by the authors based on [16].

The problems highlighted above with reference to the reduced economic efficiency of the food sector enterprises and the slow trend in increasing the value of the exported food products induce the reasoning of the ineffective management of the factors generating performance, one of which, as previously mentioned, is the innovative management. In this context, we return to the hypothesis that innovative management, by its essence, combines technological and managerial innovation, the effects on the organization's performance representing a cumulative product of both components. In this context, we specify that the statistical questionnaire 1 - INOV "Innovation in industry and services" allows to estimate the efforts of companies on 4 types of innovation: product innovation, process innovation, organizational innovation and marketing innovation. Thus, the technological aspect is found in product innovation and process innovation, while the managerial side is reflected in organizational and marketing innovation (Fig.5).

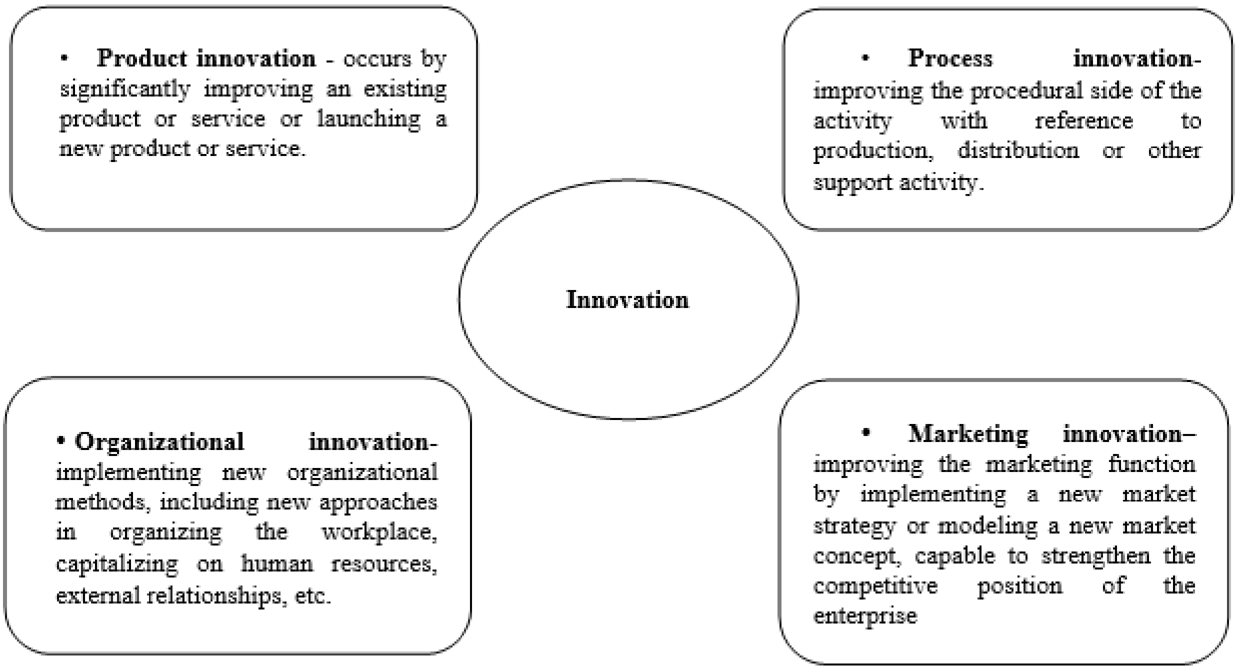

Fig. 5. Types of innovation included in the statistical questionnaire 1 - INOV "Innovation in industry and services"
Source: Developed by the authors based on [17].

Table 1. The dynamics of the innovative enterprises in the food industry of the Republic of Moldova in the period 2015-2020

Indicators	Years		
	2015-2016	2017-2018	2019-2020
The number of innovative enterprisesin industry and services, un.	673	605	448
including in the food industry, un.	*95*	*82*	*68*
The share of the innovative enterprises in the food industry,%	31.25	27.89	23.45
The share of the innovative food enterprises in the total number of innovative enterprises in industry and services, %	14.12	13.55	15.18

Source: Developed by the authors based on [18].
Note: The statistical questionnaire 1 - INOV "Innovation in industry and services" was applied only to enterprises with 10 or more employees.

Official statistical data on innovation in industry and services allow to assess the situation related to the food industry enterprises, along with other analyzed industries. Thus, in Table 1, the dynamics of the number of innovative enterprises in the food industry in the Republic of Moldova in the period 2015-2020 is presented.

The data presented in Table 1 denotes continuous reducing trends in the dynamics of the total number of innovative enterprises in industry and services. A similar trend is also noted in the dynamics of the innovative food enterprises. The share of the innovative enterprises in the food industry is also decreasing. A better situation is found in the share of innovative enterprises in the food industry in relation to the total number of enterprises in the industry and services, being noticed a growth trend. The last finding does not diminish, however, the significance of the problem of reducing the number of innovative enterprises in the food industry and denotes the need for more effective measures aimed at improving the innovative activity in that sector.

With reference to the types of innovations advocated by food enterprises in the Republic of Moldova, we deduce the following: according to the data in figures 6-8, most enterprises apply simultaneously all types of innovation. Thus, in the period 2015-2016 the share of food enterprises with mixed innovations was 47.37%, in the period 2017-2018 - 42.68%, and in the period 2019-2020 - 51.47%. On the second position are ranked innovative enterprises based on marketingmethods and companies that combine innovation based on organizational and marketing methods, the distinct weight of eachcategory varying insubstantialy in the examined period.

Thus, if the reducing tendency in the number of innovative food enterprises diminishes the development capacity of the sector, we can positively appreciate the concern of the majority of food enterprises for all types of innovation.

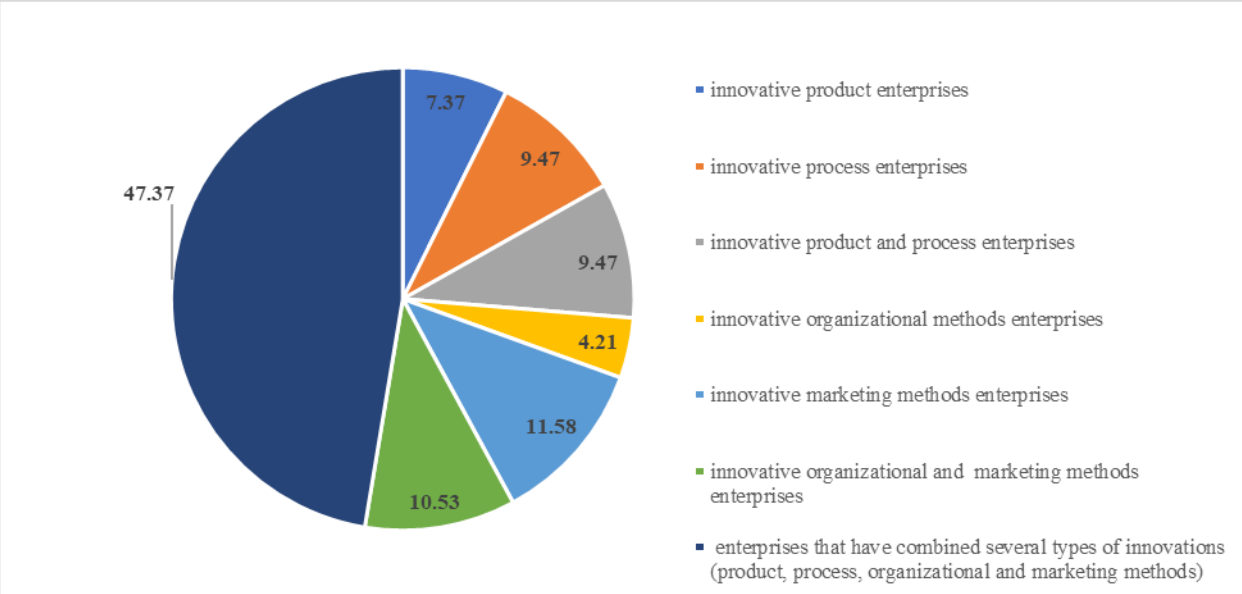

Fig. 6. The types and combinations of innovations applied by food enterprises in the Republic of Moldova in the period 2015-2016 (%)
Source: Developed by the authors based on [18].

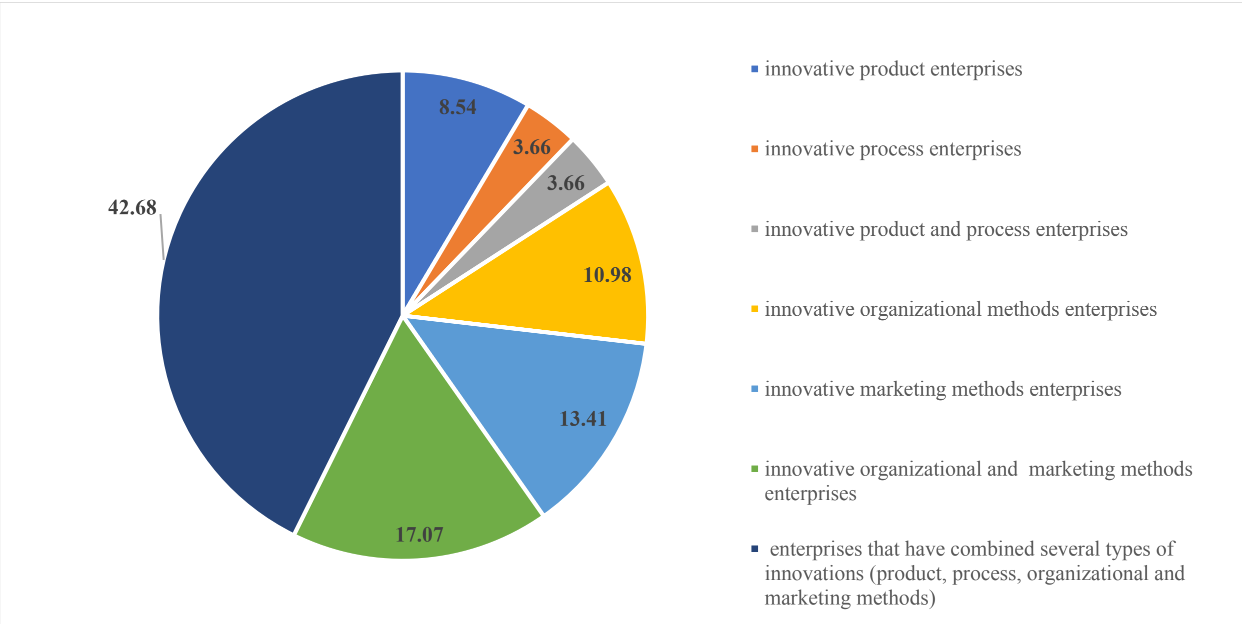

Fig. 7. The types and combinations of innovations applied by food enterprises in the Republic of Moldova in the period 2017-2018 (%)
Source: Developed by the authors based on [18].

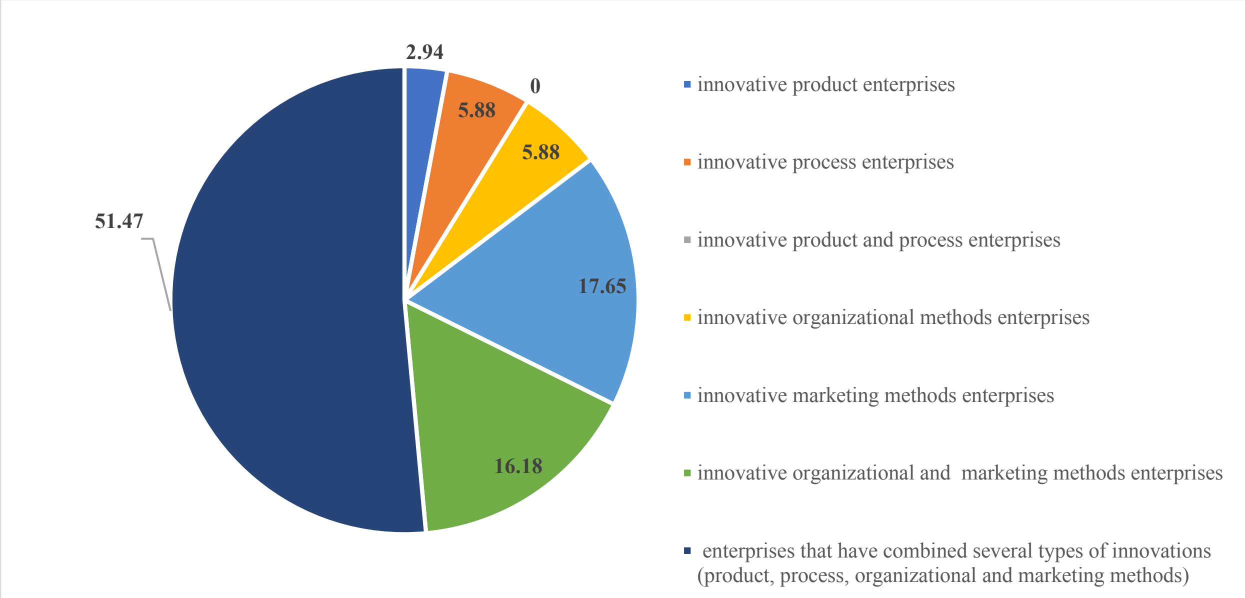

Fig. 8. The types and combinations of innovations applied by food enterprises in the Republic of Moldova in the period 2019-2020 (%)
Source: Developed by the authors based on [18].

Along with those reflected above, we note the following: admitting that enterprises that apply several types of innovation optimally combine various directions, among those that advocate for one type or a combination of two types, the enterprises that focus primarily on the managerial typeof innovation predominate (Table 2).

Table 2. The share of innovative enterprises in the food sector of the Republic of Moldova that advocate for the technological or managerial side of innovation, %

The innovation type	2015-2016	2017-2018	2019-2020
Technological	26.31	15.86	8.82
Managerial	26.32	41.4	39.71

Source: Own calculation.

By examining the data in Table 2, we find out that during the analyzed period, food enterprises are increasingly advocating for managerial innovations, which corresponds to the particularities of the current business development stage that requires increasingly ingenious and effective managerial approaches. At the same time, the drastic reduction of enterprises operating with technological innovations is negatively appreciated. In the existing context of the food market, technological innovations have a major significance and determine not only the production quality and efficiency, but also the ability of the sector to increase exports. Taking into account the slow rate of growth of food product exports, we deduce that focusing the efforts of food companies on technological innovations would contribute to increasing the competitiveness of the respective products on the foreign market.

The trends that emerged in the implementation of innovations by food companies from the Republic of Moldova denote the presence of some barriers, the identification of which is considered „...essential to understanding firms' innovation processes overcoming these barriers" [5]. The innovation barriers, in turn, are defined as „internal or external factors to a firm that decrease or even prevent the firm's propensity to innovate, reduce its ability to introduce and sustain a new or significantly improved product or process, affect innovative activity, prevent the achievement of expected results and impact business performance [10].

In order to diagnose the barriers to the innovative activity in the food industry, a structured thematic interview on a sample of 78 managers and specialists was applied. The questions formulated in the interview were pursuing the objective of evaluating the innovation obstacles and the extent to which

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they affect the performance of the enterprise, according to the respondents' opinion.

By analyzing the results of the interview, the following were found out: most of the respondents indicated financial barriers as having a major negative impact on the innovative activity of enterprises: deficiencies in attracting external resources, insufficient own resources, high costs of innovations. Next comes the reduced or uncertain demand for innovative products, followed by issues related to the quality and motivation of human resources. It should also be noted the difficulties in creating partnerships for innovation, as well as the insufficiency of information about different novelties (Table 3).

Table 3. Results of interviewing managers and specialists of food enterprises regarding barriers to innovative activity (Total score)

Barriers to innovative activity	Total score given by the respondents
Deficiencies in attracting external resources (loans, grants, subsidies, etc.)	351
Insufficiency of own financial resources	348
High costs of innovations (it costs a lot to introduce something new)	329
Low or uncertain (unclear) market demand for innovative products	275
Insufficiency of qualified personnel, able to develop and introduce innovations	267
Insufficient motivation of the company's staff for innovative activity	231
Difficulties in creating partnerships for innovative activities (with other similar companies, research institutions, etc.)	189
Insufficiency of information about various novelties in the related field	135
Others	56

Source: Own calculation.

Along with the barriers named above, the following were mentioned in the "other" category: fear of risk; financial instability in the country and, as a result, rising rates on bank loans; the instability of foreign trade policies; psychological barriers (fear of change), etc.

Being asked for their opinion on the share of influence of each group of barriers on the innovation performance of entities, the respondents stated that financial barriers reduce innovation performance by about 45%; 19% of the total reduction in the innovation performance is due to market barriers; 16% of the decrease in innovation performance is determined by the inadequate quality and motivation of human resources. The other barriers examined cumulatively exert a negative influence of 20% (Fig. 9).

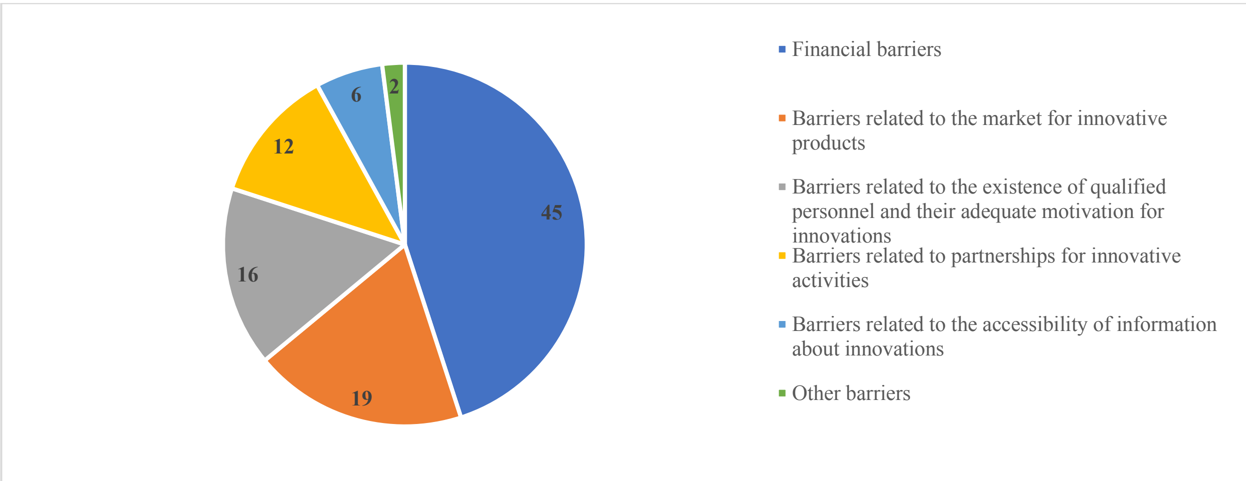

Fig. 9. The quantification of the influence of different groups of innovation barriers on the innovation performance of entities in the food industry (%)
Source: Own calculation.

CONCLUSIONS

By generalizing the presented above, we deduce the following: the increase in the number of food enterprises combining different types of innovations denotes their awareness of the complex nature of innovative approaches. At the same time, the reduction in the number of innovative food enterprises indicates major deficiencies of the innovative management in the sector. Likewise, the reduction of the share of food enterprises that operate with technological innovations diminishes the efficiency of the sector and the competitiveness of the respective products on the foreign market.

Having proven the significance of innovation in increasing the business performance, we can say that innovative management as a performance factor is insufficiently valued in the enterprises of the food industry in the Republic of Moldova.

According to the opinion of the company representatives, the financial barriers have the greatest negative impact on the innovative activity of food enterprises, followed by the barriers related to the reduced demand for innovative products, the insufficiently capitalized human factor, deficiencies in creating partnerships, insufficient information etc.In these conditions, the amplification of efforts to promote and support innovations is required as an important direction for improving the management of the food enterprises. In this context, the need for the following actions can be deduced:

-for all actors of the innovation ecosystem - the wider dissemination of information about technological innovations, the opportunities to finance innovations, as well as the experience of companies with high results in the implementation of innovations;

-for representatives of state bodies - improving state policies in supporting innovative activity; supporting and promoting partnerships in innovation;

-for the National Agency for Research and Development – highlighting, as an important priority in research in the State Program 2024-2027 - the development of partnerships between research institutions and the business environment in order to strengthen innovative activity as a pillar of the sustainable development.

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PRODUCTIVITY OF GRAIN EAR CROPS AND POST-HARVEST WHITE MUSTARD ON GREEN FERTILIZER DEPENDING ON THE SYSTEMS OF SOIL BASIC TILLAGE IN THE FOREST STEPPE OF UKRAINE

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Abstract

Five-year (2017-2021) studies on a typical deep low-humus black soil at the experimental field of Bila Tserkva National Agrarian University found that the yield of winter wheat and spring barley was almost at the same level with mouldboard and differentiated tillage in the five-field crop rotation. The research was conducted by the method of field stationary experiment. All crop rotation fields are fully deployed in space and time. The area of sown plots was 171 m^2, accounting area – 112 m^2. Repetition – three times, placement of repetitions and plots was consistent, systematic. In the tillering phase of winter wheat and spring barley, mouldboard-mouldboardless tillage had the advantage of arable layer moistening. When sowing white mustard, the most moisturized soil layers were under differentiated tillage, the least moisturized – under mouldboardless tillage. The dry mass of root residues of winter wheat was the highest under mouldboard, spring barley – under mouldboard-mouldboardless tillage, and white mustard was almost the same under these cultivation options. Grain yield was at the same level under mouldboard and differentiated tillage. The green mass of white mustard applied in the soil was significantly more under the differentiated tillage and predecessor of spring barley. The highest indicators of economic and energy efficiency were obtained by applying 12 tons of manure + $N_{95}P_{82}K_{72}$ per hectare of arable crop rotation land (including per winter wheat $N_{125}P_{90}K_{70}$, spring barley $N_{60}P_{50}K_{50}$, white mustard $N_{15}P_{15}K_{15}$) and carrying mouldboard-mouldboardless tillage in crop rotation, which involves deep cultivation of 25-27 cm in only one field, and the rest of the fields – mouldboardless and disk shallow tillage.

***Key words*:** *tillage, fertilizer, soil, crop rotation, moisture, root residues, yield, productivity, efficiency*

INTRODUCTION

According to the importance of the problems of domestic farming, dehumidification of soils takes the second place (first place – erosion and deflation) [13, 19]. The content and composition of humus is an integral indicator of soil fertility. Every year, each hectare of arable land of Ukrainian black soil loses more than 1 ton of humus, which is equal to 18-20 tons of semi-rotted cattle manure on straw litter, the rate of application of which in the country today is only half a ton per hectare [2, 34].

The large number of agricultural technological works that are executed under the conventional technologies can reduce the natural soil fertility by modifying the soil agrochemical indicators [8, 10].

A convincing factor in the dominant value of humus in soil fertility, in particular, is the fact that it contains 95-98% of soil nitrogen, 80 – sulfur and 60 – phosphorus, and 50-60% of alienated nitrogen by crops from soils of humus origin, i.e. it is its mineral forms created by the mineralization of humus [18, 20].

An alternative to manure in domestic arable farming should be primarily scientifically substantiated use of non-marketable agricultural products and green manures [17, 22]. After all, according to scientists, one ton of straw in terms of organic matter content is equivalent to 3.5-4.0 tons of manure, and applied in the soil 4.0-5.0 tons of straw provide the formation of 2.6 tons of humus [23, 30].

From the green fertilizers in Ukraine today the most common crops are the cabbage family, especially in post-harvest sowing [25, 29]. Green manures of post-harvest sowing period are placed in crop rotations of the Forest-Steppe of Ukraine, as a rule, after cereals ear crops, first of all after winter wheat and spring barley. The system of basic tillage for cereals ear and post-harvest cabbage crops today needs to be revised and detailed depending on the type, subtype, structure of sown areas, and number of fields, specialization and crop rotation fertilization system.

Today there are some recommendations of scientists on tillage for basic and post-harvest crops, but they are quite general, sometimes even contradictory, often do not take into account weather and climatic conditions, soil differences, predecessors, etc. [21, 26, 29].

In the experiments of the National University of Life and Environmental Sciences of Ukraine, the use of green mass of oilseed radish for fertilizer provided a decrease in the density of typical black soil for both plowing and deep mouldboardless tillage on 0.05 g/cm^3 and increased productive moisture reserves in the arable soil on 2.5 mm, and the yield of potato tubers, respectively, on 5.2 and 7.0 tons [12].

Systematic application of only mineral fertilizers without replenishment of the soil with organic matter leads to the dominance of mineralization of soil organic matter, in particular, and humus over synthesis (humification) [33].

On the podzolic black soil of Khmelnytsky research station and typical black soil in stationary experiment of the National University of Life and Environmental Sciences of Ukraine (Kyiv region, Fastiv district) in short- course crop rotations, the highest reserves of soil humus were recorded with combined use of manure, straw, green and half the rate of mineral fertilizers and mouldboardless tillage with periodic mouldboard plowing under sugar beets. In the plowed areas of podzolic black soil hydrolytic acidity had reached a critical value (4.24-4.38 mg.eq./100 g of soil) with the combined use of straw, green manure and high rates of mineral fertilizers. In unfertilized variants, a decrease in the hydrolytic acidity was observed with an increase in the degree of tillage minimization of typical and podzolic black soil [1].

In the southern black soil the highest productivity of green manure crops was provided by mouldboardless tillage for all crops of the five-field crop rotation [32].

Sweep plowing of leached low-humus medium loam black soil in combination with the applying of optimized rates of mineral fertilizers on the background of the effect and after-effect of bare and siderate fallow land provided an increase and improvement in the structure of spring wheat yield [15].

With insufficient soil moisture in the steppe zone, plowing 20-25 cm under soybeans has advantages over sweep plowing to the same depth and shallow hoeing of 10-12 cm of ordinary black soil [9].

In the five-field crop rotation of the Left-Bank Forest-Steppe of Ukraine with peas in unfertilized plots, the average yield of winter wheat under plowing and surface cultivation for 42 years of research was on 0.29 and 0.05 t/ha, respectively, lower than under deep mouldboardless hoeing, where this indicator was 3.56 t/ha. With the application of $N_{66}P_{62}K_{82}$, the yield of winter wheat in two crop rotations was also the highest under mouldboardless tillage [5].

The maximum moisture accumulation efficiency of typical deep medium loam black soil was recorded under shallow mouldboardless tillage, carried out simultaneously with slitting, which provided an increase in available soil moisture reserves in the arable layer on 6-18% compared to mouldboard tillage. The scientist recommends the use of mouldboard-mouldboardless main tillage in the ten-field crop rotation, during which deep plowing is carried out under sugar beets and sunflowers, shallow mouldboardless tillage – under winter wheat after corn for silage and soybeans, and different depth chiseling – under other crops [31].

Kirovohrad Institute of Agricultural Production recommends farms in the northern part of the Steppe of Ukraine under winter wheat after fallow land to use mouldboardless tillage, after corn for silage – shallow (10-12 cm) disk tillage, or "zero", provided plowing under the predecessor. Under spring barley, it is proposed to cultivate ordinary medium loam black soil with a flat cut to a depth of 20-22 cm, but under the condition of deep (28-30 cm) plowing under the predecessor. In crop rotation, mouldboard-mouldboardless tillage is recommended, in which plowing for row crops alternates with "zero" tillage for agrophytocenoses with usual row sowing method [4].

In the experimental field of Uman National University of Horticulture, high efficiency in short-course crop rotation was provided by fallow plowing under soybean to a depth of 15-17 cm, spring wheat, spring barley, spring rape and oil flax – 25-27 cm [11].

In the five-field crop rotations (fruit-changing and grain plowing) of the Right-Bank Forest-Steppe of Ukraine, scientists recommend deep (30-32 and 25-27 cm, respectively) plowing in only one field under row crop (fodder beets and corn, respectively), and in the rest of the fields – shallow (10-12 cm) tillage of typical deep black soil [16].

According to the results obtained Burcea M. [3] soil works methods have little influence on the humus content, its modification being insignificant and keeping within medium range limits. The work of the soil with the disc harrow determines the highest accumulation of humus, at a depth of 10-20 cm, with average values of 3.50%. The highest humus content is found in the 0-10 cm layer due to an accumulation of organic matter not introduced on the soil depth.

In the conditions stationary experiment of the Institute of Irrigated Agriculture of NAAS of Ukraine the most favorable agrophysical properties and water regime of the dark-chestnut soil for the cultivation of row crops is created under differentiated system of basic tillage with application of $N_{120}P_{60}$ + by-products per the hectare of the crop rotation area. The mentioned cultivation technology guarantees obtaining the best profitability level of 110.1% in comparison to 38.9% on the control [14].

In the South of Romania the associated influence of the soil tillage, plant density and hybrid used on the production of maize determined the highest yields by performing the combinator on the soil tillage, as basic tillage, using a density of 55,000 plants/ha and using hybrid PR36V52. Replacement the combinator tillage with plowing or direct seeding determined to obtain lower production up to 2,000 kg/ha regardless of the hybrid used [28]. Similar results were obtained in Ukraine with corn and sweet sorghum [6, 7].

The purpose of the study is to identify the most optimal combination of systems of basic tillage and crop rotation fertilizer, which ensures the productivity of winter wheat and spring barley at the level of 12 and 9 t/ha of dry matter, 9 and 8 t/ha of feed units, 0.55 and 0, 40 t/ha of digestible protein, and white mustard – 20-21 t/ha of green mass with high economic and energy efficiency.

MATERIALS AND METHODS

The studies were performed on a typical deep low-humus medium loam black soil of experimental field of Bila Tserkva National Agrarian University during 2017-2021 in a stationary field crop rotation, where four systems of basic tillage (Table 1) and four fertilizer systems were studied (Table 2).

In addition to the by-products of crop rotation and green mass of post-harvest white mustard, semi-rotted cattle manure, ammonium nitrate, simple granular superphosphate and potassium salt were used as fertilizers.

Soil moisture was determined by weight method [35], dry mass of root residues – by the method of Stankov [27].

Crop rotation fields were fully deployed in space and time. In the experiment, threefold repetition was placed completely on the area, plots of the first order (tillage system) – sequentially in one tier, the second (fertilizer rates) – sequentially in four tiers.

The sown area of the elementary plot was 171 m^2 (9 x 19 m), and the accounting area was 112 m^2 (7 x 16 m). The area under the experiment was 3.7 ha.

Table 1. Systems of basic tillage in crop rotation

№ field	Crop	Tillage*			
		mouldboard (control)	mouldboardless	mouldboard & mouldboardless (differentiated)	disking (continuous shallow)
		Depth (cm) and cultivation			
1	Soybean	16-18 (p.)	16-18 (d.t.)	16-18 (г)	10-12 (d.h.)
2	Winter wheat + white mustard on green manure	10-12 (d.h.)	10-12 (d.t.)	10-12 (d.h.)	10-12 (d.h.)
3	Sunflower	25-27 (p.)	25-27 (d.t.)	25-27 (p.)	10-12 (d.h.)
4	Spring barley + white mustard on green manure	10-12 (d.h.)	10-12 (d.t.)	10-12 (d.h.)	10-12 (d.h.)
5	Maize	25-27 (p.)	25-27 (d.t.)	25-27 (d.t.)	10-12 (d.h.)

**Note: p. – plowing, d.h. – disc harrow, d.t. – deep tiller.*
Source: Authors' own results.

Table 2. Fertilizer systems under crops of field grain-plowing crop rotation

№ field	Crop rotation crops	Fertilizer level	Manure, t/ha	Mineral fertilizers, kg/ha a.s.														
				total			basic fertilizer			under presowing cultivation			row fertilizer			feeding		
				N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
1	Soybean	0																
		1		30	40	30		40	30	30								
		2		40	60	40		60	40	40								
		3		60	80	60		80	60	60								
2	Winter wheat	0																
		1		100	70	50	30	70	50							70		
		2		125	90	70	30	90	70							95		
		3		150	110	80	30	110	80							120		
	White mustard on green manure	0																
		1		15	15	15	15	15	15									
		2		15	15	15	15	15	15									
		3		15	15	15	15	15	15									
3	Sunflower	0																
		1	20	50	50	35	50	50	35									
		2	30	80	80	50	80	80	50									
		3	40	100	100	70	100	100	70									
4	Spring barley	0																
		1		50	40	40		40	40	50								
		2		60	50	50		50	50	60								
		3		70	60	60		60	60	70								
	White mustard on green manure	0																
		1		15	15	15	15	15	15									
		2		15	15	15	15	15	15									
		3		15	15	15	15	15	15									
5	Maize	0																
		1	20	120	90	100		80	100	120				10				
		2	30	140	100	120		90	120	140				10				
		3	40	150	120	130		110	130	150				10				
Per 1 ha of crop rotation		0																
		1	8	76	64	57	22	62	57	40				2		14		
		2	12	95	82	72	28	80	72	48				2		19		
		3	16	112	100	86	32	98	86	56				2		24		

Source: Authors' own results.

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RESULTS AND DISCUSSIONS

In the upper (0-10 cm) layer of soil on the date of sowing of winter wheat at zero, first, second and third levels of fertilizer available moisture was less, respectively, on 0.8, 1.0, 1.2 and 1.3 mm under mouldboardless tillage, 0.3, 0.5, 0.6 and 0.8 – differentiated, 1.1, 1.3, 1.4 and 1.5 mm – under shallow tillage, compared with control, with SD_{05} = 1.0 mm. In the arable (0-30 cm) layer, this indicator was significantly lower under constant chisel and shallow than mouldboard tillage in crop rotation. Under mouldboard-mouldboardless and mouldboard tillage, the difference was 1.1-1.8 mm in favor of the latter, but it was insignificant.

In a meter layer of soil, the reserves of available moisture were on 5.8-9.7 mm lower under mouldboardless and disk than mouldboard tillage (SD_{05} = 5.3 mm), and with increasing rates of fertilizer, this difference increased. Thus, for chisel tillage on unfertilized plots, it was 6.1 mm, and on fertilized with $N_{150}P_{110}K_{80}$ – 9.7 mm in favor of the control (Table 3).

Table 3. Change in the available soil moisture reserves under cereals ear crops depending on the system of tillage and fertilization of typical black soil, mm

The main tillage in crop rotation	Fertilizer levels in crop rotation	Sowing of cereals						Tillering of cereals					
		winter wheat			spring barley			winter wheat			spring barley		
		layer of soil, cm											
		0-10	0-30	0-10	0-30	0-10	0-30	0-10	0-30	0-10	0-30	0-10	0-30
mouldboard (control)	0	9.3	32.5	108.1	19.3	49.6	116.4	14.6	39.4	121.3	12.3	31.1	114.8
	1	8.8	31.1	105.8	18.3	47.9	112.7	13.2	37.0	110.4	11.4	29.0	107.5
	2	8.2	30.0	102.7	16.8	45.8	108.9	12.8	35.5	103.6	10.1	27.4	102.9
	3	7.8	28.7	98.6	16.4	43.3	105.6	12.5	33.6	95.8	9.5	25.9	100.4
mouldboardless (chisel)	0	8.5	29.8	102.0	17.9	46.2	108.0	13.3	36.7	117.2	11.4	28.3	109.2
	1	7.8	28.2	98.4	16.5	43.4	102.3	11.8	34.2	106.7	10.6	25.8	101.1
	2	7.0	26.8	93.9	14.5	40.7	96.4	11.3	32.5	99.8	9.1	24.0	96.1
	3	6.5	25.1	88.9	13.9	37.6	92.2	11.2	30.7	91.7	8.8	22.4	93.3
mouldboard & mouldboardless (differentiated)	0	9.0	31.4	111.8	18.2	47.5	118.7	13.8	40.7	120.2	13.5	31.6	117.1
	1	8.3	29.7	108.6	16.8	45.3	116.1	12.3	38.6	109.6	12.8	29.7	110.6
	2	7.6	28.4	104.8	15.0	42.9	113.1	12.1	37.3	102.2	11.7	28.3	106.2
	3	7.0	26.9	100.2	14.3	40.2	110.6	11.6	35.1	94.6	11.0	26.9	104.4
disking (continuous shallow)	0	8.2	30.4	102.3	18.0	45.4	109.2	13.0	35.6	115.5	10.8	28.5	110.0
	1	7.5	28.6	99.3	16.7	43.1	103.9	11.6	33.4	104.9	10.0	26.0	102.2
	2	6.8	27.3	95.0	15.0	40.3	99.3	11.0	31.8	98.5	8.9	24.6	98.4
	3	6.0	25.8	89.7	14.0	37.3	94.8	10.7	30.1	91.0	8.3	22.7	94.9
SD_{05}		1,0	2.0	5.3	1.1	3.3	6.8	1.1	2.3	4.7	1.2	2.6	4.5

Source: Authors' own results.

On unfertilized variants, fertilized with $N_{100}P_{70}K_{50}$, $N_{125}P_{90}K_{70}$ and $N_{150}P_{110}K_{80}$ under mouldboard-mouldboardless tillage, this indicator was on 3.7, 2.8, 2.1 and 1.6 mm higher than in the control, but this difference was insignificant.

In the tillering phase of winter wheat available moisture in the upper soil layer was on 0.7-0.9 mm less under differentiated than under mouldboard tillage (SD_{05} = 1.1 mm). Under chisel and disk tillage this indicator was essentially lower (on 1.3-1.8 mm), than in control. In the arable layer of typical black soil available moisture under mouldboard-mouldboardless tillage was on 1.3-1.8 mm more, and under mouldboardless and shallow, respectively, on 2.7-3.0 and 3.5-3.8 mm less than under mouldboard (SD_{05} = 2.3 mm). The most moist meter layer of soil was in the control, where this indicator was on 0.8-1.4, 3.7-4.1 and 4.8-5.8 mm higher than, respectively, under mouldboard-mouldboardless, chisel and disk tillage in crop rotation (SD_{05} = 4.7 mm).

In the experiment of the National University of Life and Environmental Sciences of Ukraine, the content of available moisture in a meter layer of typical deep medium-loam black soil at the beginning of winter wheat vegetation was also higher than under mouldboard-mouldboardless tillage in ten-field crop rotation than in the control [31].

In the right-bank steppe of Ukraine only in dry years mouldboard-mouldboardless tillage of ordinary medium humus heavy loam black soil in crop rotation reduced the reserves of available moisture of one and a half meter layer of soil due to increased density of its structure, compared with different depth plowing [4].

On the date of sowing of spring barley available moisture in the upper layer of soil on unfertilized plots fertilized with $N_{50}P_{40}K_{40}$, $N_{60}P_{50}K_{50}$ and $N_{70}P_{60}K_{60}$ was, respectively, less on 1.4, 1.8, 2.3 and 2.5 mm under mouldboardless, 1.1, 1.5, 1.8 and 2.1 mm – differentiated, 1.3, 1.6, 1.8 and 2.4 mm under constant shallow tillage than in control. In the arable layer of soil, this indicator under chisel and disk tillage was, respectively, lower on 3.4-5.7 and 4.2-6.0 mm, and under mouldboard-mouldboardless – on 2.1-3.1 mm than in control with SD_{05} = 3.3 mm. At the same time, there was an increase in the difference of this indicator between the options of tillage with increasing levels of fertilizers. Thus, under mouldboardless, differentiated and systematic shallow tillage in crop rotation, it was, respectively, 3.4, 2.1 and 4.2 mm on unfertilized and 5.7, 2.9 and 6.0 mm on fertilized plots with the highest rate of fertilizers in favor of the control.

In the meter layer of soil, available moisture was on 2.3-5.0 mm more under mouldboard-mouldboardless tillage than under mouldboard tillage, but this difference did not reach SD_{05}, which was 6.8 mm. For chisel and disk tillage, this indicator was lower on 8.4 and 7.2 mm, respectively, on unfertilized plots, 10.4 and 8.8 mm – fertilized with $N_{50}P_{40}K_{40}$, 12.5 and 9.6 mm – $N_{60}P_{50}K_{50}$, 13.4 and 10.8 mm – $N_{70}P_{60}K_{60}$, than in the control.

In the tillering phase of spring barley, the available moisture in the upper layer of the soil was slightly higher (0.7-1.0 mm) under mouldboard than mouldboardless tillage. With differentiated tillage, this indicator was significantly higher (on 1.2-1.5 mm), and with constant shallow – significantly lower (on 1.2-1.5) than in the control.

In the arable layer of the soil, available moisture under chisel and constant shallow tillage was on 2.6-3.5 mm less, and under mouldboard-mouldboardless – on 0.5-1.0 mm more than in the control with SD_{05} = 2.6 mm. A similar pattern was observed in the meter layer, where the average value of this indicator under mouldboard, mouldboardless, differentiated and disk tillage was 106.4, 99.9, 109.6 and 101.4 mm, respectively. Thus, the reserves of available water in a meter layer of soil under chisel and systematic shallow tillage was, respectively, lower on 6.1 and 4.7%, and under mouldboard-mouldboardless – on 3.0% higher than in the control (Table 4).

The same pattern was observed in the research field of Kharkiv National Agrarian University in the root layer of typical deep low humus black soil, where mouldboardless tillage reduced soil moisture on 6 mm, compared with the control. According to the scientist, systematic mouldboardless tillage worsens the conditions of accumulation of soil moisture in the root layer of typical black soil, regardless of the depth of tillage [24].

In the experiments of the Institute of Agriculture of the steppe zone of NAAS of Ukraine on ordinary hard loam black soil, the advantage of mouldboardless tillage in field short-course crop rotations in terms of available soil moisture content was observed under the lack of normative amount of precipitation during December-February [20].

On the date of sowing of white mustard after winter wheat, available moisture in the upper layer of the soil under mouldboardless and disk tillage was, respectively, less on 1.2-1.6 and 0.8-1.1 mm, and under differentiated – on 1.3-1.8 mm more than in the control with SD_{05} = 1.2 mm. A similar pattern was recorded in the arable layer of soil; however, the magnitude of the increase in this indicator under mouldboard-mouldboardless tillage did not reach SD_{05} and was in the range of 1.4-2.3 mm. For chisel and systematic shallow tillage, this indicator was on 9.8 and 10.8% lower, respectively, than in the control.

Table 4. Change in the available soil moisture reserves under white mustard depending on predecessors, system of tillage and fertilization of typical black soil, mm

The main tillage in crop rotation	Fertilizer levels in crop rotation	Sowing						Mowing					
		Predecessors											
		winter wheat			spring barley			winter wheat			spring barley		
		layer of soil, cm											
		0-10	0-30	0-100	0-10	0-30	0-100	0-10	0-30	0-100	0-10	0-30	0-100
mouldboard (control)	0	11.7	42.2	94.7	10.2	38.6	108.3	6.0	20.1	72.3	5.8	18.4	66.8
	1	11.1	41.4	90.1	9.6	37.4	106.1	5.7	17.6	68.0	5.3	17.3	65.1
	2	10.7	39.5	87.3	9.3	36.9	104.6	5.4	15.7	64.2	5.0	16.0	64.3
	3	9.6	38.3	85.8	9.0	36.4	103.0	5.1	13.6	61.9	4.6	14.9	63.0
mouldboardless (chisel)	0	10.5	39.1	86.9	11.1	35.9	99.7	7.1	23.5	78.1	7.0	21.0	72.2
	1	9.7	37.5	81.6	10.6	34.4	97.0	6.7	20.7	73.2	6.4	19.5	70.3
	2	9.2	35.4	78.6	10.3	33.7	94.5	6.3	18.6	69.1	6.0	17.8	68.8
	3	8.0	33.5	76.7	10.1	33.0	92.3	5.9	16.2	66.6	5.5	16.6	67.2
mouldboard & mouldboardless (differentiated)	0	13.0	43.6	97.9	11.7	41.2	115.5	5.3	17.0	68.6	4.6	15.6	62.3
	1	12.6	43.1	93.7	11.2	40.4	114.2	4.9	14.8	64.5	4.2	14.8	61.0
	2	12.3	41.5	91.2	11.0	40.1	113.8	4.5	13.1	60.8	4.0	13.9	60.4
	3	11.4	40.6	89.9	10.8	39.7	113.4	4.2	11.2	58.7	3.6	12.9	59.2
disking (continuous shallow)	0	10.9	38.6	89.1	10.9	35.6	100.8	7.0	23.2	77.8	6.9	20.9	71.1
	1	10.2	37.3	83.7	10.4	34.2	98.0	6.7	20.4	73.1	6.4	19.5	69.3
	2	9.7	34.9	80.5	10.2	33.5	95.3	6.3	18.2	69.1	6.2	18.0	67.6
	3	8.5	33.1	78.5	10.0	32.8	93.2	5.9	15.8	66.8	5.9	16.7	66.9
SD_{05}		1.2	2.6	5.1	1.3	2.4	6.2	0.8	2.2	3.4	0.9	1.8	3.1

Source: Authors' own results.

The most moist meter layer of typical black soil was under differentiated tillage, although the increase in available moisture in it (which was 3.2-4.1 mm) compared with the control was insignificant. Reserves of available water in this layer of soil was higher on 9.6 and 7.3%, respectively, under mouldboardless and disk than mouldboard tillage in crop rotation.

On the date of sowing of green manure after spring barley, available water in the upper layer of soil was on 0.9-1.1 and 1.3-1.8 mm more, respectively, under chisel and mouldboard-mouldboardless, than mouldboard tillage (SD_{05} = 1.3 mm). The magnitude of the increase in this indicator (on 0.8-1.1 mm) with systematic shallow tillage, compared with the control, was insignificant.

In the arable and meter layers of typical black soil, reserves of available moisture was significantly higher under differentiated and significantly lower under mouldboardless and disk, than mouldboard tillage in crop rotation. The reduction of this indicator in the these layers of soil was respectively 2.7-3.4 and 8.6-10.1 mm under chisel, 3.0-3.6 and 7.5-9.8 mm under constant shallow tillage, and an increase on 2.6-3.3 and 7.2-10.4 mm under mouldboard mouldboardless tillage, compared with the control, with SD_{05} 2.4 and 6.2 mm.

At the date of applying green fertilizer into the soil, the lowest reserves of available moisture in the studied soil layers were observed after both predecessors under mouldboard-mouldboardless tillage in crop rotation. The decrease in this indicator in the layers 0-10, 0-30 and 0-100 cm was 0.7-1.2, 2.0-3.1 and 3.2-4.5 respectively under differentiated tillage; an increase on 0.8-1.2, 1.7-3.4 and 3.3-5.8 mm – under mouldboardless and disk tillage, compared to the control associated with different crop productivity.

The highest grain yield of winter wheat was obtained under mouldboard tillage in crop rotation. Under chisel and systematic shallow tillage, it was significantly lower, and under mouldboard-mouldboardless – insignificantly lower than in the control. With increasing rates of fertilizer, the difference in yield between cultivation options increased. Thus, on unfertilized plots fertilized with $N_{100}P_{70}K_{50}$, $N_{125}P_{90}K_{70}$ and $N_{150}P_{110}K_{80}$, the decrease in this indicator was 0.43, 0.56; 0.63 and 0.71 t/ha respectively under mouldboardless, 0.12, 0.18, 0.23 and 0.27 t/ha

– differentiated, 0.33, 0.46, 0.56 and 0.61 t/ha – under disk tillage, compared with the control (Table 5).

Table 5. Yield and mass of root crop residues under different systems of basic tillage and fertilizer in crop rotation, t/ha

The main tillage in crop rotation	Fertilizer levels in crop rotation	Yield, t/ha				The ratio of grain to straw		Yield of green mass of white mustard, t/ha		Mass of root residues, t/ha of dry matter winter wheat			
		winter wheat		spring barley								of white mustard	
		grain	straw	grain	straw	of winter wheat	of spring barley	after winter wheat	after spring barley	of winter wheat	of spring barley	after winter wheat	after spring barley
mouldboard (control)	0	2.73	3.30	2.37	2.56	1.21	1.08	9.86	8.83	2.04	1.72	1.81	1.62
	1	4.78	6.12	3.74	4.19	1.28	1.12	17.75	14.10	2.88	2.19	3.03	2.40
	2	6.35	8.51	4.78	5.64	1.34	1.18	21.88	18.26	4.17	2.87	3.75	3.14
	3	7.80	10.76	5.67	6.92	1.38	1.22	23.79	21.09	5.19	3.42	4.06	3.63
mouldboardless (chisel)	0	2.30	2.85	2.05	2.28	1.24	1.11	8.63	7.50	1.77	1.54	1.65	1.38
	1	4.22	5.49	3.32	3.82	1.30	1.15	16.30	12.51	2.59	1.99	2.89	2.12
	2	5.72	7.78	4.29	5.19	1.36	1.21	20.21	16.47	3.81	2.63	3.60	2.82
	3	7.09	10.00	5.11	6.44	1.41	1.26	21.95	19.13	4.77	3.13	3.89	3.28
mouldboard & mouldboardless (differentiated)	0	2.61	3.11	2.53	2.68	1.19	1.06	9.48	10.28	1.97	1.86	1.78	1.89
	1	4.60	5.75	3.87	4.30	1.25	1.11	17.26	15.44	2.79	2.29	3.00	2.61
	2	6.12	8.02	4.86	5.59	1.31	1.15	21.23	19.53	4.04	2.94	3.71	3.33
	3	7.53	10.17	5.73	6.88	1.35	1.20	22.98	22.28	5.03	3.48	4.02	3.79
disking (continuous shallow)	0	2.40	3.02	2.13	2.43	1.26	1.14	8.31	7.19	1.84	1.59	1.52	1.32
	1	4.32	5.75	3.41	3.99	1.33	1.17	15.96	12.22	2.64	2.05	2.69	2.04
	2	5.79	7.99	4.40	5.46	1.38	1.24	19.91	16.19	3.84	2.69	3.38	2.74
	3	7.19	10.35	5.25	6.72	1.44	1.28	21.66	18.89	4.83	3.22	3.69	3.22
SD_{05}		0.33	0.41	0.22	0.28			1.07	1.14	0.19	0.13	0.14	0.18

Source: Authors' own results.

Table 6. The output of by-products of cereals ear crops under different systems of basic tillage and fertilizer in crop rotation, t/ha

The main tillage in crop rotation	Fertilizer levels in crop rotation	Natural value		Dry matter		Fodder units		Digestible protein	
		winter wheat	spring barley	winter wheat	spring barley	winter wheat	spring barley	winter wheat	spring barley
mouldboard (control)	0	3.28	2.52	2.80	2.21	0.92	0.93	0.0131	0.0302
	1	5.80	4.06	4.95	3.56	1.62	1.50	0.0232	0.0487
	2	7.87	5.28	6.71	4.64	2.20	1.95	0.0315	0.0634
	3	9.83	6.40	8.38	5.62	2.75	2.37	0.0393	0.0768
mouldboardless (chisel)	0	2.89	2.33	2.47	2.05	0.81	0.86	0.0116	0.0280
	1	5.38	3.87	4.59	3.40	1.51	1.43	0.0215	0.0464
	2	7.37	5.06	6.29	4.44	2.06	1.87	0.0295	0.0607
	3	9.29	6.10	7.92	5.36	2.60	2.26	0.0372	0.0732
mouldboard & mouldboardless (differential)	0	3.17	2.75	2.70	2.41	0.89	1.02	0.0127	0.0330
	1	5.70	4.28	4.86	3.76	1.60	1.58	0.0228	0.0514
	2	7.71	5.47	6.58	4.80	2.16	2.02	0.0308	0.0656
	3	9.62	6.57	8.21	5.77	2.69	2.43	0.0385	0.0788
disking (continuous shallow)	0	2.96	2.39	2.52	2.10	0.83	0.88	0.0118	0.0287
	1	5.41	3.93	4.61	3.45	1.51	1.45	0.0216	0.0472
	2	7.37	5.13	6.29	4.50	2.06	1.90	0.0295	0.0616
	3	9.31	6.20	7.94	5.44	2.61	2.29	0.0372	0.0744
SD_{05}		0,31	0.28	0.27	0.25	0.09	0.10		

Source: Authors' own results.

The grain yield of spring barley was almost at the same level under mouldboard-mouldboardless and mouldboard tillage, and under chisel and constant shallow – significantly lower. Under mouldboardless and disk tillage, this indicator was lower on 10.9 and 8.2%, respectively, and under differentiated – higher on 2.7% than in the control.

The ratio of basic to by-products under mouldboard, chisel, mouldboard-mouldboardless and systematic shallow tillage in crop rotation was 1.30, 1.33, 1.28 and 1.35 respectively in winter wheat and 1.15, 1.18, 1.13 and 1.21 – in spring barley. Thus, this indicator was highest under disk and mouldboardless, the lowest – under differentiated tillage. On all variants of tillage with increase in norms of the applied fertilizers it grew.

The yield of winter wheat straw was significantly lower under chisel and disk than mouldboard tillage. Under mouldboard-mouldboardless tillage this indicator for winter wheat was lower than in the control, but insignificant. With differentiated tillage, the yield of straw of spring barley was on 0.17-0.23 t/ha higher, and with constant shallow tillage on 0.13-0.20 t/ha lower than in the control (SD_{05} = 0.28 t/ha) (Table 6).

Burcea M. [3] noted that total nitrogen content in the soil was lower in the variants with plowing and disk works, and the variant worked with the chisel determined the best mineralization of the nitrogen. The difference between the variants in terms of total nitrogen content is generated by the distribution of organic matter on the soil profile and the microbiological activity in the soil and decreases on the depth of the arable layer.

The yield of green mass of white mustard under sowing it after winter wheat was the highest under mouldboard tillage in crop rotation, and under chisel, mouldboard-mouldboardless and disk tillage, it decreased on 1.23-1.84, 0.38-0.81 and 1.55-2.13 t/ha, respectively, with SD_{05} = 1.07 t/ha.

As the level of applied fertilizers increased, this difference between cultivation options increased.

Under sowing of white mustard after spring barley, a significant increase in green mass (1.19-1.45 t/ha) was recorded under differentiated tillage compared to the control. Under mouldboardless and systematic shallow tillage, green mass was received less on 1.33-1.96 and 1.64-2.20 t/ha respectively than in the control with SD_{05} = 1.14 t/ha.

The mass of root residues of winter wheat in the arable layer of the soil was the highest under mouldboard tillage, and under chisel, mouldboard-mouldboardless and disk it was on 0.27-0.42, 0.07-0.16 and 0.20-0.36 t/ha less, respectively (SD_{05} = 0.19 t/ha).

The root residues of spring barley was slightly more (on unfertilized plots significantly) under mouldboard-mouldboardless than mouldboard tillage. This indicator was significantly reduced (on 0.13-0.20 t/ha) on the variants under mouldboardless and constant shallow tillage, compared with the control.

As the level of fertilizer increased, both the yield and the mass of root residues of the studied crops increased. However, the latter indicator rose much more slowly than the former. Thus, under fertilization of winter wheat with $N_{100}P_{70}K_{50}$, $N_{125}P_{90}K_{70}$, $N_{150}P_{110}K_{80}$ the increase in grain, compared with unfertilized plots, under mouldboard tillage was 75.1, 132.6, 185.7%, root mass – 41.2, 104.4, 154.4%, mouldboardless – 83.5, 148.7, 208.3 and 46.3, 115.3, 169.5%, differentiated – 76.2, 134.5, 188.5 and 41.6, 105.1, 155.3%, disk – 80.0, 141.3, 199.6 and 43.5, 108.7, 162.5%. The lag of the growth of root mass from the yield under the application of the above fertilizer rates was, respectively, 33.9, 28.2, 31.3% under mouldboard cultivation, 37.2, 33.4, 38.8% – chisel, 34.6, 29.4, 33.2% – mouldboard-mouldboardless, 36.5, 32.6, 37.1% – under systematic shallow tillage.

In spring barley, as well as in winter wheat, increase in dry weight of roots was slower than in marketable products, on fertilized variants, compared with unfertilized, recorded under mouldboardless and disk tillage. In the fertilized plots with $N_{50}P_{40}K_{40}$, $N_{60}P_{50}K_{50}$, $N_{70}P_{60}K_{60}$, compared to the unfertilized, the increase was 57.8, 101.7, 139.2% of grain and 27.3, 66.9, 98.8% of the root mass under mouldboard tillage, 61.9, 109.3, 149.3 and 29.2, 70.8, 103.2% – mouldboardless, 53.0, 92.1, 126.5 and 23.1, 58.1, 87.1% – differentiated, 60.1, 106.6, 146.5 and 28.9, 69.2, 102.5% under disk tillage. The increase in root mass was less than the increase in grain at the above rates of fertilizers, compared with unfertilized plots, respectively, on 30.5, 34.8, 40.4% under mouldboard tillage, 32.7, 38.5, 46.1% – chisel, 29.9, 34.0, 39.4% – mouldboard-mouldboardless, 31.2, 37.4, 44.0% – under constant shallow tillage.

In white mustard on fertilized plots, compared with unfertilized, the slowdown in root growth compared to aboveground mass, was less than in winter wheat and spring barley. During the sowing of this crop after winter wheat on the variants under application of the first, second and third levels of fertilizer in crop rotation, the increase in root mass lagged behind the increase in aboveground, compared with unfertilized plots, respectively, on 10.6, 14.7 and 17.0% under mouldboard tillage, 13.7, 16.0 and 18.5% – mouldboardless, 13.6; 15.5 and 16.6% – differentiated, 15.1, 17.2 and 17.8% under disk tillage.

After spring barley for the first, second, third levels of fertilization in crop rotation, the increase in green mass of white mustard, compared with unfertilized plots, was respectively 59.7, 106.8, 138.8% and root residues – 48.1, 93.8, 124.1% under mouldboard tillage, 66.8, 109.6, 155.1 and 53.6, 104.3, 137.7% – chisel, 50.2, 90.0, 116.7 and 38.1, 76.2, 100.5% – mouldboard-mouldboardless, 70.0, 125.2, 162.7 and 54.5, 107.6, 143.9% under constant shallow tillage. The difference in the growth of aboveground and underground mass at these levels of fertilizer was 11.6, 13.0, 14.7% in the control variant, 13.2, 15.3, 17.4% – under mouldboardless tillage, 12.1, 13.8, 16.8% – differentiated, 15.5, 17.6, and 18.8% – under disk tillage.

In winter wheat and spring barley, the widest ratio of grain to dry mass of root residues was under mouldboard tillage (respectively 1.505 and 1.605), the narrowest – under chisel hoeing (1.480 and 1.565). In white mustard, these differences were less expressed.

The widest ratio of grain and green manure to dry mass of roots was recorded at the first level of fertilizer, the narrowest – on unfertilized plots. Thus, at zero, first, second and third levels of fertilizer, this indicator was, respectively, 1.315, 1.645, 1.513 and 1.495 in winter wheat, 1.353, 1.683, 1.648 and 1.643 – in spring barley, 5.443, 5.923, 5.858 and 5.848 – in white mustard (after spring barley).

The dry matter of grain and straw of winter wheat was obtained significantly less under mouldboardless and disk tillage and insignificantly – under differentiated than mouldboard tillage in crop rotation. On the unfertilized plots of the plants, fertilized with $N_{100}P_{70}K_{50}$, $N_{125}P_{90}K_{70}$ and $N_{150}P_{110}K_{80}$, the collection of feed units of grain and straw was lower, respectively, on 0.61, 0.76, 0.88 and 0.98 t/ha under chisel tillage, 0.17, 0.23, 0.31 and 0.38 – mouldboard-mouldboardless, 0.47, 0.65, 0.80 and 0.86 t/ha – under shallow tillage, compared with the control. A similar pattern was observed for the output of digestible protein. With increasing fertilizer rates, the difference in the productivity of winter wheat between tillage options increased (Table 7).

Productivity of spring barley (grain + straw) on the unfertilized variants fertilized with $N_{50}P_{40}K_{40}$, $N_{60}P_{50}K_{50}$ and $N_{70}P_{60}K_{60}$ under mouldboardless tillage was, respectively, lower on 0.47, 0.59, 0.68 and 0.79, disk – 0.35, 0.46, 0.52 and 0.59 t/ha of fodder units, and under differentiated – on 0.28, 0.24, 0.17 and 0.14 t/ha higher than in the control. Dry matter and digestible protein from the main and by-products were obtained on average, respectively, – 3.56 and 0.349 t/ha under mouldboard tillage, 3.18 and 0.315 – chisel, 3.66 and 0.359 – mouldboard-mouldboardless, 3.27 and 0.323 t/ha under shallow tillage in crop rotation.

The productivity of winter wheat (grain + straw) on unfertilized plots fertilized with $N_{100}P_{70}K_{50}$, $N_{125}P_{90}K_{70}$ and $N_{150}P_{110}K_{80}$ was respectively 4.79, 8.62, 11.61 and 14.49 t/ha of dry matter, 3.80, 6.80, 9.13 and 11.33 t/ha of feed units, 0.226, 0.403, 0.540 and 0.668 t/ha of digestible protein.

When the applying $N_{50}P_{40}K_{40}$, $N_{60}P_{50}K_{50}$ and $N_{70}P_{60}K_{60}$ under spring barley, its productivity (grain + straw) increased, respectively, on 2.48, 4.39 and 6.08 t/ha of dry matter, 2.18, 3.85 and 5.31 t/ha of feed units, 0.112, 0.197 and 0.271 t/ha of digestible protein, compared with unfertilized variants, where these indicators were, respectively, 4.15, 3.72 and 0.191 t/ha.

Table 7. Productivity of fields of cereals ear crops under various systems of the main tillage and fertilizers in crop rotation, t/ha

The main tillage in crop rotation	Fertilizer levels in crop rotation	Winter wheat				Spring barley			
		Dry matter		fodder units (grain+straw)	digestible protein (grain+straw)	Dry matter		fodder units (grain+straw)	digestible protein (grain+straw)
		grain	grain+straw			grain	grain+straw		
mouldboard (control)	0	2.35	5.15	4.11	0.245	2.04	4.25	3.85	0.198
	1	4.12	9.07	7.21	0.429	3.22	6.78	6.10	0.315
	2	5.47	12.18	9.63	0.572	4.11	8.75	7.83	0.402
	3	6.72	15.10	11.88	0.702	4.88	10.50	9.34	0.480
mouldboardless (chisel)	0	1.98	4.45	3.50	0.208	1.76	3.81	3.38	0.174
	1	3.64	8.23	6.45	0.381	2.86	6.26	5.51	0.282
	2	4.93	11.22	8.75	0.516	3.69	8.13	7.15	0.366
	3	6.11	14.03	10.90	0.640	4.39	9.75	8.55	0.436
mouldboard & mouldboardless (differentiated)	0	2.25	4.95	3.94	0.235	2.18	4.59	4.13	0.213
	1	3.97	8.83	6.98	0.414	3.33	7.09	6.34	0.326
	2	5.28	11.86	9.32	0.551	4.18	8.98	8.00	0.411
	3	6.49	14.70	11.50	0.679	4.93	10.70	9.48	0.486
disking (continuous shallow)	0	2.07	4.59	3.64	0.216	1.83	3.93	3.50	0.180
	1	3.72	8.33	6.56	0.389	2.93	6.38	5.64	0.289
	2	4.99	11.28	8.83	0.522	3.78	8.28	7.31	0.374
	3	6.20	14.14	11.02	0.649	4.52	9.96	8.75	0.447
SD_{05}		0.28	0.49	0.41	0.026	0.19	0.31	0.28	0.017

Source: Authors' own results.

The average productivity of winter wheat and spring barley according to the experimental variants was 9.88 and 7.39 t/ha of dry matter, 7.77 and 6.56 t/ha of feed units, 0.459 and 0.336 t/ha of digestible protein, respectively.

The lowest cost of one grain ton of winter wheat and spring barley (respectively, 3.89 and 3.78 thousand UAH), the highest conditionally net profit (6.36 and 4.32 thousand UAH/ha) and the level of profitability (34.9 and 32.4%) were obtained in the experiment under mouldboard-mouldboardless tillage in crop rotation and application per hectare of arable land 12 tons of manure + $N_{95}P_{82}K_{72}$, including $N_{125}P_{90}K_{70}$ under winter wheat and $N_{60}P_{50}K_{50}$ – under spring barley. In this variant, the energy output with the yield of the main production of the above-mentioned crops was 78.1 and 57.7 GJ/ha, respectively, the main and secondary – 178.1 and 120.9 GJ/ha; coefficient of energy efficiency of marketable products – 1.4 and 2.3, and marketable and non-marketable – 3.2 and 4.8.

CONCLUSIONS

On the date of sowing of winter wheat reserves of available moisture in the upper (0-10 cm) layer of soil were highest under mouldboard tillage in crop rotation, in arable (0-30 cm) and meter layers – under mouldboard-mouldboardless tillage. In the tillering phase, its upper and meter layers of soil are most moist under mouldboard tillage, and arable – under differentiated. Mouldboardless and disk tillage were significantly inferior to the control variant. On the date of sowing of spring barley, the advantage of this indicator was in the upper and arable layers of the soil under mouldboard tillage, in the meter – under differentiated.

In the tillering phase of the crop, available moisture in the studied layers of typical black soil was the most under mouldboard-mouldboardless tillage, the least – under chisel and disk.

On the date of sowing of white mustard after both predecessors, the most moist soil layers were under differentiated tillage, and at the end of the growing season the reverse pattern was observed.

The ratio of grain to straw was the widest under shallow and mouldboardless tillage, the narrowest – under mouldboard-mouldboardless.

The dry mass of root residues of winter wheat was the largest under mouldboard tillage, and spring barley – under differentiated. Significantly lower values of this indicator were under mouldboardless and disk tillage. With increasing fertilizer rates, it grew more slowly than the mass of grain or green manure.

Yield of grain crops was almost at the same level under mouldboard and mouldboard-mouldboardless tillage in crop rotation. Applied in the soil green mass of white mustard after winter wheat was significantly more under mouldboard tillage, and after spring barley – significantly more under differentiated tillage. Under systematic mouldboardless and shallow tillage, the productivity of the main and post-harvest crops was significantly reduced.

The highest indicators of economic efficiency of growing cereals with post-harvest white mustard for green manure were obtained by applying 12 tons of manure per hectare of crop rotation + $N_{95}P_{82}K_{72}$ (including $N_{125}P_{90}K_{70}$ under winter wheat, $N_{60}P_{50}K_{50}$ under spring barley, $N_{15}P_{15}K_{15}$ under white mustard) and carrying out differentiated main tillage in crop rotation, which involves deep (25-27 cm) cultivation in only one field, and in the rest of the fields – mouldboardless and disk shallow tillage.

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SHAPING CIRCULARECONOMY IN ROMANIA IN THE CONTEXT OF GREEN DEAL

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Abstract

This paper is an overview of comparison of bioeconomy indicators, in Romania and European Union, related to Green Deal Pact of the EU..The so called European Green Deal, is a set of proposals adopted by European Commission in order to reduce the climate change by 2050.Official statistical data related to green transition were retrieved from Eurostat database. Specific indicators taken into consideration were circular material use rate, raw material consumption, valued added at factor cost and environmental protection expenditure. Comparison of the dynamics of these indicators for Romania vs other European Union member states, for latest available data, was plotted. When analyzing the data it can be observed that steps are being taken in each state towards fulfilling the objectives of green transition. However, Romania's bioeconomy is still underdeveloped as compared to most of the EU's member states.In order to support the Green Deal targets we need a national strategy and action plan towards green and just transition of our economy.

Key words: *bioeconomy, sustainable development, Romania,Green Deal*

INTRODUCTION

One of the most ambitious plans that European Union has ever released is The European Green Deal, which represent a growth strategy focused to transform EU's economy to become more competitive while being resource-efficient. Therefore, it is foreseen the climate neutrality by 2050, in the context of greening the economy, turning the industry and transportation into sustainable sectors and reducing pollution.

European Commission has defined in the policy area of Green Deal eight areas [7]:
- more action in order to adapt and combat the climate changes;
-energy production: clean, accessible and safe;
- targeting the industry to a clean and circular economy;
- efficient buildings in terms of energy and resources;
-creating new sustainable and intelligent mobility systems;
- biodiversity and ecosystems conservation;
- sustainable food chains (from farm to fork strategy);
- zero pollution and no toxic substances for the environments.

One of the main objectives of the European bioeconomy strategy is to create a sustainable and circular bioeconomy, in order to provide a wide range of products and services, without affecting natural resources and ecosystems. This strategy is focused on four key areas: research and innovation, the market expansion, sustainable production along with and sustainable consumptionand last but nor least, governance.

It also includes initiatives to promote the use of renewable resources, reduce food waste, and promote sustainable agriculture. It is considered that the bioeconomy can contribute to achieving the objectives of the Green Deal, by:
-Increasing Europe's economic competitiveness and ensuring a just transition.
-Producing materials from renewable resources for a climate-neutral economy.
-Improving environmental protection and protecting ecosystems [19].

This is evidenced by the general accepteddefinition of the bioeconomy, which proposes sustainable models of production and consumption of resources, while respecting planetary limits and moving away from a linear economy based on the large-scale use of fossil and mineral resources [6].

For example, the sequestration of carbon in the soil, or its storage in wood products, together with the replacement of materials produced from non-renewable raw materials (plastics, energy, textiles), generates significant carbon savings [4] and lead to the achievement of the objective of increasing climate action and the -55% target by 2030.

The use in the transport sector of cellulosic ethanol obtained from agricultural residues such as wheat straw, sunflower stalks [2] can generate emissions savings of up to 95% compared to fossil fuels, improving mobility systems [14].

The bioeconomy can ensure the achievement of just transition goals by creating 400,000 new jobs in ecological sectors by 2035, especially in rural and coastal areas, if supported and implemented through regional and national strategies [1].

In this study we have analyzed one-decade dynamics of several official statistics indicators related to green and just transition included in Green Deal targets. All indicators are included in circular bioeconomy concept, as an emerging sustainable economic growth pathway.

MATERIALS AND METHODS

Official data were extracted from Eurostat database for a ten years period. The graphics are presented for latest available data which depend on the specific indicator.Data reported for Romania were compared to EU-27 data.

Raw material consumption is a measure of how much of a given raw material is being used by a particular industry or group of industries. This consumption is calculated by taking into consideration theraw material used in the production of marketed goods and services.

The sustainability of resource use is measured by involving a composite indicator called the Circular Material Use Rate (CMUR) developed by the European Union's Statistical Office, calculated as follows:

$$CMUR = QT/GDP$$

where:

QT is the total material consumption

GDP is gross domestic product.

This indicator is used formeasuringthe efficiency of resources utilisation and for making comparisons across EU’s various regions.

A measure of goods and services value of produced in an economy, excluding taxes and subsidies, is value added at the cost of the production factors. Its calculation is made by subtracting from the production value the cost of intermediate inputs and dividing the resulted value by the number of employeesfrom the production process.

The environmental protection expenditure by institutional sectorincludes expenditure on air pollution control, water pollution control, waste management, nature protection, and other environmental protection activities.

RESULTS AND DISCUSSIONS

When analyzing the European Bioeconomy strategies already in place, it can be observed that the economic sectors included in the sphere of the bioeconomy are different, depending on the available resources and the results generated by the research and development field.Thus, the differences between approaches, priorities and key objectives are explained.

As the bioeconomy became a widespread concept in strategic documents with European coverage, and implicitly in the funding priorities of the various existing programs, national strategies became broader, covering a wide range of sectors, product generators and innovative processes. A special emphasis is placed on the transition from research-development to research-development-innovation. Therefore, it can be stated that the key element of the leap of knowledge and implicitly of the transformation of the economic system is innovation.

All in one, the bioeconomy strategy focuses on four main areas: research and innovation,

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market development, sustainable production and consumption, and governance.

Thus, although through varied approaches and various mechanisms, a collective European vision of a climate-neutral economy has emerged. Moreover, there are several other strategies and action plans supporting the transition to the bioeconomy, which have been launched recently, aimed, among other things, at managing the problems arising from the health crisis caused by COVID 19.

Still, the bioeconomy (according to the European Commission) can contribute to economic recovery from the COVID-19 crisis by aligning the economy with the resources of the biosphere. Although, there is limited data of the pandemic impact on the bioeconomy and the link between those two (bioeconomy and post-COVID-19 recovery) is still being discussed by experts, not only in light of the impacts, but also of the possible responses [21].

The passing from an extractive economy type to a regenerative one is built on a set of principles, processes and practices [15] based on the integrated approach of production and consumption cycles [5, 17].

Setting up dedicated policies and involving specialised organizations for bioeconomy on a nationaland international scale [16]is a cornerstone in the paradigm shift from the linear economy to the sustainable economy [13].

Such strategies can only rely on proper data analysis related to available resources and to consumption patterns [18]. The consumption data are needed for targeting further industrial development, for identifying research gaps and for directing the innovation practices for advancing of new technologies[3].

When we speak about circularity and the need to avoid resource depletion the key indicator is the **consumption of raw material**, which is a measure of the amount of raw materials used in a given period of time. It is an important indicator of economic activity, as it reflects the demand for goods and services.

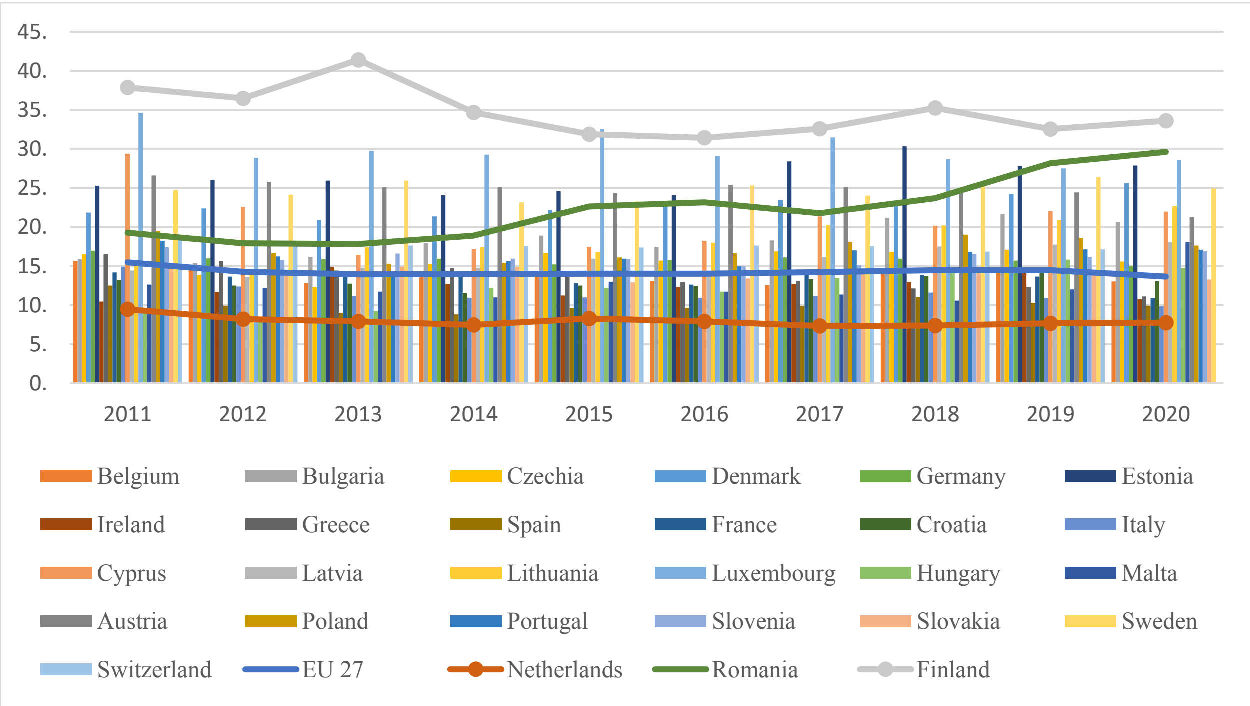

Fig. 1. Raw material consumption across EU (tonnes per capita)
Source: Own design based on the data from Eurostat [8].

Examples of bioeconomy materials include biomass, bioplastics, biofuels, biochemicals, biopolymers, and bioproducts. The flow of these materials is driven by the demand for sustainable products and services, and the need to reduce the environmental impact of production and consumption [20]. Bioeconomy material flow is the movement of materials, energy, and information within the bioeconomy. It comprises various stages of the production cycle such as extracting the raw materials, processing, transportation and use of the secondary products of the biological resources.

While in European Union the raw material consumption has slowly decreased in the last 10 years (with 11% from 2011 to 2020), in Romania it has increased significantly (with over 53% from almost 20 tonnes per capita (19,269) in 2011 to almost 30 tonnes (29,616) per capita in 2020 (Figure 1).

However, the country with the highest increase in raw material consumption was Hungary, reaching a 63 % more in 2020 than in 2011.

Although with a decreasing trend, the country with highest values for material consumption over the studied period was Finland and the one with lowest values was Netherlands.

The variety of approaches to defining and implementing bioeconomy principles creates conflicting opinions. On the one hand, there are concerns related to the over-exploitation of natural resources and biodiversity loss. On the other hand, there is a positive projection of the development and benefits of a bioeconomy, especially in terms of reducing greenhouse gas emissions and reducing human waste through recycling and reusing recovered material.

The circular material use rates indicator, which shows the share of materials used in the production process that come from recycled or reused streams is used for monitoring progress towards resource efficiency targets.

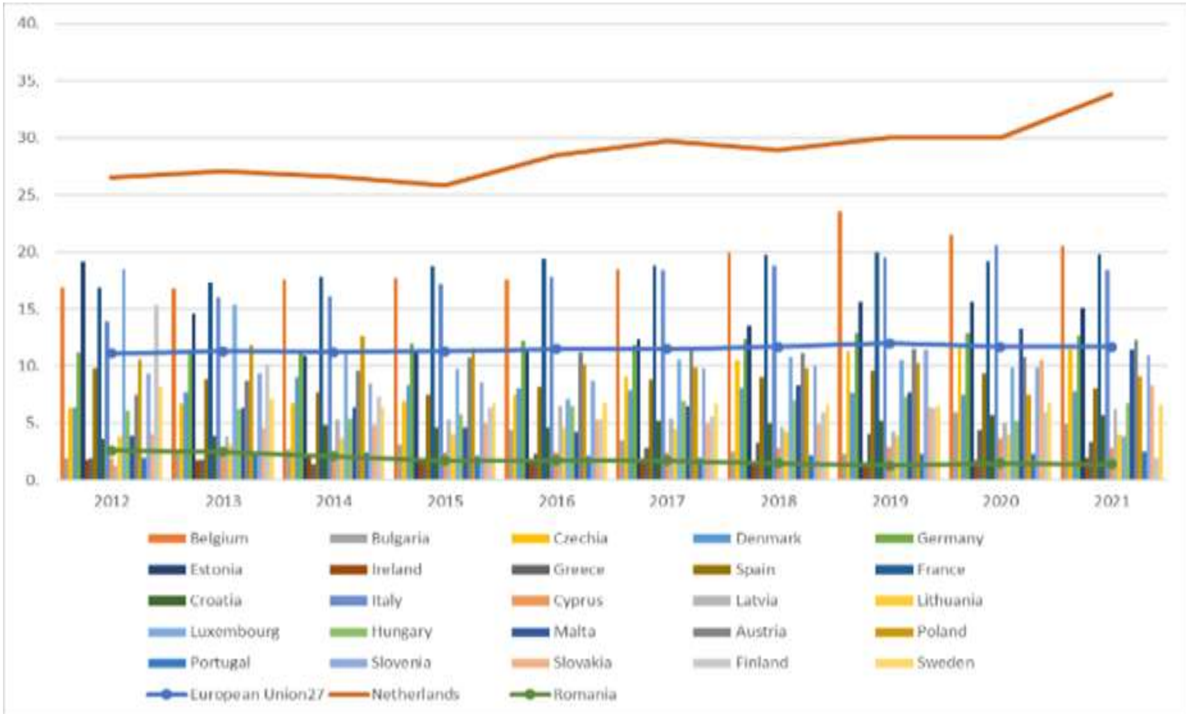

Fig. 2. Circular material use rate (%)
Source: Own design based on the data from Eurostat [9].

This approach seeks to use renewable resources and biotechnology to create products, energy, and materials that can be reused, recycled, and repurposed. It also seeks to reduce waste and emissions while promoting economic growth through the development of new markets and industries. This strategy can be applied to a wide range of materials, from food and timber to plastics and textiles. By utilizing renewable resources and biotechnology, we can create an efficient and sustainable circular bioeconomy that conserves resources and supports economic growth. Although there were released many strategies on circular economy, and countries put an effort into waste reduction, the circularity rate in EU during the last ten years

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Vol. 23, Issue 1, 2023
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was almost constant, with a very low increase rate (Figure 2).

In Romania, the use rate of circular material has decreased by 46.15% in 2021 compared with 2012. Unfortunately, in 2021, our country had the lowest circularity rate in EU. (Figure 3).

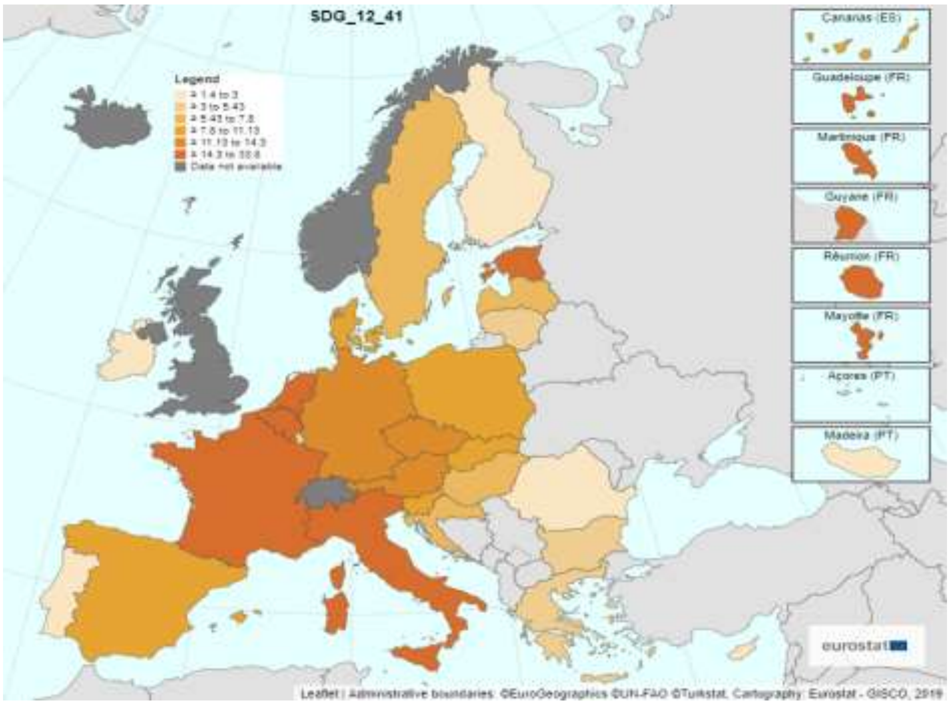

Fig. 3. Material flows for circular economy across EU, 2021
Source: Own design based on the data from Eurostat [10].

At this moment, as entire society (from producers, entrepreneurs, decision makers, and citizens) becomesmore and more aware of the need of its sustainable development, material flows in Europe's circular economy are changing.

Considering that the core principleof circular economy is closing the loop by optimizing resource use and reducing waste, the material flows indicator is reflecting the level of development of circular economy of a specific region. As this system involves reusing, recycling, and upcycling materials and products to create a more efficient and sustainable economy, it can be stated that any circular process in economy will contribute to achieving at least one target of the latest green transition strategies across nations.

In Europe, there are a number of initiatives that are being implemented to promote circular economy practices, and this is reflected in the values of the material flows from official statistics (Figure 3). These initiatives span across all sectors and include government initiatives, private sector initiatives, and citizen initiatives.

One example of a European initiative is the European Commission's Circular Economy Action Plan. This plan outlines five key areas of focus, including resource efficiency, waste prevention, reuse and repair, recycling, and bio-based products. The plan also lays out targets for each area and provides resources for implementing these initiatives. Another example of a European initiative is the European Union's Circular Economy Package. This package of measures includes rules and actions to reduce the quantities of waste and at the same time increase the reuse of materials and resources. It provides provide real support to businesses for the R&D of new practices for the circular economy.

In addition to these initiatives, each EU Member State developed its own national projects and initiatives towards circular economy processes and technologies.

For example, in Germany, the Circular Economy Promotion Act provides incentives for businesses to reduce waste and increase

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 1, 2023
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the reuse of materials and resources. In France, the Initiative for a Circular Economy has been launched to create a network of public and private actors to promote sustainable practices.

Overall, the movement towards a circular economy across Europe is gaining momentum. As more businesses, governments, and consumers become aware of the importance of circular economy practices, the material flows across Europe are changing to become more sustainable and efficient.

Another way to evaluate the bioeconomy development towards fulfilling the Green Deal targets is related to**competitiveness and innovation capacity**. This index can be used to compare the performance of different countries or regions in the bioeconomy, and to identify areas where further investment and innovation are needed.Value added at factor cost is a key indicator of economic growth, as it measures the contribution of circular economy to the overall economy. Anyway, due to the fact that several EU states treat these data as being confidential, the average data are estimated and their reliability decreases. However, available data show that there is an increasing trend of this indicator for Romania starting with 2014 (Figure4).

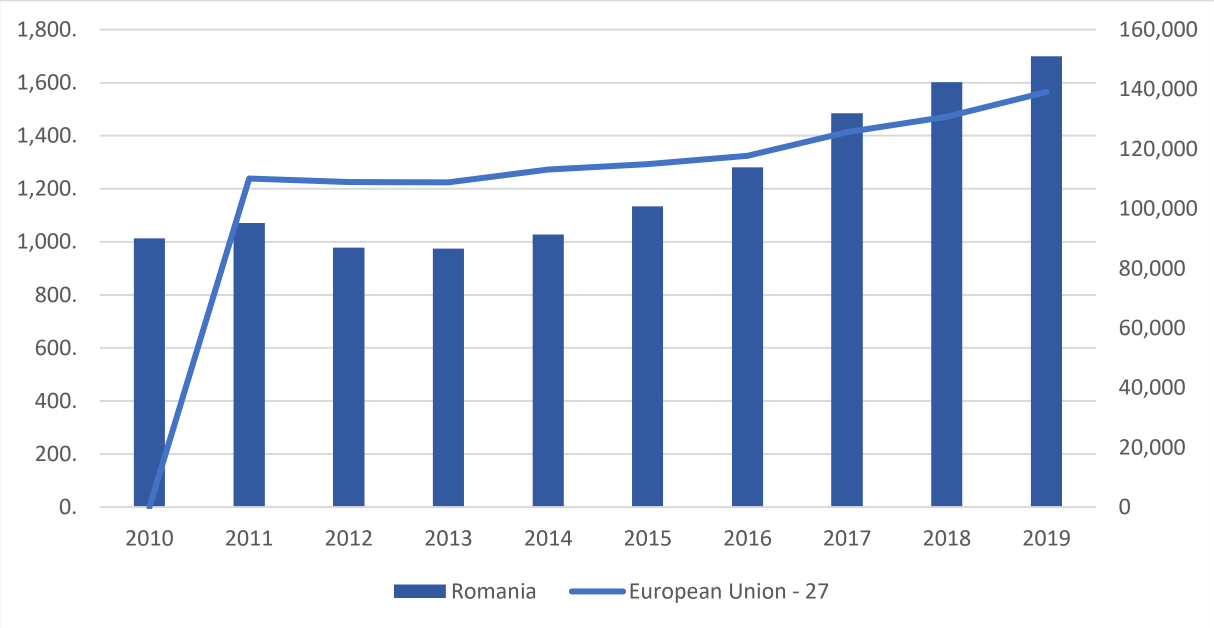

Fig. 4. Value added at factor cost for Romania as compared to EU average (million EUR)
Source: Own design based on the data from Eurostat [11].

National expenditure on environmental protection by institutional sector, includes the total amount of money spent on environmental protection, expenditure by sector (energy, transport, water, waste management, etc.) and by type of activity (prevention, restoration, etc.

The values for this indicator in Romania are plotted in Figure 5. The average environmental protection expenditure in EU, was around 2% of GDP for the last decade. In Romania, the value was below 1.6 in the period 2012-2019, with lowest value being spent in 2017.

It is obvious that EU has serious concerns for environmental protection and related issues, and therefore significant funds will be invested for this.

The European Green Deal allocation for circular economy and just transition will reach a thousand billion euros in the next ten years, bringing together citizens, businesses and local authorities to work towards a sustainable and inclusive future.

Environmental protection expenditure related to the bioeconomy typically involves investing in new technologies and research to create sustainable ways of producing food, energy, and materials that reduce the negative environmental impact of traditional economic activities. This can involve investing in renewable energy sources, sustainable agriculture and forestry, and energy efficiency measures. Governments may also invest in waste management and water pollution control measures, as well as in the development of biobased products. In addition, public funding may be used to encourage the uptake of green technologies, such as electric and hybrid vehicles, and biofuels.

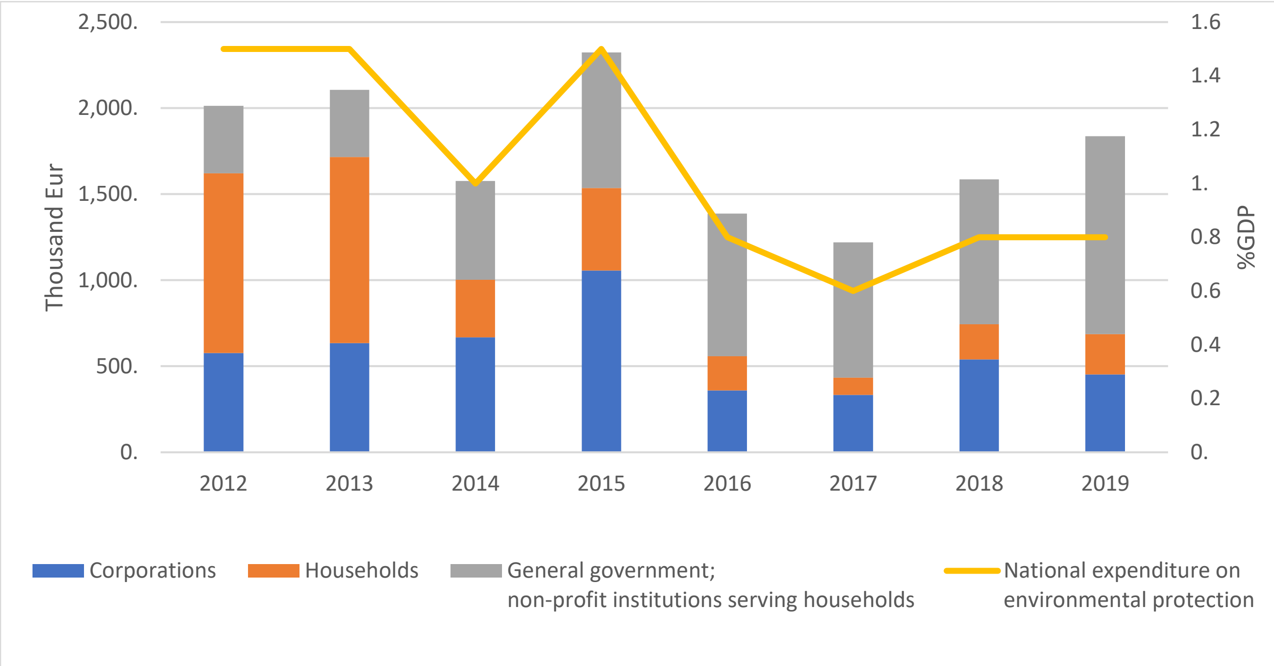

Fig. 5. National expenditures on environmental protection by institutional sector and percentage of gross domestic product.
Source: Own design based on the data from Eurostat [12].

CONCLUSIONS

The bioeconomy sector is considered an engine of change necessary for the implementation of the action plan included in the Green Pact, addressing economic, social and environmental aspects. It is a rapidly growing sector, and the material flow associated with it is becoming increasingly complex. This complexity is driven by the need to develop new technologies and processes to meet the needs of a growing global population.

Proposed by the European Commission and adopted in 2019, the European Green Deal, aims to bring climate neutrality in Europe by the next 30 years. The Bioeconomy strategy, included in this set of initiatives, aims to create a circular and sustainable bioeconomy for delivering goods and services to European citizens, while preserving resources and ecosystems.

It also includes initiatives to promote the use of renewable resources, reduce food waste, and promote sustainable practices. Steps are being taken in each state towards fulfilling the objectives of green transition. However, when analyzing the data,it can be observed that Romania's bioeconomy is still underdeveloped as compared to most of the EU's member states. A national strategy and action plan towards green and just transition of Romanian economy is definitely needed for supporting Green Deal targets.

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ORGANIZATIONAL AWARENESS AND MARKETING PREFERENCES OF MEMBERS OF AGRICULTURAL PRODUCER ORGANIZATION: THE CASE OF TURKEY

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Abstract

This paper reviews the organizational awareness and marketing preferences of members of producer organizations in agriculture. The main material of this research consisted of surveys applied to 360 producers determined via the Proportional Sampling Method in Uşak province, Turkey. According to the research results, each of the producers was a member of at least one Producers' Organization (PO). 59.1% of producers were interested in the PO, and 33.6% of them think that crops should be marketed by the Agricultural Development Cooperative. The ratio of member producers marketing their products through the POs was 19.7%. Only 38.4% of members were satisfied with the selling price of products. The POs in the region were generally successful, and the most successful one was also the Agricultural Development Cooperative with 72.3%. In the study, marketing prices, satisfaction with being a member of the POs, and satisfaction with the organizational management variables were tested by the Chi-square, and it was viewed that there was no significant difference among them. The study is important in increasing the effectiveness of the POs in all areas of agriculture and improving the organizational awareness of their members.

Key words: *marketing, members and membership, organizational awareness, producer organizations, selling price, variables*

INTRODUCTION

When the inclinations of individuals to act together are examined in working life, it is considered that organizational structure is of great importance. The organization of individuals has become a more important issue with civilization. Today, we are all witnessing that the people are organized in every field in particular and take active charge in the organizational structure [10]; [9].

In Turkey, the small scale of most agricultural enterprises, weakness in their competitive powers, and their insufficiency in marketing shares slow down the organizational activities. In addition, the low education level, the weak organizational awareness and managerial skills of rural people also become effective over organizational developments [29]; [12]; [5].

In societies that rural settlements dominate, the PO is more important [7]; [15]. Developing the rural people in all respects, equipping them with education and information, and preserving the heaviness of agriculture in the economy will only be possible with the organization of the producers. In other words, the PO is needed to protect the social and economic interests of the rural people[13]; [11].

The POs are formal rural organizations whose members organized themselves with the objective of improving farm income through improved production, marketing, and local processing activities [21]; [14]. The PO is an activity having social and economic targets. These organizations are of capital importance in keeping the culture of democracy alive, creating employment opportunities, activating resources, investing, fighting poverty, and economic and social development [20]; [28].

Several organizations take on the task of protecting the interests of rural people in Turkey [1].These organizations were

established for protecting the social, economic, and professional interests of rural people [24]; [4]. In particular, Agricultural Cooperatives, Chambers of Agriculture, Stud Breeders Association, Producer Associations, and Agricultural Credit Cooperatives are the organizations established for stated purposes.
In Uşak province, where the research was conducted, there are 73 Agricultural Development Cooperatives, 34 Irrigation Cooperatives, 1 Sugar Beet Growers Cooperative, 6 Chambers of Agriculture, 3 Stud Breeders Associations, 8 Producer Associations, 23 Agricultural Credit Cooperatives, 6 Taking Services to Villages Associations and 1 Uşak Region Livestock Farming Cooperatives Association.
In Uşak, the research region, the first PO took place with the establishment of the first sugar beet sugar factory in 1925 [19]. This organizational activity, which started with the Sugar Beet Growers Cooperative, later spread to all branches of agriculture [6]. In order that Uşak province, which has an important potential in plant and animal production, could be more active in agriculture, the producer should have sufficient knowledge about the POs and improve organizational relations.
The principal purpose of this study is to detect the producer's knowledge level about POs and to reveal statistically the rating of the relationship among parameters. The POs are agricultural cooperatives, chambers of agriculture and associations.
So that the producers can sufficiently suck advantage out of the POs, their organizational awareness must primarily improve and the organizational problems must be solved [17]; [8]. Thus, productivity will increase in the region, agricultural marketing will get easy, rural migration and unemployment will reduce.
In Uşak province, no previous study conducted about the PO has been come across previously. From this point of view, the study is important in respect to being original, scoping important data, and shedding light on other researches to be conducted on similar issues.
It is thought that this study, in addition, will also serve as a model for organizational studies in other sectors and contribute to the creation of new policies in this regard.

MATERIALS AND METHODS

Materials

The main material of this research consisted of primary and secondary data. The primary data were collected through surveys from the producers determined by the Proportional Sampling Method in the Uşak province.
The fieldwork was done in the period 2012-2013.
The previous research conducted and books published about the POs; the statistics and publications of the Ministry of Agriculture and Forestry, the Turkish Statistical Institute, and the provincial and central organizations of the POs also formed the secondary data sources of the research. Both primary and secondary data contain the latest up-to-date information on the subject.

Methods

The research was conducted in six districts and their villages including the central district of Uşak province. The provinces of Turkey were divided into zones according to their agricultural potential within the scope of the Agricultural Extension Development Project. According to this, 72 zones were deemed suitable for Uşak province within the scope of this Project. These zones were also considered as the most homogeneous zonal distribution in conducting our research and surveys.
The Proportional Sampling Method was used in determining the sampling size. In this method, the formula presented below was used [18]; [22].

$$n = \frac{N_p(1-p)}{(N-1)\sigma^2{}_{p_x} + p(1-p\,)}$$

where:
n = Sampling size,
N_p = The number of total units belonging to the sampling frame,
p = Ratio of the studied feature on in the number of total units,
$\sigma^2{}_{p_x}$ = Variance.
According to the formula, the sampling volume was calculated as 360 for an error margin of 5% and a confidence interval of 95%.

Before conducting the survey, the producers were provided informed consent and this consent was verbal. Thus, loyalty and confidence in the research were brought into.
The surveys were conducted face-to-face with the farmer members. The surveys forms; consisted of the problems of the POs, members' interest in the PO, opinions about the supervision of the POs and the government-the PO relations, preferences about the marketing of the products, opinions about the POs to market products, satisfaction status with the selling price of products, opinions on the evaluation of products and the success of the POs, etc.
After necessary controls and calculations in the filled survey forms, the data obtained were entered into the computer. A general database was created in the Microsoft Excel package program for the data entries, and a general coding plan was made according to the questions asked. Thus, the data were entered into the computer according to this coding plan and analyzed in a computer-based statistical package program. Analysis results were given in tables and supported by comments. In the analysis, in addition, it was also benefited from descriptive statistics (mean, percent, etc.) in evaluating the findings.
In the study, in addition, members' age, education, position in the PO, participation in general boards, interest in the PO, marketing of products and the advantages of the POs, satisfaction with being a member, the reason for participation in general boards, satisfaction with the management of the PO, supervision of the POs, satisfaction with product prices, the POs to market products were examined, and the relationships among variables were tested by Chi-square.

RESULTS AND DISCUSSIONS

Results

Members' interest in POs

In the study, members' interest in the PO was examined, and given in Table 1. According to this, 33.6% of members responded "Some of them are interested". The ratio of those responding "All of them are interested" was detected at 5.8% and the ratio of those responding "None of them is interested" was also 16.9%.

Table 1. Members' interest in POs

Members' interest	**Number of members**	**(%)**
Some of them are interested	121	33.6
Only a few people are interested	71	19.7
None of them is interested	61	16.9
No idea	55	15.3
Non-responders	31	8.6
All of them are interested	21	5.8
Total	360	100.0

Source: Research results.

Supervision in POs

When the question "Who should supervise the POs" is examined; the ratio of stating "Only the government should supervise" was detected as 43%, that of stating "The internal supervision should be carried out by their own organs and the external supervision should be carried out by the government" was as 28,6%. 2.8% of the members didn't respond to this question (Table 2).

Table 2. Members' point of view on supervision of POs

Members' point of view	**Number of members**	**(%)**
Only the government should supervision the PO.	155	43.0
Internal supervision should be carried out by own organs and external supervision should be carried out by the government.	103	28.6
Only independent organizations should supervise the PO.	40	11.1
Only the supervising board should supervision the PO.	33	9.2
Only top organizations should supervise the PO.	19	5.3
Non-responders	10	2.8
Total	360	100.0

Source: Research results.

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Government-PO relations

When the intervention of the government in the POs was analyzed, 5.8% of them responded "The government should not interfere in the POs at all" and 38.6% of them responded "The government should intervene in the POs when required". The ratio of those responding "The PO should be an institution of the government" is also 16.7% (Table 3).

It was thought that those responding to this question believed that the PO was an independent and autonomous institution.

Table 3. Members'vision on government and PO relation

Government and POs relations	Number of members	(%)
The government should intervene in the POs when required	139	38.6
The government should encourage, but not interfere in the POs	124	34.4
POs should be institutions of the government	60	16.7
The government should not interfere in the POs at all	21	5.8
Non-responders	16	4.5
Total	360	100

Source: Research results.

34.4% of the members requested that the government should encourage the POs. 16.7% of the members also thought that the POs should be an institution of the government.

Marketing preferences of members of POs

In Table 4, the members' marketing preferences for their products were examined and the ratio of POs to take charge in the marketing of products marketing only through traders was detected 53.4% and that of POs to take charge in the marketing of products marketing only in the marketplaces was 11.3%.

Which POs should agricultural products be marketed by?

In the study, it was also researched which POs should the products be marketed by, and the ratio of the members responding "Agricultural Development Cooperative" was determined at 33.6%, that of those responding "Agricultural Credit Cooperative" was 20.8% and that of those responding "Producer Association" was 16.7% (Table 5).

Table 4. Members' marketing preferences

Marketing preferences	Number of members	(%)
Traders	179	53.4
Agricultural Development Cooperative	39	11.6
Marketing in the marketplace	38	11.3
Trader/Marketing in the marketplace	20	6.0
Stud Breeders Association	14	4.2
Agricultural Credit Cooperative	13	3.9
Agricultural Development Cooperative/Trader	11	3.3
Agricultural Development Cooperative/ Trader/Agricultural Credit Cooperative	6	1.8
Stud Breeders Association/Trader	6	1.8
Trader/Agricultural Credit Cooperative	4	1.2
Agricultural Development Cooperative /Trader/Marketing in the marketplace	3	0.9
Agricultural Development Cooperative/ Marketing in the marketplace	1	0.3
Stud Breeders Association/Trader/Marketing in the marketplace	1	0.3
Total	335	100.0

Source: Research results.

Table 5. Members' PO preferences in the marketing of agricultural products

POs	Number of members	(%)
Agricultural Development Coop.	121	33.6
Agricultural Credit Cooperative	75	20.8
Producer Association	60	16.7
Chamber of Agriculture	45	12.5
Non-responders	39	10.8
Stud Breeders Association	18	5.0
Irrigation Cooperative	2	0.6
Total	360	100.0

Source: Research results.

Members' satisfaction with selling price of agricultural products

69.72% of the members market their products.

In the research, the members' satisfaction status with the selling prices of products was examined, and the ratio of those responding "I am very satisfied" was detected at 2.8%, those responding"I am satisfied" was at 10.8%, those responding "I am partially satisfied" was at 24.7%, those responding "I am not satisfied" was at 24.7% and those responding "I am not at all satisfied" was 32.2%. 4.7% of the members did not respond to this question (Table 6).

Table 6. Members' satisfaction with selling prices of agricultural products

Satisfaction level	Number of members	(%)
Not at all satisfied	116	32.2
Partially satisfied	89	24.7
Not satisfied	89	24.7
Satisfied	39	10.9
Non-responders	17	4.7
Very satisfied	10	2.8
Total	360	100.0

Source: Research results.

In Table 7, the reasons for the members' dissatisfaction status with the product prices were examined. Accordingly, 42.2% of the membersalleged the unstable product prices as a reason for dissatisfaction. 14.5% of the members also responded "The deduction is high".

Table 7. The reasons for members' dissatisfaction with selling prices of agricultural products

Reasons	Number of members	(%)
Unstable product prices	152	42.2
Non-responders	93	25.8
Too high deduction	52	14.5
Paying a late of the product amount	31	8.6
Payment noncash	30	8.3
Other	2	0.6
Total	360	100.0

Source: Research results.

The most important reason for price instability was that the sector in which the product was marketed was generally the private sector and this sector was also the determining power. In addition to the government taking the necessary measures in this regard, it would be also beneficial for the POs to take a more active part in marketing.

Evaluation of agricultural products via POs

Members' opinions regarding processing by the POs instead of marketing products were also examined and the ratio of those responding "Product prices increase" was identified as 51.1%, the ratio of those responding "Job opportunities arise " was 26.4%, and the ratio of those responding "Members have a voice in the industry sector" was also 10% (Table 8).

Table 8. Members' point of view on evaluation of agricultural products by POs

Members' opinion	Number of members	(%)
Crop prices increase	184	51.1
Job opportunities arise	95	26.4
Members have a voice in the industry sector	36	10.0
Profit is distributed at the end of the year	25	6.9
Non-responders	14	3.9
Other	6	1.7
Total	360	100.0

Source: Research results.

Success levels of POs

In this part of the study, the success status of the POs was researched and they were examined into five groups according to their success. Accordingly, the Agricultural Development Cooperative ranked 1 with10.9%, the Sugar Beet Growers Cooperative ranked 2 with 10.7% and the Stud Breeders Association ranked 3 with 10% in a very successful group. The Agricultural Credit Cooperative ranked 1 with 66.3% in the successful group. This was followed by the Producer Union with 61.8% and the Agricultural Development Cooperative with 61.4% (Table 9). The Irrigation Cooperative ranked 1 in the unsuccessful (31.3%) and very unsuccessful (28.1%) groups. In general, the POs in the research region were successful. Because, 72.3% of the members of the Agricultural Development Cooperative, 37.5% of the members of the Irrigation Cooperative, 68.8% of the members of the Agricultural Credit Cooperative, 58.7% of the members of the Sugar Beet Growers Cooperative, 68.6% of the members of the Stud Breeders Association, 67.7% of the members of the Producer Associations and 52.8% of the members of the Chamber of Agriculture considered as successful the cooperative or association which they established.

Table 9. Success levels of POs

POs	Number of members	Very successful (%)	Successful (%)	No idea (%)	Unsuccessful (%)	Very unsuccessful (%)
Chamber of Agriculture	218	3.7	49.1	1.8	31.2	14.2
Agricultural Credit Coo.	163	2.5	66.3	1.2	19.6	10.4
Stud Breeders Assoc.	140	10.0	58.6	5.7	17.1	8.6
Agricultural Devel. Coo.	101	10.9	61.4	4.0	8.9	14.8
Sugar Beet Growers Coo	75	10.7	48.0	6.7	17.3	17.3
Producer Associations	68	5.9	61.8	1.5	20.5	10.3
Irrigation Cooperative	32	9.4	28.1	3.1	31.3	28.1

Source: Research results.

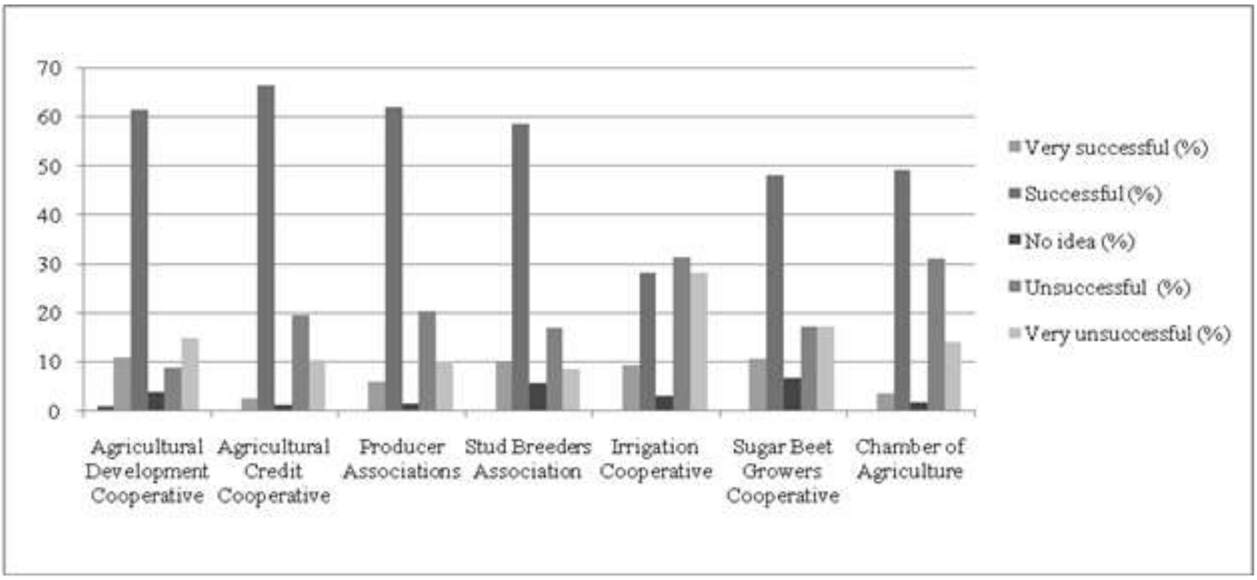

Fig. 1. Success grapg of the POs
Source: Own results.

The success status of the POs was also given in Figure 1.

Statistical test

In the study, the Chi-square independence test was used in determining the correlation among variables. According to χ^2 independence test:

There was a significant relationship between the members' age and their knowing the advantages of the POs to the other those. While the members thinking that the POs provide an advantage were in the 41-50 age group, those thinking that they do not provide any advantage were also in the 31-40 age group.

Whether the members were willing to become a member of the POs was examined by age groups, and it was detected that those in the 30-50 age group were more willing. When the Chi-square analysis regarding the members' satisfaction levels with membership was also examined, those being satisfied and very satisfied were in the 41-50 age group, those being partially satisfied were in the 31-40 age group and those being unsatisfied were in the 51-60 age group.

In the study, the distribution of participation in general boards, the most important organ of the POs, according to the members' age groups was examined, and it appeared that there were those not participating in none of the general boards in all age groups. Most of those participating in all of the general boards were in the 41-50 age group, and this meant that young members took interest in the general boards.

In the study, the distribution of the members' satisfaction levels with the management of the organization according to age groups was also researched, and it was determined that partial satisfaction in all groups came into prominence. It was identified that especially the members in the 41-50 age group were satisfied with the works of the management.

In the research, Chi-square analysis results regarding the members' education levels, knowing the advantages of the POs, satisfaction levels with being a member of the POs and the management, the reasons for their participation in the general boards, and most important problems of the POs were examined, and it was detected that there was not a significant relationship among variables.

Whether or not the members read the articles of association of the PO while becoming a member of the PO, and the relationship of which with educational status was analyzed by khi-square. Accordingly, as the level of education was high, the status of reading the articles of association of the PO was also high.

The relation of the members' participation in the general boards with their education levels was examined, and it was defined that the ratio of those graduating to secondary education from the members participating in all general boards was higher than the others. Likewise, the ratio of reading the articles of association of the PO of the members participating in all general boards was also higher than the others.

It was detected that 66.1% of members worked in non-agriculture.

In the research, a chi-square analysis of the relationship between the members' doing/not doing status non-agriculture businesses and the satisfaction levels with being a member of the POs was also performed. According to this, it was identified that the members not doing non-agriculture businesses and farming only were very satisfied with the POs, and among those being satisfied, the retired ones were also in the majority.

In the research, the membership periods to the POs were compared with the organizational and managerial satisfaction levels, and it was identified that the new members were more satisfied. When the members' membership periods and their participation status in general boards were examined, that new members were in the majority among those participating in all of the general boards occurred. When the members' membership periods to the PO and the POs in which the products will be marketed were examined, it was identified that the agricultural development cooperative was considered more. In addition, it was researched what can be the contribution if the products are processed by the POs, and it was understood that the selling price of the products could increase according to the Chi-square analysis. In addition, marketing prices, satisfaction with being a member of the POs, and satisfaction with the organizational management variables were tested by the Chi-square, and it was viewed that there was no significant difference among variables.

The duty of the members in the PO, knowing the definition and advantages of the PO, reading the articles of association, the satisfaction with being a member, their ideas about problems and inspection, and their preferences in the marketing of products were explored. It was viewed that there was no significant relationship among variables.

In the study, a significant relationship was found between the members' taking charge in the POs and the government's intervening/not intervening in the management of the organization, and most of the chairman of the board stated that the government should intervene when necessary.

When the relationship between the members' participation in the general boards and the satisfaction levels with being a member of the POs was examined, it was determined that those being very satisfied were those participating in all the general boards, and those not being satisfied at all were also those not participating in the general boards at all. When the participation in the general boards and the satisfaction levels with the management of the organization were examined, it was detected that most of those being very satisfied were those participating in all of the boards. Likewise, those not being satisfied and not being satisfied at all with the management of the organization were those not at all participating in the general boards.

One of the most important factors for the success of the POs is that members own their own organizations and are interested in organizational works. For this purpose, the members' being interested in organizational studies were also researched and it was understood that only some members were interested in the organizational studies.

Discussions

The discussion section takes an important place in the comparison of scientific research results. In this study also, obtained findings were discussed with those of some research.

In the study,19.7% of the members stated that they market their products only through POs, and 29.3% of them both through the PO and trader or in the marketplace. In the study conducted by [25], was emphasized that the market share of cooperative organizations was over 90%, especially in Northern European countries.

In the research, when the members were asked which of the POs should market the products, it was revealed that the agricultural development cooperative ranked number one with a ratio of 33.6. Agricultural development cooperatives are established by the members for an economic purpose. [26] reviewed agricultural development cooperatives and the other POs activating in Africa and other regions. In the study, it was stated that during the pre-structural adjustment era, many governments from developing countries supported agricultural development cooperatives and POs. These organizations however often failed to provide desired services to members due to political interference, internal governance, and managerial problems. In the study, it was also emphasized that all the agricultural organizations were not active. In another study conducted by [27], the evidence for improving access to markets, information, and technologies was emphasized, and the conditions that facilitate the success of agricultural development cooperatives in providing such services were examined.In another study, it was emphasized that although agricultural development cooperatives aim to enhance agricultural production and marketing, in some countries such as China, not all members sell their products through agricultural cooperatives [16].

In the study, 51.1% of the members asserted that by the evaluation of products through the POs product prices will be stabilized and 26.4% of them also that job opportunities will arise. By this means, in the region, it was stated that it will be contributed to the prevention of unemployment, the development of rural areas, and the slowdown of rural migration. [23] explained that the POs assist their members in purchasing, processing, and marketing stages of products, they arise new job opportunities for members and provide training support for them in related fields. In addition, they stated that one of the most important means for the economic and social development of rural areas and agricultural enterprises is the POs.

Although there were POs that did not succeed in the research area, they were successful in general. It was viewed that the satisfaction with the works of the management was effective in the success of the POs. [2], in their study, expressed that 59.3% of the POs they examined were unsuccessful. In the study, the main reasons for the failure were stated as the members' distrust of the POs, that the organizational request did not come from the members, and that the POs were not attached priority in some agricultural supports. In the study conducted in Poland by [3], it was stated that variables such as the leader’s strength, previous business acquaintances, the initial selection of members, and the number of members had a significant positive impact on the likelihood of success of the researched organizations. In another study, it was stated that social capital has been the key element in the formation and development of the POs [30].

In this research, it is determined that PO-government relations are weak and the government should not interfere in the POs. In the research conducted by Erbaş (2018), it was emphasized that the government should not interfere in the POs at all. He specified that unions and organizations in the Turkish constitution have to be encouraged and supported. As a principle, it is natural that professional associations may contact politics. But, ideological policies and organic relations with any political party may harm the organization movement and the chambers of agriculture. Political connections should be related to agricultural policies and producers' problems [11].

CONCLUSIONS

In this study, in which the members' organizational awareness and marketing preferences were investigated, it was revealed that the effectiveness of POs should be increased in all fields.

The research results revealed that most of the members marketed their products through traders. The reason for this was that the POs were insufficient in marketing. Ergo, marketing the crops through the POs is always important for organizational success. In this case, that cooperatives established for economic purposes take a more active role in marketing will be the right choice.

In the research, the members' satisfaction situation with their products' marketing price was also examined, and it was identified that the ratio of the members being very satisfied with it was very low. On the other hand, the rate of those not being dissatisfied was found to be quite high.

The opinions of the members about the processing of the products by the POs showed that price stability would be achieved in the case of the processing of the products by the POs.

In the research region, although the POs were sufficient in numbers, it was viewed that the members did not have enough information about the PO, and their interests in the PO were low. These were important obstacles to effective membership.

Finally, a strong member-PO relationship is needed in order that POs can achieve their purpose and be effective in sustainable rural development. Stronger agriculture is needed for a stronger country, and stronger POs are needed for stronger agriculture.

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BEHAVIOUR OF SWEET POTATO MOISTURE CONTENT IN A HYBRID DRYING SYSTEM

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Abstract

The aim of this study is to investigate different time-dependent drying and moisture content under different infrared (IR) and hot-air drying levels and product quality. In this experiment it was used a hybrid drying system to minimize energy consumption during the drying operation and to reduce environmental impact by reducing product loss in wastes. Three different levels of sweet potato slices thickness (1, 3, 5 mm), were pre-treated by dipping into a solution of 0.5 % sodium meta-bisulphite and 1% citric acid for 30 min. Four different levels of infrared radiation (0.861, 0.973, 1.039 and 1.161 kW.m-²) and three different levels of air-drying temperature (45, 55 and 65°C) were using. The changes in moisture content during the drying process with a constant air velocity of 1.2 m. s-1 were noticed. The moisture content decreased with drying time. To obtain the desired moisture content from (6.92% to 7.52%), the drying time for 1mm and 0.861 kW.m-² was 165,150 and 105 min while for 5mm and 1.161 kW.m-² was 330, 270 and 240 min at 45, 55 and 65 °C, respectively. The total energy consumption decreased from 14.685 kW. h to 5.72 kW. h as the radiation intensity increased from (0.861 to 1.161 kW.m-²).

Key words: *sweet potatoes, moisture content, energy consumption, infrared, hot-air drying*

INTRODUCTION

Keeping a product fresh is the best way to preserve its nutritional value, but most storage techniques require low temperatures, which can be difficult to maintain throughout the distribution chain. On the other hand, drying is a suitable alternative for postharvest management. Fruits, vegetables and their products are dried to enhance storage stability, minimize packaging requirements and reduce transport weight [27].

In recent years, industrial dryers have replaced traditional methods of drying agricultural products. In industrial dryers, drying conditions are better controlled, drying times are reduced and the quality of the end product is improved [28].

The most popular and efficient way to preserve food is convective drying (hot air) drying, the high temperature and long process time induce a series of chemical and biochemical conversions resulting in a change of colour, taste, aroma and nutrient properties [5, 15].

Therefore, it is needed to develop new drying systems and design new dryers. Technique such as infrared drying. Infrared drying technology was developed 30 years ago, but has recently gained popularity due to energy efficiency and lower costs compared to vacuum or microwave drying, good quality of the dried product and reduction in drying time [8, 15].

Also, it can reduce crop losses, improve the quality of dried product such as texture, colour, taste and flavour significantly and is economically beneficial compared to traditional drying methods [9].

Despite advantages, due to the limited penetration depth, IR energy is usually applied in combination with other drying methods, such as hot air, microwave and vacuum drying [26].

Application of combined IR to food processing has gained momentum due to its inherent advantages over hot air heating [4].

Hybrid drying is promising because it can provide high quality with possibly low energy consumption [6].

The combination of IR with convective hot air drying has been informed as an better drying technique with the ability of producing high-quality products in shorter drying time since it combines quick heating of IR and improved dehumidifying ability of convective drying [19].

It was found that drying of apple (Golden Delicious) slices with the Infrared-Hot air setting was 57.5 and 39.1 % faster than Infrared-Cold air and Hot air setting, respectively [10].

Worldwide, sweet potato is the seventh in the world food production after maize, wheat, rice, potato, cassava, and barley. About 90 million tons are produced globally each year from about 18 million feddans area (1,800 hectare); 70% of which are grown in developing countries [14].

In evaluation to other major staple food crops, sweet potatoes have good flexibility to peripheral growing situations, short production cycle, and high yield potential [31]. Sweet potato achieves a number of basic roles in the global food system, all of which have important suggestions for meeting food requirements, reducing poverty, and increasing food security [13].

It is a highly nutritious vegetable and its consumption has been increased in various parts of the world in recent years [29].

The sweet potatoes have a good sources of energy, protein, fibre, and minerals including potassium, vitamin A, carotenoids and phenolic compounds and they are rich in starch, which represents more than 50% of the carbohydrate components so the sweet potatoes have high demand[11].

The beta carotene content would be very useful in alleviating vitamin A deficiency among children below six years, pregnant women and adults [17].

Sweet potato is a low input crop used as vegetable, desert, source of starch and animal feed, [24].

The researches on sweet potato processing focused on fried, dried, flour sweet potato products [16], [21].To produce ready-to-eat dried sweet potato products, chemical pretreatment before drying.

The best pretreatment method before drying of any fruit should reduce drying time while keeping high quality of product (color, nutritional properties, taste, etc.) [12].

On the basis of biochemical parameters of sweet potato flour, the highest retention of ascorbic acid content (42.93 mg/100 g), total sugar (45.56 %), titratable acidity (1.62 %), carotenoid content (2.03 mg/ 100 g), crude fiber content (7.73 %) and protein content (3.04 %) were obtained in treatment 1 % sodium meta-bisulphite + 1 % lemon juice solution for10 minutes followed by solar drying [18].

The moisture content decreased with drying time irrespective of drying air temperatures indicating continuous drying process. The decrease in the drying time of the green peas with increase in drying air temperature (50°, 60°, and 70°C). The drying rate was higher at 70°C when compared to 50°C and 60°C drying air temperature [22].

The effects of infrared radiation intensities of 1,830, 2,385, 2,640, 2,880, and 3,165 W/m^2 and at air velocities of 1.0, 1.5, and 2.0 m/s of Sweet Potato slices dried on drying time. The drying time was shortened with increasing infrared radiation intensity at constant air velocity. the DTs ranged between 168 and 213, 153 and 186, 135 and 178, 135 and 162, and 120 and 157 min, respectively [19].

Energy consumption during drying is affected by many parameters including drying temperature, infrared power, air velocity and structure (porosity, absorption ability, surface properties, etc.), moisture content and amount of the material [32].

In the hot-air and infrared dryer, the apple samples were dried at temperatures of 90, 120 and 150°C and radiation intensity of 0.22, 0.31 and 0.49 W/cm^2. When air temperature and radiation intensity increasing total energy requirement decreases The maximum and minimum value of total needed energy 1.54 and 1 kWh was obtained at a radiation intensity of 0.22 and 0.49 W/cm^2, respectively [26].

A comprehensive analysis of dried products was performed on their drying kinetics, drying time, specific energy consumption, shrinkage, rehydration ratio, color, vitamin C, and lycopene. The results showed that drying time was prolonged with increasing air velocity while it was shortened with increasing infrared radiation intensity [20].

Apple slices were dried in a convective dryer at air temperatures of 50, 60 and 70 °C, and air velocities of 1, 1.5 and 2 m s–1. The total energy consumed in drying apple slices at different air temperatures and flow rates. when air temperature increasing, the air flow rate, energy consumption of drying process decreases [3]. These comments are in agreement with the results informed for tomato [25].

The aims of the research were:

-To assess and monitoring the drying behavior of sweet potato slices moisture content using a hybrid of the infrared radiation and hot air heating method.

-Studying the effect of air temperature, radiation intensity and initial chemical treatment with 0.5% sodium meta bisulfate solution and 1% citric acid for 30 minutes on the changes in the moisture content, total and specific energy consumption of sweet potato slices during drying with the hybrid dryer.

MATERIALS AND METHODS

Fresh sweet potatoes samples were stored in a refrigerator at about 4ºC for experiments. Initial moisture content was determined using the AACC method [1] it was ranged from 3.8 to 4.2 kg water/kg dry matter. Before drying the sweet potatoes were cleaned, peeled. Then, the samples were cut into slices of 3mm using digital Vernier calliper. Then, the samples were pretreated with 0.5 % sodium meta-bisulphite, and 1% citric acid to retain the colour by preventing the browning [30].

Drying Apparatus

The dryer was used for conducting the experimental work for drying sweet potatoes at the Agricultural Engineering Department, Faculty of Agric. Tanta University.

The hybrid infrared-hot air dryer used for the experimental set up. The drying bed consists of three drying shelves. Each shelf was (60* 43 *40) cm (L * W* H). The dryer made of stainless steel, it consists of a box-type drying chamber, two ceramic Infra-red heaters(wavelength of 2-10 µm; length of 24.5 cm/width of 6 cm/max power of 1,000W/ up to 750°C, two an electric heater(1,000W-Turki) were connected to a thermocouple type (K) to control and measure air temperature and digital thermostat (AUTONICS – Korean), connected to the electric circuit for stopping and connecting the heater and keeping the pre-adjusted temperature relatively constant throughout each experimental run, a centrifugal fan(220wzl-10W-1,500 rpm), a drying tray, a 5kg load cell with HX711 Amplifier Rated Output: 1.0±0.15mV/V, Operation temp. range -20~+60°C, Combined error (%RO) : < ±0.03), and two control panels. The air velocity was kept constant at 1.2 m. s^{-1}as recommended by [7]. The distance between the IR emitter and the drying tray was kept constant at 20 cm [12].

Variables under study were:

-Pre-treatments of sweet potato slices included (with a solution containing 0.5 % sodium meta-bisulphite, 1% citric acid for 30 min).

- Four radiation intensity (0.861, 0.973, 1.093 and 1. 161kW.m^{-2}).

- Three hot air-drying temperature (45, 55 and 65 ºC), at constant air velocity (1.2 m. s^{-1}).

Experimental Measurements and Instrumentation ***Moisture measurement***

Moisture content of the samples was determined by drying in an oven at 105°C for 24 hours as recommended by [1].

The average initial moisture content was found to be 380 - 420 % (dry basis).

The moisture of samples was also calculated following Equation:

$$M_d = \frac{W_w - W_d}{W_d} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where:

Md is the moisture content dry basis (%)

Ww is the initial weight of sweet potato samples (gr);

Wd is the dry weight of sweet potato samples (gr).

Air velocity

General LCD digital Anemometer (model DCFM 700) was used for measuring the air velocity.

The unit is a self – contained direct reading portable instrument.

Energy requirements

After the drying tests, the drying curve and hence the drying time can be determined for each specific condition.

The energy amount used in the hybrid infrared-hot air drying is achieved from the totality of the energies consumed by the fan (E_F) and electric heater (E_e) and infrared emitter (E_{IR}).The specific energy consumption which is a measure of the energy needed to evaporate a unit mass of water from the product.

The total energy (E_t) and specific energy consumption (SEC) by hybrid infrared dryer for drying 220 g of sweet potatoes samples at 3mm thicknesses, different drying air temperatures and infrared radiation intensity were calculated following Equation [2]:

$$E_t = Ee + E_f + E_{IR} \qquad (2)$$

E_{IR}-measured electric energy consumption of infrared emitter, (kW.hr),
E_h-measured energy required for heating the ambient air by electric heater, (kWh),
E_f - measured electric energy consumption of fan, (kW.hr),
SEC is calculated using Equation (3) [23].

$$SEC = Et / Mw \qquad (3)$$

where:
SEC = The specific energy consumption (kW. hr/kg water)
mw = The amount of water removed (kg)

Experimental Procedure

A total of 220 g. sweet potato samples on a perforated tray were used. Initial moisture content was measured before the drying process by taking (5 g) of sample in three replicates.

The treated sweet potato slices were dried at different levels of infrared radiation intensity including 0.861, 0.973, 1.093 with changed air-drying temperature of 45, 55, 65ºC and and 1.161 kW. m^{-2}, at constant air velocity of 1.2 m/s.

RESULTS AND DISCUSSIONS

Influence of drying parameters on the change of sweet potatoes moisture content

Figures 1,2 and 3 shows the variation of moisture content versus drying time for the various drying air temperatures of 45, 55, 65 andf our different levels of infrared radiation intensity including 0.861, 0.973, 1.093 and 1.161 kW. m^{-2}. The sweet potato initial moisture content was ranged from 3.8 to 4.2 kg water/ kg dry matter, after drying reduced to 0.069 to 0.0752 kg water/kg dry matter. The drying shadowed a falling rate period and the increase in temperature faster the drying process. As drying air temperature increased, moisture removal also increased and ultimately resulted in the reduction in drying time. Drying time reduced from 165 to 60 min. as the air temperature and infrared radiation intensityincreased from 45 to 65ºC; 0.861 to 1.161 kW. m^{-2}, respectively.

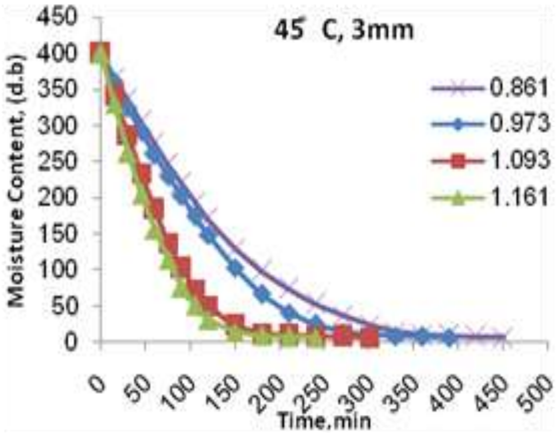

Fig. 1. Effect of drying time and radiation intensity on sweet potatoes slices moisture content at constant drying air temperature of 45 ºC
Source: Authors' determination.

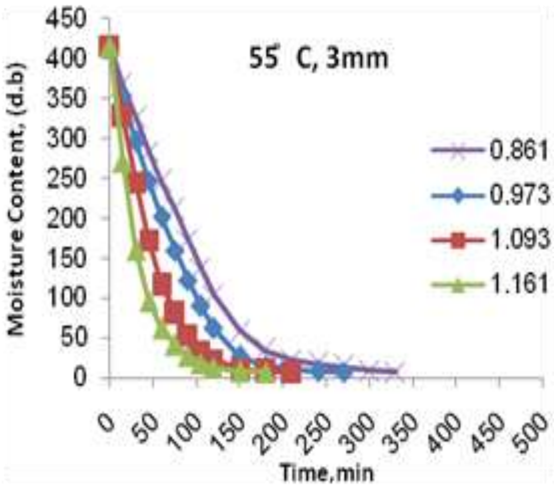

Fig. 2. Effect of drying time and radiation intensity on sweet potatoes slices moisture content at constant drying air temperature of 55 ºC
Source: Authors' determination.

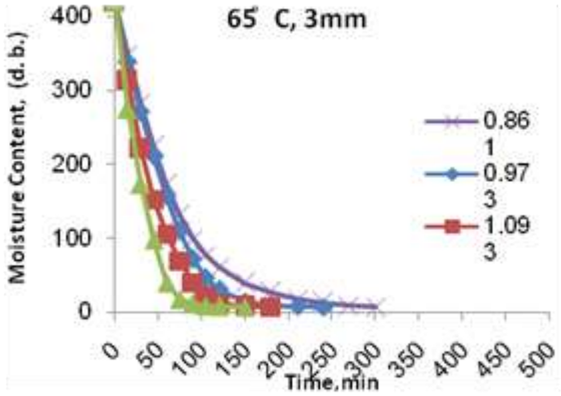

Fig. 3. Effect of drying time and radiation intensity on sweet potatoes slices moisture content at constant drying air temperature of 65 ºC
Source: Authors' determination.

Total energy consumption (ET)

Figure show the effect of different treatments (temperature, thickness and infrared radiation intensity) on total energy consumption, respectively. The highest total energy value 14.685 kWh was obtained at 45 C 0.861kW.m-². Increasing the temperature from 45 to 65 C decreases the total energy while the lowest total energy (5.72 kWh) was obtained at an air temperature of 65 C and 1.161 kW.m-². As showing in Fig.4

Drying temperature increases the rate of moisture removal from the product and reduces the drying time, and total energy value will decrease with increasing temperatures.

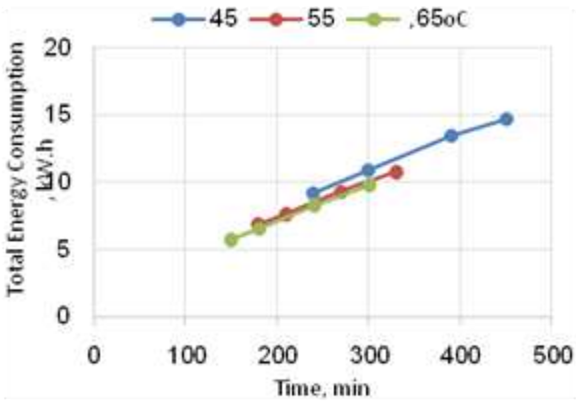

Fig. 4. Total energy requirement for hybrid dryer at different temperatures
Source: Authors' determination.

Specific energy consumption (SEC)

According to Figure 5, the lowest SEC (30.991kWh/kg) was obtained at an air temperature of 65 ºC and 1.161 kW.m-². Additionally, the sample at an air temperature of 45C for drying sweet potato had the highest SEC (79.485 kWh/kg) at an air temperature of 45 ºC and 0.861 kW.m-². This can be due to the low moisture removal from the drying product and the increase in drying time. As the air temperature grows from 45 to 65 ºC, the thermal gradient within the drying product increases. Further, by enhancing the drying temperature from 45 to 65 ºC, the difference between the drying temperature and the ambient temperature increased. As a result, increasing the temperature difference significantly decreased the drying time of the product, which is a strong reason for the reduced energy consumption.

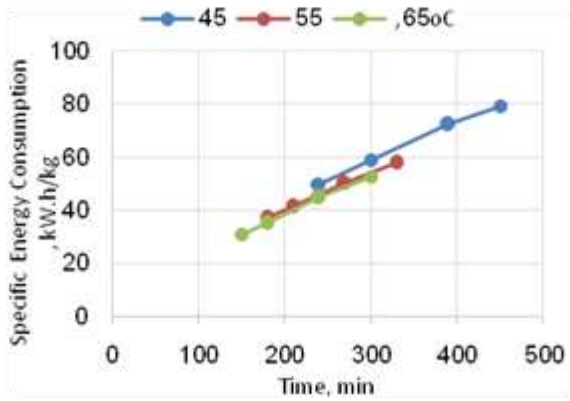

Fig. 5. Effect of drying time and different drying air temperature on specific energy consumption under hybrid drying system.
Source: Authors' determination.

CONCLUSIONS

The intensity of infrared radiation and drying air temperature had a significant effect on the moisture content of sweet potato slices. The moisture content of sample slices decreased when the radiation intensity and the drying air temperature increased.

Changing the radiation intensity from 0.861 to 1. 161kW.m^{-2} and a minimum air temperature of 45°C, the drying time decreased from 450 to 240 min.

Changing the radiation intensity from 0.861 to 1. 161kW.m^{-2} and a maximum air temperature of 45°C, the drying time decreased from 300 to 150 min.

It is clear that the moisture content decreases endlessly with drying time. During the beginning phases of the drying process, the rate of drying was fast, but it became quite slow throughout the drying method.

Comparison between drying data at various conditions revealed that the drying time of slices at higher IR power permissible limits must be determined.

Drying temperature increases the rate of moisture removal from the product and reduces the drying time, Specific energy consumption and total energy value will decrease with increasing temperatures.

Based on the results, the following recommendations are made:

-Sweet potatoes pretreated with 0.5 % sodium meta-bisulphite, and 1% citric acid to retain the color by preventing the browning and reduce drying time.

-In order to achieve the lowest total energy and best color when drying sweet potatoes, it is advised to utilize 1.161 kW m^{-2} as the ideal level of radiation intensity. These conditions include drying air temperature of 65°C, air velocity of 1.2 m/s, and slice thickness of 3 mm.

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SIMULATION OF SOCIO-ECONOMIC SECURITY OF RURAL AREAS IN THE CONDITIONS OF SUSTAINABLE DEVELOPMENT: A CASE STUDY OF UKRAINE

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Abstract

In the article we proved that, the need to take into account the identified indicators of social tension and indicators of the level of social and economic security in rural areas becomes especially relevant for the formation and implementation of sustainable development programs. Since the resource provision of programs to support the development of rural areas is limited and in the process of their implementation questions will arise regarding the priority of financing the needs of this or that region or community, the results of modeling the indicators of dynamics and the state of socio-economic security can provide an answer to the question of specifying the process of identifying the region, which most needs the implementation of appropriate measures to stabilize the situation and bring it to a qualitatively higher level.

Key words: *rural areas, rural population, socio-economic security, sustainable development, socio-economic development*

INTRODUCTION

The specificity of the current state of development of the world economic system consists in the emergence of a whole complex of negative trends in the sphere of formation of high standards of the quality of life of the rural population. In turn, this also directly affects the effectiveness and functionality of the state's socio-economic policy to ensure the sustainable development of rural areas. At the same time, the need to create a sufficient level of socioeconomic security in the countryside is determined by a number of factors, the most important of which are the specific features of the nature and results of work, characteristics of rural areas, socio-demographics, and other conditions. It should be noted that state policy in the field of socio-economic development of rural areas is always complex and represents a combination of targeted development projects of the central government and local self-government bodies. In turn, this approach allows combining the central and regional budgets to finance targeted programs for the development of rural areas. However, as practice shows, the needs of sustainable development usually exceed the resource capabilities of budget financing, which requires the search for additional sources of investment in the development of rural areas, including under the conditions of private-state partnership.

The most significant threats to the socio-economic security of rural areas in Ukraine are of a financial, legislative, and social nature. At the same time, each type of threat is revealed in a combination of factors of a different nature. At the same time, each such factor can be endowed with different natural features. For example, the legislative field, having a number of subjective features at the state level, has an objective nature in relation to the region. Financial threats, on the contrary, depending on the place of their localization, can have both objective and subjective nature. All of this determines the increasing relevance of research aimed at ensuring the socio-economic security of rural areas through the formation of functional systems for their sustainable development in conditions of increased destructive influence of external externalities.

The study of issues related to ensuring an adequate level of socio-economic security of rural areas is not new for modern economic science, as it is based on the principles of ensuring the minimization of the gap in the socio-economic development of the territories, and also provides for the observance of the principles of sustainable development defined by the relevant programs of the OUN. In this aspect, it is appropriate to note the works of such researchers as I. Balaniuk [1], O. Binert [2], I. Britchenko [3-11], Y. Chaliuk [12], M. Dziamulych [13-21], N. Khomiuk [22], S. Koshova [23-24], A. Marcuta [26], M. Masl'an [27], A. Nikolaeva [29], A. Popescu [30-39], T. Shmatkovska [40-42], R. Sodoma [43-48], O. Stashchuk [49-51], I. Tofan [52], I. Tsymbaliuk [53], I. Yakoviyuk [54], V. Yakubiv [55], O. Yatsukh [56], and many others. At the same time, there was an objective need to improve existing efforts to ensure the social and economic security of rural areas, which is caused by the dynamic development of destructive processes in the global and regional economic systems. According to the results of the assessment of modern economic policy trends, it was established that there is an objective need to model the processes of socio-economic development in the countryside to ensure the proper level of its socio-economic security both in the short-term and the long-term perspective.

MATERIALS AND METHODS

In the process of implementing the research, we normalized the indicators selected for modeling the socio-economic security of rural areas, i.e., the transition to indicators that do not have units of measurement, using a system of formulas:

– for stimulants:

$$Z_i = \frac{x_i - x_{min}}{x_{max} - x_{min}}$$

– for destimulators:

$$Z_i = \frac{x_{max} - x_i}{x_{max} - x_{min}}$$

where:

Z_i – a normalized value of the *i*-th indicator;

x_i – indicator value *i*;

x_{max} and x_{min} – respectively, the maximum and minimum value of the i-th indicator in all regions.

The calculation of the integral indicator of the level of economic security of the rural areas of the Ivano-Frankivsk region was carried out by the method of weighted sums:

$$I = \sum_{i=1}^{n} a_i z_i, \qquad \sum a_i = 1, \qquad 0 \le a_i, z_i \le 1$$

where:

a_i – weighting factors that determine the degree of contribution of the *i*-th indicator to the integral index;

z_i – normalized assessment of the *i*-th indicator.

In the process of implementing the presented research, we applied the algorithm of discriminant analysis, which includes the following steps.

1. We determine for the input data matrices X and Y the estimates of the vectors of the average values of $\underline{x}$ and $\underline{y}$ and the covariance matrices S_x and S_y:

$$\underline{x} = \left(\frac{x_1}{x_2}\right); \qquad S_x = \left(S_{11_x}\, S_{12_x}\, S_{21_x}\, S_{22_x}\right)$$

$$\underline{y} = \left(\frac{y_1}{\bar{Y_2}}\right); \qquad S_x = \left(S_{11_y}\, S_{12_y}\, S_{21_y}\, S_{22_y}\right)$$

where: $\underline{x_j} = \frac{1}{n_1}\sum_{i=1}^{n_1} x_{ij}$; $\underline{y_j} = \frac{1}{n_2}\sum_{i=1}^{n_2} y_{ij}$

$$S_{kj(x)} = \sum_{i=1}^{n_1} (x_{ij} - \underline{x_j})(x_{ik} - \underline{x_k})$$
$$= \underline{x_j x_k} - \underline{x_j}\,\underline{x_k};$$
$$S_{kj(x)} = S_{jk(x)};$$
$$S_{kj(y)} = \sum_{i=1}^{n_1} (y_{ij} - \underline{y_j})(y_{ik} - \underline{y_k})$$
$$= \underline{y_j y_k} - \underline{y_j}\,\underline{y_k};$$
$$S_{kj(y)} = S_{jk(y)};$$
$$j = (1,2).$$

2. We calculate the unbiased estimate of the total covariance matrix:

$$\hat{S} = \frac{1}{n_1 + n_2 - 2}\left[n_1 S_x + n_2 S_y\right]$$

3. We calculate the inverse matrix $\hat{S}^{-1}$.
4. We calculate the estimation vector of the coefficients of the discriminant function:

$$Z_a = \hat{S}^{-1}(\underline{x} - \underline{y})$$

5. We find estimates of the discriminant function:

$$Z_x = x^T \times a\,,$$
$$Z_y = y^T \times a\,,$$

where: x^T, y^T – transposed to the x and y matrices.

6. We calculate the average values:

$$\underline{Z_x} = \frac{1}{n_1}\sum_{i=1}^{n_1} Z_{xi};\ \underline{Z_y} = \frac{1}{n_2}\sum_{i=1}^{n_2} Z_{yi}$$

7. We find the limit of discrimination:

$$c = \frac{1}{2}(\underline{Z_x} + \underline{Z_y})$$

8. We write down the discriminant function (model):

$$Z = a_1 z_1 + a_2 z_2$$

If Z ≥ C, then the territorial system (rural areas) should be assigned to the population X, and if Z > C, then to the population Y.
We used the formula given below to calculate social tension in the rural areas of the studied region of Ukraine:

$$\mathrm{CH} = ln\left|\frac{\sum_1^6 x_i}{\sum_1^8 z_i}\right|,$$

where:
X_1 – number of dropped-out persons;
X_2 – number of registered unemployed;
X_3 – number of families and singles who are on the apartment register;
X_4 – number of registered crimes (units);
X_5 – emissions of pollutants (thousand tons);
X_6 – number of deaths (mortality rate) (per 1,000 of the existing population);
Z_1 – number of subjects of the unified state register of enterprises and organizations of Ukraine;
Z_2 – capital investment per person, hryvnias;
Z_3 – number of arrivals;
Z_4 – number of employed citizens;
Z_5 – average monthly nominal salary, UAH/month;
Z_6 – provision of housing for the population (on average per person; m2 of total area);
Z_7 – number of hospital and outpatient clinics;
Z_8 – number of births (per 1,000 of the available population).

RESULTS AND DISCUSSIONS

The absence or significant limitation of statistical data on the assessment of socio-economic security of rural areas makes it impossible to use certain common methods. We offer a slightly modified approach, which makes it possible to conduct a study of the specified problem based on the basis of the existing statistical base.
Note that in order to ensure the evaluation of the food component of the economic security

of the territorial systems of the Ivano-Frankivsk region of Ukraine under our study, a set of the following indicators was selected:
1) grain production per person, t;
2) potato production per person, t;
3) production of vegetables per person, t;
4) production of fruits and berries per person, t;
5) meat production per person, t;
6) milk production per person, t;
7) egg production per person, million pieces;
8) sales area of stores that sell food products, m^2.

To evaluate the investment component, we selected the following indicators:
1) capital investment per person, hryvnias;
2) direct foreign investment (share capital), UAH per person.

To evaluate the foreign trade component, we selected the following indicators:
1) volumes of exports of goods per capita, thousands of US dollars;
2) volumes of import of goods per capita, thousands of US dollars;
3) coefficient of export coverage by import.

To evaluate the social component of economic security, we selected the set of indicators presented below:
1) real wage index, %;
2) unemployment rate of the working population, %;
3) the number of persons brought to administrative responsibility (per thousand inhabitants);
4) the number of hospital beds (per person);
5) provision of housing for the population (on average per person; m^2 of total area);
6) the number of preschool educational institutions (per thousand inhabitants);
7) the number of full-time general educational institutions (per thousand inhabitants).

In the process of conducting the research, we normalized the selected indicators, i.e. transition to indicators that do not have units of measurement, using the appropriate system of formulas (the formulas are presented above).

Note that the calculation of the integral indicator of the level of socio-economic security of the rural areas of the Ivano-Frankivsk region of Ukraine was carried out using the method of weighted sums, using the formula presented above.

The weighting coefficients were found using the service capabilities of the MS Excel spreadsheet using the coefficients of determination between the relevant components of economic security and demographic indicators in the rural areas of the Ivano-Frankivsk region of Ukraine. The integral indicator was calculated separately for each component, and then for the Ivano-Frankivsk region of Ukraine in general.

Based on the results of the research (complex analytical calculations and grouping), we established that the indicator of the integral indicator of socio-economic security of the rural areas of the studied region of Ukraine is low. A very low level of economic security in 2020 can be observed in the Nadvirna, Tysmenytsia, Rozhniativ, Bohorodchany districts, low – in Kosiv, Kolomyia, Kalush, Dolyna, Verkhovyna, Horodenka, Tlumach, Sniatyn, Halych districts, medium – in Rohatyn district of Ivano-Frankivsk region (Fig. 1, Table 1).

Table 1. Grouping of territorial systems of the Ivano-Frankivsk region according to the integral indicator of the level of socio-economic security of rural areas in 2020

An integral indicator of economic security	Level	Territorial systems
0.20 – 0.36	Very low	Nadvirna, Tysmenytsia, Rozhniativ, Bohorodchany districts
0.37 – 0.51	Low	Kosiv, Kolomyia, Kalush, Dolyna, Verkhovyna, Horodenka, Tlumach, Sniatyn, Halych districts
0.52 – 0.67	Average	Rohatyn district

Source: own development.

The cartogram we constructed (Fig. 1) makes it possible to visualize the obtained research results (Table 1).

Analysing the dynamics of indicators of socio-economic security of rural areas of Ukraine in the studied period (Fig. 2) made it possible to establish their instability and difficulty in forecasting and does not follow clear trends of its change in a positive direction during the studied period.

Fig. 1. Cartogram of the grouping of districts of the Ivano-Frankivsk region of Ukraine according to the integral indicator of the level of social and economic security of rural areas in 2020
Source: own development.

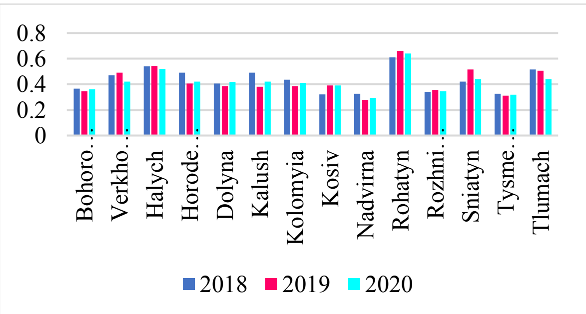

Fig. 2. Dynamics of the level of social and economic security of rural areas of the Ivano-Frankivsk region of Ukraine in 2020 - 2018.
Source: own development.

The method of discriminant analysis was used in the study in order to predict the threshold levels of indicators of socio-economic security of the rural areas of the studied region of Ukraine. At the same time, aggregates X and Y were formed from the values of rural population growth and the integral indicator of socio-economic security of rural areas of the studied region of Ukraine, while one aggregate included values with positive population growth, and the other – with a negative.

Based on the algorithm of discriminant analysis (which we set out in this study above), given and described in detail in the work [25], discriminant functions were developed for the studied periods, which are presented in Table 2.

Table 2. Models of threshold levels of economic security (taking into account the growth of the rural population) of the Ivano-Frankivsk region of Ukraine for 2015-2020

Year	Discriminant model, limit of discrimination
2015	$Z = 1.452P + 13.618I.\ C=5.847$
2016	$Z = 0.914P – 1.296I.\ C=1.026$
2017	$Z = 0.731P + 2.193I.\ C=0.998$
2018	$Z = 0.629P – 0.343I.\ C=0.146$
2019	$Z = 0.858P + 3.547I.\ C=1.387$
2020	$Z = 0.353P + 5.764I.\ C=2.978$

where: Z – discriminant model, P – population growth, I – integral index of economic security, C – the limit of discrimination.
Source: own calculations.

By setting the value of the increase in the rural population and the integral index of economic security in each analyzed period in the discriminant model Z and comparing its value with the discriminant limit C, we obtained the following research results: the threshold level in 2015 is exceeded by Bohorodchany, Verkhovyna and Nadvirna districts; in 2016 – Bohorodchany, Kosiv, Verkhovyna, Dolyna, Nadvirna, Rozhniativ and Tysmenetsia districts; in 2017 – Dolyna, Bohorodchany, Verkhovyna, Kolomyia, Nadvirna districts; in 2018 – Bohorodchany, Verkhovyna, Dolyna and Nadvirna districts; in 2019 – Bohorodchany and Dolyna districts; in 2020 – Bohorodchany, Nadvirna, Dolyna, Kalush, Tysmenetsia, Kolomyia districts (Fig. 3).

At the same time, the discriminant analysis was formed from the aggregates X and Y, which were constructed, respectively, from the values of social tension and the integral indicator of economic security of the territorial systems of the Ivano-Frankivsk region of Ukraine in the studied period. Note that the indicator of social tension was calculated based on the methodology of V. Nahornyi [28], which was modified in accordance with the available statistical base.

Fig. 3. Cartogram of the visualization of the value of the discriminant function and the limit of discrimination (taking into account the growth of the rural population) in the Ivano-Frankivsk region of Ukraine in 2020.
Source: own development.

Thus, we have visualized the results of the study for 2018-2020 regarding the rural territorial systems of the base region of Ukraine (Fig. 4).
Models of threshold levels of socio-economic security (taking into account social tensions) of rural areas of the Ivano-Frankivsk region of Ukraine for 2015-2020 are given in Table 3.

Table 3. Models of threshold levels of socio-economic security (taking into account social tensions) of rural areas of the Ivano-Frankivsk region of Ukraine for 2015-2020

Year	Discriminant model, limit of discrimination
2015	*Z = -2.131CH - 0.5012. C=-2.056*
2016	*Z = -4.623CH–1.0992. C=-4.085*
2017	*Z = -5.761CH +0.1593. C=-4.195*
2018	*Z = -10.386CH – 14.7091. C= -15.581*
2019	*Z = -6.621CH + 3.622. C=-6.3*
2020	*Z = -7.543CH + 0.957. C=-3.953*

where: *Z* – discriminant model,
CH – index of social tension,
I – integral index of economic security,
C – the limit of discrimination.
Source: own calculations.

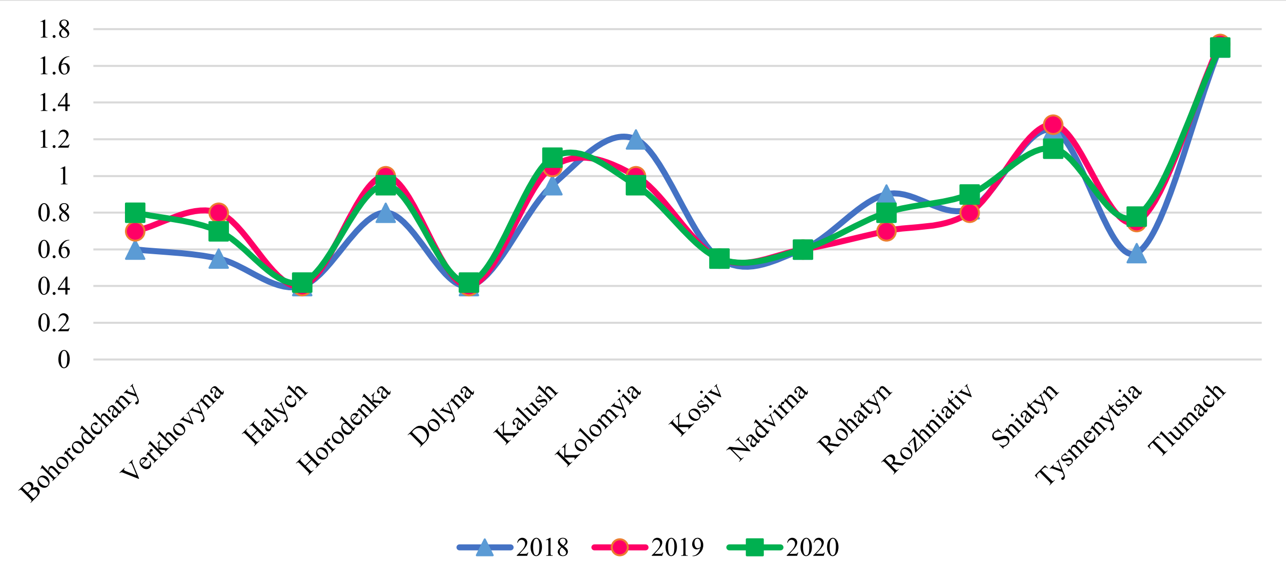

Fig. 4. Dynamics of changes in the level of social tension in rural areas of the Ivano-Frankivsk region of Ukraine for 2018-2020
Source: own development.

By entering the values of social tension and the integral index of socio-economic security in each studied period into the discriminant model Z and comparing its values with the discriminant limit C, a complex of the following results was obtained: the threshold level in 2015 is crossed by Dolyna, Halych, Nadvirna, Kosiv, Verkhovyna and Rohatyn districts; in 2016 – Halych, Dolyna, Kosiv, Nadvirna, Rohatyn districts; in 2017 – Dolyna, Halych, Nadvirna, Kosiv districts; in 2018 – Dolyna, Kosiv, Nadvirna, Halych, Bohorodchany, Rozhniativ, Verkhovina, Horodenka districts; in 2019 – Dolyna and Bohorodchany districts, in 2020 – Bohorodchany, Nadvirna, Dolyna, Halych, Kosiv and Kolomyia districts (Fig. 5).

Fig. 5. Cartogram of the visualization of the value of the discriminant function and the limit of discrimination (taking into account social tension) in the Ivano-Frankivsk region of Ukraine in 2020.
Source: own development.

Thus, it is possible to assert the need for the formation of an effective and efficient mechanism for ensuring the socio-economic development of rural areas, which should be based on a long-term regional state policy regarding the sustainable development of territories, which would, in particular, provide for the need to finance relevant projects at the expense of effective tax policy and investment sources of private-public partnership.

In our opinion, ensuring socio-economic security of rural areas in Ukraine should be carried out by forming a set of socio-economic goals and tools for their implementation. At the same time, practical control over the achievement of these goals should also be entrusted to the state, including regional authorities, which must directly participate in the formation of programs for the socio-economic development of the regions, and will also directly dispose of the funds necessary for financing the specified projects. At the same time, the sustainable development of rural areas will be based precisely on the implementation of the specified investment projects, as a result of which the general level of economic security of the regions will increase.

At the same time, it should be noted that the practical implementation of any projects and programs of socio-economic development of rural areas is impossible without an adequate amount of financial resources and sources of their replenishment. However, taking into account the systemic changes that are currently taking place in the economic system of Ukraine, determining the specifics of financing such projects requires additional research.

CONCLUSIONS

Based on the results of the conducted research, we come to a conclusion regarding the need to form effective programs for the development of rural areas of Ukraine, which is determined both by the need to ensure the socio-economic development of the village and the formation of labor resources for the agricultural sector of Ukraine. At the same time, the main obstacle to the implementation of such programs, which should be based on the principles of sustainable development of regions, are resource limitations, which are manifested in the insufficient amount of investment resources to achieve complex goals. At the same time, this resource limitation consists in the limitation of available resources, such as financial, human, material and natural resources. This can significantly affect the possibility of effective implementation of programs for the introduction of new technologies, infrastructure development, improvement of the quality of life and other initiatives aimed at the effective development of rural areas of Ukraine. Accordingly, such a lack of resources can become an obstacle in the development of certain industries, which are essential for the economic development of rural areas - such as agriculture, tourism, agrarian processing, etc. Therefore, the effective use of available resources and their optimal distribution in the process of implementing programs of socio-economic development of rural areas is an important task of ensuring their sustainable development. Since the resource provision of programs to support the development of rural areas is limited and in the process of their implementation questions will arise regarding the priority of financing the needs of this or that region or community, the results of modelling the indicators of dynamics and the state of socio-economic security can provide an answer to the question of specifying the process of identifying the region, which most needs the implementation of appropriate measures to bring the situation to a qualitatively higher level. At the same time, as the analysis of the calculated indicators on the materials of the Ivano-Frankivsk region of Ukraine shows, within the studied region it was possible to form groups of rural areas with differentiated values of the studied indicators, which, in our opinion, should also affect the mechanism of funding distribution under socio-economic development programs rural areas of Ukraine.

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COST EFFICIENCY IN THE PRODUCTION OF CROP PRODUCTS AS A FACTOR OF FORMATION OF COMPETITIVENESS IN INTERNATIONAL MARKETS

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Abstract

It was established that there is a close relationship between the level of costs and the yield of crops. At the same time, there is a manifestation of the law of diminishing returns, which leads to a drop in the level of profitability and profitability of production with an increase in the level of costs. The construction of the dependence of the paired regression of productivity-costs-profit, productivity-costs-level of profitability was carried out. The value of the coordinates of the point of intersection of the dependence of the profit and costs on the productivity of wheat, corn for grain, and sunflower was determined. The economic meaning of the obtained coordinates will be that with a given increase in X (yield), the amount of profit per 1 ha of the sown area will exceed costs per unit of land area following the established dependencies. It is proposed to determine the economic efficiency index of crop production intensity. The calculation of this index made it possible to establish that it was on average 4.506 for sunflower, 2.500 for wheat, and 2.102 for corn. For the first time, the influence of the index of economic efficiency of the intensification of the production of individual crop on the level of their profitability was evaluated. It was established that this rela was non-linear for wheat and sunflower, and linear for grain corn. The practical significance of the obtained results is that the optimal values of the index of economic efficiency and production intensification were determined for sunflower and wheat.

Key words: *costs, economic efficiency, the law of diminishing returns, profitability, production intensity.*

INTRODUCTION

Ukraine is among the most important cereals producing countries in the world coming on the 9th position after China, USA, India, Russia, Brazil, Indonesia, Argentina, and France. By crop, at the global level, Ukraine is ranked 9th for wheat production, the 6th for maize and the 4th for barley [26].

In 2021, the export of grain crops exceeded 50 million tons. This level makes it possible to provide food for almost 400 million people in the world [27]. However, the Russian invasion of Ukraine almost stopped these exports, which could increase hunger in the world. This also applies to its position in the world markets of agricultural products. Therefore, the question arises: what are the potential opportunities for Ukrainian producers in terms of the level of efficiency and intensity of production of the main agricultural crops. This problem is also very closely related to international competition and features of state support for agriculture in different countries of the world. The fact is that agricultural products on the world market, which are exported from many countries, contain a subsidy component. In Ukraine, the level of subsidies in 2020–2021 was actually symbolic. This fact must be taken into account when evaluating the cost effectiveness. As a working hypothesis, the assumption was put forward that the effect of the law of diminishing returns leads to a drop in the level of production efficiency and an increase in the cost of production. Based on the fact that competitiveness is considered by us as the ability of the enterprise to produce competitive products of appropriate quality and price under the conditions of maintaining profitability at a level that ensures expanded production and financial stability. It is the effect of the law of diminishing returns that ultimately leads to a deterioration in the level of competitiveness of agricultural producers. Only the presence of an economic mechanism that allows enterprises to receive an appropriate level of profit and the ability to effectively make investments can create a real basis for increasing the production of agricultural products and their export.

The problem of the formation and effectiveness of costs, and the value of goods is one of the central ones since the birth of economic science. At the same time, many questions remain today that require further research both from the point of view of theory and practice. This problem contains various components that determine the process of cost formation, which, in turn, makes it possible to conduct a wide variety of research. Let’s dwell only on certain points that characterize the whole variety of cost efficiency problems.

It is emphasized that the joint use of the latest technologies by farmers in Ethiopia makes it possible to minimize the production costs while simultaneously eliminating the adverse effects of soil degradation and climate variability [15]. The influence of production concentration on cost efficiency is also confirmed in the studies of Pokharel and Featherstone [18]. They concluded that scaling up and diversifying production can reduce costs for agricultural cooperatives. Tohidnia and Tohidi, using different methods of measuring the global cost-effectiveness for homogeneous process networks, concluded that there is a relationship between the global economic efficiency of the network system and its subsystems [23].

Another problem that researchers from India are paying attention to is related to the price of resources. In their opinion, due to a market failure or other imperfections, the price mechanisms, and accordingly the distribution of resources, may differ from the socially optimal equilibrium, misinforming private and state institutions, which, in turn, negatively affects the general well-being of society [3]. An analysis of the impact of one of these resources, namely pesticides, carried out on the example of French farms, proved that the costs of this article could be reduced by more than 50 % by eliminating technological inefficiencies [8].

The authors concluded that the elimination of this inefficiency can help achieve the goals of reducing the use of pesticides and increase the level of greening of production. There was also a study of the relationship between the duration of the formation of transaction costs and their value on the example of food industry and agribusiness enterprises [1]. The authors’ conclusions were that the buyer's solvency and leverage reduce the duration of transaction agreements, and accordingly, the costs. On the other hand, deals made during a recession generate additional costs.

Lukyanova, Kovshov, Zalilova consider the optimization of the structure of cultivated areas, fodder crops in particular, to be one of the important factors in reducing costs and increasing their efficiency [12]. In addition, another reserve for improving the efficiency of the livestock industry can be the optimization of livestock sizes, which will further increase the level of efficiency and, accordingly, reduce the relative amount of costs [6]. Jiang and Sharp also emphasize that the analysis shows a significant relationship between cost efficiency and capital intensity, livestock quality and livestock size [7]. The issue of the risk impact in the process of product value formation [2, 20], pricing [4], startups [24] is separately investigated. The relevant aspects of the problem of cost efficiency formation, optimization the degree of intensity, and their influence on agricultural competitiveness are underlined in the works of Ukrainian scholars [9–11, 14, 16, 17].

In this case, we presented a very small number of questions related to the problem of determining the value of goods and the effectiveness of costs in agriculture. In fact, their circle is much larger and covers the period starting with the Physiocrats. In each time period, this issue had its own characteristics, but its relevance is not lost even today.

At the same time, for each country must emphasize the characteristics of the economic mechanism's construction, which compels producers on the one hand to successfully invest resources in production, and on the other – to raise their volumes and, therefore, contribute to economic development. Our study will focus on elucidating these challenges.

The purpose of the study is to assess the impact of the level of production intensity on the formation of its efficiency and competitiveness under the conditions of the law of diminishing returns and in this process. The goal was also to develop an own methodology for assessing the level of production efficiency of individual crops, which would take into account various factors of its formation.

MATERIALS AND METHODS

In the process of research, the dialectical method of cognition, the systematic approach to the study of economic phenomena and processes, and the monographic method (analysis of the scientific achievements of domestic and foreign scientists on the problems of estimating the level of income of the population, the structure of expenses, and the quality of life) were used. Of the special research methods, abstract-logical (for theoretical generalizations and formulation of conclusions), economic-statistical (construction of groupings), graphic (when constructing graphic images), correlational analysis (for construction of the dependence of the level of costs and productivity, productivity and level of profitability, level profitability of production). A proprietary methodology for determining the index of economic efficiency of intensification is proposed.

RESULTS AND DISCUSSIONS

Agricultural enterprises of the Kharkiv region acted as the object of the research. Data for 2020 on wheat, corn for grain, and sunflower were used for the analysis. The number of enterprises was the same for the production of wheat – 471, corn for grain – 319, and sunflower – 484.

At the first stage of the research, the dependences between the level of costs and three indicators of their effectiveness were modeled: yield, profitability, and profit per hectare of planted area (Table 1).

Table 1. Regression models of the dependence of the level of production efficiency on costs for individual crops in agricultural enterprises of the Kharkiv region in 2020

Indicators	Yield, c/ha (y)	Profit per 1 ha, UAH (y)	Level of profitability, % (y)
Wheat			
Costs (x)	У=40.58 + 0.00070x	У=13,761.5 – 0.30x	У=190.47 – 0.0065x
Corn for grain			
Costs (x)	У=45.75 + 0.00039x	У=8,994.2 – 0.174x	У=88.79 – 0.0008x
Sunflower			
Costs (x)	У=18.93+ 0.00027x	У=13,156.2-0.23x	У=171.69-0.0040x

Source: own calculations based on data from statistical reporting of agricultural enterprises.

The obtained values of the regression functions allow us to assess how the level of efficiency changes for each crop when the level of costs changes by 1 hryvnia. It was established that under the conditions of an increase in the level of costs by 1,000 UAH/ha, the fastest rate of change in all efficiency indicators occurs in wheat. Accordingly, on average, for the totality of enterprises, the increase in yield was equal to 0.7 c/ha, the decrease in profit was 300 UAH/ha, and the decrease in the level of profitability was 6.5 %. The last two results are evidence of the manifestation of the law of diminishing returns.

Moreover, a similar situation occurred with corn for grain and sunflower. Another important point is the fact that all obtained regression equations are reliable. The actual values of Fisher's test (F) exceed those in the table. This is certainly because the formed aggregates included several hundred enterprises. In addition, the level of reliability (p) was less than the critical value (0.05) in all cases except one for corn in the "yield-profitability" dependence system.

To highlight the noted dependencies in more detail, it was decided to use the grouping method (Tables 2, 3, 4). All enterprises were divided into six groups. The first conclusion that can be drawn from the results of the groupings concerns the fact that the amount of yield and costs per unit of land area are closely related. For wheat, the average yield in the group of enterprises with costs up to 5,000 UAH/ha was 42.4 c/ha, with costs 10,000.1–15,000 UAH/ha – 54.3 c/ha, and with costs over 20,000.1–25,000 UAH/ha – 68.7 c/ha. At the same time, the productivity of enterprises with level of expenses over 25,000 UAH/ha turned out to be somewhat lower – 66 UAH/ha.

This fact indicates that the technological limit of productivity growth has been reached and the further increase in costs for wheat will not lead to an increase in productivity. As for corn for grain, the trend was similar. In enterprises with an expenditure level of up to 10,000 UAH/ha, the average yield is 50.1 c/ha, in enterprises with an expenditure level of 15,000.1–20,000 UAH/ha – 62.4 c/ha, and enterprises with an expenditure level of more than 35,000 UAH/ha – 63.4 c/ha. In this case, it is worth noting that the amount of productivity in the last two groups has almost not changed, with a significant difference in the level of costs. It may also indicate that the limit of technological efficiency has been reached.

For sunflowers, the dependence on costs and productivity was most clearly expressed. According to this crop, the average yield in enterprises with an expenditure of up to 5,000 UAH/ha was 18.9 c/ha, with an increase in expenditure of 10,000.1–15,000.1 UAH/ha – 21.8 c/ha, and in the last group with a level of costs over 25,000 UAH/ha – 39.9 c/ha.

Thus, in contrast to the two previous sunflower cults, the most favorable situation for increasing the level of productivity is created under the conditions of increasing production intensity.

Table 2. The influence of the level of costs per 1 sown area on the level of economic efficiency of wheat production in agricultural enterprises of the Kharkiv region in 2020

Indicators	Groups by level of expenses, UAH/ha						
	under 5,000	5,000.1–10,000	10,000.1–15,000	15,000.1–20,000	20,000.1–25,000	over 25,000	average
Number of enterprises	21	103	173	97	38	39	471
Average costs per 1 ha, UAH	3,462	8,032	12,655	17,185	21,612	32,674	14,312
Yield	42.4	45.6	51.0	54.3	68.7	66.0	52.8
Costs per 1 ha, UAH:							
seed	397	818	1,076	1,454	1,591	2,251	1,195
mineral fertilizers	725	2,117	3,143	4,150	4,913	6,936	3,447
fuel	437	988	1,184	1,642	3,448	6,813	1,709
remuneration	347	760	1,589	2,596	2,486	2,912	1,767
depreciation	270	638	985	1,661	1,789	2,318	1,187
Cost of 1 c, UAH	82	176	248	316	315	495	271
Income per 1 ha, UAH	20,146	21,883	25,610	27,055	33,393	32,094	26,105
Profit per 1 ha, UAH	14,785	12,196	11,485	8,280	8,688	3,531	10,214
Level of profitability, %	276	126	81	44	35	12	64

Source: own calculations based on data from statistical reporting of agricultural enterprises.

Thus, for all three crops, we have an established relationship between costs and productivity.

As for individual expenditure items, the trend turned out to be similar. For all three crops, the largest difference by the group was the cost item "Fuel". According to this the difference between the first and the last group was 34.4 times for sunflower, 15.6 times for wheat, and 10.8 times for corn for grain. Thus, it is a sunflower that has the highest level of differentiation in spending under this article. As for the cost items that had the least differentiation, they were different for the selected crops. The smallest difference was observed for sunflower, wheat, and the cost

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Vol. 23, Issue 1, 2023
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item “Seeds”, and for corn for grain – according to the cost item “Labor payment”. As for expenses under the expense item “Depreciation”, the pace of its change was higher than the average only for sunflower. This expense item is important because it serves as an indicator of the innovativeness of the production of a particular crop. In this case, the conclusion is also quite obvious – the increase in the level of expenses for fixed assets, and accordingly the amount of depreciation, is very closely related to the growth of the yield level of all crops. This is a completely logical result because obtaining high yields of crops requires not only investments in current costs, but also capital investments.

Table 3. The influence of the level of costs per 1 sown area on the level of economic efficiency of the production of corn for grain in agricultural enterprises of the Kharkiv region in 2020

Indicators	Groups by level of expenses, UAH/ha						
	under 10,000	10,000.1–15,000	15,000.1–20,000	20,000.1–25,000	25,000.1–35,000	over 35,000	average
Number of enterprises	57	96	69	42	34	21	319
Average costs per 1 ha, UAH	7,499	12,617	17,005	22,429	29,762	57,099	16,962
Yield	50.1	55.2	62.4	65.3	60.9	63.4	58.4
Costs per 1 ha, UAH:							
seed	1,235	2,164	2,930	2,972	3,880	6,689	2,595
mineral fertilizers	1,279	2,207	3,014	4,171	5,370	11,017	3,047
fuel	843	1,543	1,866	2,866	3,181	9,079	2,042
remuneration	1,065	1,051	2,083	3,391	4,816	4,966	2,063
depreciation	493	1,170	1,355	2,073	2,548	4,291	1,448
Cost of 1 c, UAH	150	229	272	343	489	900	291
Income per 1 ha, UAH	23,776	25,834	29,825	28,965	28,736	28,626	27,235
Profit per 1 ha, UAH	14,285	8,884	10,864	5,120	6,411	13,688	9,259
Level of profitability, %	151	52	57	21	29	92	52

Source: own calculations based on data from statistical reporting of agricultural enterprises.

Table 4. The influence of the level of costs per 1 sown area on the level of economic efficiency of sunflower production in agricultural enterprises of the Kharkiv region in 2020

Indicators	Groups by level of expenses, UAH/ha						
	under 5,000	5,000.1–10,000	10,000.1–15,000	15,000.1–20,000	20,000.1–25,000	over 25,000	average
Number of enterprises	20	103	178	89	50	44	484
Average costs per 1 ha, UAH	3,600	8,049	12,420	17,219	22,611	38,492	14,275
Yield	18.9	21.7	21.8	24.8	27.5	39.9	23.8
Costs per 1 ha, UAH:							
seed	776	943	893	603	672	588	795
mineral fertilizers	520	1,056	1,594	2,312	2,674	3,648	1,748
fuel	449	1,160	1,868	3,224	5,219	5,931	2,387
remuneration	288	811	1,574	1,841	2,487	9,899	2,007
depreciation	403	927	1,795	2,488	2,914	5,530	1,966
Cost of 1 c, UAH	173	672	1,112	1,501	2,294	2,709	1,228
Income per 1 ha, UAH	26,880	23,404	22,841	25,977	28,997	43,863	25,482
Profit per 1 ha, UAH	21,595	13,538	11,357	9,915	6,904	5,816	11,267
Level of profitability, %	409	137	99	62	31	15	79

Source: own calculations based on data from statistical reporting of agricultural enterprises.

Regarding the effectiveness of the costs incurred. In this case, three indicators were determined for its evaluation: income and profit per 1 ha of cultivated area and the level of profitability of production. It was established that only the value of income per 1 ha of the sown area had a close direct relationship with the number of expenses incurred. In particular, for wheat, the average amount of income per 1 hectare was 20,146 UAH/ha in enterprises with an expenditure level of up to 5,000 UAH/ha, and in enterprises with an expenditure level of 10,000–15,000 UAH/ha – 25,610 UAH/ha. And enterprises with a level of expenses over 25,000 UAH/ha – 32,094 UAH/ha. For sunflower, this trend was most clearly manifested, and for grain corn, it was manifested to a lesser extent. Also important are the trends associated with changes in two other indicators – profit per hectare and the level of profitability. They clearly state the effect of the law of diminishing returns, which was first mentioned in the works of Turgot

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[21, 22]. Today, in the most developed countries of the world, one of the main factors in overcoming the effect of this law is state support for agriculture [5, 11, 19, 25].

It makes it possible to maintain the appropriate level of production intensity.

In the absence of this support, the effect of the law of diminishing returns would inevitably lead to a decrease in the level of costs and, accordingly, the level of crop yields.

In Ukraine, the level of state support is very insignificant and, accordingly, has almost no effect on the formation of the level of intensity and efficiency of production.

To consider this situation in more detail, let's turn to the data on the level of state support according to the Producer Support Estimate (PSE) indicator. This indicator characterizes the amount of state support under various programs to the value of the gross product in agriculture (Table 5).

The given data refer to different countries and continents. According to 2021 data, the highest level of state support took place in Iceland (58.0 %) and Norway (49.6 %). At the same time, it was the smallest in Ukraine – 1.1 % of the value of the agricultural product. Moreover, in 2014, 2016, and 2017, its value was negative, which indicates that agriculture acted as a donor to other sectors of the economy. There was no such situation in any of the analyzed countries. Even Turkey has a significantly higher level of state support than Ukraine. Thus, under these conditions, the only competitive advantage of domestic producers of agricultural products on international markets should be the efficiency of production, in particular, costs under the conditions of the law of diminishing returns.

Table 5. The dynamics of income support for agricultural producers through budget transfers (PSE, %) in Ukraine and certain countries of the world for 2013–2021, %

Country	2013	2014	2015	2016	2017	2018	2019	2020	2021
Australia	2.2	1.9	1.8	1.7	2.7	2.4	3.2	3.3	2.8
Canada	9.2	7.9	7.8	9.4	7.7	7.8	8.7	8.2	11.7
Iceland	41.4	50.5	57.1	59.7	58.9	57.5	56.5	57.2	58.0
Norway	56.6	59.3	59.4	60.6	55.1	58.1	55.4	53.4	49.6
Turkey	20.9	26.1	26.4	29.4	23.8	15.2	17.4	26.0	15.1
Ukraine	0.0	-1.4	0.5	-1.4	-0.8	2.1	2.8	1.4	1.1

Source: [13].

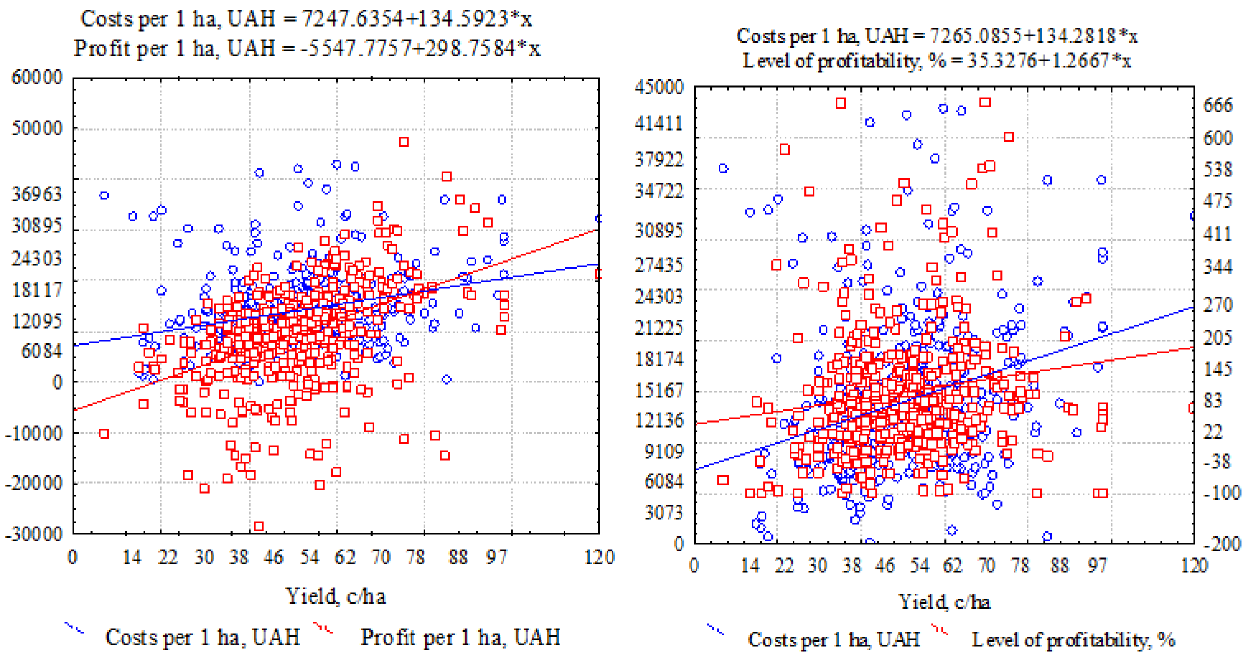

Fig. 1. Dependence of the level of profit and the level of profitability on costs and yield of wheat in agricultural enterprises of the Kharkiv region in 2020

Source: own calculations.

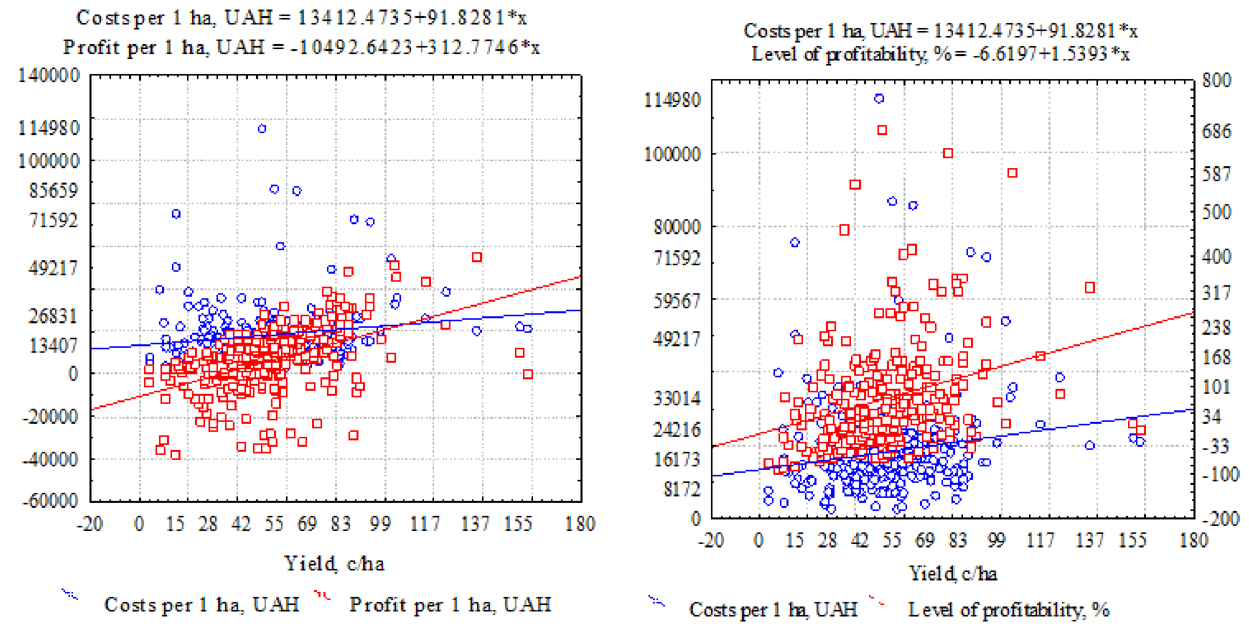

Fig. 2. Dependence of the level of profit and the level of profitability on costs and the yield of corn per grain in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

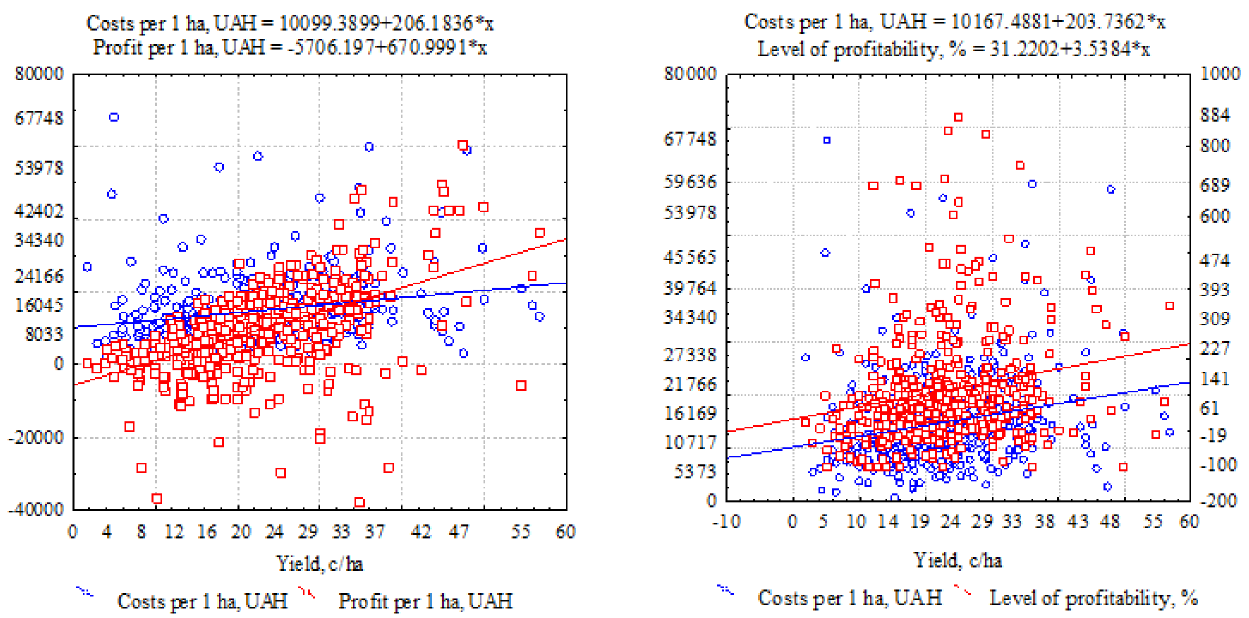

Fig. 3. Dependence of the level of profit and the level of profitability on costs and yield of sunflower in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

Therefore, the question arises: exactly what factors encourage entrepreneurs to invest capital in production. In this case, we have already emphasized the connection between the level of costs and the yield of crops. However, what is the nature of the relationship between productivity and profitability? To comprehend this, the dependencies between productivity and profit were built, as well as the paired regression dependences of productivity-costs-profit and productivity-costs-profitability. (Figs. 1, 2, 3).
As a grouping indicator, crop productivity was used. As dependent variables, costs, profit, and level of profitability were chosen.
Even though the coordinates of the point of intersection of the regression lines can be clearly determined on the graph. It turned out

that both the profit and the level of profitability for all crops had a positive relationship with them. In addition, the intersection point of the regression line in the figures makes it possible to establish the level of productivity at which the rate of increase in the costs will be lower than the rate of increase in profit. This situation concerns the cost-yield and profit-yield dependences. This is because the dependent values have one dimension and, accordingly, the point of intersection. To mathematically determine these positions, it was decided to combine these equations and find the corresponding values of the X-axis (Table 6).

This point is located through the solution of the corresponding system of equations. The economic content of the obtained coordinates will be that at a given increase in X (yield), the profit per 1 ha of the sown area will exceed costs per unit of land area by the established dependencies. In other words, the level of profitability should be equal to 100 %.

This amount is such that it already provides an excess profit and significant incentives for the application of specific actions regarding the further growth of crop yields.

Table 6. The profit, productivity and the level of profitability of crop production in accordance with the obtained regression equations in agricultural enterprises of the Kharkiv region in 2020

Crops	The equation of regression of the dependence of consumption (y) – yield (x)	Profit-yield dependence regression equation	Estimated indicators	Value
Wheat	y = 7,247.6+134.59x	y = -5,547.78+298.8x	yield, c/ha	77.9
			expenses, profit UAH/ha	17,738
			profitability level, %	133.6
Corn	y= 13,412.5+91.83x	y = -10,492.6+312.78x	yield, c/ha	108.2
			expenses, profit UAH/ha	23,347
			profitability level, %	159.9
Sunflower	y = 10,099.4+206.18x	y = -5,706.2+671.00x	yield, c/ha	33.9
			expenses, profit UAH/ha	17,074
			profitability level, %	151.2

Source: own calculations based on data from statistical reporting of agricultural enterprises.

It was established that to wheat, this situation occurs at the level of productivity – 77.9 c/ha, the level of costs – 17,738 UAH/ha, and the level of profitability – 133.6 %. Regarding corn for grain, these indicators were equal to 108.2 c/ha, 23,347 UAH/ha and 159.9 %, respectively. For sunflowers, respectively – 33.9 c/ha, 17,074 c/ha, and 151.2 %. These positions form a group of enterprises that had the highest efficiency and competitiveness in the production of these crops

However, as we have already noted based on the above research results, the increase in costs leads not only to an increase in the level of crop productivity but also includes the law of diminishing returns, which in turn hurts the amount of profit per one hectare of the planted area, as well as on the level of profitability. In this case, a contradiction arises.

On the one hand, we have a situation where the increase in productivity makes it possible to increase the profitability of crop production, and on the other hand, the increase in productivity is directly related to costs per unit of land area, and accordingly, in the final case, will lead to a drop in profitability.

To more objectively assess this situation, we propose to determine the economic efficiency index of the level of crop production intensification according to the following formula:

$$I_{ef} = \sqrt[3]{\beta_c \mathrm{I}_c \times \beta_{profit} \mathrm{I}_{profit} \times \beta_{\mathrm{p}} \mathrm{I}_{\mathrm{p}}} \quad (1)$$

where:

I_{ef} – index of economic efficiency of intensification of crop production;

β_c, β_{profit}, β_p – weighting ratios of costs, profits and profitability;

I_c, I_{profit}, I_p – indices of compliance of actual data on the level of costs, profits per 1 ha of the sown area and profitability. Indices of correspondence of actual data to model data are calculated as the ratio of the actual value to the model value:

$$Ii = F_i/M_i \quad (2)$$

where:

I_i – index of compliance of actual data on the i-indicator;
F_i – the actual value of the i-th indicator;
M_i – model value of the i-th indicator.

In turn, weighting coefficients are calculated in proportion to the level of variation of the balances for each indicator. The residuals themselves are defined as the difference between the actual and model values of each indicator.

$$\beta i = r_{max}/r_i \quad (3)$$

where:
βi – i-culture weighting factor;
r_{max} – the maximum value of the coefficient of variation among these indicators;
r_i – the value of the coefficient of variation for the i-indicator.

The actual values of βi and coefficients for individual crops and indicators are shown in Table 7. The value at level 1 is evidence that the level of variation of the indicator was the highest in this culture. Accordingly, according to other indicators, its value will be more than 1. This allows you to eliminate the effect of the variability of individual indicators on the final result.

Table 7. The value of the β and coefficient for individual crops in agricultural enterprises for 2020

Culture	Costs per 1 ha, UAH	Profit per 1 ha, UAH	Level of profitability, %
Sunflower	1.00	2.60	3.07
Wheat	1.19	1.15	1.00
Corn for grain	1.00	3.23	1.28

Source: own calculations based on data from statistical reporting of agricultural enterprises.

The economic content of the index of economic efficiency of intensification is that if its value is equal to 1, we will have a situation when the level of expenses, the amount of profit or the level of profitability correspond to the values obtained by their value according to the models.

However, this is only one of the possible options. A situation is possible when one of the indices included in the model will be greater than 1, and the others will be smaller. This especially applies to the situation when the law of diminishing returns is in effect. In this case, the indices of correspondence of the actual data on the level of expenses will be greater than 1, and other indices will be less than 1.

Table 8. Grouping of agricultural enterprises by the value of the index of economic efficiency of intensification by individual crops for 2020

Economic Efficiency Index	Costs per 1 ha, UAH	Productivity, c/ha	Profit per 1 ha, UAH	Level of profitability, %
Sunflower				
under 1	16,469	24.8	-827	-3.2
1.1–2	15,608	19.2	1,913	9.7
2.1–4	12,097	23.0	16,116	180.6
4.1–6	14,713	26.4	14,655	108.3
6.1–8	14,434	28.3	15,581	106.9
over 8	15,188	26.3	14,002	112.4
Wheat				
under 0.5	17,018	56.2	497	1.8
0.51–1	17,358	51.3	-2,210	-8.3
1.1–1.5	12,952	54.3	13,675	111.5
1.51–2.5	12,668	50.3	13,430	113.4
2.51–3.5	14,493	52.1	12,191	84.5
3.51–4.5	14,268	54.8	13,148	94.9
over 4.5	13,612	53.5	12,745	96.1
Corn for grain				
under 0.5	18,562	58.5	-1621	-5.3
0.5–1	14,589	59.3	964	3.6
1–1.5	17,024	50.1	-1809	-7.5
1.5–2.5	15,822	55.9	13209	110.2
2.5–3.5	21,913	76.1	25386	212.9
over 3.5	21,375	90.1	32206	222.5

Source: own calculations based on data from statistical reporting of agricultural enterprises.

In any case, a value larger than one for the index of economic efficiency of intensification indicate that in this enterprise the values of the indices included in model

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will exceed those results predicted by the existing dependencies. This, in turn, may indicate a higher overall efficiency of the production of this culture at the enterprise.

To assess the real situation with the peculiarities and dependencies of the index of economic efficiency of intensification, it was calculated using three selected crops as examples (Table 8). The first thing to notice is the significant variation of index values among crops.

The largest value of the index was found for sunflower – 4.506, then for wheat – 2.500, and the smallest value was for corn for grain – 2.102. It should be noted that this does not indicate that the production efficiency of sunflower was higher than corn for grain. The discrepancy data only indicate that the relative deviation of the actual data from the model data for sunflowers was higher than for corn for grain. This may be an indication of the greater riskiness of the production of this crop in terms of the costs incurred and the result obtained. The subjective factor also plays a greater role in this case, both from the point of view of production technologies and business.

Regarding the dependence of the value of the index of economic efficiency of intensification, we note that a clear dependence of its value on the level of costs and productivity was not established. This suggests that the level of expenses largely does not determine the final efficiency of management. That is, you can incur expenses, but this will not be a guarantee that we will get the planned yield.

This conclusion somewhat contradicts the one we made above about the existence of a dependence between costs and productivity, however, the used calculation method ties this dependence even to the profit per 1 ha and level of profitability of production. At the same time, such dependence took place in terms of the amount of profit per 1 ha of the sown area and the level of profitability.

For all three cultures, in the groups with the lowest value of the index of economic efficiency of intensification, the profit per 1 ha and the level of profitability turned out to be the lowest. For corn, there were even three such groups per grain. As for the further trend, it can be characterized as non-linear for wheat and sunflower, and linear for grain corn.

The non-linear nature of the dependence was verified on the example of primary data (Figs. 4, 5). In this case, we have confirmation of the revealed trend.

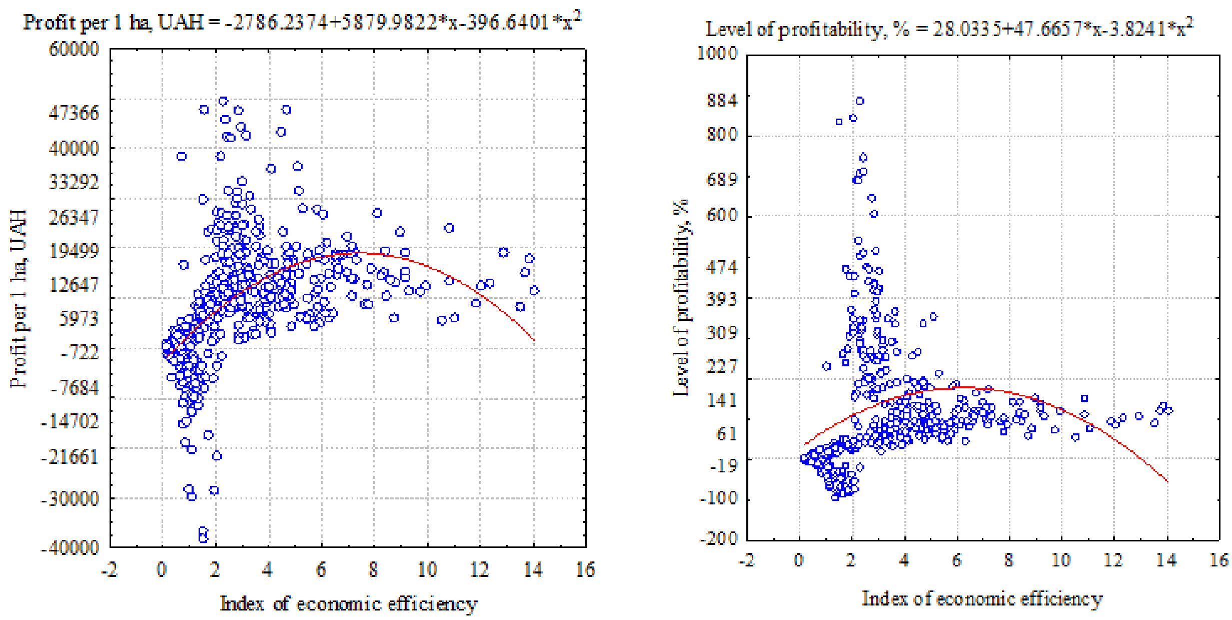

Fig. 4. Dependence of the level of profit and the level of profitability on the value of the index of economic efficiency of the intensification of sunflower production in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

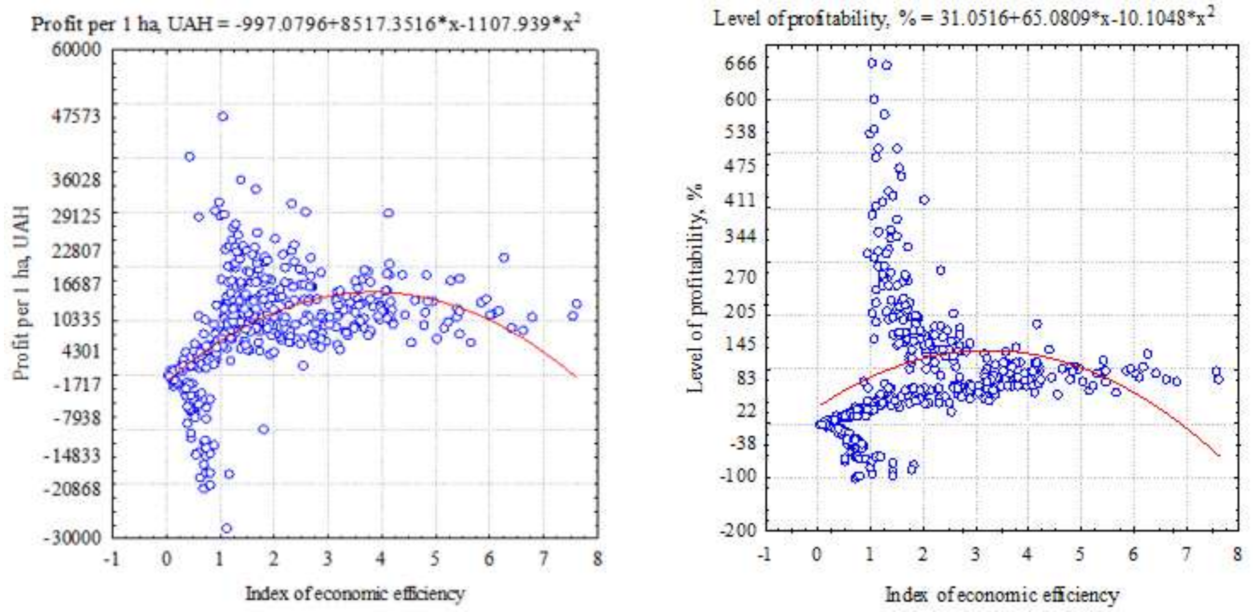

Fig. 5. Dependence of the level of profit and the level of profitability on the value of the economic efficiency index of the intensification of wheat production in agricultural enterprises of the Kharkiv region in 2020
Source: own calculations.

To establish the maximum of the function, appropriate calculations were carried out. It turned out that the maximum function for sunflowers was 7.41 for profit, and 6.23 for profitability.

For wheat, these values of the economic efficiency index were respectively equal to 3.84 in terms of profit and 3.22 in terms of profitability. The question arises, what practical conclusions can be drawn based on the calculations made? First of all, any process that is evaluated from a new point of view makes it possible to notice those moments that were not ascertained before. Secondly, our analysis made it possible to establish that the economic mechanism for corn for grain, which should contribute to increasing the level of crop productivity, is working well. At the same time, the maximum of the index of economic efficiency of intensification occurs for sunflower and wheat, after which it decreases. In this case, this fact can cause the actions of producers, which will be aimed at stopping investment, and accordingly, reducing the level of productivity, and ultimately the competitiveness of the enterprise. To prevent this phenomenon, it is necessary, as already mentioned above, to introduce real state support for manufacturers. However, the question lies in the mechanism of providing this support. One of its options may be the use of the economic efficiency index of intensification as a criterion for determining its necessity and size. The specific parameters of this index for wheat and sunflower were determined by us.

CONCLUSIONS

The conducted research made it possible to establish certain important features of the formation of the mechanism of producers' interest in increasing the level of intensity of production of crops.

It was established that the level of connection between the costs and the efficiency of production of wheat, sunflower, and corn per grain is weak. This is due to the complex mechanism of the interaction of capital with nature and the significant influence of the subjective factor. At the same time, the level of reliability of the built models was high, which allows them to be used assess established trends.

It was found that there is a clear relationship between the costs and the yield of crops. It has a different character, both from the point of view of the rate of increase in productivity, and changes in costs for individual articles. This dependence is also supplemented by the action of the law of diminishing returns, which leads to a drop in the level of profit and the level of profitability of production.

It was also established that the growth of productivity, under the conditions of optimal costs, is the basis of increasing both the level of profitability and the level of profitability of production.

The level of productivity of crops that allows forming the most effective parameters of production and competitiveness in terms of productivity, profitability, and level of profitability has been determined. These can serve as appropriate beacons for agricultural producers.

A methodology for determining the economic efficiency index of intensification is proposed. This index allows you to combine the level of productivity, costs, profitability, and the level of profitability of production at the same time. The practical approbation of this methodology made it possible to establish that there is a direct relationship between the value of the economic efficiency index of intensification and the profit per 1 ha and level of profitability of corn production. As for wheat and corn per grain, this dependence has a non-linear character.

The value of the index of economic efficiency of intensification, at which the level of profit and the level of profitability was maximum, was determined.

We believe that one of the effective measures to maintain this level of profitability is state support for the production of these crops, taking into account the parameters of the economic efficiency index of intensification determined by us. This will make it possible to create an effective mechanism for further increasing the production of crops without reducing the level of competitiveness of enterprises.

Prospects for further research may be related to the development of a specific mechanism of state support for agricultural enterprises, taking into account the economic efficiency index of intensification.

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DIGITAL TOOLS UTILIZED IN ONLINE, HYBRID AND TRADITIONAL TECHNING MODELS IN PRE-UNIVERSITY STUDIES

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Abstract

In connection with the changes imposed in recent years, the trend in education has been set by forms of education based on the use of digital technologies. Thus, also at the level of pre-college education, forms of online education have emerged that are adapted to the legal requirements, to the subject, but also to the experience of the teaching staff in the field of digital skills. In this sense, we have proposed an analysis of the digital systems used in pre-college education. This research is divided into three parts: the analysis of teachers' experiences in the classroom, the use of digital tools, and the process of assessing students using digital methods. The method used in this research is based on a survey based on a questionnaire. The results sought were the opinions of elementary school teachers about the use of digital tools throughout the educational process. The conclusions concerned the degree of use of digital resources in the educational process and proved the reluctance of teachers and parents to use them.

Key words*: *education, online platform, online evaluation, digital resources, rural education

INTRODUCTION

In a hyper-connected society, in order to meet the new demands of society, the education sector is going through significant challenges in the process of transforming learning models. The process of teaching how to adequately interact as active and engaged citizens in society is perhaps the most difficult task facing teachers today. Moreover, at the school level, the level of knowledge of teachers and students about digital technologies must be taken into account in order to be able to design new educational models that meet their current needs.

In this sense, this problem has been addressed in several researches from which we recall the objective proposed in the study carried out by Lun et. al. [9] is to investigate the effects of two online platforms (Telegram and Google Classroom) on the frequency of use and ease of use among pre-university students during a Covid-19 pandemic. The main proposed objective is to compare the frequency of use of pre-university students who use any of the online platforms for online learning. In addition, another aim is to determine the ease of use of both online platforms based on the experiences of pre-university students. The research was based on quantitative indicators for which a random sample of 100 students from the pre-university environment was taken. Quantitative data on frequency of use and ease of use were collected through a survey questionnaire distributed to 100 research participants. The results of the study show the usefulness of Telegram and Google Classroom as online platforms for teaching and learning, including for preschool students. These platforms encouraged preschoolers to be more engaged in learning during the Covid 19 pandemic.

Another work, carried out by Kamal A. A, et. al. [8] shows that "the use of the online environment increased significantly, which led educational institutions to adopt online learning due to health restrictions". It was "found that online learning would not be a hindrance but a blessing for academic excellence in the face of calamities like the COVID-19 pandemic".

Another paper analyzed the digital gaps during pandemic of the young generation. Iivari et. al. [6] argues that "information management research should better recognize children, their digitized everyday lives and their basic education as significant areas of concern" and that "we should also aim to influence the basic education of the younger generation – in order to equip them with skills and competences important to them".
Rural education in the research carried out by Biriescu and Băbăita [4] is one of the important factors in regional development. The authors proposed a software capable of analyzing the performance of the education system in regional development based on major indicators of efficiency and effectiveness.

MATERIALS AND METHODS

The analysis of the use of digital means in the teaching process at the level of pre-university education was based on a study carried out among teachers from 3 schools. The construction of the questionnaire was done by specifying clearly and in detail the problem to be researched, establishing the theoretical and working hypotheses, establishing the variables and transposing them into questions.
The questionnaire included closed and open questions, precisely to capture the respondents' opinions as best as possible. Closed questions were used to collect quantifiable information, and open questions were used to collect subjective information. The methodology for creating the questionnaires was based on the following considerations: the confidentiality of the respondents was preserved; words and expressions were used according to the meaning of the respondents; questions that may indicate answers were avoided; a certain consistency was sought in the order of the questions, the organization of the questions was made by sections in accordance with the proposed objectives; several categories of questions were introduced, respectively, those of accommodation, difficult questions, easy questions, questions describing the subjects.
To develop the questionnaire, the following stages were completed: the delimitation of the research topic and the sections in correlation with the objectives; making questionnaires in written and online format; organization of data collection procedures; collection of information; creating the database for data entry.
The questionnaire consisted of two sections and 37 questions, of which 5 were open questions. Respondents were also given the opportunity to add their own answers to most questions. We elaborated:
-a section dedicated to teachers that includes information regarding: (seniority, status, field of activity, age, subjects taught, school and educational level at which they teach;
-a section for appreciative evaluation for the last three years of teaching.
In the second section, the questions are focused on the three teaching methods practiced in the last five years in pre-university education, namely: online education – 2020; hybrid education – 2021; physical education – 2022. Frequencies were calculated using IBM SPSS Statistics software [5].

RESULTS AND DISCUSSIONS

Looking at the life cycle of a food product, it
In an era of rapid technological changes, new ways of cultural production, consumption and dissemination, access to cultural content create great opportunities to promote cultural heritage at home and abroad as a prerequisite for sustainable development [11].
In a modern and dynamic world, where information is updated every second, every person, regardless of age and occupation, is obliged to learn and improve continuously. In the era of new information and communication technologies, the Internet has revolutionized all areas of social and professional life, including education, training and culture. Internet education represents a new way of learning for the student but also a new way for the teacher to teach [3]. The digitization of education brings a challenge to the entire education system, not just distance education [1].

In order to determine the digital models used in primary education, information was analyzed regarding: age, seniority, platforms used in the transmission of information, platforms used in classroom management, use of online course support, types of online applications used, students' access to learning materials online course, online teaching methods, online assessment.

Regarding the age of the teachers, the range with the minimum age at which a teacher can be hired and the average age at which teachers retire was taken as a hypothesis. In this sense, we have established four age ranges presented in Table 1. In the schools where the study was carried out, the highest share (35.7%) was among teachers who are between 30 and 39 years old. According to the data presented, the fewest teachers are young ones with a weight of 14.3%.

Table 1. Age of the teachers

Age	Frequency	Percent	Valid Percent	Cumulative Percent
Under 29 years old	4	14.3	14.3	14.3
30-39 years	10	35.7	35.7	50.0
40-49 years	8	28.6	28.6	78.6
50-59 years	6	21.4	21.4	100.0
Total	28	100.0	100.0	

Source: Own determinations.

The experience in education is given primarily by the seniority of the teaching staff and the performance of an educational unit is analyzed including the share of experienced teachers.

Table 2. Seniority in education

Seniority	Frequency	Percent	Valid Percent	Cumulative Percent
Under 5 years	7	25.0	25.0	25.0
5-9 years	6	21.4	21.4	46.4
10-14 years	5	17.9	17.9	64.3
15-19 years	6	21.4	21.4	85.7
Over 20 years	4	14.3	14.3	100.0
Total	28	100.0	100.0	

Source: Own determinations.

As shown in Table 2, the highest share is recorded for people who have less than 5 years of experience in education. However, cumulatively, the experience of staff with more than 5 years of experience is approximately 75%.

In recent years, the transformations in Romania's economy and implicitly in education had digitization as its main objective. Banciu et al. appreciate that the Romanian digital transformation is in accordance with the European directives in this field, but also with the global trends of the 21st century [2]. In this sense, the digital platforms used in the education process, classroom management platforms, for access to digital information and the types of online applications used in the education process were analyzed [3]. The degree of use of platforms for the transmission of information was presented in Table 3. More than 89% of the interviewed teachers appreciated that they used the Google Meet platform while only 3.6 used the Zoom platform to participate in online lessons with students.

Table 3. Platforms used in the online transmission of information

Platforms	Frequency	Percent	Valid Percent	Cumulative Percent
Google Meet	25	89.3	89.3	89.3
Zoom	1	3.6	3.6	92.9
Google Meet and Zoom	2	7.1	7.1	100.0
Total	28	100.0	100.0	

Source: Own determinations.

Social Media represents a set of electronic platforms, applications, websites that offer various services through an Internet network and can facilitate the creation of links based on various criteria that allow the connection and interaction of users with each other [7].

Table 4. Platforms used for classroom management

Platforms	Frequency	Percent	Valid Percent	Cumulative Percent
Google Classroom	27	96.4	96.4	96.4
Zoom	1	3.6	3.6	100.0
Total	28	100.0	100.0	

Source: Own determinations.

Regarding the digitization of the classroom management mode, as shown in Table 4, more than 96% of the responding teachers used the resources of the Google Classroom platform for classroom management.

According to the study, from the data also presented in Table 5, the most appreciated platform that allowed access to digital resources (over 67%) is School on the internet.

Table 5. Platforms used for access to digital resources

Platforms	Frequency	Percent	Valid Percent	Cumulative Percent
School on the internet	19	67.9	67.9	67.9
EDU network	3	10.7	10.7	78.6
Digitaliada	1	3.6	3.6	82.1
Mozabook	1	3.6	3.6	85.7
Google Classroom	2	7.1	7.1	92.9
Wordwall	1	3.6	3.6	96.4
Other	1	3.6	3.6	100.0
Total	28	100.0	100.0	

Source: Own determinations.

The digital course supports preferred by many teachers are documents in '.pdf' format (Portable Document Format), with a share of over 44% of the responding teachers, data presented in Table 6.

Table 6. Types of course support used in online education

Course support you used	Responses		Percent of Cases
	N	Percent	
Doc	11	19.0	39.3
Pdf	26	44.8	92.9
Youtube	10	17.2	35.7
Website	10	17.2	35.7
Virtual laboratory	1	1.7	3.6
Total	58	100.0	207.1

Source: Own determinations.

According to the teachers, the students had access to the materials throughout the online education period.

The methods by which you received materials are different. In the opinion of the responding teachers, more than 50% appreciated that the students most frequently received materials through the Classroom platform, data presented in Table 7.

Table 7. Students' access to course materials

Student access to course materials	Responses		Percent of Cases
	N	Percent	
During the class taught online	15	29.4	53.6
Through materials sent by email or WhatsApp	9	17.6	32.1
Classroom materials	26	51.0	92.9
On Youtube	1	2.0	3.6
Total	51	100.0	182.1

Source: Own determinations.

Teaching methods differ from one type of education to another. As the educational paradigm has changed, classical methods have been adapted to the new online environment. Thus, over 30% of teachers, according to Table 8, used explanation as a teaching method during the online school period. According to the data presented in this table, the method using scanned documents was the least used method. Preda M. et. al. said that to improve the quality of education in their schools, the teachers indicated specially to change the methods of teaching [10].

Table 8. Online teaching methods used

Teaching methods used during online classes	Responses		Percent of Cases
	N	Percent	
Lecture	6	6.6	21.4
Explanation	28	30.8	100.0
Case Study	7	7.7	25.0
Links to Sites	6	6.6	21.4
Youtube movies	9	9.9	32.1
Online games	13	14.3	46.4
Team works on common document	4	4.4	14.3
Online project	15	16.5	53.6
Scanned documents with solutions	2	2.2	7.1
Other	1	1.1	3.6
Total	91	100.0	325.0

Source: Own determinations.

The educational assessment process has also undergone various updates, as shown in Table 9, more than 16% of the interviewed teachers used tests in the form of online quizzes on various platforms. In this case the most popular platform is Google Forms, which was used by over 13% of all respondents. Evaluation, however, remains a more difficult point, as the study shows, more than 80% of teachers have resorted to traditional methods, using digital methods only for visualization.

Table 9. Evaluation of students in online education

Student assessment in online education	Responses		Percent of Cases
	N	Percent	
Oral	26	44.1	92.9
Written, by showing answers or pictures to the camera	23	39.0	82.1
Questionnaire - Google Forms	8	13.6	28.6
Questionnaire - Own institutional platform	1	1.7	3.6
Questionnaire - Other	1	1.7	3.6
Total	59	100.0	210.7

Source: Own determinations.

CONCLUSIONS

Analyzing the average age of the teachers, we can say that the analyzed schools benefit from experienced teachers, open to adopting new technologies.

The use of digital resources for the transmission of information to students, classroom management, access to information and creation of digital content have a high share among teachers, which we assume have adapted to the new requirements;

Regarding the evaluation process and the methods used in online teaching, we can see that there is a reluctance to use digital means. Certainly, participation in a continuous training program would reduce these gaps.

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STUDY ON THE SUNFLOWER SEEDS MARKET IN ROMANIA

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Abstract

The present research aims to present and analyze the production and marketing of sunflower seeds in Romania, based on data obtained from the National Institute of Statistics and from the website of the Ministry of Agriculture and Rural Development, for the period 2015-2020. In order to highlight as realistically as possible the production and marketing of sunflower seeds at the national level, it was necessary to analyze the most important quantitative indicators, such as: the total area cultivated with sunflowers; the total production of sunflower seeds; average production of sunflower seeds per hectare; the average price for sunflower seeds on the domestic market; the exports and imports of sunflower seeds related to Romania. The sunflower crop has a particular importance, being spread all over the globe, but in different proportions from one region to another. Sunflower seeds are characterized by superior nutritional value because they contain monosaturated fats, proteins, polysaturated fats, as well as other beneficial elements for the human body. In 2020, Romania ranked first among the sunflower growers and producers in the European Union.

Key words: *sunflower, cultivated area. seeds yield, average export price, exports and imports, Romania*

INTRODUCTION

According to studies regarding sunflowers, it has been found that it is widespread around the globe, being cultivated especially for seeds that are rich in oil. Sunflowers are native to America and are annual plants [3, 5].
It is necessary to specify that sunflowers have many uses because they are used in: human nutrition, especially through the sunflower oil; animal food; industry etc [2, 7, 11, 12].
It has been found that sunflower is a plant with a cycle of vegetation about 120 days, with a height that varies between 1.7 m and 2.5 m. Sunflower cultivation is suitable on several types of soil, but the most favorable ones are those that have a pH between 6.5-7.5 [3].
Sunflowers are oleaginous plants that are very widespread in Romania. Many farmers in our country have turned to sunflower crops, due to the fact that, on the one hand, it has many uses, and on the other hand, it benefits from financial aid from the state [10].
According to specialists in the field, sunflowers have a number of advantages from an agronomic point of view, such as:
-the fertility status of the soil is quite good after the sunflower crop;
-it is a very good precursor plant, especially for autumn wheat;
-the crop does not require huge expenses.
-sunflower withstands better the water stress;
-the works carried out on this culture are mechanized, thus facilitating the work of the farmer etc [7].

Photo 1. Sunflower field
Source: [1].

In Romania, sunflower is considered a valuable plant because, on the one hand, it is grown on large areas, and on the other hand, it has a favorable secretion of nectar [7, 14].

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Another special aspect that is attributed to sunflower seeds is that they have a complex nutritional value, because they contain a substantial amount of: vitamin E; proteins; magnesium; monosaturated and polysaturated fats [4, 6, 13, 11].

Farmers in Romania will grow sunflowers on the long term due to the fact that it has both technical and economic advantages.

In this context, the goal of the paper is to analyze the evolution of cultivated area, production, yield, average export price of seeds and also export and import of sunflower seeds in the period 2015-2020 in Romania.

MATERIALS AND METHODS

The present research highlights the main trends related to the production and marketing of sunflower seeds in Romania for the period 2015-2020. In the paper are presented and analyzed a series of quantitative indicators, as follows: the total area cultivated with sunflower at national level; the total production of sunflower seeds at national level; the average production of sunflower seeds per hectare recorded at national level; the average price for sunflower seeds on the domestic market; exports and imports of sunflower seeds recorded by Romania.

The empirical data underlying the present research were obtained from the National Institute of Statistics and from the website of the Ministry of Agriculture and Rural Development.

In order to make the research as clear as possible, it was necessary to present the results in graphical form.

RESULTS AND DISCUSSIONS

Between 2015-2020, certain changes related to the production and marketing of sunflower seeds were observed in Romania. At national level, it was found that sunflowers are grown on large areas, especially in: Dobrogea; the Romanian Plain and the Western Plain [1].

During the analyzed period, the area cultivated with sunflowers at national level varied from one year to the next. The most significant area with sunflower crops was recorded in 2019 (1,282,697 ha). At the opposite pole, the smallest area cultivated with sunflower was of 998,415 ha (2017) (Fig. 1). In 2020, the area cultivated with sunflowers at national level increased by 12.9% compared to 2015. Also in 2020, there was a decrease of 11.0% of the area cultivated with sunflowers, compared to 2019, when the maximum cultivated area was registered.

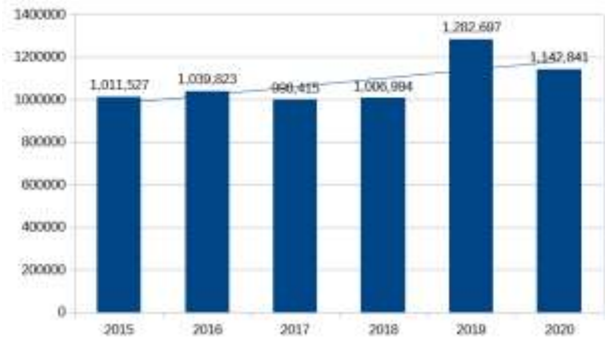

Fig. 1. Sunflower area cultivated at national level, in the period 2015-2020 (ha)
Source: Own design based on NIS database 2022 [9].

In Romania the sunflower crop is sustained by various forms of support, such as:
-Direct payment schemes;
-Transitional national aid 1 (ANT 1); - TNA
-State aid for the diesel fuel used in agriculture [8].

In the period 2015-2020, at national level, the total production of sunflower seeds recorded a series of oscillations. From the data presented it can be easily ascertained that, between 2015-2019, the production of sunflower seeds was on an upward trend, and in 2020, there was a significant decrease compared to 2019 (-1,446,285 tons). The lowest production of sunflower seeds was achieved in 2015 (1,785,771 tons), and the most significant was of 3,569,150 tons (2019) (Fig. 2). The total production of sunflower seeds in 2019 was closely connected on the one hand with the cultivated area, and on the other hand with the average production per hectare achieved. In 2020, the production of sunflower seeds increased by 18.8% compared to 2015, but decreased by 40.6% compared to 2019. The decline in sunflower seeds production was mainly due to the drought in 2020.

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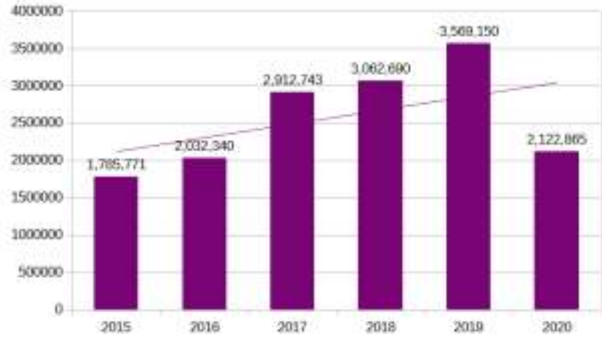

Fig. 2. Total production of sunflower seeds at national level, in the period 2015-2020 (tons)
Source: Own design based on NIS database 2022 [9].

In 2020, Romania ranked first in the top of sunflower seeds producers in the European Union [1].
The average production per hectare of sunflower seeds in Romania changed from year to year during the analyzed period. From the data presented, it can be seen that the most significant average production per hectare of sunflower seeds was recorded in 2018 (3,041 kg/ha), and the lowest was of 1,765 kg/ha (2015) (Fig. 3). In 2020, the production of sunflower seeds changed as follows:
-increased by 5.2% compared to 2015;
-decreased by 33.3% compared to the previous year;
-decreased by 39.0% compared to 2018, when the maximum point for the average production per hectare in the analyzed period was reached.

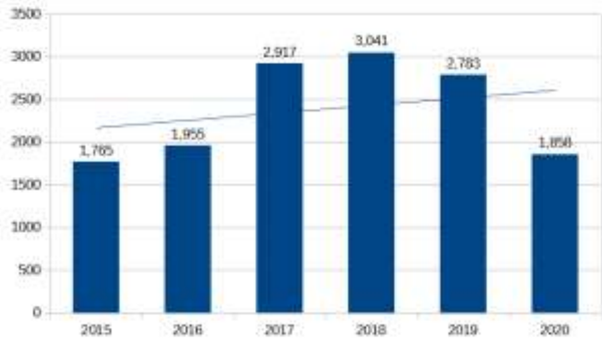

Fig. 3. Average production of sunflower seeds per hectare at national level, in the period 2015-2020 (tons)
Source: Own design based on NIS database 2022 [9].

According to the data provided by the Ministry of Agriculture and Rural Development on the average price for sunflower seeds on the domestic market for the period 2015-2020, it was found that it has changed. The highest average price was recorded in 2016 (1.51 lei/kg). At the opposite end, the lowest average price was highlighted in 2019 (1.29 lei /kg). This price recorded in 2019 was determined by the generous offer existing on the domestic market, due to the achievement of a very high total production of sunflower seeds.
In 2020, the average price for sunflower seeds on the domestic market remained constant, compared to 2015, at 1.50 lei/kg.
Quantitative exports of sunflower seeds related to Romania have recorded variations from one period to another. The largest quantitative exports were highlighted in 2019 (2,104,661.9 tons). Romania's massive exports of sunflower seeds in 2019 were possible due to the large production. In 2015, the smallest quantitative exports of sunflower seeds related to Romania were made, of 1,099,348.7 tons. Reduced quantitative exports were influenced by the achievement of a small production of sunflower seeds. In 2020, quantitative exports increased by 40.4% compared to 2015. It is necessary to specify that Romania exports most of the sunflower harvest, because it has a limited processing capacity [1].

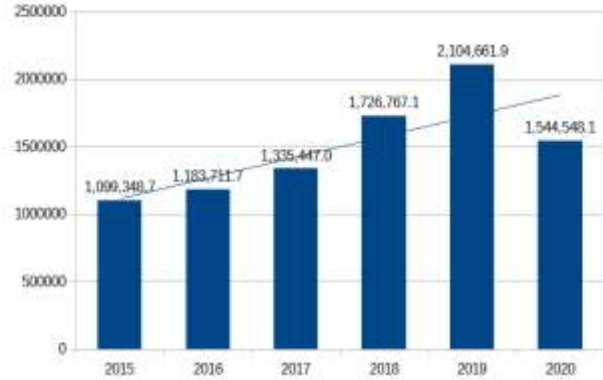

Fig. 4. Quantitative exports of sunflower seeds related to Romania in the period 2015-2020 (tons)
Source: Own design based on data provided by the Ministry of Agriculture and Rural Development database 2022 [9].

Romania's main export markets for sunflower production are: Turkey; Bulgaria; Hungary; France; the Netherlands, Spain etc [1].
The value of exports for the “Sunflower Seeds” category recorded by Romania in the analyzed period varied from one year to another. The most substantial value of exports

was of EUR 757,016.6 thousand (2019), and the lowest was of EUR 452,228.0 thousand (2015). This situation was influenced, on the one hand, by the quantity exported and, on the other hand, by the export price. In 2020, the value of exports for the “Sunflower Seeds” category increased by 33.9% compared to 2015.

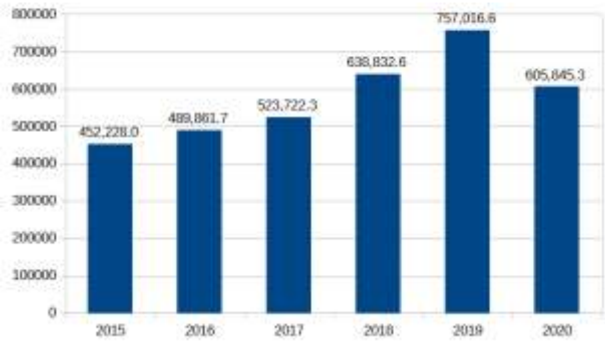

Fig. 5. Value of exports for the category "Sunflower seeds" related to Romania, in the period 2015-2020 (thousand Euro)
Source: Own design based on data provided by the Ministry of Agriculture and Rural Development database 2022 [9].

Regarding the quantitative imports of sunflower seeds related to Romania for the period 2015-2020, it was found that they recorded a series of variations. The largest amount of sunflower seeds imported was recorded in 2019 (333,590 tons), and the lowest was of 189,252.40 tons (2015) (Fig. 6). In 2020, Romanian imports of sunflower seeds increased by 32.4% compared to 2015.

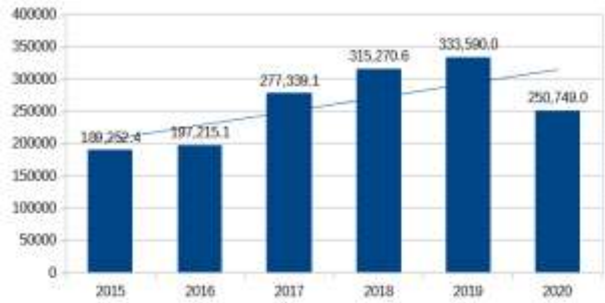

Fig. 6. Quantitative imports of sunflower seeds related to Romania in the period 2015-2020 (tons)
Source: Own design based on data provided by the Ministry of Agriculture and Rural Development database 2022 [9].

The value of imports for the category “Sunflower Seeds” registered by Romania, oscillated from one year to the next, in the interval under analysis. It was determined, on the one hand, by the quantity imported and, on the other hand, by the import price. During the analyzed period, the value of imports for the category "Sunflower seeds" registered an upward trend. In 2015, the lowest value of imports was of 127,697.6 thousand Euro (Fig. 7).
At the opposite end, the highest value of imports for the “Sunflower Seeds” category was of EUR 207,088.0 thousand (2020).

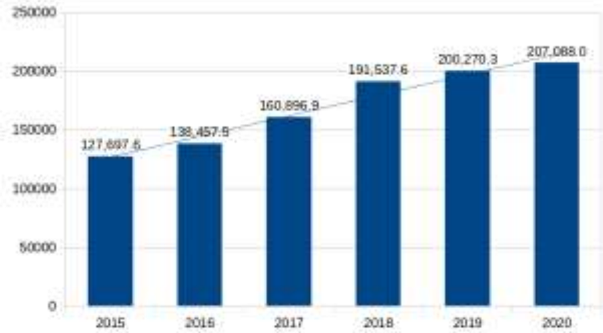

Fig. 7. Value of imports for the category "Sunflower seeds" related to Romania, in the period 2015-2020 (thousand Euro)
Source: Own design based on data provided by the Ministry of Agriculture and Rural Development database 2022 [9].

CONCLUSIONS

According to the analysis of the most significant specific indicators for the production and marketing of sunflower seeds in Romania, between 2015-2020, the following results were obtained:
-In 2019, the largest surface cultivated with sunflowers was of 1,282,697 ha;
-The largest production of sunflower seeds was achieved in 2019 (3,569,150 tons);
-In 2018, the highest average production per hectare of sunflower seeds was achieved, 3,041 kg/ha;
-In 2016, the highest average price for sunflower seeds on the domestic market was recorded of 1.51 lei/kg;
-The most significant sunflower seed export was of 2,104,661.9 tons;
-In 2019, the highest value of exports for the category "Sunflower Seeds" was recorded, 757,016.6 thousand Euro;
-The largest amount of sunflower seeds imported was of 333,590 tons (2019);

-In 2020, the highest value of imports was recorded for the category "Sunflower seeds", of 207,088.0 thousand Euro.

In order to increase the competitiveness of the sunflower seed production and marketing sector, we recommend the following:

-expansion of areas cultivated with sunflowers;

-increasing the yield per hectare;

-expanding the processing capacities of sunflower seeds and marketing an increased amount of sunflower oil, both on the domestic market and on the external market;

-attracting domestic and foreign investments;

-access to European funds.

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RURAL TOURISM, AGROTOURISM AND ECOTOURISM IN ROMANIA: CURRENT RESEARCH STATUS AND FUTURE TRENDS

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Abstract

This work represents a contribution to the knowledge of the state of research in the field of rural tourism, agritourism and ecotourism in Romania, identifying the main trends and proposing future research lines and themes. Secondary data such as journal articles, proceeding papers reports and statistical data were analysed to obtain an image of the current stage in research with the topic rural tourism, agritourism and ecotourism in Romania. A systematic bibliometric analysis was conducted on the literature retrieved from the Web of Science Core Collection database using the VOS Viewer software tool. Using the specific keywords "Rural Tourism", and "Agrotourism", and "Agritourism" and "Ecotourism", and "Romania" 440 articles were reviewed and analysed. The results show that studies concerning these keywords and their influence on the development of rural areas in Romania represent an important and dynamic research topic in the last 10 years. Eight major research themes were identified regarding rural tourism, agritourism and ecotourism in Romania. The findings made in this paper will add to the existing body of knowledge of Romanian tourism research in general and, rural tourism research in particular.

Key words: *rural tourism, agritourism, ecotourism, rural development, Romania*

INTRODUCTION

Promoting responsible, sustainable, and universally accessible tourism contributes to achieving the 17 Sustainable Development Goals (SDGs). Thus, tourism contributes to: job creation and income generation; stimulating sustainable agriculture and capitalizing on its results through tourist structures; development and strengthening of local communities; conservation of local biodiversity and natural and human heritage, which become the main attraction of an area.

Sustainable tourism involves the adoption of responsible production and consumption [86]and meeting the demands of the contemporary consumer (experience, excitement, escape, entertainment, education and ecology) [79].

According to the World Tourism Organization, international tourism recovered in 2022 approx. 63% of pre-pandemic levels, with Europe leading the way. Europe, recorded 585 million arrivals in 2022, i.e. approx. 80% of pre-pandemic levels (-21% from 2019) [87].

In Romania, the gross domestic product directly from tourism had a value of 31,564.6 million lei from the national gross domestic product in 2019 [32]. Statistical data show that the share of the tourism industry in Romania's gross domestic product stagnated between 2018-2020 at 5.3% [72].

Rural tourism and agritourism in Romania have a long history, although until 1990 there was no organized system at the national level. A study carried out by the Tourism Research Institute in 1972 identified 118 localities with the potential of a tourist village, of which 14 were nominated with this title, but a year later a decree prohibited the lodging of tourists at peasants. However, the villages of Sibiel and

Lerești were included in the tourist circuit on the condition that tourists cannot be accommodated by locals [16].

Romania has joined the European Federation of Rural Tourism (Rural Tour) [24] since 1995 and is represented internationally and nationally by ANTREC (National Association of Rural, Ecological and Cultural Tourism).Through its 16 regional branches [4] and over 2500 members during over 25 years of activity, ANTREC promoted the rural environment and had a major contribution to the implementation and development of rural tourism and agritourism in Romania. A major contribution to the development of rural tourism, agritourism and ecotourism in Romania was made by a number of other non-governmental organizations, among which we mention: Operation Village Romaine, the Adept Foundation, the "Mihai Eminescu Trust" Foundation, the Romanian Ecotourism Association and the "My Transylvania" Association. They organized qualification courses, exchanges of good practices for rural entrepreneurs, gastronomic and cultural events. All events contributed to the promotion of the Romanian rural environment.

The specialized literature groups the tourist villages in Romania according to their predominant characteristics and the main activities carried out, as follows: ethnographic-folkloric, climatic and landscape, of artistic and craft creation, for practicing sports, fishing and hunting, pastoral, vineyards, and orchards [47]. Over time, the number of tourist structures with accommodation function in rural Romania has increased, and the quality of services has become better and better in close connection with the increase in popularity of holidays in rural areas [51].

Rural tourism products are a combination of resources and services and contribute to the ability of each tourist destination to offer unique experiences [77].

The concept of rural tourism and agritourism varies greatly from one country to another and depends on the approach of professionals in this field, the type of accommodation structure and the nature of the activities carried out [80].

Rural tourism uses a wide range of types of tourist structures with an accommodation function and capitalizes through events, fairs and cultural manifestations the entire natural and human tourism potential of the countryside, with the involvement of the local population [40]. Rural tourism is defined by three main elements: people, space and products, characterized by their authenticity and traditional character [18].Cozma et al. (2021) consider that "community-based tourism" is one of the most appropriate forms of tourism development in Romanian villages [17].

Recent studies have assessed the impact of tourism on local communities, whether positive or negative, and residents' perceptions of it [61].

Agritourism involves the diversification of farm activity to generate additional income, complementary to agricultural income, with positive implications for rural and local development [10; 75]. Chase et al (2018) propose that agritourism be framed within a conceptual framework that encompasses five types of activities closely related to active farms: direct sales, education, hospitality, recreation, and entertainment, with core and peripheral levels [8].

Ecotourism can be a model of sustainable exploitation of resources [33].

In Romania, the Romanian Ecotourism Association (AER) was established in 2003 with the aim of creating a national partnership between the process of development and promotion of ecotourism. Through all the actions taken, it promotes the concept of sustainable tourism. Eight ecotourism destinations are currently certified in Romania, and two others are at various stages in the evaluation process for certification [3].The development of ecotourism destinations is carried out with the involvement of all local actors, who can express their vision and identify opportunities for involvement in the sustainability of the area [41].

AER is currently implementing a project called "Digital Routes of cultural heritage for a sustainable future" together with NGOs from different countries. Within it, more than 20 digital routes are proposed for our country [81].

Different authors emphasize the need for innovation in rural tourism and agritourism and for continuous change, which will have the effect of maintaining the farm's competitiveness. To improve the tourist experience [38] innovations can cover different aspects such as products, processes, marketing, organization. They can be carried out directly by entrepreneurs or through collaboration with other entities [58]. Examples of innovations in rural tourism are presented for Romania and Poland as: thematic villages, educational farms, and the creation of tourism product networks [65].

To measure the impact of agritourism on rural development, Karampela and Kizos (2018) propose the use of a system based on variables and composite indices [36].

The motivation of the present paper is to investigate the evolution of scientific research regarding the rural tourism, agrotourism and ecotourism in Romania through review and analysis. To achieve such a complex objective, three research questions (RQ) are proposed:

- RQ1: What is the distribution of scientific production in this field of knowledge in the last ten years?
- RQ2: What are the main research clusters on rural tourism, agrotourism and ecotourism in Romania?
- RQ3: What are the core themes and research directions in this field of knowledge?

MATERIALS AND METHODS

Secondary data such as journal articles, proceeding papers reports and statistical data were analysed to obtain an image of the current stage in research with the topic rural tourism, agrotourism and ecotourism in Romania.

The quantitative structure of the bibliometric analysis makes it ideal for this study because it maintains the authors' bias under control. Its ability to handle massive databases allows it to extract information from a large corpus. In the current study, a review and a bibliometric analysis was performed to identify, organize, and analyse trends in the proposed research area. Selecting the right database is decisive for a well-performed evaluation. We used the Web of Science Core Collection which is a comprehensive bibliographic data source.

The methodology was applied to generate a complete search of the WOS database using the syntax: “rural tourism” OR ”agrotourism” OR ”agritourism” OR ”ecotourism” AND “Romania” in the title, abstract and keywords of the papers. To refine the search, two filters were applied to the dataset: “language” (English) and “year of publication” (1990 – present 20 January 2023). The application of these filters resulted in 440 documents that constitute the data set to be analysed. Excel software was used for data extraction from Web of Science Core Collection and Vosviewer software for bibliometric analysis of the results.

RESULTS AND DISCUSSIONS

Ruiz-Real et al. (2020) showed that Romania is among the countries with a considerable number of studies on rural tourism [59]. In the international specialized literature on rural tourism, agritourism or ecotourism there are case studies, while comparative studies suggesting future research directions in the context of sustainable development are lacking [37].

Bibliometric research allows the creation of a systematic overview of the evolution of research in a field and is a valuable tool for stating future research directions in the respective domain [2].

RQ1: The distribution of scientific production in this field of knowledge in the last ten years

Descriptive analysis

In the first stage of the descriptive analysis, the main 5 categories that registered the most publications in the analysed period from the Web of Science Core Collection were identified (Table 1). The increased interest of the authors for the sustainability tourism is noted.

Out of the total of 440 articles identified, 375 were published in the last 10 years, which shows the interest of researchers in the given topic. The trend noted is that after each year or at most two years of increase in scientific production, a slight decrease is encountered in the following year, as is the case in 2019, 2020, and 2022.

Table 1. Distribution of papers according with the first 5 Web of Science Categories

Web of Science Categories	Frequency	Percentage of total sample
Economics	87	19.77
Agricultural Economics Policy	73	16.59
Environmental Sciences	70	15.91
Business	50	11.36
Management	36	8.18
Other	124	28.18
Total	**440**	**100**

Source: Developed by authors, based on WOS database.

The fluctuation could be influenced by a multitude of factors, including the number of entities involved in research on sustainable tourism, the concern of civil society on sustainable tourism, etc. (Table 2).

Table 2. Year of publication in WOS within the last 10 years

No	Publication Year	Frequency	Percentage of total sample
1	2022	39	10.40
2	2021	51	13.60
3	2020	35	9.33
4	2019	44	11.73
5	2018	51	13.60
6	2017	50	13.33
7	2016	43	11.47
8	2015	29	7.73
9	2014	21	5.60
10	2013	12	3.20
	Total	375	100.00

Source: Developed by authors, based on WOS database.

RQ2: The main research clusters on rural tourism, agrotourism and ecotourism in Romania

Science Mapping

Conceptual structure: Co-word analysis. In the first phase, the co-occurrence term analysis was performed for the analysed sample, respectively, the research published from 1990 until now. In this sense, the following restrictions were applied to the VOSviewer (Nees Jan van Eck; Ludo Waltman, 2022) program: the analysis was performed in the "Abstract" field, and the minimum number of occurrences of a term was limited to 20. The result was the network visualization map based on the text data shown in Figure 1.

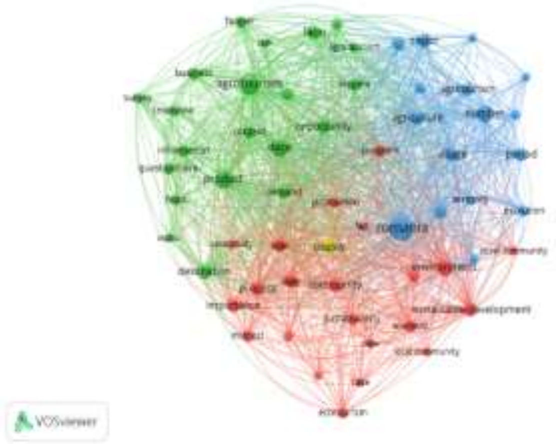

Fig. 1. Network visualization map based on text data – term co-occurrence
Source: Own processed data on [45].

The main findings indicate that 60 items were registered, grouped in 4 clusters, which generated 1,704 links and a total link strength of 9,704.

The terms grouped in the 4 resulting clusters are symbolized in different colours for each cluster, standing out as the main themes: ecotourism, environment, community, sustainable development, sustainable tourism (cluster 1 – red, with 22 items); agrotourism, product, data, farm, destination, tourism development (cluster 2 – green, with 21 items);

Romania, agriculture, agritourism, rural development, village (cluster 3 – blue, with 16 items); county (cluster 4 – mustard with 1 term).

The co-occurrence of all keywords identified in the selected articles (minimum 5 co-occurrence) was determined. (Figure 2).

As expected, out of the total of 1383 keywords identified, 63 have an occurrence of at least 5. These are grouped into 6 clusters.

Table 3 shows the main keywords identified and their occurrence.

It is noted that the authors with the largest number of articles on this topic are Călina A. and Călina J., with 12 articles published, respectively, and 51 citations of them, respectively, total link strength 40.

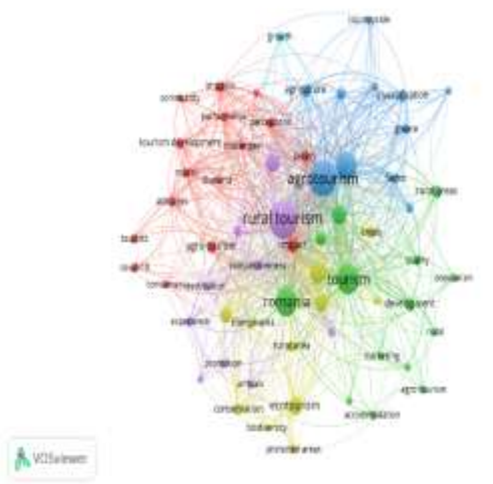

Fig. 2. Key words occurrence in analysed papers
Source: Own processed data on [45].

Table 3. All key words occurrence and their total link strength in the identified papers

Key words	Occurrences	Total link strength
Rural tourism	99	253
Agrotourism	89	221
Agritourism	53	173
Tourism	61	146
Sustainability	27	103
Management	22	88
Sustainable development	35	85
Impact	17	66
Typology	10	54
Agriculture	12	53
Rural development	27	52
Sustainable development	27	52

Source: VOSviewer, version 1.6.18

RQ3: The core themes and research directions in this field of knowledge

Rural tourism, agritourism and ecotourism – as possible means of sustainable development of the rural area

Tourism is the engine of diversification of economic activities in rural areas and is a component of local development models [73]. Agritourism is perceived as "smart chances" for the mountain area, if there is the support of the entire local rural community [11]. It plays an important role in the sustainable development of rural tourism, the reduction of poverty and the revitalization of rural areas [35]. Agrotourism, like ecotourism, represents complementary activities to agricultural ones [39; 63] contributes to the increase of agricultural incomes in the context of the valorisation of natural, cultural and social resources [27] and to the preservation and promotion of traditional agricultural practices [46; 60].

There are studies that show that oenological tourism [49; 76] and the gastronomic sector are closely related to rural areas and contribute to their sustainable development. Closely related to sustainable tourism, gastronomic tourism is often associated with local products and gastronomic products registered on various national or international quality schemes [67]. Approximately 90% of the agritourism guesthouses in the villages of Mărginimea Sibiului offer tourists traditional products [71]. Local gastronomy creates links between agriculture and tourism [70].

Ecotourism involves the integration of various activities in nature, in close connection with local culture and contributes to the sustainable use of local tourism resources [69].

Accessing financial support from the European Union for diversifying the activity and developing the pluriactivity of farms through agritourism

Galluzzo N. emphasized that the access to European funds for agritourism determined the diversification of resources and the activity of farms and the reduction of socio-economic marginalization in the Romanian countryside. There is a positive correlation between the development of agritourism and the low population density in the locality. The development of agritourism in Romania was closely related to the natural and human resources of the rural environment [29].

In a study carried out in the farms that cultivate lavender in Romania, it is shown that the diversification of their activity through tourist activities (the organization of festivals, brunches, picnics in the plantation or photo sessions), increases the profitability of the business and the satisfaction of the farmers. In those rural areas that are already known as tourist destinations, the tourist offer could be diversified by offering walks in the plantations, observing the beauty of the landscape and aromatherapy or selling lavender-based products [84]. Rural areas already known as tourist destinations that introduced lavender fields in their portfolio could benefit from diversifying their tourist offer with products such as breakfast or tours in lavender gardens, observing the landscapes of lavender-scented villages, combined with unique nature walks , photo sessions, as well as the sale of lavender-based products (essential oil, perfumed water, honey, soap, jam, etc.).

A study conducted among agricultural producers, tourism service providers and tourists in the Brașov area shows that permaculture can also be successfully integrated into the rural tourism product, contributing to the development of the rural area [23].

The challenges faced by rural tourism during the COVID-19 pandemic and recovery measures

The restrictions imposed by the Covid pandemic, the desire for personal security and the imposed distancing have determined the increase in domestic tourist flow [48].Most tourists chose to spend their vacation in the countryside, preferring small accommodation units and as many activities as possible in nature, in small groups [56]. For Romania, the development of domestic tourism during the pandemic was also stimulated by the granting of incentives for public sector employees.

Mitrică and collaborators investigated the impact of the Covid-19 pandemic in the rural area of the Subcarpathian area of Buzau, showing that rural tourism is more resistant to the crisis [42].

For the training of future specialists in rural tourism and agritourism, a web page type application was created that was used starting from the period of restrictions imposed by the Covid-19 pandemic [12].

The Covid-19 pandemic has caused changes in the profile and behaviour of tourists who are increasingly better informed and more concerned about their health and well-being. In this context, during the pandemic period, habits in choosing tourist destinations have also changed, with rural tourism becoming the most preferred choice [54].

As measures to recover tourism during the pandemic period and in the next one, specialized literature proposes the diversification of offers, personalized packages, raising the quality standard of services and better promotion through social networks [55].

The use of modern technologies to expand the productive capacity of agritourism guesthouses and their promotion

Călina et al. [6] have shown that modern technologies such as geographic information system (GIS), photogrammetry and UAV flights can be used for the sustainable development of agritourism guesthouses. They are effective tools for management and control of the quality and efficiency of works specific to agricultural production.

Voda et al. (2022) show that smartphone applications used for tourism will lead to the transformation of rural areas into proactive and creative tourism destinations [85].

Velea et al. (2021) propose the use for information and in the tourism marketing mix of the WECTOU platform created by Meteo Romania. This provides information on the number of days with good/bad weather for outdoor activities; snow cover and vegetation cover index [83].The same author and his collaborators propose the use of the "Holiday Climate Index" for the exploitation of natural resources, including the climate, for tourism purposes [82].

For the young generation, the Internet is the main source of information. During nature hikes, digital maps or software are starting to be used to allow the recognition of spontaneous flora [69].

The use of new technologies in tourism determines the improvement of economic, social and ecological performances [21].

To promote these forms of alternative tourism in Romania, it is recommended [49, 50]: the application of new communication models based on social-media networks; e-marketing; using virtual reality experience for memorable and immersive experiences. Onu R. (2018)

shows that those companies that promote themselves through Social Media platforms, donot only do online marketing but build relationships [50].

Analysis of accommodation capacity and its use in different rural/agritourism destinations

In 2021, 9,146 tourist structures with accommodation functions were operating in Romania, of which 3,460 were agro-tourism guesthouses, representing 37.7% of the total. There was a 23.5% increase in their number compared to 2019. Agritourism pensions are preferred by tourists for lower prices, the possibility of renting in small groups and quality food services [56].

A recently published study shows that the top three rural tourism/agritourism destinations in Romania are the Brașov area, the Maramureș area and the Sibiu area. According to the authors, in the year 2021 (August) the number of tourist structures and the index of net use of the registered accommodation capacity in the three areas was: 387 and 31.4% (Brașov); 264 and 26.4% (Maramureș); 146 and 35.6 % (Sibiu)[1]. In all three rural tourism/agritourism destinations there are picturesque landscapes, nationally renowned local events, well-preserved and valued local customs and crafts, culture, traditional agriculture, local gastronomy and numerous possibilities for spending free time in nature.Various thematic routes have been created in Maramureș and Sibiu, and the cultural authenticity and local gastronomy attract many tourists [5; 7; 68].

Numerous authors highlighted the increase in the number of agro-tourism guesthouses in Romania from 500 units in 2000 to over 2,500 units, 44,499 beds, respectively, 1,004,400 tourist arrivals and 1,928,485 overnight stays in 2017 [15; 25; 26; 28; 30; 34; 35; 64].

Other authors have highlighted the territorial differences regarding the quality of services offered by agritourism guesthouses. These can be attributed to factors such as: the lack of a strategic management system at the national level; the lack of a national strategy for the development of agritourism; different natural and anthropogenic tourism resources, etc. [62].

Agrotourism is a useful tool for the sustainable development of the rural environment [43] inthe sense of reducing socio-economic marginalization [28] and increasing farmers' incomes.

Analysis of consumer preferences regarding rural tourism, agritourism and ecotourism

Rural tourism ranks among the top preferences of tourists concerned about the sustainability of tourist destinations and knowing the lifestyle of the Romanian peasant [66].

Following the investigation of the opinion of 758 people regarding the preferences related to the forms of accommodation in the countryside, approx. 37% of them prefer accommodation in agritourism guesthouses. Tourists over 46 years old choose this option in proportion to over 50%. The main aspects followed by tourists in choosing a tourist structure are the quality of services, cleanliness, hygiene and price [9]. During the years 2016-2018 approx. 90% of the tourists who stayed in agritourism guesthouses were Romanian [43].

Among the expectations of tourists during holidays spent in the countryside are: the desire to explore the environment by hiking; practicing various activities related to adventure tourism; the possibility to benefit from different entertainment options under conditions where safety and security prevail [57].

Another study on the quality of agritourism services in Romania shows that for tourists the beauty of the landscape is particularly important, along with the need for safety, hospitality of the hosts and the possibility of practicing activities for recreation and relaxation [78].

Different authors have tried to create the profile of the tourist who spends his vacation in rural tourism/agritourism or ecotourism destinations.

The ecotourist is perceived as a person with a high level of training, with an above-average income, willing to spend a "content vacation" [19] and benefit from unique experiences in direct contact with nature and the local community [14].

Among the benefits that the practice of these forms of alternative tourism bring are the stimulation of the economy of rural areas, the possibility of capitalizing on surplus products, the enhancement of traditional gastronomy, the protection of the environment and the preservation of traditions [74].

Young people know well the main ecotourism destinations in Romania, which they choose according to the uniqueness [31] and beauty of the landscape, the multitude of outdoor activities and the hospitality of the hosts [69].

Constantin et al. (2022) emphasize the importance of accessibility in ecotourism destinations, the need for intelligent development of transport and communications. Also important is the direct relationship between the profile of the ecotourist, the level of satisfaction and the intention to revisit an ecotourism destination [13]. Dumitras et al. (2017) state that ecotourists who spend a stay in the national parks prefer to travel between 150-300 km from their home to them, and the average duration of the stay is approx. 3 days [22].

Analysis of the perception of local residents regarding the quality of rural tourist destinations

A group of authors proposes the use of "QUALITEST", a working tool that offers the possibility to explore the characteristics of the area and to analyze the perception of the local community about the quality of the tourist destination [44]. In rural tourist destinations, the most important attributes associated with their success and attractiveness are: hospitality and the quality of local gastronomy. Long-term sustainability can only be achieved with the involvement of the local community.

Analysis of the development potential of rural tourism in the counties of Romania

The development potential of rural tourism at county level can be determined based on a composite index. Such an index determined in 2016 highlighted that the main development poles are in Suceava, Harghita, Brașov, Argeș, Mureș and Sibiu counties, four of which are located in the Center development region [20]. Such indicators allow the assessment of rural tourism performance and development potential. The authors highlighted the link between rural tourism and the sustainable development of rural areas.

At the national level, it is noted that the most developed areas in terms of rural tourism are the Center, North-East and North-West of the country. In 2016, these three regions held approx. 71% of all existing tourist structures at national level [53]. The determination of the Herfindhal-Hirschman Index (HHI), Gini-Struck Coefficient (GSC) and Concentration Coefficient (CC) allowed the conclusion that at the national level in 2016 there was a moderate concentration of agritourism.

Popescu A. (2018) points out that even if the development of rural tourism is dynamic, the future evolution depends on investments in infrastructure, the hospitality of the locals, the improvement of the professional skills of tourism entrepreneurs, the quality/price ratio, the promotion of tourist products, etc. [52].

CONCLUSIONS

The main research themes identified in the literature on rural tourism, agritourism and ecotourism in Romania refer to:

-The role of these forms of tourism in the sustainable development of the rural area;

-Accessing financial support from the European Union for diversifying the activity and developing the pluriactivity of farms through agritourism;

-Challenges faced by rural tourism during the Covid-19 pandemic and recovery measures;

-The use of modern technologies and the Internet to expand the productive capacity of agritourism guesthouses and their promotion;

-Analysis of the dynamics of accommodation capacity and its use in different rural tourism/agritourism destinations;

-Analysis of consumer preferences regarding rural tourism, agrotourism and ecotourism;

-Analysis of the perception of local residents regarding the quality of rural tourist destinations;

-Analysis of the development potential of rural tourism;

The development of rural tourism, agritourism and ecotourism contributes to changing the image of the rural environment and brings a series of benefits for the rural community, among which we mention: the preservation and enhancement of the natural and anthropogenic tourist heritage; creating jobs and improving the professional and digital skills of people involved in services; the generation of incomes complementary to agricultural ones; improving the general appearance of localities; conservation of biodiversity; promoting local gastronomy; the direct exploitation of local products or those registered on different national or community quality schemes, supporting the local economy and creating short food supply chains.

There is a growing demand for sustainability and uniqueness of vacations.

The promotion of rural tourism and agritourism in Romania must be done starting from the use of technologies and the Internet and by organizing local events. Within them, traditions, gastronomy and local products must be in the first place. Romanian villages in general and tourist villages in particular, require a digital transformation.

Future research directions related to rural tourism, agrotourism and ecotourism must assess the level of management and marketing knowledge of the owners of rural tourism structures.

There are no studies related to the assessment of the quality of life, health, safety and security of the owners of tourist structures in the rural environment. They must be adapted to an increasingly saturated, competitive and digital market. Due to their multiactivity, the pressure they are subjected to can affect their physical and mental health.

There are no studies that show which are the main booking platforms with which the owners of guesthouses in the rural area collaborate to make their services known and for their marketing.

There is a correlation between the multitude of agreement possibilities and the duration of the stay. Studies are needed to identify and quantify the share of additional services offered by rural guesthouses and the income from these activities.

In the context of digitization and the use of innovative technologies in the rural environment, studies are needed to assess whether tourist villages can be perceived as "smart villages".

Studies related to the consumption behavior of tourists in the post-pandemic period in general and of the young generation in particular are needed.

Some studies could identify how many of the tourist/agritourism guesthouses in an area organize camps for children, what kind of activities are offered to them and who are the people who manage the leisure activities. It would thus be determined that guesthouse owners call on the services of animators for holiday centers.

Another possible direction of research is related to the identification of the measures that the administrators of rural guesthouses take to protect water and energy resources used for tourism purposes or to reduce food waste. Such studies could thus make the connection with the sustainable development goals established in the 2030 Agenda for sustainable development.

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GLOBAL TRENDS ON RESEARCH TOWARDS AGRICULTURE ADAPTATION TO CLIMATE CHANGE

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Abstract

Increasing awareness of the importance of food security and human concerns about the changes that have occurred in ecosystems has led to an increase in research on the impacts of climate change on agriculture. Climate change, a topic addressed worldwide, generates imbalances in the agricultural sector on multiple levels, such as: productivity, profitability and labour requirements. The aim of the present paper is to highlight the importance of approaching the subject related to the impact of climate change on the agricultural sector, at the same time emphasizing the existing connections on different fields of study: strategic management, agronomy, ecology, agricultural practices, agricultural policies. The method used in the research used is bibliographic analysis, with the help of which the process of evaluating the relevant sources of information on the subject of "adaptation of agriculture to climate change" is carried out. The results demonstrate the fact that this theme is increasingly addressed by researchers since 1986, the key words being represented on the one hand by the elements of ecosystems, natural phenomena, but also by the effects felt both at the level of producers and at the level of the whole populations.

Key words: *bibliometric analysis, climate change, agriculture*

INTRODUCTION

Climate change is a change in the global environment, especially changes in average temperature and precipitation, attributable to human emissions of green house gases and human activities. These have negative effects on life and the environment, such as extreme weather events, changes in rainfall patterns, ocean acidification and loss of biodiversity. Urgent action is recommended to reduce emissions and mitigate the effects of climate change [11].

Agriculture is one of the sectors most affected by climate change. The specialized studies that deal with this topic have demonstrated the fact that the damage caused by the climate affects both the plant sector and livestock. generating losses in productivity, profitability and manpower. Food security is clearly threatened by climate change causing instability in agricultural production and changes in markets, food prices and supply chain infrastructure [7].

Agricultural adaptation to climate change refers to how agriculture can be adapted to cope with the negative effects of climate change, such as droughts, floods, extreme heat and temperature fluctuations [2, 9].

These may include technologies such as the use of drought-resistant crops, efficient irrigation, the use of organic fertilizers and pesticides, the use of climate change monitoring and farmer information systems. Collaboration between farmers, researchers and governments is also important to find effective andsustainable solutions to climate change in the agricultural sector [3].

Climate is an important factor in agricultural production. In the last decade, in all fields, there has been an intensification of research regarding the potential impact of the phenomena generated by climate change on the economic results of farms as well as on agricultural productivity [6, 15].

Climate change is one of the most important problems facing the world today and has greatly reshaped or is changing the earth's ecosystems. Of course, climate change has always been an ongoing process on earth, but recently, over the past 100 years or so, the intensity of these changes has increased at a

rapid pace. The average temperature has increased by 0.9 °C since the 19th century due to human activity, and this increase is expected to reach 1.5 °C or more by the year 2050 [10].
Climate change can have a major impact on agriculture by altering weather conditions and rainfall patterns. Changes in rainfall regimes can affect agricultural production by reducing irrigation and personal water use. In addition, heavy rains and floods can destroy crops and cause significant economic losses to farmers. In addition, rising temperatures lead to increased evaporation, which affects crop yields and leads to economic losses [5]. Changes in temperature and precipitation regimes lead to changes in vegetation cycles and changes in harvest time. Climate change can lead to increased pest populations and the emergence of new diseases that can affect crops. On the other hand, floods also have a negative impact, with agricultural and coastal areas affected, as well as access roads and infrastructure [12].
Alan Pritchard used the term "bibliometrics" as early as 1969 and it is considered a statistical and mathematical method applied to books and other publications [13].
Recently, bibliometric research has been frequently used in the specialized literature because it has the ability to illustrate a specific or general field of interest [8]. As seen by Broadus (1987) [1], bibliometrics involves the quantitative study of published works, bibliographic records, or both. Bibliometrics is described as a mathematical and statistical method that transforms the nature and state of written communication [8, 14].
Daim (2006) argues that this approach aims to explore, organize and analyze large-scale data from historical inputs to observe unseen patterns, topics that will be easier for researchers to understand [4].
The aim of the paper is to provide an overview of the research carried out on the subject of "adaptation of agriculture to climate change", starting from 1986. Furthermore, by bibliometric analysis, the related fields of interest to the studied subject will be identified, as well as the countries that give special interest to it.

MATERIALS AND METHODS

In order to determine the evolution of the inclusion of the topic related to climate change in the field of research, a retrospective and descriptive bibliometric study was carried out through the Web of Science platform [17]. Through the Web of Science database, scientific articles on a specific topic were exported in text format, and with the help of VOSviewer software, graphical images were generated that included keywords from the publications and their usage by year. Also, images were generated that indicate the countries that attach particular importance to the researched topic.
The results of the search in the database specified above, on the topic "climate change agriculture", returned a number of 21,630 papers, from the year 1986 to the year 2022. The results were sorted by relevance, and the first 1,000 records were exported to Excel as plain text for analysis with Excel and VOSviewer.

RESULTS AND DISCUSSIONS

Numerous studies show the population's concern about climate change, especially among producers who have faced major imbalances in recent years. Thus, the special importance is highlighted by the number of 21.6 thousand scientific works whose key words in the description, title or summary include climate change and agriculture, in the period 1986-2022.
The fields in which these scientific papers were included were represented by environmental science (7.4 thousand papers), environmental studies (2.8 thousand papers), atmospheric science methodology (2.6 thousand papers), water resources (2.1 thousand papers), multidisciplinary geosciences (2 thousand papers), agronomy (1.8 thousand papers), ecology (1.7 thousand papers), green sustainable scientific technology (1.6 thousand papers), multidisciplinary agriculture (1.4 thousand works), etc. Other fields in which papers have been published on climate change in agriculture are biology, agricultural

engineering, horticulture, management, analytical chemistry and biophysics.

Analyzing Figure 1, it can be seen that the maximum number of specialized papers on the subject of interest was reached in 2011 when 77 articles were published. It can be seen that starting from 2007 the number of publications began to increase, being 2.5 times higher than the previous year (41 publishers compared to 16).

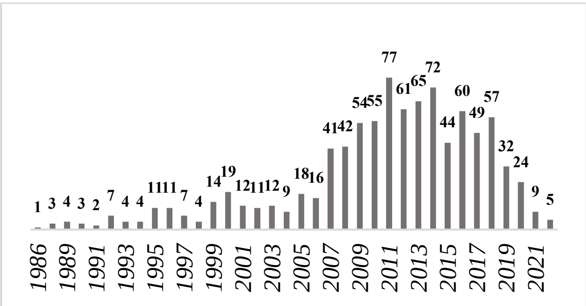

Fig. 1. The number of specialized papers existing in the data base
Source: own processing based on WoS results using Excel.

Even if in recent years, the number of articles written on this topic has decreased, the topic remains topical both for producers and researchers. This is probably due to the fact that new concepts have been developed, attention being directed not so much to the phenomenon itself, but to methods of adaptation and resistance to climate change, the focus being more recently on the development of intelligent farming systems in from a climate point of view, sustainable management of waterresources, maintenance of soil quality in the context of desertification and aridification of the climate in certain regions.

Figure 2 shows words interrelated with climate change, namely adaptation, vulnerability, variability, sensitivity, drought, irrigation, emissions, changes in impact, conservation, biodiversity, foodsecurity, and economic impact. Thus these words are included in 5 clusters as it can beseen in Figure 2.

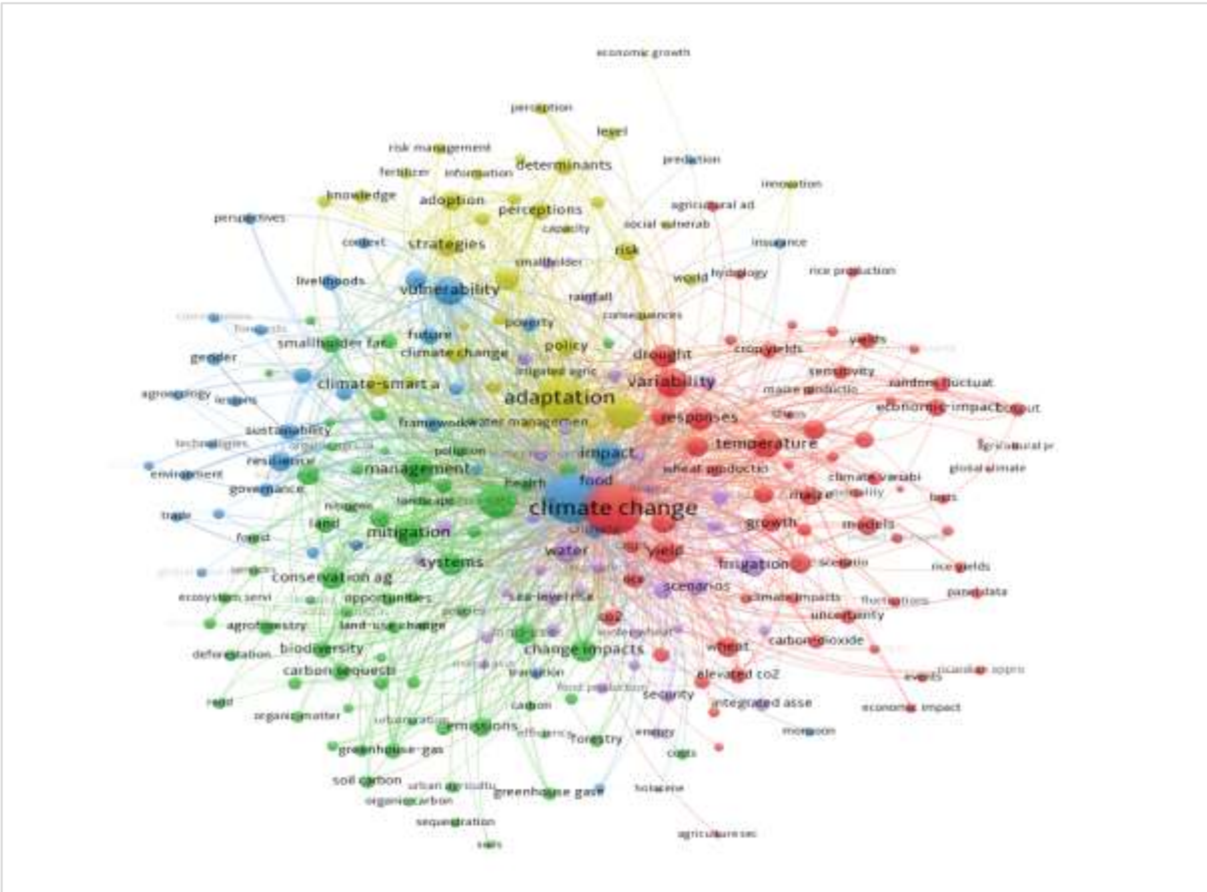

Fig. 2. Connectivity of key words used (climate change, agriculture) with other related terms
Source: own processing based on WOS results using VOSviewer.

The 1st cluster refers mostly to temperatures, drought, variability, yields, carbon dioxide emissions, global climate, climate variability, crops, focusing on the production of wheat, rice, peas, but also on the impact that climate change has on producers such as uncertainty, stress, sensitivity, events, economic impact, fluctuations and responses. Cluster 2 includes terms such as outlook, vulnerability, environment, sustainability, organic, future, trade, global food, forecasting, resilience, government, livelihoods, technologies, agrotechnologies, community.

Cluster 3 is associated with adaptation, strategies, smart agriculture, fertilizers, information, risks, perceptions, determination, capacity, knowledge, risk management, policy.

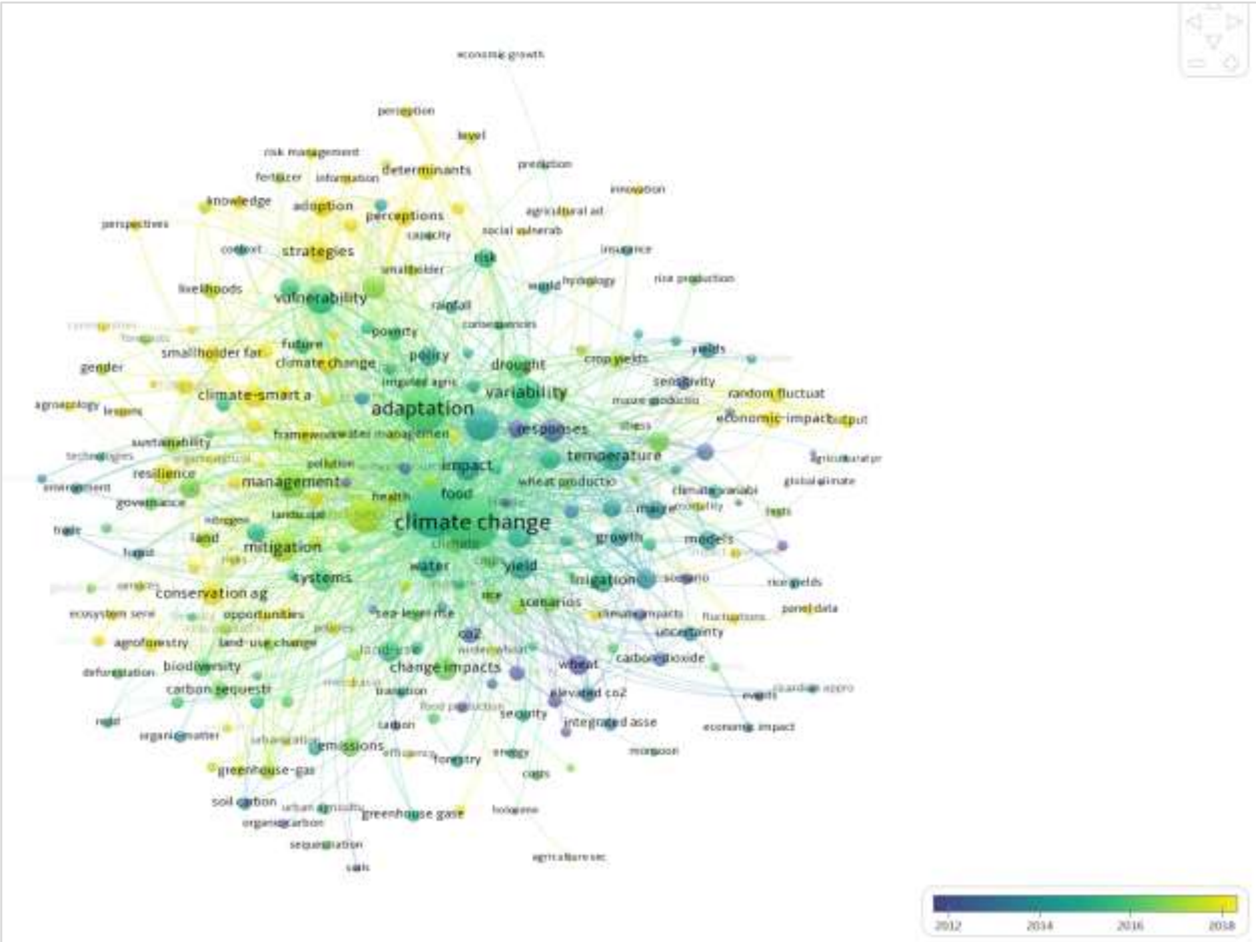

Fig. 3. Linkage of climate change in agriculture with other related terms by year
Source: own processing based on WOS results using VOSviewer.

The 4th cluster emphasizes food security and the environment, being interconnected with biodiversity, management, migration, urbanization, environment, deforestation, conservation, sustainable agriculture, ecological agriculture, impact of changes, small producers,

rural agriculture, agroforestry, pollution, carbon, emissions, forest.

The 5th cluster includes terms such as economy, security, energy, sea level rise, water basins, water resources, small producers, precipitation (Figure 2).

Furthermore, Figure 3 shows the links between the key words used in the data base search and other related terms that have been used over time in different publications. Thus, in 2012 and 2013, studies focused on water resources, carbon dioxide, economic impact, environment, trade, food production, scenarios, organic carbon, uncertainty, responses, integration, rise ofsealevel.

In 2014 and 2015, the key words used in specialist papers were yields, water, technologies, transition, models, growth, temperatures, impact, science.

In 2016 and 2017, the spectrum of key words interconnected with climate change expanded, using terms such as biodiversity, water, precipitation, drought, land use, sustainability, adaptation, vulnerability, impact of changes, management, migration, risks, systems. Later in 2018, the focus shifted to the use of adaptation practices, with the main topics being smart climate, strategies, adaptation, foodsecurity, health, information, agroecology, perception, vulnerability, conservation, crop production, risks, impact economic, fluctuations, fertilizers (Figure 3).

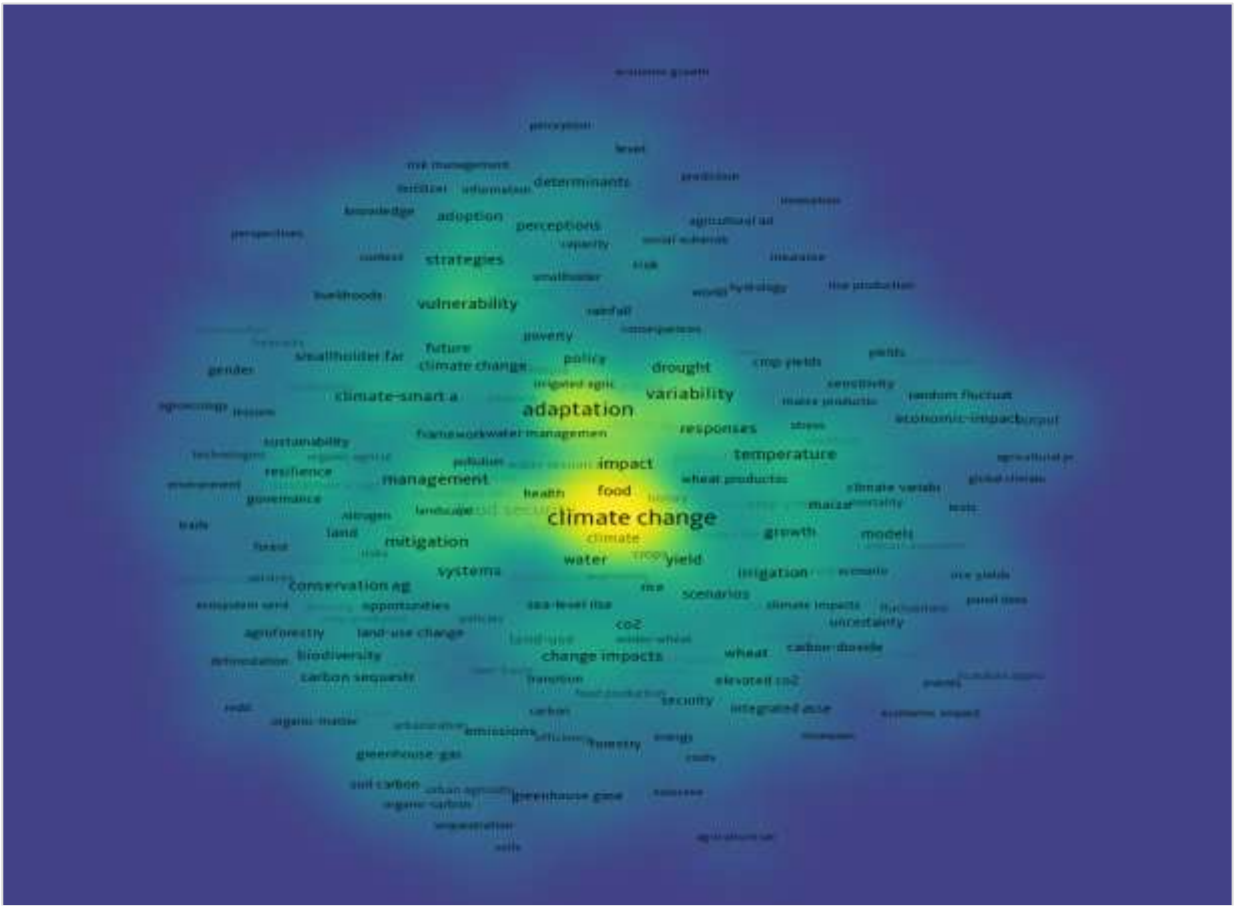

Fig. 4. Graphic representation of key words density
Source: edited by authors based on WOS results using VOSviewer.

In Figure 4, the density of key words is presented, which is represented by a color, and this color depends on the number of articles made in the vicinity of the node. Thus, the yellow color shows the key words that are most frequently used, while the blue color shows the least-used words in specializedworks.

It should be noted that there are groups of words such as "climate change", "adaptation", "vulnerability", "agriculture" and "foodsecurity" which frequently returned among the basic key words in the literature (Figure 4).

Analyzing the frequency of co-authors per country, we can observe the degree of relationship between the countries most interested in research on the specified topic.

In Figure 5, different colors can be seen on the map, illustrating the diversification of research directions. Large nodes are countries of particular interest in our study, and connections between nodes represent cooperative relationships. The distance between the nodes and the thickness of the connections represent the level of cooperation between the nodes (Figure 5). The United States of America, together with England, Austria and Germany, pay special attention to the analyzed topic. It is also noted that Germany, Belgium, Poland, the Netherlands, Sweden show a high degree of cooperation. On the above map, Romania is missing, showing the low degree of cooperation with the other countries shown on the map (Figure 5).

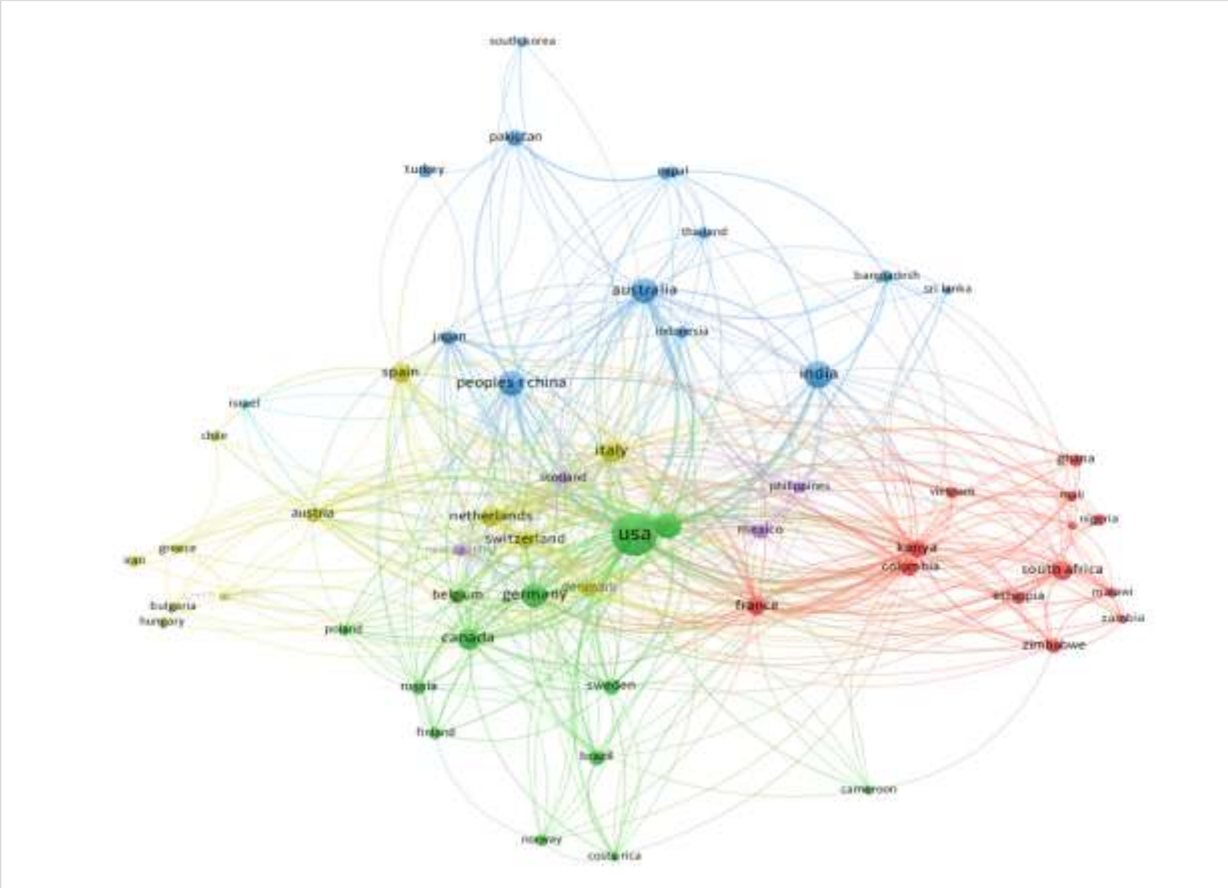

Fig. 5. Graphic representation of co-author countries
Source: edited by authors based on WoS results using VOSviewer.

The past 20 years have seen both the highest global temperatures and the highest number of natural disasters. Is possible that the impact of climate change on agriculture to be uneven across the world. In the future, increased drought is likely to reduce agricultural production in some regions while other may benefit from climate change by extending the growing season—plants will have more time to grow, flower, and bear fruit.

CONCLUSIONS

The paper analyzed theimportance of the research topic "climate changes, agriculture", the articles published in the period 1986-2022 being analyzed.

The numerous specialized works identified show the increased interest in the study of these phenomena at the level of the agricultural sector, from the point of view of the impact on productions and generated incomes.

Following the analysis, the results show that since 2006, the number of researches has doubled from 16 publications per year to over 40 publications per year.

Moreover, the frequency of related words used confirms that climate change is a key element for food security, environment, sustainability, health and economic impact.

Thus, we can affirm the fact that the subject related to climate change and the agricultural sector is a topic researched at a global level for the food safety of the population, but also the environment, biodiversity and sustainability, concerns that directly affect producers, being illustrated by key terms encountered in there search such as sensitivity, vulnerability, adaptation, risk, uncertainty, economic impact and production fluctuations.

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ENVIRONMENTAL CHALLENGES OF TRANSPORT ACTIVITIES IN THE AGRI-FOOD SECTOR

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Abstract

In a society dominated by an ever-evolving transport sector and experiencing profound technological change in all areas, we cannot deny the impact of transport on the environment. This paper has examined the main environmental impacts of transport activities associated with the food sector in order to undertake a critical review of the challenges we may face in developing this sector. The main objective was to show the links between transport activities throughout the food life cycle and the environment. The paper reviewed the main studies in the field and the results identified the main ways in which transport affects the environment and identified some solutions to reduce its impact. The materials used in the research cover a wide range of information on the environmental impacts of transportation activities. Available scientific literature containing information on transportation was used, and the scientific material was analyzed theoretically. Our brief review of the environmental impacts of transportation activities related to agriculture showed that greenhouse gas emissions in this sector are increasing. Our research has shown that it is necessary to use efficient vehicles, reduce transport distances, develop cooperation in transport networks, use new types of packaging, etc.

Key words*: *transport, food chain, life cycle, emissions, carbon footprint

INTRODUCTION

In rural areas, inadequate transport infrastructure, combined with the dispersion of producers and the absence of associations or cooperatives, leads to low producer prices and high transport costs [1]. Good rural transport infrastructure is therefore essential to facilitate access to markets, increase agricultural production and develop modern supply chains for agricultural products [5]. Any investment in infrastructure can reduce the cost of procuring inputs and transporting produce to market [20]. However, with the development of roads, railroads, etc. in rural areas, we are increasingly confronted with the phenomenon of increasing greenhouse gas emissions related to the local transport sector [23] and delivery logistics. Therefore, it is very important to “engage farmers in climate mitigation actions and help deliver a range of environmental and economic co-benefits” [2].

Transport in agriculture is generally calculable, as we can determine the necessary technical and human resources (land, fuel, etc.) in advance. For a farm's agricultural machinery, fuel consumption is the most important indicator of transport [26]. However, when calculating fuel consumption, many elements (weight of trailers, load, quality of roads, etc.) must be considered, which vary in time and space. Bernhardt et. al [4] have demonstrated that there are differences in fuel consumption by road type, traffic volume and speed.

There are many environmental problems associated with transport, as this sector is “responsible for a large part of the global consumption of energy and material resources” [3]. The sector contributes significantly to the emission of pollutants and noise, which affects health, plant growth, and biodiversity.

In this context, the purpose of the paper was to analyze the relationship between transport activities related to agriculture and the environment. We highlight the main challenges in this area by looking at work that has been done to identify the environmental impacts of transport activities. In this way, we want to give an overview of the environment challenges related with transport identified by various researchers in this field.

MATERIALS AND METHODS

This review article examines the links between the transport sector and the environment, drawing attention to the main direct and indirect impacts of this type of activity. The materials used cover a wide range of information summarizing the environmental problems due to transport activities from the available scientific literature.

RESULTS AND DISCUSSIONS

Agriculture contributes to global warming with a large amount of methane and nitrous oxide, while the transport sector contributes with CO2 emissions that have a relatively small impact during the life cycle of the food [15]. However, transport releases CO^2 emissions through the burning of fossil fuels, which are consumed, for example, in transporting produce from the field to the silo, transporting it to processing plants or slaughterhouses, transporting it to the supermarket, transporting inputs (fertilizers, feed and others) etc.

Carbon footprint of transport activities from food chain

According to Konieczny et. al [13], the European food transportation produces 54% of total nitrous oxide, 45% of total CO2, 23% of total non-methane volatile organic compounds, and 20% of other gases. However, the contribution is different according to the type of product, from 50% in fruits and vegetable sector to under 10% for the meat sector. In USA, food transportation utilizes around 19% of the total fossil energy (7% in agricultural production) [Pimentel et al. 2006] and most of the food is transported by truck [22].

The connection between transport and environment

The quality of the fleet can cause large amounts of pollution. There are some measures that can be applied to reduce the impact on the environment, such as use of fuel-efficient vehicles; use of local vehicle brands to reduce maintenance costs; use of professional drivers to improve fuel efficiency; monitoring of fuel consumption and vehicle use; preventive maintenance; and responsible disposal of parts [7].

Within local food distribution systems, it is assumed that there is a smaller ecological footprint because the distances between producer and consumer are smaller and the energy required for transport is reduced [8]. If transport is carried out over longer distances, energy-intensive logistics systems are required [9], which depend on the geographical location, food product, seasonality, and mode of transport [10] and include different transport sectors (transport inputs, packaging transport, waste transport, transport to storage, transport to the point of consumption, etc.).

Reducing the negative footprint of transport on the environment can also be achieved by optimising transport: through joint purchases, the creation of transport networks (by pooling resources, improving travel planning for better sharing of vehicles), the establishment of storage areas, etc. To promote collaboration regarding supply chains and logistics, "partners should reduce packaging and avoid single-use items, plan transport to reduce emissions and favour procurement of locally produced items as long as their supply, durability, adequacy and environmental sustainability can be ensured." Also, "coordination and collaboration with food aid suppliers, packaging suppliers, transporters is crucial, to identify the most sustainable packaging and research potential alternatives to improve cost-effectiveness and better preserve food aid products throughout the supply chain and shelf life" [6].

The way we ensure the connection between the production site and the distribution centres influences the environmental impact caused by transport. So, choosing suppliers or buyers based on transport distance reduces carbon emissions and pollution. Of course, if possible, means of transport that consume less carbon can be chosen (maritime or rail transport), measures can be taken to support local markets to shorten transport distances (the purchase of locally produced foods can reduce GHG emissions involved in the transport and storage of food), or a cost-benefit analysis can be carried out depending on delivery time, costs, emissions, capacity, packaging, etc. We can also reduce the need for transport and the associated carbon emissions by consolidating distribution centres or improving warehouse logistics.

The distance required for transport also influences the type of packaging used and indirectly the waste generated during delivery. If the size of packaging is reduced, the fuel needed for transport is reduced. Reducing plastic packaging and promoting reusable packaging also optimises the space required for transport.

LCA - environment impact related with transport

Looking at the life cycle of a food product, agricultural production has a greater impact on the environment compared to other activities such as transport and processing. However, reducing transport-related greenhouse gas emissions in rural areas is important to curb global warming, and many papers propose measuring the direct and indirect environmental impacts of transport systems through life cycle analysis. LCA have been used to analyze transportation systems since the 1990s, as they can provide information on direct and indirect environmental impacts [14].

LCA models can be used as decision support tools to assess the impacts of transportation infrastructure [17] or in infrastructure procurement [25], [12], [24]. In addition, LCA can be used to find environmentally sound solutions for different geographic dimensions of transportation to support sustainability [11].

There are many studies that use LCA models to analyse the effects of transport during the life of a product. Notarnicol et al. [18] point out that these models need to consider emissions from fuel use (based on hours worked, tractor power, farm type and soil) and distances between the locations of agricultural production, inputs and the place of processing, retail, or consumption.

Molina-Besch et. al [16] indicates that food LCAs usually take in consideration the transport from producer to retail, food waste in transport, food transport by households etc. Most studies conclude that the means of transport and distance are very important and that the only solution is to develop efficient packaging or to use reusable large containers. Indeed, the packaging solution of LCA can influence the choice of transport mode, which may be an energy-intensive mode such as air freight or a long-distance road transport. In these cases, the environmental impact of transport is estimated based on the weight of the food and its packaging.

According to Notarnicola et al [19], logistics is an important phase in terms of environmental impact within LCA due to the associated emissions to the atmosphere that occur during transport. In their model they considered: transport by lorry from the producer/farm to a regional distribution centre and from the regional distribution centre to the retailer (a total distance of 500 km); a 20% increase in fuel consumption for refrigerated transport; transport of consumers within a 4 km limit. This model LCA has proven that the environmental impact of transport during the life cycle of the product is less significant than the impact caused by the end-of-life phase of a food product (solid waste treatment, uneaten food, human metabolism excretions, etc.).

Payen et. al [21] show in their LCA model, that the transport from Morocco to France has a major impact on the environment within the life cycle of the tomato: acidification of the soil, eutrophication of the seas and depletion of fossil resources.

CONCLUSIONS

Our brief overview of the environmental impacts of transportation activities related to agriculture has shown that greenhouse gas emissions in this sector are increasing. Reducing this environmental impact can be achieved through the following measures: use of efficient vehicles, reduction of distances, cooperation within a transport network, introduction of new types of packaging, etc. Various LCA models have also been created to account for transportation activities from the acquisition of the input to the consumer's journey to the destination. They point out many other elements that need to be considered when estimating the impact of transportation, such as: Fuel consumption, energy consumption, type of product, type of packaging, weight of food, change of source of supply to local suppliers, etc.

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PERFORMANCE OF LARGE AGRICULTURAL COMPANIES IN ROMANIAN AGRICULTURE

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Abstract

This paper explores the profitability of large-scale agricultural companies in Romania in terms of land area under cultivation, i.e., companies with over 2,000 hectares and legally organised as limited liability companies paying corporate tax. The research is based on the financial results account, in which the information is structured by activity, and covers both the cultivation and financial activity, and allows the determination of potential cash accumulation balances, useful in showing how the factors of production involved are remunerated and how the agricultural activity yields financial resources, indicators known as interim management statements. The details of these accumulation balances are shown in the profit and loss statement by: 'trade margin', 'production of the financial year, 'value added', 'gross operating surplus', 'operating profit', 'financial result', 'gross result for the year' and 'net result for the year'. Thus, the interim management statements (IMS) as successive fractions in establishing the final result, are determined in cascade, starting from the most comprehensive, i.e., the trade margin and the production of the financial year, and ending with the net result for the year, which summarises the process of the profit or loss from an unprofitable activity, also specifying how the managerial activity of the company was carried out at each level of accumulation.

***Key words*:** performance, plant-based agricultural holding, interim management statements

INTRODUCTION

In the economic literature and in current practice, the concept of agricultural holding is used alongside the concepts of agricultural unit and agricultural enterprise, all these concepts overlapping and even replacing each other. Thus, the agricultural holding is the production unit which owns a distinct property and whose main factors of production are land, plants and/or animals, with the aim of achieving regular agricultural production. The characteristics of agricultural holdings in Romania, given the existence of a multitude of typologies, can be highlighted by looking at the legal criterion of ownership, identifying family agricultural holdings, agricultural holdings of the trading company type ("general partnerships", "limited partnerships", "limited partnerships by shares", "joint-stock companies" and "limited liability companies"), associative agricultural holdings ("simple companies" and "agricultural companies"), public agricultural holdings and agricultural cooperatives. Taking into account the criterion of size in terms of land area owned, the numerical evolution of agricultural holdings in Romania according to the General Agricultural Census and the Structural Survey in Agriculture, in 2016 the general picture was as follows: 71.84% very small agricultural holdings, 27.06% small agricultural holdings, 0.55% medium agricultural holdings, 0.18% large agricultural holdings and 0.37% very large agricultural holdings [3]. But financial performance is the desideratum of any agricultural holding, regardless of the size category to which it belongs, and its measurement requires the application and use of a wide range of indicators [5]. In order to measure and manage the overall performance of large-scale plant-based agricultural holdings, a critical analysis was carried out by reviewing scientific publications dedicated to this field of research [1]. Thus, the aim of this analysis is to identify these influencing factors, the indicators that give meaning to the evolution of the enterprise [12] and its desire to be efficient. The profit and loss statement is a model that brings business performance to the fore over a given period, including agricultural holdings, and is a managerial tool aimed to examine an economic entity in order to identify and solve the problems that arise [4]. The profit and loss statement is that component which reflects business performance, i.e., the extent to which it has achieved its objectives in terms of profit [11]. Profit ultimately reflects business performance and the ability of that company to reinvest or pay dividends. Summary indicators are determined in the profit and loss statement which refer to the yearly activity of the respective agricultural holding. The profit and loss statement, as required by Romanian accounting law [17], shows the incomes and expenses generated by a company's activity for a given period and explains how the results are formed. Carrying out various activities related to different sectors of the economy results in a certain effort involving certain expenses, which naturally generate effects materialised in wealth, added value, different earnings [6]. Earnings are generated by resources that have been realised from the activities carried out: operating, commercial, financial, investment and expenses correspond to the consumptions made to achieve the object of activity. Consequently, the comparison of the earnings obtained with the expenses incurred, allows obtaining an overall result that indicates the ability of a business to generate cash flows, determined by [6]:

Result = Income (resources) - Expenses (uses)

Based on this result, we can state that profitability refers to the ability of an agricultural holding to obtain economic benefits from the use of production factors and capital, regardless of their origin, by breaking down the profitability threshold (minimum turnover for the activity to be profitable) [2]. Profitability denotes the efficiency of the activity of the agricultural holding in question, taking into account all stages of the cultivation: supply, production and sale. As an absolute measure, it is equivalent to profit, as a relative measure it is reflected by the rate of return. Thus, the difference between the effects generated and the efforts made is reflected in the profitability of the firm's activity through the achievement of a certain profit in terms of the volume of earnings compared to the volume of expenses, and the relationship between effects and efforts generates the profitability of the firm, i.e., indicates the firm's performance [6]. Thus, the profit and loss statement also shows the partial indicators of profitability: the operating profit and the financial result, as well as the overall indicator of profitability: the result for the year (before and after tax). In French practice, companies are required to draw up the Interim Management Statements, with the presentation of additional information at various stages of the results, based on specific investigative techniques, which are also useful for establishing a financial diagnosis [9]. Interim management statements are indicators that highlight the fractional nature of the formation of the result for the year. In reality, the table of interim management statements merely presents the sequence of the business activities from a different perspective with a view to determining the net result. Accordingly, the interim management statement shows part of the profitability as the difference between two values, usually between earnings and expenses pertaining to a given activity. Thus, in order to be able to characterise the level or the development and performance of agricultural holdings in Romania, they have been analysed one by one, determining for each one the influencing factors, namely those independent, causal variables which determine their change over time and consequently the evolution of these dependent variables [12]. Thus it is specified the development of the agricultural society analysed, as well as the existing relationship between resources, as main production factors, and the way they are managed and used.

In this context, this paper explores the profitability of large-scale agricultural companies in Romania in terms of land area under cultivation, i.e., companies with over 2,000 hectares and legally organised as limited liability companies paying corporate tax.

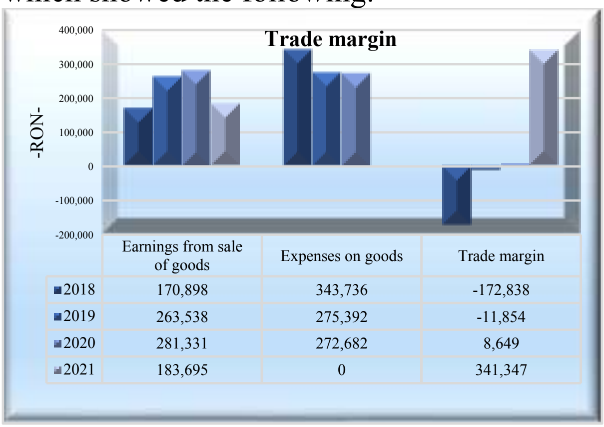
MATERIALS AND METHODS

The purpose of drawing up the table of interim management statements is to assess the profitability of a large-scale vegetable agricultural holding in Romania, generated by the activity of the agricultural company under study, between 2018 and 2021. The study of the structure of the activity of the large-scale plant-based agricultural holding is presented with the help of indicators that allow the analysis of its evolution over time ("trade margin", "production of the financial year", "value added", etc.), the study of the operating resources (return on labour, return on fixed assets used, etc.), the analysis of profitability and its evolution over time, by determining the percentage variation of the main intermediate management statement and identifying the causes of these variations. The relationships underlying the construction of the IMS are presented in Figure 1.

Fig. 1. The relationships underlying the construction of the Interim Management Statements (IMS)
Source: Own design.

RESULTS AND DISCUSSIONS

The large-scale plant-based agricultural holding was established in 1994 and has an agricultural area of 2930 ha, located in Romania, South-Muntenia Region, Ialomița County, in an agricultural area that offers pedological and climatic potential of high fertility, and also traditionally agrarian, which is an advantage for the practice of high-yield agriculture. The climate of Ialomița County is temperate-continental, with a relatively high annual and diurnal temperature range, with very hot summers, which are periodically dry, and cold winters, frequently marked by heavy blizzards. The predominant soils are chernozems, but also alluvial soils, cambic soils and reddish-brown soils. The main activity of the agricultural holding under study is the cultivation of cereals and oilseed crops on an area of land that falls into the medium and large category. The areas under cultivation are both owned and leased. The main crops grown are maize, rapeseed, sunflower, wheat, soy and barley. As of 2020, about three quarters of the land under cultivation has been irrigated, and the solid technical and material base enables carrying out agricultural work independently, without having to call on third parties. Analysing the profit and loss statement and the ability of the large-scale plant-based agricultural holding in Romania to generate income from ongoing activity, based on the use of existing resources involving expenses [6], the interim management statements were determined, which showed the following:



	Earnings from sale of goods	Expenses on goods	Trade margin
2018	170,898	343,736	-172,838
2019	263,538	275,392	-11,854
2020	281,331	272,682	8,649
2021	183,695	0	341,347

Fig. 2. Trade margin of large-scale agricultural holding
Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company

The trade margin is the first intermediate management statement determined and refers to the commercial activity carried out by the agricultural holding under study.

The trade margin of the large-scale plant-based agricultural holding in Romania showed an upward trend during the analysed period 2018-2021. In 2018 and 2019, this indicator was negative, which shows that the earnings from the sales of agricultural commodities did not cover the expenses generated by their realisation. But it is noticed that the decrease of the loss occurs from 2019, with 93.14% compared to the previous year, so that from 2020, the trade margin from the sales of goods is positive (RON 8,646) and with a significant increase in 2021 compared to 2020 of 3,946.66% (RON 332,698). Production of the financial year is an indicator which, in addition to the earnings from agricultural products sold by the large-scale agricultural holding, also includes those stored or used for self consumption as well as fixed production.

Table 1. Variation of the trade margin of large-scale agricultural holding

No.	Indicator	Years under review					
		2019/2018		2020/2019		2021/2020	
		RON	%	RON	%	RON	%
1.	Earnings from sale of goods	+92,640	154.21	+17,793	106.75	+1,555,619	652.95
2.	Expenses on goods	-68,344	80.12	-2710	99.02	+1,222,921	548.48
3.	**Trade margin**	**+160,984**	**6.86**	**+20,503**	**72.96**	**+332,698**	**3,946.66**

Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company.

Table 2. Variation in production of the financial year of Large-scale agricultural holding

No.	Indicator	Years under review					
		2019/2018		2020/2019		2021/2020	
		RON	%	RON	%	RON	%
1.	Production sold	+1,001,389	105.40	+154,328	100.79	+16,785,262	185.21
2.	Earnings pertaining to costs of stocks	-223,975	69.01	+1,801,591	461.27	- 2,258,028	198.16
3.	Capitalised production	-460,155	66.28	+140,236	115.51	-810,137	22.45
4.	Production of the financial year	**+317,259**	**101.54**	**+2,096,155**	**110.01**	**+9,116,541**	**139.56**

Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company

The production of the financial year of the large-scale plant-based agricultural holding is mainly made up of the agricultural production sold, i.e., 89.88% in 2018, 93.30% in 2019, 85.48% in 2020 and 113.44% in 2021. The value of the agricultural production sold increased during the period under review by 5.40% in 2019 compared to 2018, 0.79% in 2020 compared to 2019 and 85.21% in 2021 compared to 2020. While in 2018, 2019 and 2020 the value of the stock of agricultural products increased compared to the beginning of the period, in 2021 the change in stocks decreased significantly compared to the beginning of the period (by RON -4,558,306). It is noticed that the turnover in 2021 increased by 91.85% compared to the previous year, which indicates an increased efficiency of the farm's activity.

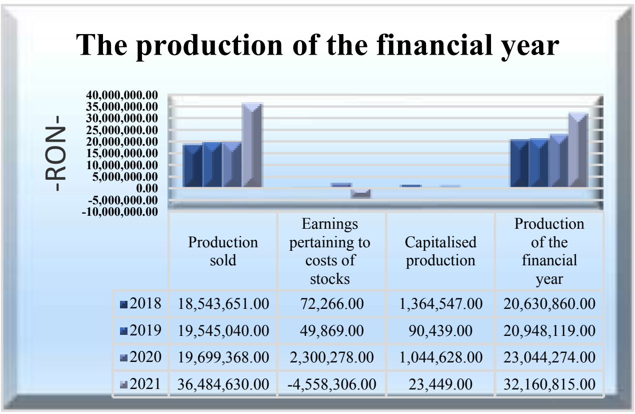


Fig. 3. Production of the financial year of the large-based agricultural holding
Source: Own processing, data according to Profit and Loss Statement of Large-scale plant-based agricultural company.

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Fig. 4. Regression of turnover evolution –linear model
Source: Own design of the results.

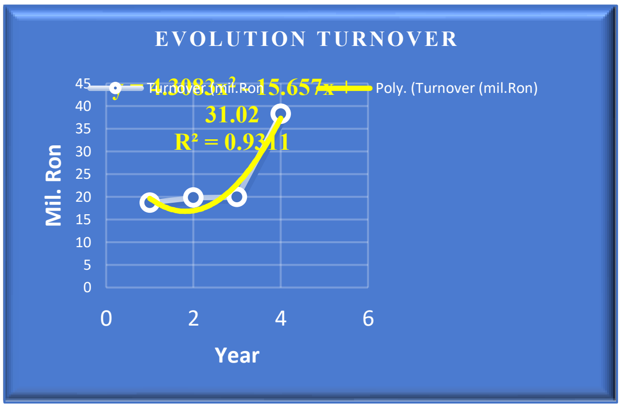

Fig. 5. Regression of turnover evolution – parabolic model
Source: Own design of the results.

Turnover, included only in the income statement structure and not in the interim management statement, is an overall indicator of sales, from both sales and production activities [16].
The earnings the production of fixed assets decreased in 2019 compared to 2018 and in 2021 compared to 2020 by 33.72% and 77.54%, respectively

. During the period under review, year-on-year increases in the production indicator were ecorded, with the highest value recorded in 2021, a good agricultural year for agricultural practice, by 39.56% over the previous year.

Table 3. Turnover of the large-based agricultural holding

No.	Specification	2018	2019	2020	2021	Evolution of Indicator		
						2019/ 2018	2020/ 2019	2021/ 2020
		- RON-				-%-		
1.	Net turnover	18,714,549	19,808,578	19,954,148	38,281,308	105.85	100.73	191.85

Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company.

The coefficient of determination R^2 shows to what extent the mathematical model used is the adaptation of the data on the basis of which it was obtained. The closer the value of this coefficient is to 1, the more adapted the chosen model is, and the higher the value of R^2, the better the regression function estimated at the observed values is explained. R^2 =0.9311 in the case of the parabolic model, very close to value 1, higher than 0.6517 for the linear model.
The most basic concept to measure the income and performance of an economic entity or even the entire economy is the **added value** created by its economic activities [7]. **Value added** expresses the creation or increase in value of the goods and services from third parties. It can also be referred to as "economic profit" as it attempts to capture the real profit of the analysed agricultural holding [8]. It refers to the gross value added and makes the link between the micro (plant-based agricultural holding) and macroeconomy. At macroeconomic level, this value added measures the contribution of the plant-based agricultural holding within its own sector, i.e., agriculture, with a higher size also making a greater contribution. At microeconomic level, value added is an indicator that allows the plant-based agricultural holding under study to measure its economic strength. **Value added** measures the financial performance that focuses on maximising shareholder value as opposed to simply maximising net profit [13].

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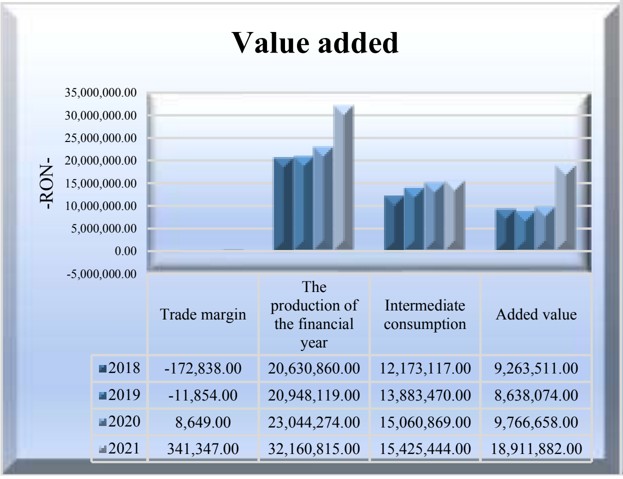
Table 4. Variation in value added of large-scale agricultural holding

No.	Indicator	Years under review					
		2019/2018		2020/2019		2021/2020	
		RON	%	RON	%	RON	%
1.	Trade margin	+160,984	6.86	+20,503	-72.96	+332,698	3,946.66
2.	The production of the financial year	+317,259	101.54	+2,096,155	110.01	+9,116,541	139.56
3.	Trade discounts received	+606,673	161.99	+215,876	113.62	+74,281	104.12
4.	Trade discounts granted	-	-	+26,551	-	+13,721	151.68
5.	Intermediate consumption	+1,710,353	114.05	+1,177,399	108.48	+364,575	102.42
6.	Added value	**-625,437**	**93.25**	**+1,128,584**	**113.07**	**+9,145,224**	**193.64**

Source: Own processing, data according to Profit and Loss Statement of Large-scale plant-based agricultural company.



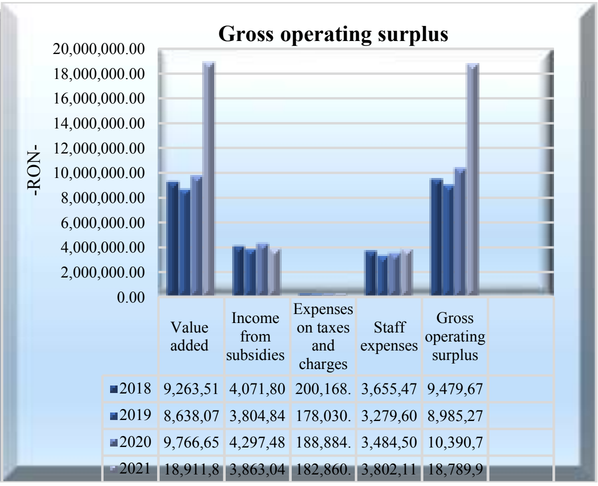


Fig. 6. Value added of large-scale agricultural holding Fig. 7. Gross operating surplus of large-scale agricultural holding
Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company.

For the analysed plant-based agricultural holding, it is noticed that this indicator shows increases from one year to the next, with the exception of 2019 when there was a decrease compared to the previous year of 6.75%. A major contribution to added value is made by the production of the financial year, the company also receives some trade discounts from third parties. The trade margin contributed insignificantly to the formation of this trade value, moreover, in 2018 and 2019, being negative, led to its decrease. Intermediate consumption including expenses from third parties which include expenses on inventories and works and services performed by third parties represents in the income realised from the trade margin and production of the financial year, accounts for 56.79% in 2018, 61.65% in 2019, 60.64% in 2020 and 44.94% in 2021.

Although the value of these consumption is increasing during the period under review, the percentage decrease in 2021 is due to the significant increase in the income of the plant-based agricultural holding.

The value added is of particular interest in the financial analysis of the plant-based agricultural holding under study, as it links the micro and macroeconomic environment where it operates and assesses its specific contribution to the achievement of its own production. Compared with turnover, value added is a more synthetic indicator because it highlights the commercial performance, i.e., the production and sales capacity of the plant-based agricultural holding, but also measures its specific contribution to the production of its output, thus reflecting the degree of usage of its own factors of production. In countries such as Germany and France value added is integrated into several areas of accounting [7].

The gross operating surplus corresponds to the economic result of the plant-based agricultural holding, generated by production operations, differentiated from the financial policy, depreciation policy or provisions made, and considered an essential indicator for its management analysis and for carrying

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out comparative analyses between agricultural holdings of the same profile. In general, economic value is created by investments with a higher return compared to their cost.

Table 5. Variation in operating profit of large-scale agricultural holding

No.	Indicator	Years under review					
		2019/2018		2020/2019		2021/2020	
		RON	%	RON	%	RON	%
1.	Gross operating surplus	-494,395	94.78	+1,405,472	115.64	+8,399,207	180.83
2.	Other operating income	-85	99.97	+455,951	244.91	-347,720	54.88
3.	Other operating expenses	+105,297	142.77	+348,823	199.24	+431,879	161.67
4.	Depreciation and amortisation	+88,852	102.67	+616,801	118.07	+810,196	120.11
5.	Operating profit	-688,629	88.94	+895,799	116.18	+6,809,412	205.88

Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural holding

Table 6. Financial result of large-scale agricultural holding

No.	Indicator	Years under review					
		2019/2018		2020/2019		2021/2020	
		RON	%	RON	%	RON	%
1.	Financial income	48,792.00	955.85	-4015.00	92.63	-31,494.00	37.61
2.	Financial expenses	-10,620.00	73.60	82,752.00	379.57	-28,518.00	74.62
3.	**Financial result**	**+59,412.00**	**-72.11**	**-86,767.00**	**248.56**	**-2976.00**	**104.81**

Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company.

During the period under review, **the gross operating surplus** showed an upward trend, with the exception of 2019, when it decreased by 5.22% compared to the previous year. In the following years, i.e., 2020 and especially in 2021, **the gross operating surplus** recorded increasing values from one year to the next, values that allowed the agricultural holding to renew its fixed assets through depreciation, covering income tax, paying dividends to shareholders, etc. In general, economic value is created through investments with increased profitability compared to its cost [15]. **The gross operating surplus** is a fundamental financial resource for the agricultural holding under review, the first level for building the overall cash flow of the holding, and therefore the starting point for determining the cash flow statement [10].

The operating income assesses the economic profitability of the large-scale agricultural holding under review and corresponds to its normal and current activity, including transactions carried out in the previous years but relating to the current year.

Determining this result is useful for comparing the performance of plant-based agricultural holdings with different financial policies.

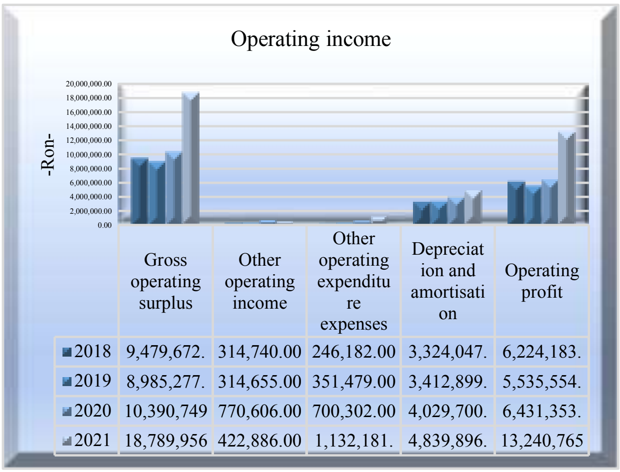

Fig. 8. Operating income of large-based agricultural holding
Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company.

The operating income of the analysed agricultural company is positive throughout the period under study and an increase in its value is observed, except for 2019 compared to 2018 when it decreased by 11.06%. The year 2021, compared to the previous year, led to an increase in this result by 105.88% which highlights a very beneficial agricultural year for the economic activity of the company.

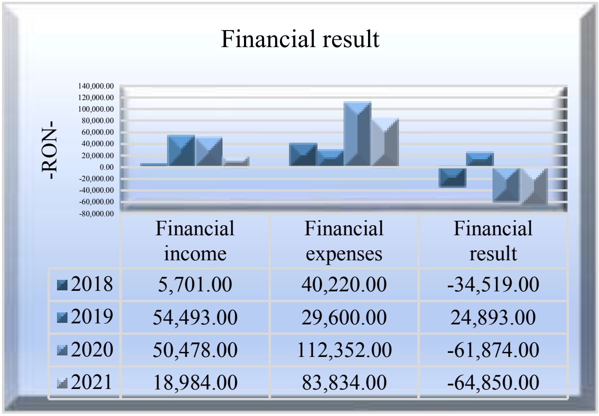

Fig. 9. Financial result of large-scale agricultural holding
Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company.

The operating income provides the basis for the strategies that the management of the plant-based agricultural holding can adopt to increase this result, by increasing earnings or decreasing expenses, while keeping the other factor constant, or increasing both components, subject to the restriction that the income increase rate should exceed the expenses increase rate [10]. The flows that determine the result are to be understood, in principle, as the variation in equity during a financial period [11].

The financial result represents the outcome of the financial activity, allowing the impact of the financial policies of the plant-based agricultural holding to be assessed. It should be noted that during the period under review, financial expenses exceeded income from this activity, recording financial losses, with the exception of 2019, when the financial result was positive.

The net result for the year expresses, in absolute terms, the net return after deducting the total expenses and income tax from total income [10]. The definition of business performance differs, depending on the users' interest and the accounting principles, conventions and rules used to determine the result [11].

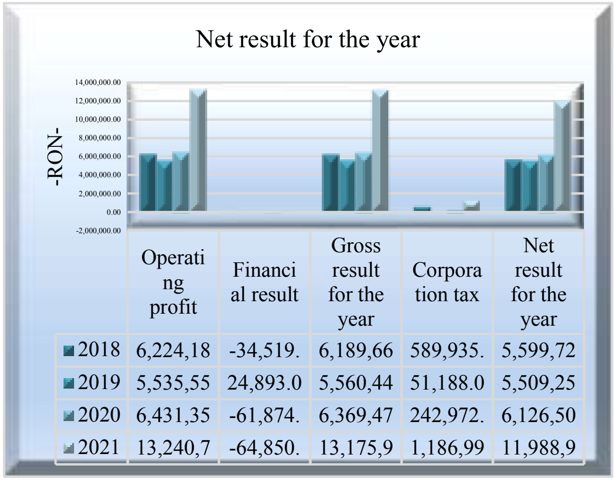

Fig. 10. Net result of large-scale agricultural holding
Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company.

For the agricultural holding analysed, this result is positive over the period 2018-2021 with increases in absolute value from one year to the next, except for 2019 when there was a slight decrease of 1.62%. The net result for the year achieved by the agricultural holding is the result that was subject to the decision of distribution by the general meeting of shareholders [10].

Table 7. Variation in net result of large-scale agricultural holding

No.	Indicator	Years under review					
		2019/2018		2020/2019		2021/2020	
		RON	%	RON	%	RON	%
1.	Operating profit	-688,629	88.94	+895,799	116.18	+6,809,412	205.88
2.	Financial result	+59,412	72.11	-86,767	248.56	-2976	104.81
3.	Gross result for the year	-629,217	89.83	+809,032	114.55	+6,806,436	206.86
4.	Corporation tax	-538,747	8.68	+191,784	474.67	+944,025	488.53
5.	Net result for the year	-90,470	98.38	+617,248	111.20	+5,862,411	195.69

Source: Own processing, data according to Profit and Loss Statement of large-scale plant-based agricultural company

CONCLUSIONS

The results of the study show that companies need to determine efficiency and performance indicators by comparing the effects achieved with the efforts and resources consumed by the company and operated by management [11].

The assessment of performance differences and financial position depends on the nature of the company's activity and the system of tools used in asset management [4]. Identifying the potential profit or loss facilitates decision making in order to have an improvement of the activity in the large-scale plant-based agricultural holding under study [14] thus:

-For the financial year 2019, the agricultural plant-based agricultural holding had a significantly positive Result for the operating activity and the Result for the financial activity was also positive which denotes that the agricultural company has a favourable position on the market, as a result of an operating activity with increased profitability, which allows the release of high liquidity, useful for recovering financial expenses uncompensated by financial income, and obtaining profit. The large-scale plant-based agricultural holding is ideally located for a company producing agricultural products, with a good financial balance and an operating profit well above financial expenses.

-For the financial years 2018, 2020, 2021 the plant-based agricultural holding had a significantly positive Result for the operating activity and the Result for the financial activity was negative which indicates that the plant-based agricultural holding balances the operating profit by covering operating expenses at the expense of operating income, with the mention that it has a high level of financial expenses.

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STUDY REGARDING THE IMPLEMENTATION OF NATIONAL QUALITY SCHEMES FOR AGRI-FOOD PRODUCTS - TRADITIONAL ROMANIAN PRODUCTS

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Abstract

Consumers are increasingly paying attention to the origin and quality of the products they consume. In the last decades there has been a significant increase in interest in agri-food products certified under quality schemes, which are often perceived as being of superior quality with unique sensory properties. Quality schemes are a way of recognizing the quality of agri-food products to enable consumers to make informed choices. In addition to product quality, producers must maintain a food safety standard through clear rules and verified by the competent institutions of the Romanian Government. The purpose of the paper is to analyse the implementation of the national schemes regarding traditional products. The data provided by Ministry of Agriculture were used to create an image on the present situation. Romania is strongly represented by products with national quality schemes, but not necessarily at the EU level. Romania certified 764 products from 2020 until 2022. In 2022 the producers were being forced to reauthorize themselves in order to maintain the right to sell the traditional product on the Romanian market because of a legislative change on the perspective on the National Register of Traditional Products. Now Romania have 732 valid certificates for traditional products in 37 counties of 42.

Key words**:** *agri-food products, quality schemes, traditional products, Brasov county, Romania*

INTRODUCTION

Demand for better food quality and consumer awareness of how it is produced and processed is growing. This leads to the emergence of public and private standards as an increasingly dominant instrument of governance in the agri-food chain, both nationally and internationally [5].
Romania is an important country in ten EU agriculture due to its large cultivated areas and production [24].
In Romania has aligned its legislation to the EU standards concerning the quality of agri-food products [3, 9].
The products that have a national recognition in Romania are: Traditional Romanian Products, Consacrated Romanian Recipes, Mountain Products. In general, these types of food are an important part of the culture, history, identity, heritage and local economy of a region or country [4] and comprise elements specific to each country's cuisine as more emphasis is given to the concept of national identity and traditionalism [23].
Quality schemes are a way of recognizing the quality of agri-food products to enable consumers to make informed choices. All products certified under quality schemes are accompanied by specific logos attesting to the recognition of well-defined technical specifications; thus distinguishing itself on the shelf from other products in the same category. Participation in quality schemes is entirely voluntary.
The statistical data shows that in Romania there were 764 products certified as Traditional Products (between the 2020-2022) and 1319 Mountain Products (between the 2017-2022).
At national level the traditional products and products obtained from consecrated Romanian recipes are managed by the Ministry of Agriculture and Rural

Development through the County Agriculture Directorates through registration or authorization at the Veterinary and Food Safety Directorates in each county.

Romania has made progress related to the transformation of the national food system. Regarding the classification made by the Global Food Security Index (GFSI) 2018, Romania ranks 38th with a total score of 68.9 points, out of a total number of 113 monitored countries. The Global Food Security Index monitors three strategic criteria: accessibility, availability and quality and safety [22].

MATERIALS AND METHODS

The purpose of this research is to analyze the traditional Romanian products in four counties in Romania.

The materials used in writing this paper consist of national and international normative acts, EU databases (e-Ambrosia - the EU geographical indications register)[8] and Romanian databases (National Register of Traditional Products for each year between the 2005-2022) [10]. The National Register of Mountain Products [11] has also been researched, with the data analysis period between 2017-2022.

The methods used the logical and sociological method and the analytical method. They had the role of performing a systematic analysis of the information from the studied sources like the archive of some national normative acts in order to elaborate the points of view and the conclusions of this paper.

This research presents the analysis of the evolution of products certified by Romanian quality schemes at the level of Romania, taking into account the period between 2005-2022.

During the research, the data were provided by the Ministry of Agriculture and Rural Development through public registers.

RESULTS AND DISCUSSIONS

Since the 1990s, quality schemes have gained momentum, becoming important, "not only in politics, but in agriculture and the food industry, as the focus has shifted from quantity to quality" [2].

The notion of "traditional product" was regulated for the first time in Romania in 2004 [15][21].

According to the statistical analysis regarding traditional Romanian products, there were 764 products certified (Fig. 6) but 732 products with valid certificates, the rest of it being cancelled (Table 1).

Table 1. Status of certified traditional products and mountain products from the counties of Romania

	County	Traditional products	Mountain products	Traditional products + Mountain products
1	Alba	49	44	93
2	Arad	7	1	8
3	Argeş	40	5	45
4	Bacău	4	36	40
5	Bihor	8	5	13
6	Bistrița Năsăud	31	210	241
7	Botoşani	26	Out of area	26
8	Braşov	174	64	238
9	Brăila	0	Out of area	0
10	Bucureşti	19	Out of area	19
11	Buzău	33	11	44
12	Caraş-Severin	12	41	53
13	Călărași	0	Out of area	0
14	Cluj	14	78	92
15	Constanța	1	Out of area	1
16	Covasna	23	256	279
17	Dâmbovița	5	8	13
18	Dolj	3	Out of area	3
19	Galați	14	Out of area	14
20	Giurgiu	1	Out of area	1
21	Gorj	8	53	61
22	Harghita	2	73	75
23	Hunedoara	10	63	73
24	Ialomița	0	Out of area	0
25	Iași	20	Out of area	20
26	Ilfov	4	Out of area	4
27	Maramureş	57	86	143
28	Mehedinți	3	5	8
29	Mureş	3	14	17
30	Neamț	29	23	52
31	Olt	3	Out of area	3
32	Prahova	6	12	18
33	Sălaj	15	0	15
34	Satu Mare	28	29	57
35	Sibiu	17	41	58
36	Suceava	19	39	58
37	Teleorman	0	Out of area	0
38	Timiş	4	1	5
39	Tulcea	20	Out of area	20
40	Vâlcea	17	99	116
41	Vaslui	3	Out of area	3
42	Vrancea	0	22	22
Total products:		732	1,319	2,051

Source: Own calculation based on the data from [10, 11].

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Out of the 42 counties in Romania, only 37 have certified products as traditional.

Within the National Register of Mountain Products 1,319 products were registered between the 2017-2022.

The contribution of the mountain areas to GDP was 48.7 million Euro, for which Romania came on the 8th position among other European countries [18].

Agriculture is one of the high importance branches of the economy as growing crops and raising farm animals are destined to offer raw materials to processing industry in order to achieve food products ready to cover the consumption needs of the population and to ensure food security [19].

The mountain area is delimited in 27 counties by Decision no. 506 of July 20, 2016 regarding the establishment of the institutional framework and some measures for the implementation of Delegated Regulation (EU) no. 665/2014 of the Commission of March 11, 2014 supplementing Regulation (EU) no. 1.151/2012 of the European Parliament and of the Council regarding the conditions of use of the optional quality designation "mountain product" [5].

The mountain area contains an impressive number of localities: 948. In comparison with traditional products, which are not limited only to the mountain area, and are found in 37 counties in Romania.

Fig. 1. Mountain Product Logo
Source: [12].

Regarding the top of the 7 counties in terms of number of certified mountain products, Covasna (256) and Bistrița Năsăud (210) are on the first two places, followed by Vâlcea (99), Maramureș (86), Cluj (78), Harghita (73) and Brașov (64) (Table 1).

Regarding the traditional products, most of the certificates can be found in the counties of Brașov, Alba, Maramureș and Argeș. The counties with the fewest certified products are: Olt, Vaslui, Harghita, Constanța and Giurgiu. (Table 1).

All the counties included in the mountain area have at least one certified mountain product, but we cannot say the same about traditional products. Out of a total of 42 counties, there are 5 counties that have not certified any traditional product. These are the following: Brăila, Călărași, Ialomița, Teleorman and Vrancea.

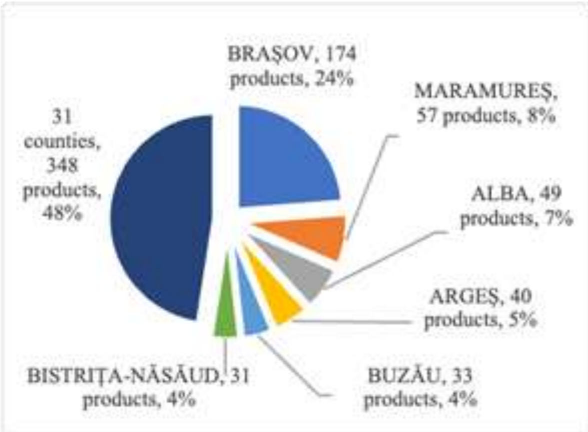

Fig. 2. Status of traditional products by county
Source: Own determination based on the data from [10, 11].

Out of a total of 732 traditional products, 52% is represented by only 6 counties (Brașov, Maramureș, Alba, Argeș, Buzău and Bistrița-Năsăud), while the remaining 48% of the products are owned by the other 36 counties (Fig. 2).

All traditional products with valid certificates can be found in the public database on the website www.madr.ro within the National Register of Traditional Products.

The counties of Maramureș, Alba, Argeș, Buzău and Bistrița-Năsăud do not have a large share, but it is considerable. These are situated among the top 6 counties with a large number of certified products (Fig. 2).

Brasov county is the most representative for the national traditional product quality scheme; it has the largest number of certified products in Romania: 174 traditional products and 64 mountain products. It is on the 1st place for traditional products, but on the 7th place for mountain products.

Regarding the location on the map, Brasov County is located in the center of Romania. It has an area of 5,363 square kilometers, which represents 2.3% of the total area of the country (Map 1).

Brașov County is dominated by mountainous areas, so the relief is formed by four major units:

1.Southern Carpathians (The Făgăraș Mountains, The Bugegi Mountains, The Piatra Craiului Mountains) in the South

2.The Sub Carpathians (The Ciucaș Mountains) in the South-Eastern part

3.The Perșani Mountains in the North

4.The Târnavelor Plateau in the North-West part and two extended depression areas (the Brașov Depression and the Făgăraș Depression) [20].

Map 1. Map of Romania – the Brașov county on the map
Source: [25].

The next county in the ranking being Maramureș with 57 certified products (almost 3 times less than Brașov).

From the point of view of the product category, 304 meat products, 131 milk products, 114 pastry and bakery products, 113 fruit-vegetable products, 29 beverages, 28 fish products and 6 other products were certified at the national level as products from other categories.

Examples of certified traditional products: Green walnut jam as at Coana Mărioara from Argeș county, Oltenesc brisket from Mangalița - Ferma lu Ghirță from Dolj county, Pear tart from Văsuoiu from Sibiu county.

Order no. 724/2013 on the attestation of traditional products, with subsequent amendments and additions, defines the characteristics and criteria that a producer must meet in order for the Ministry of Agriculture and Rural Development to certify a traditional agri-food product [17]. Also, for the attestation of traditional products, the manufacturer will draw up a specification along with which he will submit micro-biological and physico-chemical analysis bulletins.

In the sense of Order 724/2013, the terms used are defined as follows: according to art. 2 paragraph (a): ”traditional product is a food product for which local raw materials are used, does not contain food additives, presents a traditional recipe, a traditional production and/or processing method and is distinguished from other products similar belonging to the same category" [17] and according to art. 2 paragraph (b): "traditionality represents the element or set of elements by which a product is distinguished from other similar products belonging to the same category; traditionality cannot be limited to a qualitative or quantitative composition or to a production method established by a community or national regulation or by voluntary standards; however, this rule does not apply if the respective regulation or standard has been established in order to define the traditionality of a product" [17].

Fig. 3. Traditional product logo during the period between 2013-2020
Source: [13].

From 2013 to 2020, the traditional product was marketed alongside the logo regulated by Order 724/2013. It was changed in 2020 by Order 112/2020.

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In order to be sold, traditional products must have the "certified traditional product" logo with the unique certificate number issued by Ministry of Agriculture and Rural Development and must be accompanied by a photocopy of the certificate on the shelf at the place of sale (Fig. 4).

Fig. 4. Current traditional product logo
Source: [14].

Registration is not allowed in the case of a product whose traditionality is due to the application of a technological innovation, the production process must be traditional.

The national legislation mentions specific elements regarding the production of products certified as traditional products, such as:

• production cannot be treated at an industrial level, i.e. there are mentions regarding the quantity produced cannot exceed "the average quantity of 150 kg/liters per day total certified traditional product and no more than 400 kg/liters per day total certified traditional products, except the production of bread and traditional bakery products - which cannot exceed the average amount of 300 kg per day total certified traditional product and no more than 800 kg per day total certified traditional products" [18];

• the raw materials used in the manufacturing process do not contain in their composition additions obtained by chemical synthesis and not only, such as: "food additives, flavors, vitamins, minerals; the origin of the raw materials" [18].

An important element regarding the attestation of a traditional product is the fact that the raw material must be local, i.e. the raw material used to obtain the traditional product and which is produced on the territory of the state where the traditional product is manufactured (in the sense of this research paper that is Romania state).

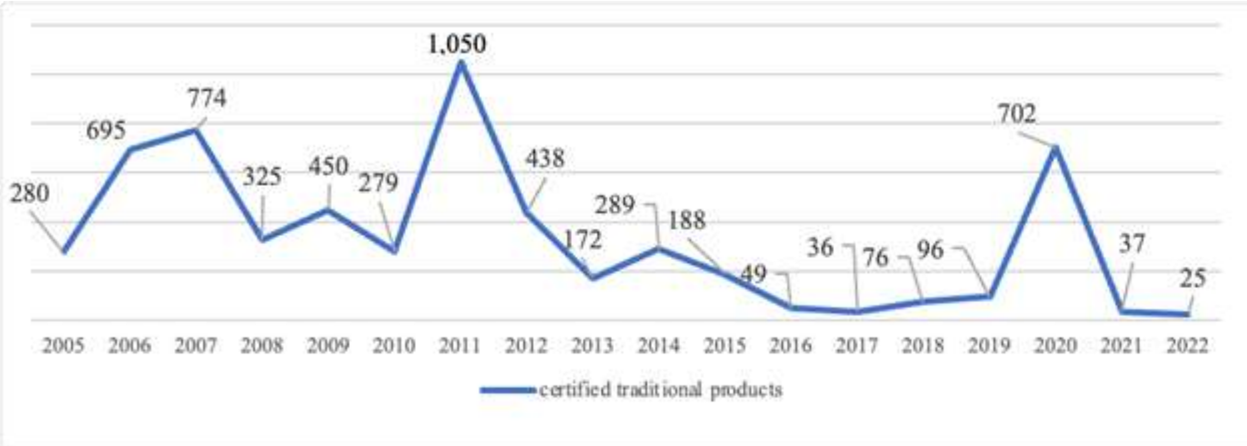


Fig. 5. The dynamics of certified traditional products between 2005-2022
Source: Own determination [10, 11].

Analyzing the data, it is observed that 2011 presents an impressive number of authorizations: 1050 of new traditional products have been authorized to be marketed. Means of certification and general conditions imposed for traditional products at the level of the European Union are provided for in EC Regulation number 509/20.03.2006 of the Council regarding guaranteed traditional specialties from agriculture and food products [6] and in EC Regulation number 1216/18.10.2007 of the Commission [7] regarding the establishment the application rules of EC Regulation number 509/2006 of the Council. The member states adopted their own legislation in addition to the European one. Since 2013, the logic of certifying traditional products has changed starting with the implementation of Order no. 724/2013 regarding the attestation of traditional products. It regulated the establishment of the National Register of Traditional Products managed by Ministry of Agriculture and Rural Development. In the period between 2014-2019, 834 products were certified.

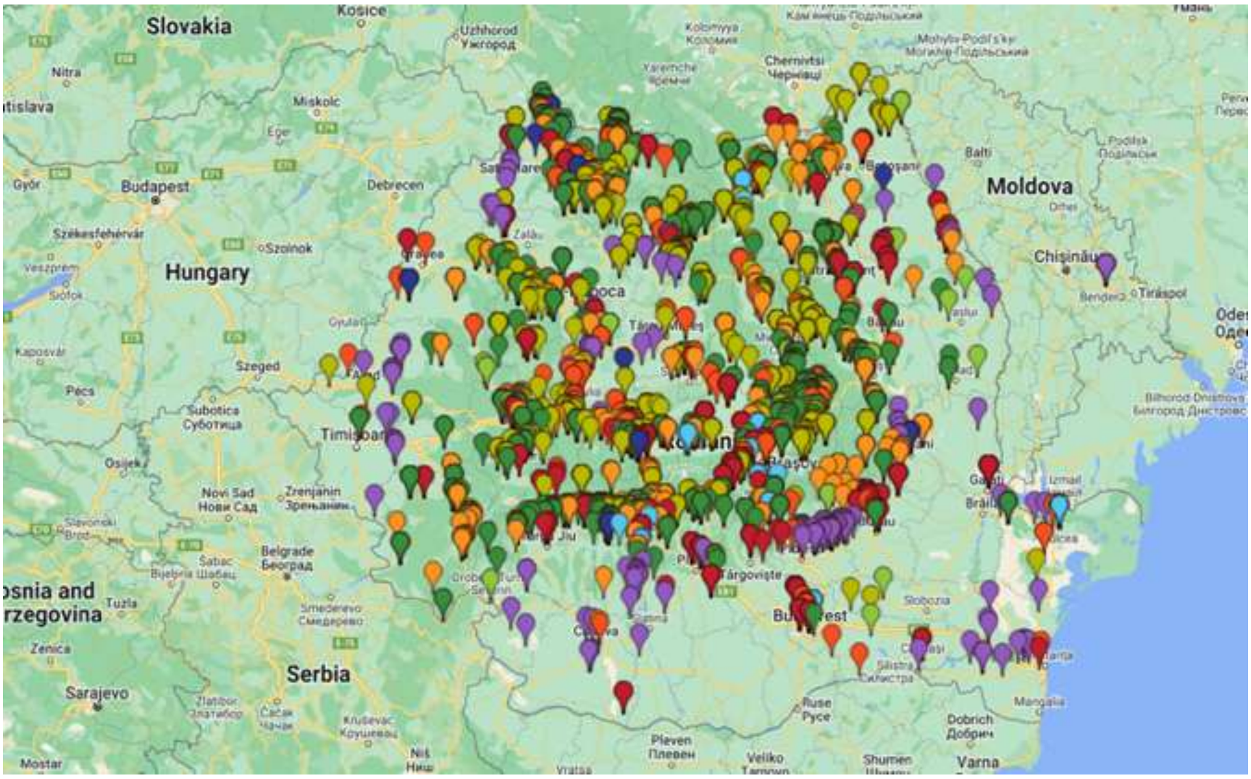
Putting things in perspective, starting with 2016 there was a massive decrease in new traditional products on the Romanian market. From 2016 to 2019, only an average of 64 traditional products per year were authorized (Fig. 5).

In the current NRTP, only 2020, 2021 and 2022 are specified as attestation years because on June 23, 2020, Order 112/2020 was published in the Official Gazette amending the provisions of Order 724/2013, specifying the following according to Article IV: Titular economic operators of traditional product certificates issued by the Ministry of Agriculture and Rural Development prior to the entry into force of this order have the obligation to request their change by 31.12.2020 [16]. Economic operators being obliged by law to reauthorize their products even if they had received the certificate in 2020, being required to send the original traditional product certificate and the sanitary-veterinary and food safety authorization or registration to Ministry Of Agriculture And Rural Development.

From 2020 to 2022, 764 traditional products have been certified in Romania. From the analysis of the statistical data, the year 2020 had a very big impact on the registration of traditional products because the producers had to reauthorize themselves, even if they were previously authorized (Fig. 5). The total number of traditional products with valid certificates is 732 (because 32 of them were cancelled).

The evolution of statistical data from the period 2014-2019 does not necessarily have an impact on the calculation of the current total number of certified products.

We can mention that the year 2020 represents a new start in terms of traditional products in Romania; changing (as it was in 2013) the legislative norms, forcing economic operators to go through a reauthorization process in order to maintain Romanian traditional product certificate.



Map 2. Manufacturers from the CCFP Database
Source: [1].

Therefore, the representatives of the Ministry of Agriculture and Rural Development noticed the need for legislative changes to stimulate producers to authorize/reauthorize, depending on their situation.

An important element that must be discussed is that through this reauthorization process, it is assumed that the cleanliness rules and food safety standards are fully respected.

All certified products on the territory of Romania can be found in the CCFP database managed by AFRI (Agency for the Financing of Rural Investments): Catalogue of Certified Food Products. It manages the list of certified products such as traditional product, mountain product, established recipe, protected designation of origin, protected geographical indication, certified wines, guaranteed traditional specialty, certified ecological products.

Also, within the site, an interactive map of the producers has been implemented through which the consumer can find out specific information about the certified products of the area where they are located or the area of interest; information such as: description of the certified product, what type of recognition it has, what year it was certified, manufacturer details, contact details and exact location (Map 2).

Through the CCFP portal, economic agents can submit documents online for the certification of agri-food products as traditional products, in accordance with the provisions of Order no. 724/2013 regarding the attestation of traditional products.

CONCLUSIONS

In Romania, progress has been registered in terms of the alignment of national legislation with the norms of European legislation in the field of the quality of agri-food products.

In the current context of globalization, more and more emphasis is placed on returning to the concept of national identity, promoting more and more traditionalism.

Romania has great potential in this regard, the transfer of cultural heritage for future generations being protected by national legislation.

Consumer behavior has become more refined and the need for access to information has increased.

Traditional products must be hygienically labeled and marketed accordingly. If there is no evidence of compliance with quality measures, consumer behavior may become selective due to lack of confidence in ensuring food safety and concerns about nutritional products.

With only 10 products certified by the European Commission through quality schemes with European recognition (protected designation of origin, traditional specialty guaranteed and protected geographical indication), Romania is poorly represented internationally in the field of agri-food product quality, but it is still recognized at the level of the member states of the European Union as an important country in the EU agricultural sector.

From a national perspective, Romania has now many more products recognized under national quality schemes: 732 traditional products, 171 products obtained from consacrated Romanian recipes and 1,319 Mountain products (certified between 2017-2022).

In 2021, Romania went through a legislative change regarding the perspective on the National Register of Traditional Products when Order no. 112/904/208/2020 on the amendment and completion of the Order of the Ministry of Agriculture and Rural Development, the Ministry of Health and the President of the National Consumer Authority. This meant that producers were obliged by law to follow a reauthorization process if they wanted to maintain their traditional Romanian product certificate.

In conclusion, Romania is well represented by traditional products, but at national, not European level: national quality schemes do not imply European recognition (while European quality schemes - such as organic farming products - are also recognized at national level, i.e. at member states of the European Union level).

Romania has a uniform representation of certified products throughout the country: 37

counties out of 42 have certified traditional products.

In the top 3 counties if we analyze the total of traditional products plus mountain products are Covasna (279), Bistrița Năsăud (241) and Brașov (238) (Table 1).

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COMPARATIVE STUDY ON THE EVOLUTION OF THE NUMBER OF AGRICULTURAL FARMS, THE AVERAGE SIZE AND AGRICULTURAL PRODUCTION IN THE SOUTH-MUNTENIA AND SOUTH-EAST REGIONS OF ROMANIA

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Abstract

Starting from the importance of the optimal size of an agricultural holding for increasing the efficiency of the activity carried out, the objective of this work was to carry out a comparative analysis between 2 development regions of Romania regarding the situation of agricultural holdings. The choice of the two regions, South-Muntenia and South-East, was made based on their agricultural potential, and the monitored indicators were both the number of agricultural holdings and their size. The analysis assumed the monitoring of the evolution of the indicators in the period 2010-2020. The comparison was made not only between the two development areas, but also at the national and community level, the aim being to identify some solutions for the development and increase of the economic performance within the agricultural holdings in Romania and for the reduction of existing gaps both at the national and regional level and community. In order to carry out the research, we started from the analysis of specialized literature, following the role that agriculture has in economic development, as well as how it contributes to the formation of the GDP, followed by the collection, processing and analysis of regional and community statistical data regarding to the situation of agricultural holdings. The processing and interpretation of the data allowed us to formulate conclusions regarding the situation of agricultural holdings in the two development regions and to formulate recommendations. From the conducted research, it emerged that there are differences in Romania's agriculture both at the national and regional levels. For the year 2020, the average surface of an agricultural holding in Romania was 4.42 ha, which shows that in the Sud-Muntenia region the holdings are the closest to this average, having an area of 4.4 ha. At the level of the South-East region, the agricultural area is almost 50% larger than the average area, given that it is 6.7 ha. This influences both the way agricultural land is exploited and the profitability of agricultural holdings.

Key words: *agricultural holding, number of holdings, size, South-Muntenia region, South-East region*

INTRODUCTION

In the contemporary economy, agriculture, as the fundamental economic branch, has an important role contributing to economic development both at the national, community and world level [25]. Agriculture is thus a strong balancing factor with a role in solving serious problems such as: smoothing social conflicts generated by the food problem, environmental degradation, population growth and implicitly the need for food, thus ensuring food security etc. [21, 24, 19].

Over time, agriculture has been subjected to multiple and important paradigm transformations, thus becoming a determining sector in the modern economy and significantly contributing to the growth of gross added value, which in turn influences the growth of the Gross Domestic Product [26].

According to the data published in 2021 by the Food and Agriculture Organization (FAO), it shows that at a global level the added value generated by agriculture, forestry and fishing in 2018 was 3.5 trillion USD with a percentage increase of 73% and with a absolute increase of 1.5 trillion USD compared to 2000. The largest increase was recorded by Asia, which from 2000 to 2019 had a percentage increase of 84%, and in absolute values of 1.2 trillion USD. Asia's contribution to global added value was 64%. The United States of America recorded an increase in value added of 52% in the period 2000-2019. Africa was the one that from an added value of 170 billion USD in 2000 reached a value of 404 billion USD in 2019. The increase was thus 42%. Europe had a 19% increase and Oceania a 9% increase in agricultural value added, after registering a decrease since [5].

The countries that registered the highest added value from agriculture, forestry and fishing in 2019 were China, India and the United States of America [1, 8].

According to Eurostat data, in 2021 the obtained agricultural production had a value of 449,500 million euros, calculated at the value of basic prices. In 2021, agricultural production increased by 8% compared to the previous year, and this was due not only to the increase in production, but also to inflation, which in turn led to an increase in the price of agricultural products and services. Also analyzed from the perspective of the contribution of these two elements to the increase, it turns out that the majority share was the increase in prices (by 90%), while the increase in production had an increase of only 10% [7].

The states that contributed approximately 63% to the increase in agricultural production in the European Union were France with 18% (82.4 billion euros), Italy with approximately 14% (61.2 billion euros), Germany and Spain with approximately 13 % (ie 59.2 billion euros, respectively 57.1 billion euros), the Netherlands with approximately 7% (30.6 billion euros), Poland with almost 6% (27.9 billion euros) and Romania by 5% (21.1 billion euros). Romania, along with Italy, is one of the European countries with the largest grain production [27].

The highest growth rates were recorded by Bulgaria with a 37% increase, Romania with a 25% increase and the Czech Republic with a 16% increase. The countries that recorded decreases were Slovenia, with 4% and Denmark with 2%. The countries that recorded relatively unchanged agricultural production values were Cyprus, Malta and Finland [7, 25].

The largest share in the value of agricultural production was determined by the value of vegetable production (55%). The increase compared to 2020 was 13%, meaning 249 billion Euros. A little more than a third (36%) came from animal production and animal products had a weight of 36% in the total agricultural production. The increase compared to 2020 was 3%, which in absolute values means approximately 163 billion Euros. Agricultural services and secondary activities contributed 9% [7].

All these are elements that demonstrate both the important role of agriculture in economic development, but also the way in which this contribution is distributed worldwide and at the community level. Agriculture remains one of the sectors of activity that contribute to economic development, to the emergence of additional jobs, to the risks related to food security, to the increase of incomes, all thus contributing to the creation of a fairer society. In this way, it is possible to reach that sustainable economic system that corresponds to the sustainable development objectives of the UN [28]. The current way of managing agricultural activity, finding solutions to obtain sustainable production leaves its mark on future generations. One of the factors that contribute to increasing the efficiency of agricultural activity and obtaining profitability is the size of the agricultural holding, which in turn is influenced both according to the number of agricultural holdings, according to their surface, but also depending on the structure [6]. In this way, there is an increase in the efficiency of the use of resources, but it also actively contributes to the increase of sustainability [23].

Analyze the size of agricultural holdings and the relationship between this and productivity is important because it also influences access to the different categories of resources, such as financial resources, human capital, organizational structure, vulnerability to market changes, etc. [18, 20].

Also, the size of the farm, along with the institutional support, are factors that decisively influence the marketing behavior of farmers, a mandatory requirement for the development of any business [3].

The economic size of a farm is also quantified by the value of the production obtained and evaluated at the price obtained at the farm gate [3].

However, in the current period, when humanity has faced numerous economic, sanitary (Covid-19), social, military conflicts (the war in Ukraine) we find that profitability is no longer the only objective that must be pursued, but also the development of regional businesses that to be able to support the consumption needs in conditions where the global system is interrupted [11, 22]. According to Guth et al. there are other non-financial indicators that can directly influence the size of agricultural holdings, and their tracking is important from the point of view of the durability and sustainability of the following areas. The pursuit of economic efficiency is important, but in the case of small farms, although sometimes inefficient or irrelevant in relation to modern agriculture, their important role for local development must be recognized [10].

MATERIALS AND METHODS

The methodology used in the research involved the use of analysis methods and techniques based on the principle of triangulation, according to which the data were collected, processed and interpreted, so that they could then be transformed into conclusions and recommendations regarding the level of development of agriculture in the two regions (South-Muntenia region and South-East region).

The bibliographic study sought to highlight the role that agriculture has on the economic development registered at the national, community and world level.

To carry out the quantitative and qualitative analysis, they were taken from national and international databases (National Institute of Statistics, Eurostat, FAO).

The indices used were:

- The dynamics index with a fixed base, through which the value of the increases or decreases recorded in 2021 compared to 2017 could be determined:

$I_{t/1} = (y_t/y_1) \times 100$ [2]

- the dynamic index based on the chain, through which the value of the increases or decreases recorded in the period 2017-2021 could be determined

$I_{t/t-1} = (y_t/y_{t-1}) \times 100$ [2]

Comparand cele 2 relatii rezulta ca:

$I_{t/1} = \Pi\, I_{t/t-1}$ [4]

RESULTS AND DISCUSSIONS

Romania is one of the countries of the European Union with a developed agricultural potential as a result of the agricultural areas owned, but also due to the soil fertility, which is why the participation of agriculture in the formation of GDP was 4.4% in 2021. Compared to the previous period, the share decreased, but it was 6.4% of GDP in 2011 and 7.4% in 2012. According to statistical data, it turns out that Romania is the country that, at the level of the European Union, has the largest number of agricultural holdings [9], being characterized by a pronounced form of structural division of agricultural land.

Analysis of the data published in the 2020 Agricultural Census, which are still partial, shows that the number of agricultural holdings registered in 2019 was approximately 2,887 million. Although there is a decrease of 27% compared to 2010 and 25% compared to 2007, the year of Romania's accession to the European Union, their number is still increased compared to the community level.

Of the total of these holdings, 99% have legal personality, the difference of 1% being represented by small, subsistence farms. The continuous decrease in the number of agricultural holdings is also the result of an increase in the average area and the "settlement" of the situation immediately following the agricultural reform started after 1989, characterized by the fragmentation of property. The development of modern farms, which use a new, digital technology, the understanding of the concept of profitability have contributed to the increase of the average area of agricultural holdings. In this way, it was reached that in 2020 the average agricultural surface of a holding was 4.42 ha, an increase of 28% compared to 2010. With all this, compared to the other member states, Romania is still among the countries with the smallest average areas of an agricultural holding. In relation to the form of organization, agricultural holdings are divided into holdings with legal personality, which in the present case had an average surface of 195 ha, for the year 2020, and entities without legal personality (the majority of subsistence agricultural holdings) whose the average surface was approximately 2.7 ha, at the level of the same year. In relation to the used agricultural surface, which determines the size class of the agricultural holdings, the data showed that there is an inversely proportional relationship between their number and the exploited surface. Thus, in 2020, agricultural holdings with areas smaller than 1 ha, although they represented 53% of the total agricultural holdings, exploited less than 5% of the agricultural area, while agricultural holdings with an area larger than 50 ha, which had represented approximately 1% of the total holdings, they used an area of approximately 53% of the total (Figure 1).

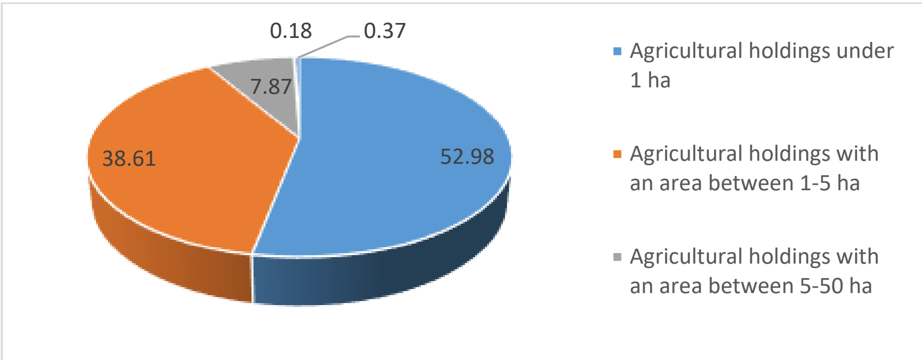

Fig. 1. Structure of agricultural holdings, by size class, in 2020 (%)
Source: own processing [17].

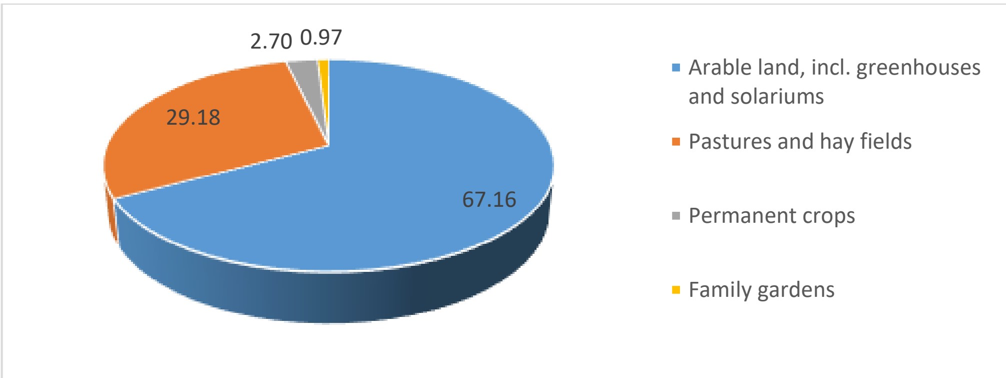

Fig. 2. The use of agricultural land, by categories of use, in 2020 (thousands ha)
Source: own processing [17].

Regarding the way of using the agricultural areas, it is found that in 2020 the largest share of the used agricultural area was owned by agricultural lands, including greenhouses and solariums, with 67% (8,571 thousand ha), followed by pastures and hay fields with 29% (3,724 thousand ha), permanent crops with 2.7% (344 thousand ha) and family gardens with less than 1% (124 thousand ha) (Figure 2).

Figure 3 shows both the evolution of the number of agricultural holdings in Romania, as well as the evolution of the used surfaces and the average surfaces for an agricultural holding, noting that there is a direct correlation between the decrease in the number of holdings and the increase of the average surfaces.

The to regions that are the subject of the case study are located in Microregion two (South-East Region) and Microregion three (South-Muntenia Region). The reason for choosing them is their geographical proximity and the fact that they benefit from similar conditions for practicing agriculture, both from a climatic, pedological and organizational point of view.

The South Muntenia region includes the following counties: Arges, Calarasi, Dambovita, Giurgiu, Ialomita, Prahova and Teleorman. The South-East region includes the following counties: Braila, Buzau, Constanta, Galati, Tulcea and Vrancea.

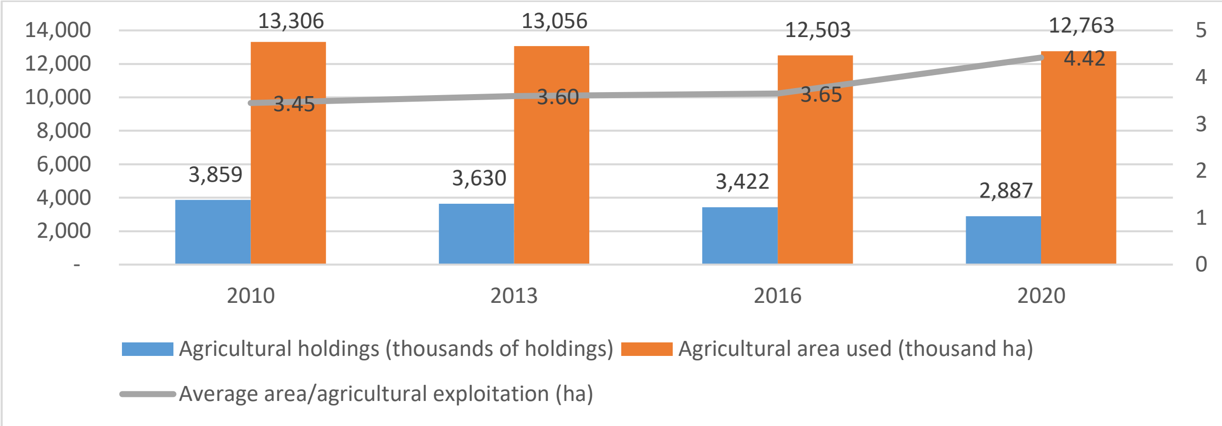

Fig. 3. The situation of their agricultural exploitation and of the surfaces in Romania, in the period 2010-2020
Source: own processing [12, 13, 14, 15, 16, 17].

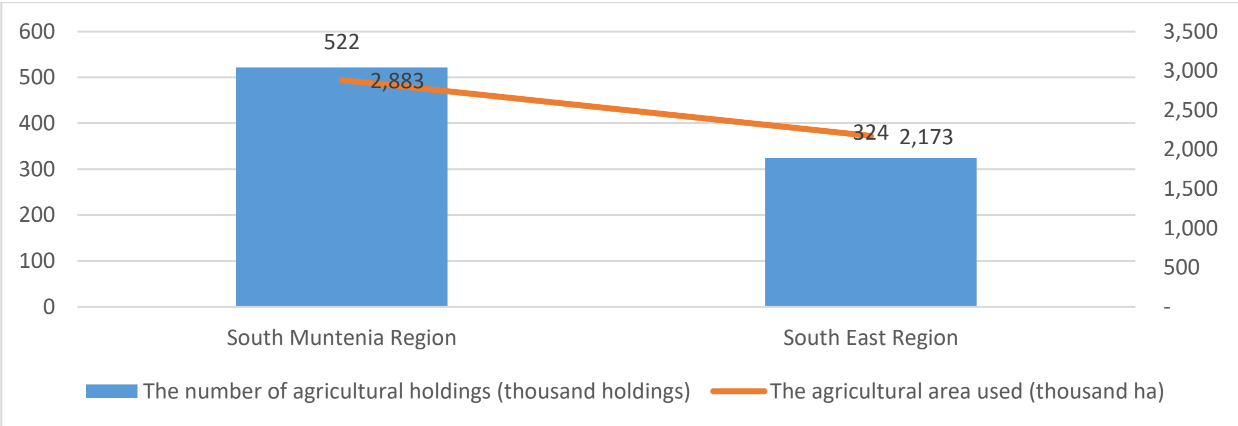

Fig. 4. The number of agricultural holdings and the average area in the South-Muntenia and South-East Regions, in 2020
Source: own processing [12, 13, 14, 15, 16, 17].

The analysis carried out for the year 2020 highlights the fact that the number of agricultural holdings in the South-Muntenia Region was 10% higher than that of the holdings in the South-East Region, but this is not due to the areas occupied by the two regions, which are approximately equal (The Southeast Region has an area of 35,762 km^2, and the South-Muntenia Region has an area of 34,489 km^2). The difference regarding the average area is given by the number of existing agricultural holdings in the two development regions. (Figure 4).

The value of agricultural production recorded in 2021 was approximately 104 billion lei. The way in which the two sectors, vegetable and animal, contributed to obtaining the production was 71%, respectively 27%, the difference of 2% being represented by the value of agricultural services.

At the level of the 2 regions, in 2020 the production value represented a little over a third of that achieved at the national level, the contribution of each region being 17.6% for the South-Muntenia Region and 13.4% for the South-East Region. The increase in 2021 was supported by regional increases, so that for the South-Mountain Region this was 1.3%, and for the South-East Region the increase was 5%. In these regions, due to their agricultural potential, the shares of production, both from the vegetable and animal sectors, were above the national average (Figure 5). Regarding plant production, the South Region - Muntenia recorded a 31.4% increase, and the South-East Region an 82.5% increase, and for livestock production, there were decreases. At the national level, the regions that had increases were the North-East Region with an increase of 5.1% and the North-West Regions West-Oltenia with increases of 2.8%.

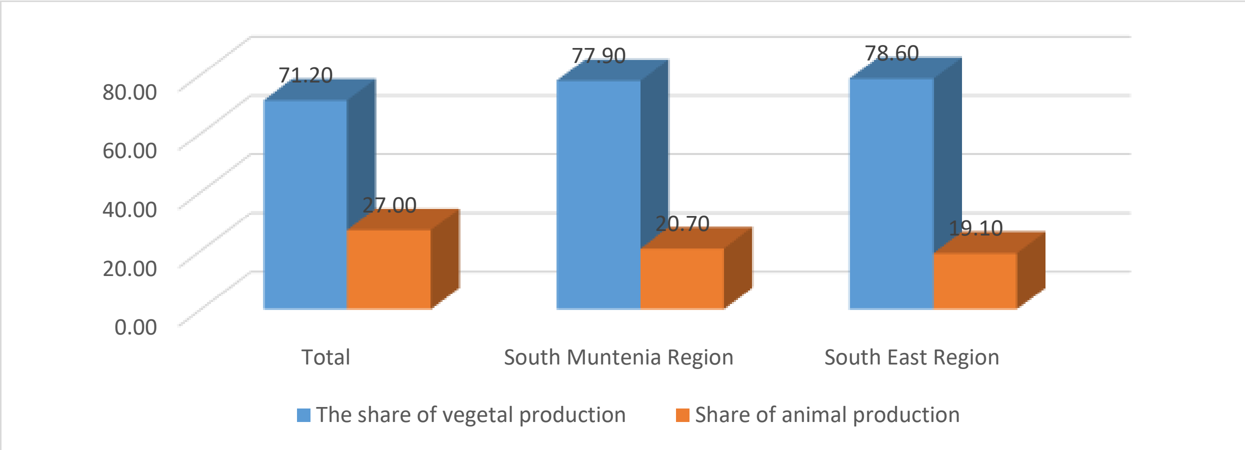

Fig. 5. Share of agricultural production in 2021 (%)
Source: own processing [12, 13, 14, 15, 16, 17].

The production indices recorded at the level of the two analyzed regions highlight the fact that two activity sectors are above the average (plant and service sectors), while the livestock sector is below the average of the branch (Table 1).
Compared to the total for the country, the South-Muntenia region registered an increase of +6.5 percentage points, and the South-East region increased by +38 percentage points.

Table 1. Agricultural production indices, 2021 compared to 2020

	Total branch	Vegetal sector	Animal sector	Agricultural services
Total country	114.3	122.2	99.8	99.3
South-Mountenia region	120.8	131.4	94.7	123.5
South East Region	152.3	182.5	96.9	111.2

Source: own processing [12, 13, 14, 15, 16, 17].

CONCLUSIONS

The conclusions arrived at after analyzing the statistical data regarding the two development regions highlight the fact that they recorded the highest increases in production compared to the national average, but also compared to the other six development regions. This is due to the agricultural potential that the South-Muntenia and South-East regions have, an aspect supported by the agricultural area owned, which places them on the 1st and 2nd place among the development regions. At the same time, the average areas registered in the two regions in 2020 were: 4.4 ha in the South-Muntenia Region and 6.7 ha in the South-East region, compared to the average area registered at the national level of 4.42 ha.
Therefore, we note the existence of regional differences in the growth rate of the size of economic farms.
The size of agricultural holdings, when we talk about small sizes, influences their profitability not only as a result of the volume of production obtained, but also due to the fact that they face some barriers in terms of innovation or less access to technology (digitalization, robotization, etc.) and technologies (precision agriculture, hybrids, new varieties, etc.) at lower investment funds, all translating into viability and competitiveness.

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ESTIMATING VOLATILITY SPREADS BETWEEN MELON, WATERMELON, AND GRAPE MARKETS WITH THE DIAGONAL BEKK-GARCH (1.1) EQUATION MODEL

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Abstract

This investigation has been conducted to determine the fluctuations in the real prices of melon, watermelon, and grapes cause volatility in their own and other markets in Turkey. Diagonal-Bekk Garch (1,1) model was used under the Full-rank constraint with 101 monthly data for the period 2010M01-2022M08. The results of the research have put out that the shock or uncertainty experienced in the melon and watermelon market has increased the uncertainty both in its own market and in the watermelon and grape markets. Shocks in the grape market have only increased the uncertainties in its own market. In addition, it has been determined that the shocks in the melon and watermelon markets are permanent in these markets in the short and long term, but the shocks in the grape market do not have a permanent effect in the short and long term. As a result, it may be necessary to reduce the negative effects of this situation on consumers and to regulate and renew policies that will minimize the risk for producers and consumers in the face of high price volatility.

Key words: *market volatility, Diagonal-Bekk Garch (1.1) model, melon, watermelon, grape*

INTRODUCTION

Agricultural price fluctuations create risks and uncertainty in the markets. In the last decade, food prices experienced two significant increases in 2007-2008 and 2010-2011, and also, in the last two years, the effect of the pandemic has been influential on price fluctuations. In addition to the causes of price fluctuations, issues such as the loss of welfare and social unrest caused by price volatility in society have been examined by different researchers, and the relationships between price policies applied by governments and price variables have been evaluated [4, 6, 10, 12, 14]. As a matter of fact, it has been reported that while stocks are formed during periods of high agricultural production, due to supply and demand mismatch, serious price fluctuations occur during periods of excess demand [3].
Melon, watermelon, and grape markets have an important place in agricultural activities in Turkey, and although these products change over the years, they are also subject to foreign trade.
Turkey has 3% of the world's watermelon planted areas and is the most produced vegetable after tomato. Watermelon is a product that is generally subject to domestic consumption [18].
Turkey ranks second in the world in melon production and annual production is 1.5-2 million tons. While 3,670,000 tons of fresh grapes are produced in Turkey, it ranks first in the world for raisins [19].
For this reason, it is extremely important to determine the price volatility of the melon, watermelon, and grape markets, and to ensure price stability in the markets of these products, which have a significant share in the Turkish economy.
And also, Turkey has an international competitive power in these products as well as in tomatoes and walnuts [1, 2].
ARCH, GARCH, and EGARCH models are generally used to determine price volatility. There are also many studies on the price

volatility of agricultural products. For example, [7] determined the relationship between crude oil and agricultural commodity prices. Similarly, [3] determined whether it affects the price flow from the wheat market to the flour market with the balance price relationship between wheat and flour prices. In addition, the price and volatility risk arising from the links between the energy and agricultural commodity markets was determined by the GARCH model [5]. Similarly, the volatility of sugar prices in Turkey was determined using ARCH, GARCH, and EGARCH analyses [16]. Research on price volatility in the markets is still up-to-date and examples can be multiplied on this subject [11, 15, 16, 21].

Melon, watermelon, and grape prices and markets, which have an important place in agricultural production in Turkey, fluctuate throughout the production season.

Consumers are adversely affected by these fluctuations.

These three products are both loved and consumed abundantly, not only in the world but also in Turkey. For this reason, it should be revealed how the macro variables of the said markets are affected by the uncertainty in their variances against the negative or positive variables that occur. It should be determined how the melon, watermelon, and grape markets affect both their own short and long-term uncertainties and the uncertainties of the competitor's market. Modeling how the melon, watermelon, and fresh grape markets, which are important for Turkey, affect each other, and how the changes in one market affect its own market and the other two markets are very important to understand the causes of price fluctuations.

The periods when these three products are offered to the market the most coincide with each other and the price of the products usually determines the consumer's preferences.

On the other hand, in the face of negative or positive shocks that will mobilize the markets such as rising input costs, it is necessary to produce policies on how can protect producers and consumers from price fluctuations that will occur in the future. Therefore, this research has been conducted to determine the fluctuations in the real prices of melon, watermelon, and fresh grapes cause volatility in their own and other markets in Turkey by using the Diagonal BEKK GARCH (1,1) model, under the Full Rank constraint.

MATERIALS AND METHODS

Data set

Average kilogram prices of melons, watermelons, and grapes were taken from the reports of the Istanbul Vegetable-Fruit Market Directorate, and the data set of the research was created with 101 monthly data for the period 2010M01-2022M08 [13].

In addition, the raw data of the three markets for the analyzed period were converted to real values for analysis.

In addition, the raw data of the three markets for the analyzed period were converted to real values for analysis.

The returns of the series were determined by the equation (P_t: the current real prices of the relevant markets, P_{t-1}: the prices of the previous period):

$$R_{i,t} = \Delta \log(P_t) = 100 * \log(\frac{P_t}{P_{t-1}}), i = 1,2,3 \quad .....(1)$$

Econometric Method

Since the possible price volatility difference is evaluated with the diagonal BEKK approach in various market evaluations [8, 9], the Diagonal BEKK GARCH (1,1) method was preferred under the Full Rank constraint to evaluate the price volatility in the melon, watermelon and grape markets.

The diagonal BEKK-GARCH equation is presented below:

$$H_t = C^{''}C + B^{'}H_{t-1}B + A^{'}\varepsilon_{t-1}\varepsilon^{'}_{t-1}A \quad ... \quad (2)$$

In this equation, C: the constant matrix coefficients, A, B: the effect of short and long term shocks in the markets.

The matrix expansion in the BEKK approach is presented below [8, 9]:

Assuming Ω is equal to an 3x3 matrix, C ′C,

$$
= \begin{bmatrix} c_{11} & 0 & 0 \\ c_{12} & c_{22} & 0 \\ c_{13} & c_{23} & c_{33} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ 0 & c_{22} & c_{23} \\ 0 & 0 & c_{33} \end{bmatrix}
$$

$$
\begin{bmatrix} c^2 & c_{11}c_{12} & c_{11}c_{13} \\ c_{11}c_{12} & c_{12}^2 c_{22}^2 & c_{12}c_{13} + c_{22}c_{23} \\ c_{11}c_{13} & c_{12}c_{13} + c_{22}c_{23} & c_{13}^2 c_{23}^2 c_{33} \end{bmatrix} \quad .... (3)
$$

The Ht matrix is represented by the following formula:

$$
H_t = \begin{bmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix} \quad ..... (4)
$$

The final state of the equation is as follows:

$$
H_t = \begin{bmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix} = \begin{bmatrix} \Omega_{11,t} & \Omega_{12,t} & \Omega_{13,t} \\ \Omega_{21,t} & \Omega_{22,t} & \Omega_{23,t} \\ \Omega_{31,t} & \Omega_{32,t} & \Omega_{33,t} \end{bmatrix}
$$

$$
+ \begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix}' \left(\begin{bmatrix} u_{1,t-1} \\ u_{2,t-1} \\ u_{3,t-1} \end{bmatrix} \begin{bmatrix} u_{1,t-1} \\ u_{2,t-1} \\ u_{3,t-1} \end{bmatrix}' \right) \begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix}
$$

$$
+ \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} & h_{13,t-1} \\ h_{21,t-1} & h_{22,t-1} & h_{23,t-1} \\ h_{31,t-1} & h_{32,t-1} & h_{33,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix} \quad ..... (5)
$$

Finally, each conditional variance and covariance equation is represented by the following equations:

$$h_{11,t} = \Omega_{11} + a_{11}^2 u_{1,t-1}^2 + b_{11}^2 h_{11,t-1} \quad (6)$$

$$h_{12,t} = \Omega_{12} + a_{11} a_{12} u_{1,t-1} u_{1,t-1} + b_{11} b_{22} h_{12,t-1} \quad (7)$$

$$h_{13,t} = \Omega_{13} + a_{11} a_{33} u_{1,t-1} u_{3,t-1} + b_{11} b_{33} h_{13,t-1} \quad (8)$$

$$h_{22,t} = \Omega_{22} + a_{22}^2 u_{2,t-1}^2 + b_{22}^2 h_{22,t-1} \quad (9)$$

$$h_{23,t} = \Omega_{23} + a_{22} a_{33} u_{2,t-1} u_{3,t-1} + b_{22} b_{33} h_{23,t-1}$$

$$h_{33,t} = \Omega_{33} + a_{33}^2 u_{3,t-1}^2 + b_{33}^2 h_{33,t-1} \quad (10)$$

$$h_{33,t} = \Omega_{33} + a_{33}^2 u_{3,t-1}^2 + b_{33}^2 h_{33,t-1} \quad (11)$$

RESULTS AND DISCUSSIONS

Before starting the calculations to detect price volatility, 101 monthly data sets for the period 2010M01-2022M08 were generated. A number of analyses were made to determine the effect of price volatility between markets after the current prices were converted to real. When Table 1 is examined, descriptive statistics will be seen. When the average price values are examined, the highest prices of the three markets were determined for grapes, melons, and watermelons, respectively. According to the maximum and minimum values, the highest kilogram price of melon was 46,044₺, watermelon was 33,106₺, and grape was 76,331₺.

The results of kurtosis, skewness, and Jarque-Bera (whether the series are normally distributed or not) showed that all series have asymmetric distribution.

Table 1. Descriptive statistics table of prices (TL/kg) of melon, watermelon, grape*

	r_melon	r_watermelon	r_grape
Mean	13.891	9.381	20.189
Median	12.082	7.921	18.828
Maximum	46.044	33.106	76.331
Minimum	4.450	2.496	8.505
St. Dev.	7.094	5.356	10.302
Distortion	1.650	1.960	2.224
Kurtosis	6.681	7.829	11.107
Jarque-Bera	102.916	162.849	359.904

Source: [13] *Calculated by authors.

Figures 1, 2 and 3 show price volatility graphs of real prices over time. Compared to the melon market, more price volatility is observed in the watermelon and grape market. The highest price volatility occurred in the watermelon market. 2010-01 serious increase in the price of watermelon and melon come to the fore.

Towards the end of the same year, there is an increase in prices in the grape market.

The most serious increase in the watermelon market was in 2014.

After 2016, it is observed that the prices in the other three markets are more stable.

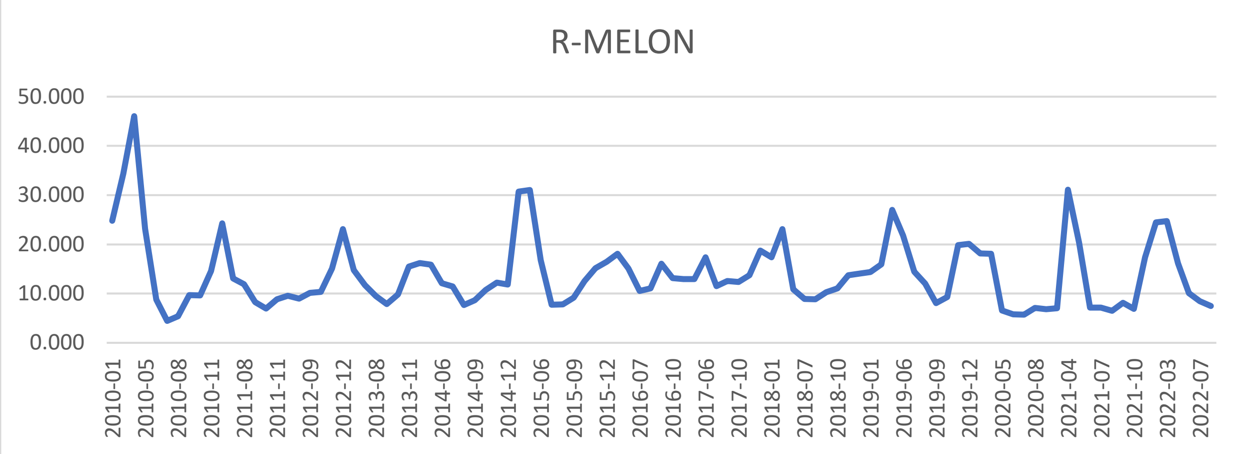

Fig. 1. Price volatility graph of real melon prices over time (TL/kg)
Source: [13].

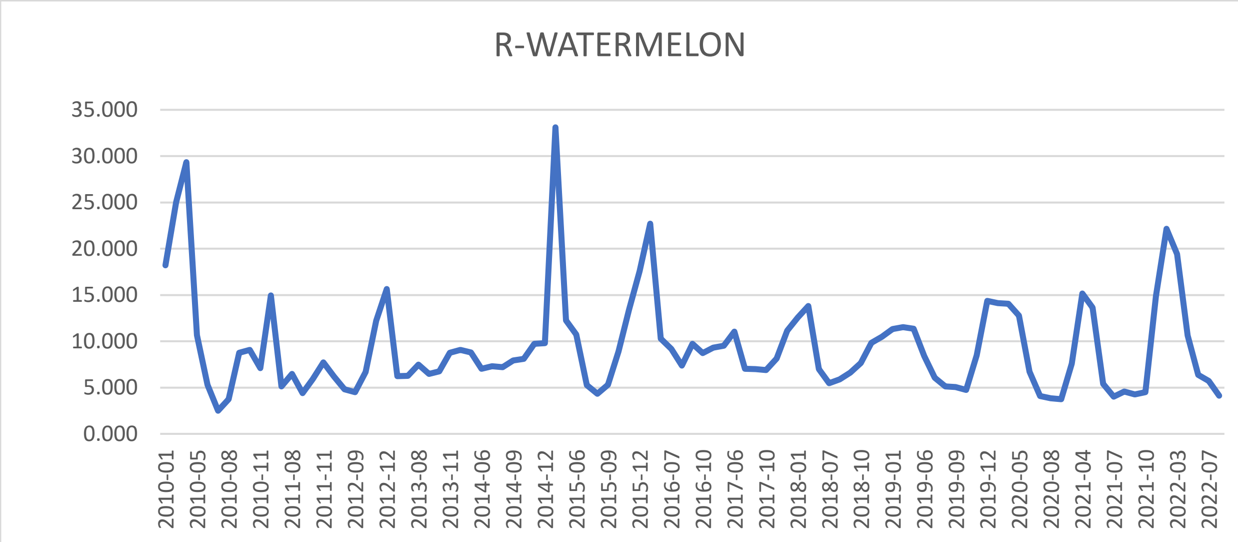

Fig. 2. Price volatility graph of real watermelon prices over time (TL/kg)
Source: [13].

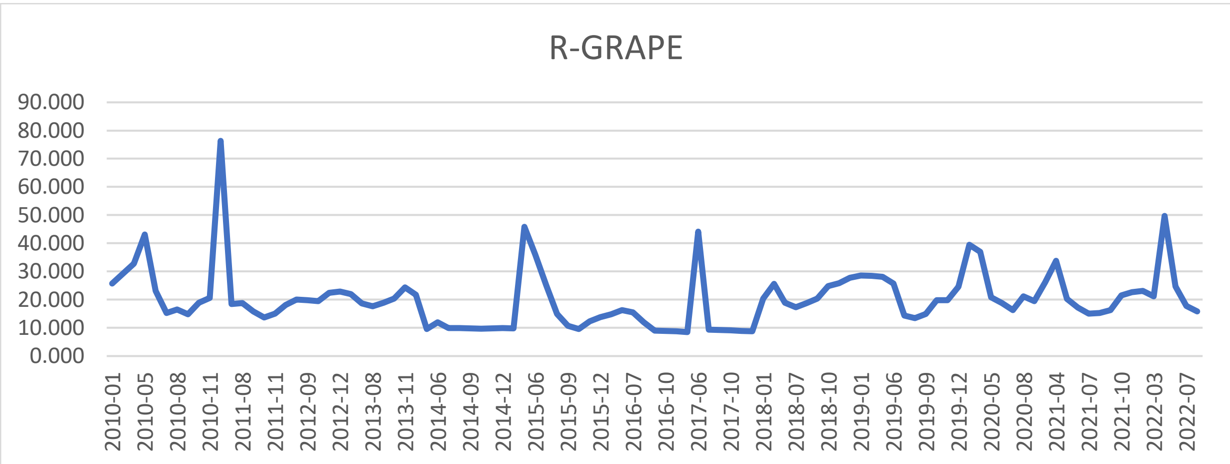

Fig. 3. Price volatility graph of real grape prices over time (TL/kg)
Source: [13].

The results of the ADF unit root test applied for the series are given in Table 2. Fixed and trend-free, only constant and trend-containing unit root tests were applied to the series, respectively. In this context, it has been determined that the series are stationary only in constant and constant-trend.

Diagonal Bekk Garch (1,1) model results under full-rank constraint are given in Table 3. Substituted coefficients show the long-term averages of the markets. The long-term averages of all the coefficients [C(1), C(2), C3), C(5) 1%, C(4) and C(6) 5%] were found to be statistically positive and significant. Although there is no variance and covariance pass-through in these coefficients, shocks or uncertainties in the markets cause price fluctuations of 7.5% in the melon market, 5.9% in the watermelon market and 16.1% in the grape market.

Table 2. Results of the Stationarity Test of the Series*

Dickey-Fuller (ADF) Test Statistic				
	Extrinsic Variable: Constant		Exogenous Variable: Constant and Trend	
	t-statistic	Possibility	t-statistic	possibility
r.melon	-7.382	0.000	-7.330	0.000
r.watermelon	-8.516	0.000	-8.504	0.000
r.grape	-7.044	0.000	-7.013	0.000

(1) The lag length for all series was chosen as 1 according to the Schwarz information criterion.
Source: *Calculated by authors.

The coefficients of the variance equations are presented in the second part of Table 3 and C(7-18) represents the ARCH and GARCH coefficients. While coefficients of C(7), C(8), C(10), C(12), C(13), and C(14) were found to be statistically positive and significant at 1%, coefficients of C(9) and C(10) are also positive and significant at 5%. The fact that the coefficients giving the GARCH effect are statistically significant and at the same time, the sum of the coefficients giving the ARCH and GARCH effect is greater than one indicates that shocks have a permanent effect in the short term and long term.

In the last part of Table 3, the transformed coefficients of variance are presented. M shows the transition effect of coefficient variables in covariance matrices. M coefficients are statistically positive and significant. A shock that will occur in the melon market [M (1,1)] increases the uncertainty in its own market by 23.2%, the uncertainty in the watermelon market [M(1.2)] by 14.6%, the uncertainty in the grape market [M (1.3)] by 24.8% and it is statistically significant by 1% and 5%, respectively. Level is important. A shock in the watermelon market increased the uncertainty in its own market [M (2.2)] by 10.5%, while the uncertainty in the grape market [M (2.3)] increased by 15.7%. The coefficient of covariance matrices [M (3.3)] indicates that shocks in the grape market increase the uncertainty in its market by 81.4%. The A1 and B1 coefficients of the relevant markets show the effects of ARCH and GARCH in the markets. As a matter of fact, the A1 coefficient represents the permanence of the short-term shocks of the markets, and the B1 coefficient represents the permanence of the long-term shocks. The fact that the A1+B1 coefficients are greater than one means that the short and long-term shocks in the markets are permanent. Therefore, the fact that the ARCH and GARCH coefficients of the melon and watermelon markets are greater than one [A1(1,1) + B1(1,1) =1,036], [A1(2,2) + B1(2,2) = 1,164] proves the permanence of the short and long-term shocks that will occur in these two markets. Contrary to the other two markets, the fact that the sum of ARCH and GARCH coefficients of the grape market [A1(3,3) + B1(3,3) = 0,707] is less than one indicates that the shocks are not permanent for this market. Similar results have been obtained in studies investigating whether short- and long-term shocks have a permanent effect on the markets. For instance, it has been found that the conditional variances of grains and oil and the real exchange rate returns are affected by the long-term volatility of both own and other markets. In addition, it has been determined that this effect can be both direct and indirect [20]. Similarly, the effects of volatility in sugar prices in Turkey were determined using

ARCH, GARCH and EGARCH analyses and it was emphasized that the sugar market was affected by short and long term shocks [17].

Table 3. Diagonal BEKK-GARCH (1,1) Analysis Results*

System:SYS04				
Prediction Method: ARCH Maximum Likelihood (Marquardt)				
Covariance Type: Diagonal BEKK				
Substituted Coefficients	Coefficient	Standard error	z-statistic	Probability
C (1)	7.584***	0.873	8.681	0.000
C (2)	0.498***	0.085	5.826	0.000
C (3)	5.951***	0.550	10.813	0.000
C (4)	0.103**	0.044	2.343	0.019
C (5)	16.167***	2.602	6.121	0.000
C (6)	0.586**	0.199	2.940	0.033
Coefficient of Variance Equation				
C (7)	4.816***	0.527	9.132	0.000
C (8)	3.042***	0.439	6.927	0.000
C (9)	5.156**	0.527	9.132	0.010
C (10)	1.127***	0.307	3.671	0.000
C (11)	0.023	3.869	0.006	0.995
C (12)	7.404***	0.754	9.807	0.000
C (13)	0.791***	0.183	4.305	0.000
C (14)	1.089***	0.189	5.762	0.000
C (15)	0.661**	0.282	2.345	0.019
C (16)	0.245	0.192	1.320	0.186
C (17)	0.075	0.202	0.373	0.708
C (18)	0.046	1.059	0.043	0.965
Log likelihood	-899.1156			
Akaike info criterion	18.34231			
Hannan-Quinn criter	18.81124			
Schwarz criterion	18.53210			
Covariance Type: Diagonal BEKK				
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1				
M = full rank matrix, A1= diagonal matrix, B1= diagonal matrix				
Converted Coefficients of Variance				
	Coefficient	Standard error	z-statistic	Probability
M (1,1)	23.203***	5.081	4.566	0.000
M (1,2)	14.656***	3.407	4.301	0.000
M (1,3)	24.838**	11.880	2.090	0.030
M (2,2)	10.529***	2.394	4.397	0.000
M (2,3)	15.715**	7.299	2.153	0.030
M (3,3)	81.413***	16.163	5.036	0.000
A1(1,1)	0.791***	0.183	4.305	0.000
A1 (2,2)	1.089***	0.189	5.762	0.000
A1 (3,3)	0.661**	0.282	2.345	0.010
B1(1,1)	0.245*	0.192	1.320	0.186
B1 (2,2)	0.075	0.202	0.373	0.708
B1 (3,3)	0.046	1.059	0.043	0.965

*, ** and *** indicate the significance level at 10%, 5% and 1%, respectively.
Source: *Calculated by authors.

The combined price volatility graph of the simultaneous returns of the markets over time is given in Figure 4.

In all of the analyzed markets, price increases are observed in 2011 and 2015. Moreover, more price fluctuations were detected in grape prices compared to the melon and watermelon markets in 2017.

As a matter of fact, when Figure 4 is examined, price fluctuations can be clearly seen in the melon market in 2021 and in the watermelon market in the first months of 2022.

Variance and conditional variance and conditional correlation graphs are presented in Figures 5 and 6. It is seen that the markets exhibited high price volatility in 2010, 2015, and 2020.

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Vol. 23, Issue 1, 2023
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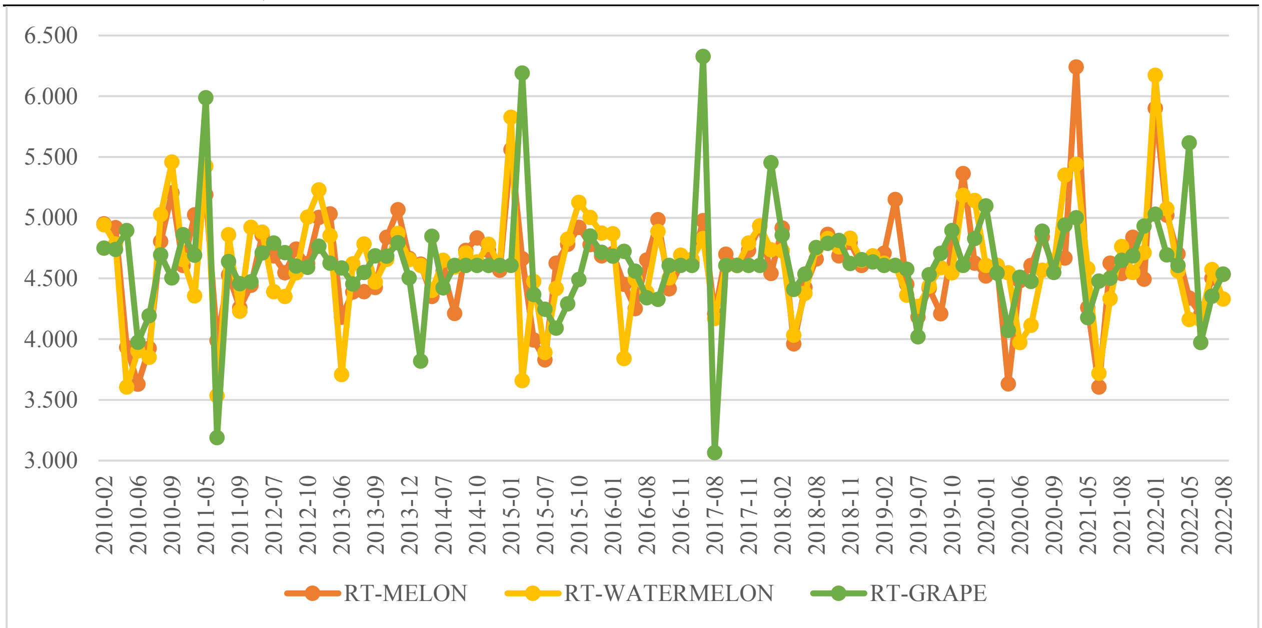

Fig. 4. The combined price volatility graph of the simultaneous returns of the markets over time (TL/kg)*
Source: *Calculated by authors.

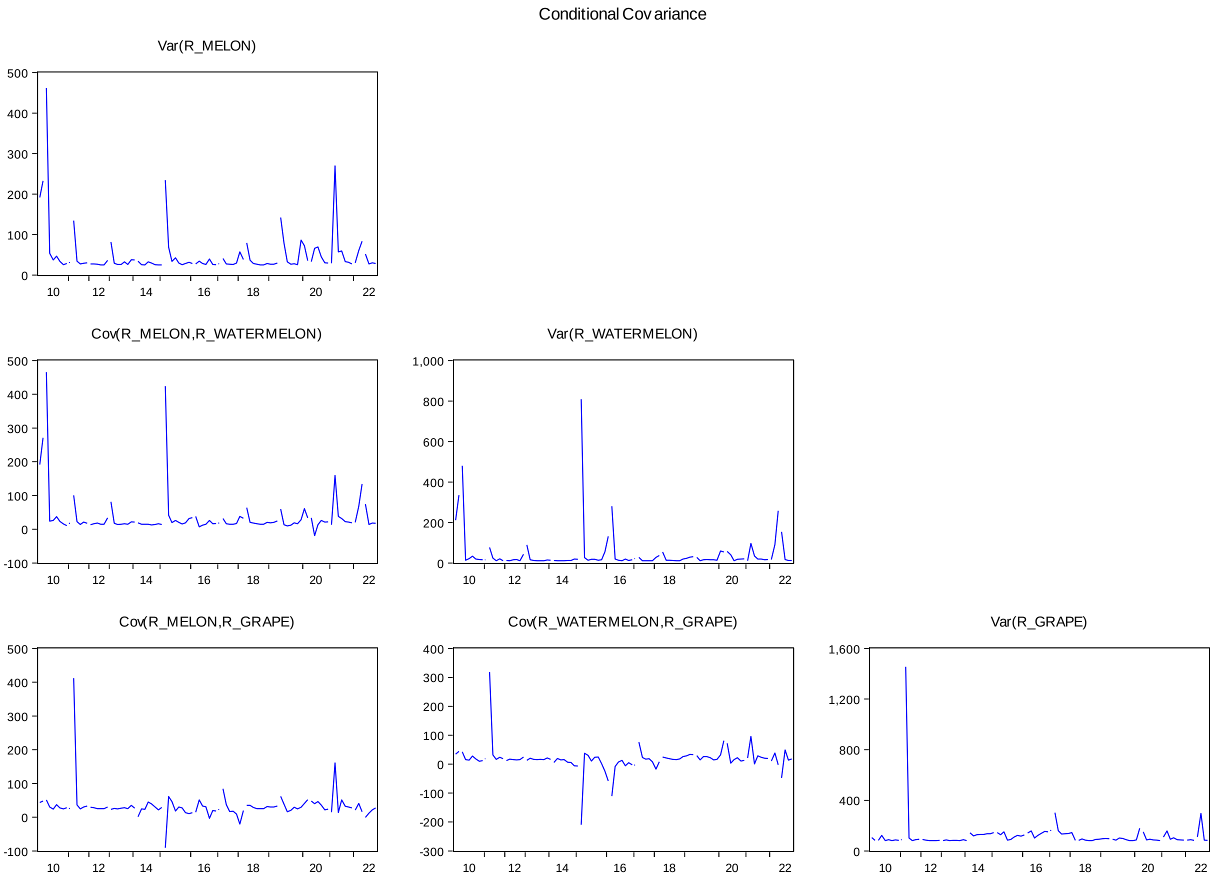

Fig. 5. Variance and conditional covariance graphs of data series*
Source: *Calculated by authors.

This may be due to the reflection of Turkey's political, economic, and social crises on the markets in the mentioned years. In addition, the world food crisis in 2010, the political crises experienced accordingly, and finally the Covid-19 pandemic, which started in 2019 and whose effects are still continuing, have affected the markets. On the other hand, the climate change experienced in recent years and the increase in input costs negatively affect the markets and cause serious price volatility in the markets.

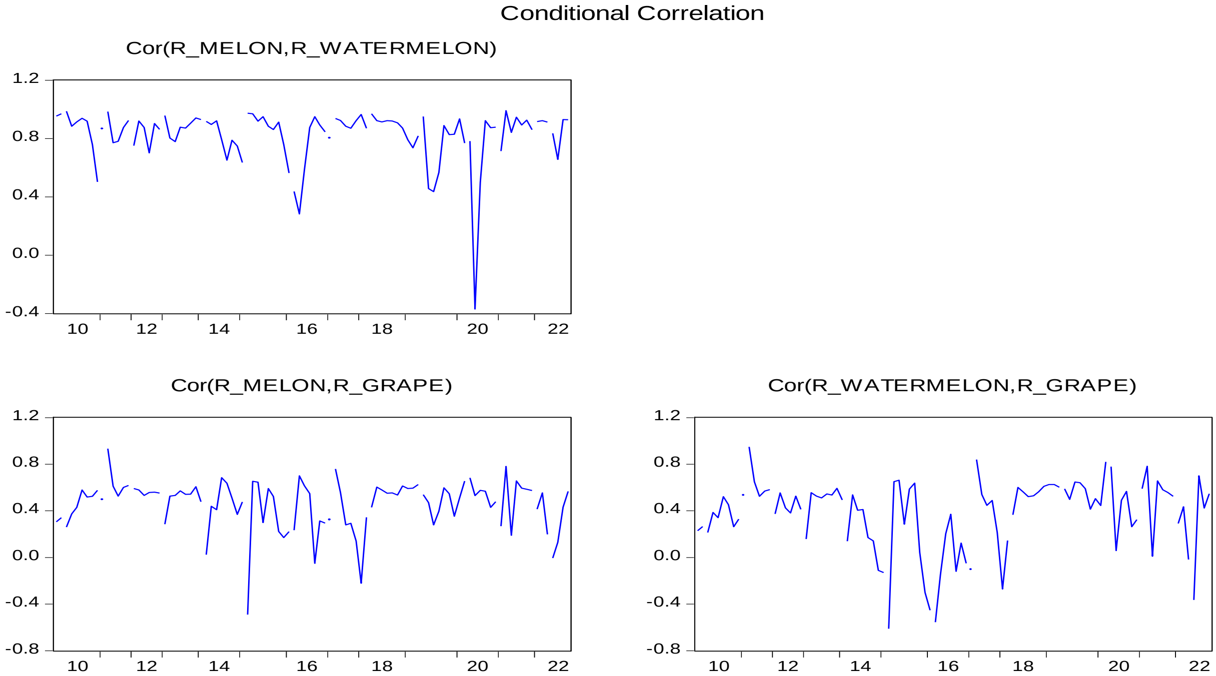

Fig. 6. Conditional correlation graphs of data series*
Source: *Calculated by authors.

CONCLUSIONS

Diagonal-Bekk Garch (1,1) model was used under the Full-rank constraint to analyse the price volatility in the melon, watermelon and grape markets. According to the results obtained from the Diagonal-Bekk Garch (1,1) model, the shock or uncertainty in the melon market has increased the uncertainty both in its own market and in the watermelon and grape market. Similarly, a shock in the watermelon market increased the uncertainty both in its own market and in the grape market. Shocks in the grape market, on the other hand, increase the uncertainties in its own market. Moreover, it has been determined that the shocks in the melon and watermelon markets are permanent in these markets in the short and long term, but the shocks in the grape market do not have a permanent effect in the short and long term. There is a spread of instability among the markets, and the effects of spillover from one sector to another sector vary depending on the market volumes of the sectors.

Problems in product supply, increases in oil prices, increases in production input costs, as well as the fact that agriculture is a risky and uncertain sector, cause price fluctuations in the markets. As the price fluctuations in the markets continue to be high in the medium and long term, the income level that will experience real income loss is an important issue for the low-income segment. It is essential to reduce the negative effects of this situation on consumers and to regulate and renew policies that will minimize the risk to producers and consumers in the face of high price volatility. It is also necessary to partially control the market uncertainties in the agricultural sector by focusing on the domestic production of the majority of the inputs in the relevant markets, especially by the important actors that have an impact on the economy.

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CUTTING SYSTEM INFLUENCE ON THE QUALITY OF ROSE FLOWERS

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Abstract

This study evaluated the quality of rose flowers, based on the length of the floral stem, according to the cutting system, as a plant maintenance work. The researches were organized during 2017 - 2018 at the Teaching and Research Base of the University of Life Sciences "King Mihai I" from Timisoara. Six rose varieties were studied: Acapella (Aca), Barkarole (Bar), Double Delight (D De), Golden Elegance (G El), Lady in Purple (L Pu), and Pascali (Pas). Three cutting systems were performed, at two buds, at five buds, and at seven buds. The varieties Acapella, Barkarole and Golden Elegance provided flowers with a longer stem, and the varieties Double Delight, Lady in Purple and Pascali provided flowers with a shorter stem, in all three cutting systems. The system of cutting at two buds facilitated obtaining the longest flower stems (eg 118.00 cm for the Barkarole variety). On the basis of PCA (correlation), a diagram was resulted that contained the distribution of the experimental variants (represented by rose varieties) in relation to the cutting system (2; 5; 7 buds - as biplot). According to PCA, PC1 explained 93.597% of variance and PC2 explained 5.635% of variance. Cluster analysis generated a dendrogram of the variants association, based on the Euclidean distances, according to each cutting system (Coph.corr.=0.828 for cutting to 2 buds; Coph.corr=0.884 for cutting to 5 buds; Coph.corr=0.732 for cutting to 7 buds).

Key words: *floral stem length, maintenance cutting, PCA, quality indices, roses, variable buds number*

INTRODUCTION

The rose (*Rosa* spp.) is part of the Rosaceae Family, Genus Rosa which includes a large number of species, about 200 species [21].
As an ornamental plant, the rose has been cultivated since ancient times, since 3000 years BC in China, the Mediterranean countries, West Asia (Persia) [4, 15]. In the Northern Hemisphere, about 150 rose species are known and cultivated, with an ornamental purpose but also as a raw material resource for different economic sectors [8]. It is estimated that between 8 and 20 rose species contributed to obtaining the current complex hybrid rose forms, namely 'Rosa × hybrida' [21].
The rose is often considered the 'Queen of the Flowers' and has been studied in relation to the presence, role and importance of this flower in art and symbolism [17]. In addition to the ornamental properties of the rose, many pharmaceutical and medicinal properties (antioxidant, antibacterial, antitussive, antidiabetic, hypnotic, etc.) have been found based on active principles identified in different species of rose [5, 8, 18]. As a result of the high content of natural molecules, with various biological properties, the rose represents a valuable resource for perfumery and cosmetics [19]. The content of vitamins, minerals, and bioactive substances determined over time the study and use of the rose for food purposes (dyes, flavours, functional foods, etc.) [8, 19, 26].
Most often, however, the rose is used for ornamental purposes, and as a result of the importance of the rose in this direction, some studies have investigated the genetic diversity and selection of the continuous flowering gene (RoKSN) in the rose [25].
As an ornamental plant, the rose is cultivated for its decorative role in open spaces (gardens, parks, etc.), in pots, or for cut flowers with different uses [9, 10, 28].
The rose is present in ornamental spaces of urban ecosystems, in different proportions, together with other plant species [28]. For

urban areas, information obtained on the basis of test plants [11], can be useful for indicative purposes in characterizing the biotope conditions of urban ecosystems, when establishing floristic compositions in ornamental spaces and intervention measures.

The relationship of the rose with soil conditions and growing substrate, with the regime of nutrients and the regime of water was studied [14, 24, 29]. The relationship of rose plants with different pathogens was also evaluated [20], and the imaging analysis facilitates the quick and non-destructive identification of symptoms at the foliar level [13].

As a result of the importance of the rose for multiple uses, the improvement and production of biological material has shown interest [12], and some studies have analyzed certain trends for the rose market [9, 27], and for sustainable practices of cultivating ornamental plants [9].

The quality of rose flowers is ensured primarily through genetics, but also culturally (technologically), according to the purpose of the flowers use.

The present study evaluated the rose flowers quality, according to the floral stem length, as an effect of maintenance cutting works, on a variable number of buds.

MATERIALS AND METHODS

The study took place between 2017 and 2018 at the Teaching and Research Base of the Faculty of Engineering and Applied Technologies Timisoara, University of Life Sciences "King Mihai I" from Timisoara. Six varieties of rose were studied, the abbreviations used in the study are presented in brackets: Acapella (Aca), Barkarole (Bar), Double Delight (D De), Golden Elegance (G El), Lady in Purple (L Pu), and Pascali (Pas). Three cutting systems were performed at two buds, at five buds and at seven buds, figure 1.

Fig. 1. The cutting system and examples of rose varieties studied; A – (a) cut to two buds, (b) cut to five buds, (c) cut to seven buds; B – the rose varieties studied: (1) – Acapella, (2) – Barkarole; (3) – Double Delight, (4) – Golden elegance, (5) – Lady in Purple, (6) – Pascali; C – single stem rose flower

Source: original figure.

Adequate maintenance of the plants was ensured by tilling the soil and watering, as appropriate. The length of the rose flower stems was evaluated according to the cutting

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system made. Observations were made on 15 plants, in three repetitions. For the comparative analysis of the data, the average value per experiment was considered as the control variant, in the case of each cutting system (two buds, five buds, or seven buds).

The recorded values, for each variety and cutting system, were analyzed mathematically and statistically by appropriate methods. For the comparative evaluation of the differences between the variants, the LSD values (significance limit of the differences) were calculated, in relation to safety thresholds of 5 %, 1 % and 0.1 %. The ANOVA test was applied in order to evaluate the presence of the variance, and the safety of the obtained data. Principal Component Analysis was applied, in order to obtain the variants distribution according to the cutting system (two buds; five buds; seven buds) as biplot. Cluster Analysis was applied, in order to obtain the dendrogram of the variants, based on similarity according to the length of the floral stem, within each cutting system. Appropriate statistical safety parameters were considered for the certainty of the results. The PAST software [16] and the statistical calculation module in EXCEL were used for data analysis and graphical representations.

RESULTS AND DISCUSSIONS

The maintenance of roses by cutting at a variable number of buds (two, five, and seven buds) led to the formation of flower stems with variable lengths within the six rose varieties considered in the study. The differentiated variation of the values for floral stems length was recorded, both according to the cutting system (number of buds) and to the varieties of roses used in the study. The average values recorded during the study period, the differences and the level of significance, are presented in Tables 1, 2 and 3.

Table 1. Values of the rose flower stem in the case of cuttings at two buds

Experimental variants	Experimental years							
	2017				2018			
	Average values	Percentage values	Differences	Significance	Average values	Percentage values	Differences	Significance
Acapella	91.30	103.05	2.70		92.00	102.42	2.17	
Barkarole	117.33	132.43	28.73	***	118.00	131.36	28.17	***
Double Delight	65.66	74.11	-22.94	oo	67.35	74.97	-22.48	oo
Golden Elegance	111.66	126.03	23.06	**	114.33	127.27	24.50	***
Lady in Purple	62.33	70.35	-26.27	ooo	63.33	70.50	-26.50	ooo
Pascali	83.33	94.05	-5.27		84.00	93.51	-5.83	
Control	88.60	100.00			89.83	100.00		
Limits of significance of differences	LSD5%=12.44; LSD1%=17.46; LSD0.1%=24.66				LSD5%=11.84; LSD1%=16.63; LSD0.1%=23.47			

Source: original data.

Table 2. Values of the rose flower stem in the case of cuttings at five buds

Experimental variants	Experimental years							
	2017				2018			
	Average values	Percentage values	Differences	Significance	Average values	Percentage values	Differences	Significance
Acapella	89.66	119.72	14.77	***	91.00	120.35	15.39	***
Barkarole	95.00	126.85	20.11	***	95.66	126.53	20.06	***
Double Delight	49.66	66.31	-25.23	ooo	51.00	67.45	-24.60	ooo
Golden Elegance	95.00	126.85	20.11	***	95.66	126.53	20.06	***
Lady in Purple	48.00	64.09	-26.89	ooo	48.33	63.92	-27.27	ooo
Pascali	72.03	96.18	-2.86		72.00	92.22	-3.60	
Control	74.89	100.00			75.60	100		
Limits of significance of differences	LSD5%=5.66; LSD1%=7.95, LSD0.1%=11.22				LSD5%=7.44; LSD1%=10.44; LSD0.1%=14.75			

Source: original data.

Table 3. Values of the rose flower stem in the case of cuttings at seven buds

Experimental variants	Experimental years							
	2017				2018			
	Average values	Percentage values	Differences	Significance	Average values	Percentage values	Differences	Significance
Acapella	82.33	124.95	16.44	***	84.63	121.40	14.92	***
Barkarole	70.66	107.24	4.77		73.66	105.67	3.95	
Double Delight	47.66	72.33	-18.23	ooo	56.00	80.33	-13.71	ooo
Golden Elegance	90.35	137.12	24.46	***	93.33	133.88	23.62	***
Lady in Purple	42.00	63.74	-23.89	ooo	44.33	63.59	25.38	ooo
Pascali	62.33	94.60	-3.56		66.33	95.15	-3.38	
Control	65.89	100.00			69.71	100.00		
Limits of significance of differences	LSD5%=7.52; LSD1%=10.56; LSD0.1%=14.91				LSD5%=4.57; LSD1%=6.41; LSD0.1%=9.06			

Source: original data.

The analysis of the experimental data safety, and the presence of variance, was done by the Anova test (Alpha=0.001), and the results obtained are presented in Tables 4, 5 and 6. In all three cases, the safety of the recorded results, and as well as the presence of the variance were confirmed (F>Fcrit, p<0.001).

Based on PCA (correlation), the diagram in Figure 2 resulted, which includes the distribution of the experimental variants (rose varieties) according to the cutting system (two, five or seven buds, as biplot). PC1 explained 93.597% of variance, and PC2 explained 5.635% of variance. In the neutral position (center of the diagram) the control variant was positioned (as the average of the experience values). Associated with seven buds (ace biplot) the variety Acapella (Aca) and the variety Golden Elegance (G El) were positioned. Associated with two buds (ace biplot) the variety Barkarole (Bar) was positioned. The other three varieties Pascali (Pas), Lady in Purple (L Pu) and Double Delight (D De) were positioned independently of the analysis parameters, as a biplot (two buds, five buds, seven buds).

Table 4. ANOVA test for the data series (cuttings at two buds)

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	15743.89	6	2623.981	48.77558	1.46E-15	4.894189
Within Groups	1882.896	35	53.79704			
Total	17626.79	41				

Source: original data.

Table 5. ANOVA test for the data series (cuttings at five buds)

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	14394.58	6	2399.097	239.5075	6.59E-27	4.894189
Within Groups	350.5878	35	10.01679			
Total	14745.17	41				

Source: Original data

Table 6. ANOVA test for the data series (cuttings at seven buds)

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	10301.47	6	1716.912	111.3459	2.59E-21	4.894189
Within Groups	539.6869	35	15.41962			
Total	10841.16	41				

Source: original data.

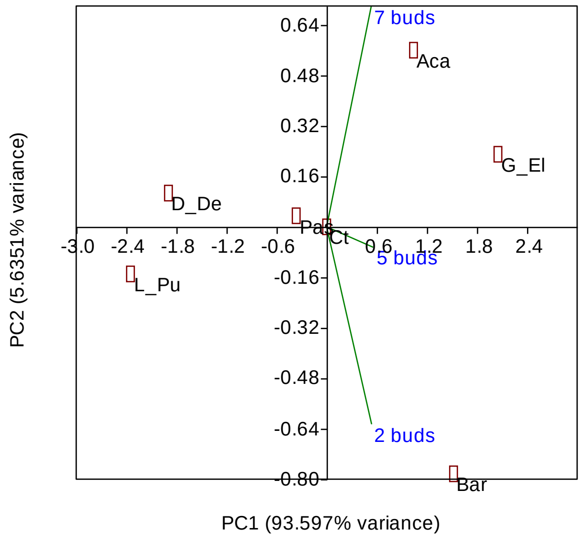

Fig. 2. PCA diagram, correlation, for the rose varieties studied according to the cutting system
Source: original figure.

Cluster analysis have facilitate to obtaining the variants dendrogram, based on the Euclidean distances, Figure 3, in relation to each cutting system (Coph.corr.=0.828 for cutting to two buds; Coph.corr=0.884 for cutting to five buds; Coph.corr= 0.732 for cutting to seven buds). From comparative analysis of the statistical safety coefficient values (Coph.corr), it was found that in the case of the cutting system at five buds, the association of the variants (of the studied rose varieties) was obtained in higher statistical safety conditions according to Coph.corr=0.884, compared with the results from the other two cutting systems (Coph.corr.=0.828 for cutting to two buds, respectively Coph.corr.=0.732 for cutting to seven buds). Also, within these series of data, related to this cutting system (cuttings to five buds), the highest level of similarity was recorded regarding the response of the varieties studied by the floral stems length, the rose varieties Barkarole (Bar) with Golden Elegance (G He), in which case SDI=0.00.

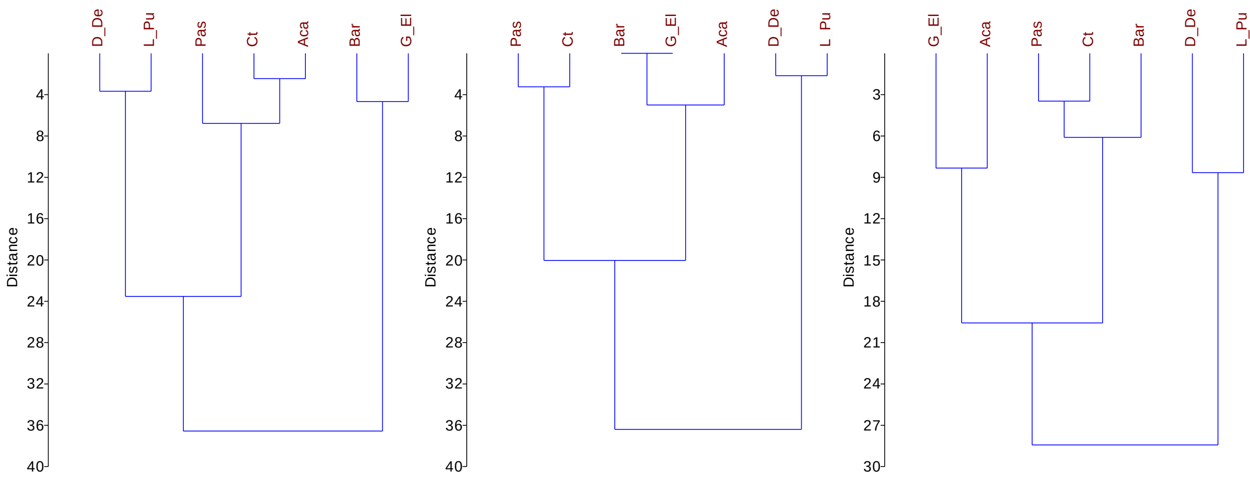

Fig. 3. Cluster dendrogram of the rose studied varieties, based on the Euclidean distances, according to the cutting system; (a) cutting to two buds; (b) cutting to five buds; (c) cutting to seven buds
Source: original figure.

High level of similarity was recorded, in the case of the cutting system at two buds, for the rose variety Acapella (Aca) with the control variant (Ct), in which case SDI=2.45; this was followed by the roses varieties Lady in Purple (L Pu), and Double Delight (D De), in which case SDI=3.67. In the case of the rose cutting system at seven buds, high level of similarity was recorded between the Pascali (Pas) variety and the control variant (Ct), SDI=3.47, followed by the Pascali (Pas) and Barcarole (Bar) varieties, SDI=7.83.

In all three cases, given the cutting system (two buds, five buds, and seven buds), the cultivars Lady in Purple (L Pu) and Double Delight (D De) were in the same subcluster, with comparatively shorter floral stems with the other rose varieties studied. High level of similarity of these varieties (L Pu and D De) was recorded in the case of the rose cutting system at five buds (SDI=2.16), and followed by the rose cutting system at two buds (SDI=3.67), and then, in the case of the system of cutting at seven buds (SDI=8.66). These varieties showed a high independence from the cutting system, in relation to the rose floral stem length.

Depending on the rose variety, and the cut flowers destination, one, or another cutting system can be chosen, according to the buds number, in order to obtain different flowers, with variable stem length. Graphic representation of the stem length in the varieties of roses studied, compared to the average value, is presented in Figure 4 for the cutting system at two buds, Figure 5 for the cutting system at five buds and in Figure 6 for the cutting system at seven buds.

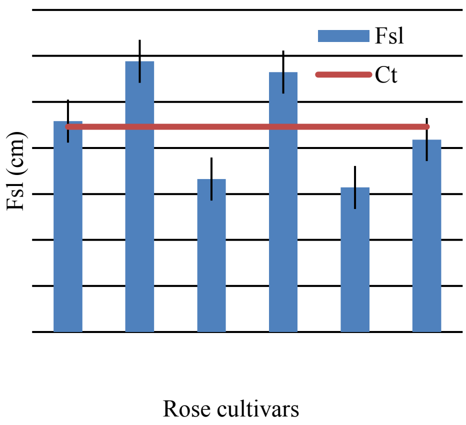

Fig. 4. The graphic distribution of the values for the flower stem length, in the rose varieties analysed (cuttings at two buds)
Source: original figure.

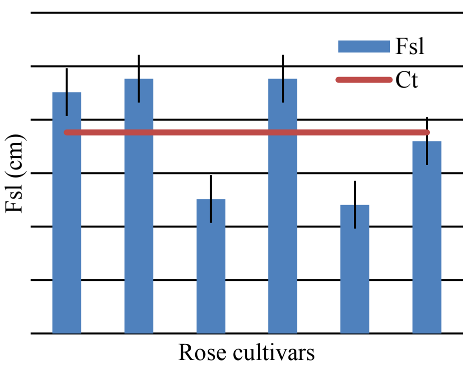

Fig. 5. The graphic distribution of the flower stem length values, in the rose varieties analysed (cuttings at five buds)
Source: original figure.

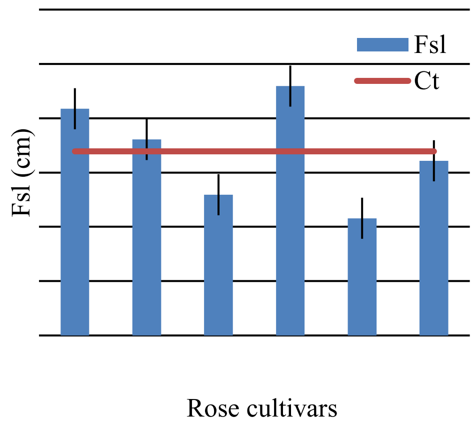

Fig. 6. The graphic distribution of the flower stem length values, in the rose varieties analysed (cuttings at seven buds)
Source: original figure.

In species with a woody architectural structure, the maturation of woody tissues, the accumulation of mineral elements in the shoot structure and the quality of buds depend on vegetation factors, among which the fertilization system and plant nutrition play an important role [2, 22]. Rose flower quality has been studied and associated with calcium (Ca) nutrition, but also in relation to other nutrients, such as Na, K and Mg [3]. Cabrera et al. (2009)[7] studied the production of rose flowers and the accumulation of ions in greenhouse conditions, in relation to stress under experimentally controlled salinity conditions ($NaCl$ + $CaCl_2$) and found the negative influence of salinity on biomass, cut flower production and quality the leaves. The dynamics of nutrients (N, K) and phytoassimilates, in terms of transport and storage in the structure of rose plants for cut flowers, were studied in a hydroponic culture system [1].

Rose maintenance cuts, as integrated works in culture technology, are made, usually, in relation to the cultivated genotype, according to the architectural system of the plant, in relation to the landscaping in which it fits, but also in the relations to the purpose and destination of the flower production (ornamental; source of raw material for different industries, such as cosmetic, food, medicinal, perfumery, pharmaceutical, etc.) [23].

In the case of roses plants, cultivated for cut flowers, in relation to the rose genotype, flowers colour, and the ornamental frame or context, different type of flowers, with a long, medium or short stem are used [6].

In order to study the optimization the rose flower production (the number and the quality of the leaves) according to the main determinants (genotype characteristics, plant structure, growing environment, maintenance techniques), Buck-Sorlin et al. (2011)[6] used a 3D modeling approach for structural and functional growth of rose plants.

Based on some structural-functional models of plants, by techniques of driving some shoots (bending) Zhang et al. (2020) [30] obtained vertical shoots with a better growth (35 and 59%), compared to the control plants (without bent shoots), a fact that can contribute to the increase in the quality of the stems of the rose shoots and the quality of the rose flowers.

In the case of this study, the quality of the rose floral stems (shoots with flowers), was evaluated according to the rose plants maintenance cuts, and different results was obtained which showed that the quality of the flowers can be controlled through the accessible work technique.

CONCLUSIONS

The quality of rose flowers, assessed in this study, based on the floral stem length, varied according to the cutting system (two buds; five buds; seven buds), but also in accordance with rose variety studied.

The cutting system at two buds facilitated obtaining the longest flower stems (eg 118.00 cm in the Barkarole variety), compared to the other two cutting systems, at five buds and at seven buds.

The rose varieties Acapella, Barkarole and Golden Elegance provided flowers with a long stem, and the varieties Double Delight, Lady in Purple and Pascali provided flowers with a shorter stem, in all three cutting systems.

Based on PCA (correlation), PC1 explained 93.597% of variance, and PC2 explained 5.635% of variance, depending on the cutting system (two, five, or seven buds, as biplot).

Cluster analysis ansured the grouping of rose varieties based on the length of the flower stalks, in relation to each cutting system, thus facilitating the choice of that cutting system that offers the quality of the flowers in relation to their use.

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EVALUATION OF GERANIUM VEGETATIVE PROPAGATION UNDER THE INFLUENCE OF SOME BIOACTIVE SUBSTANCES

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Abstract

The study evaluated the vegetative propagation of geraniums, Pelargonium peltatum, under the influence of some bioactive substances. 10 products with biostimulatory effect were tested, along with a control variant: V1 (control, water treatment), V2 (Radifarm, 0.2%), V3 (Radistim, powder - cuttings treatment at planting), V4 (Ecopan-1, 1.5%), V5 (Legume extract 1, 1.5%), V6 (Aromatic plant extract, 1.5%), V7 (Legume extract 2, 1.5%), V8 (Ecopan-2, 1.5%), V9 (Bionat Plus, 1.5%), V10 (Dill Essential oil, 1/50), V11 (GMO Essential oil, 1/100). The uniform geranium cuttings, 10 cm long, and with a pair of leaves at the top, were placed on a peat-based rooting substrate. The rooting process was evaluated in terms of the roots number (RN) and the roots length (RL). The planting took place on February 20, and the determinations were made on March 6 (T1), March 13 (T2), March 20 (T3) and April 2 (T4). The variants V2 and V3 were highlighted, as roots number (RN_{V2}=18.5±1.21, respectively RN_{V3}= 11.5±1.21), and variants V10 and V6 as root length (RL_{V10}=17.20±0.20 cm, respectively RL_{V6}=16.10±0.20 cm). Strong, positive correlations were identified between RN-T3 and RN-T2 ($r=0.795^{**}$), between RL-T3 and RL-T2 ($r=0.801^{**}$), and between RN-T4 and RN-T3 ($r=0.756^{**}$), in statistical safety conditions ($^{**}p<0.01$). Based on PCA, PC1 confirmed 42.128% of variance, and PC2 confirmed 33.487% of variance. The values of the parameters RN and RL at the T4 moment (considered the end of the rooting process) were evaluated in relation to intermediate values (T2, T3) by regression analysis and equations were obtained in statistical safety conditions (R^2 = 0.992 for RN, respectively R^2 = 0.981 for RL, p <0.001 in both cases).

Key words: *biostimulators, geranium, models, rooting process, vegetative propagation*

INTRODUCTION

The geranium is a perennial evergreen plant, from the *Geraniaceae* Family, *Geranium* L. Genus, which includes about 325 species [2, 19, 21, 35]. The great diversity of *Geranium* species has been studied in relation to the habitats and different adaptations to the growing conditions [3, 25, 27, 33].

Geraniums are of interest from an ornamental point of view, but also for bioactive compounds, essential oils with various uses in the pharmaceutical, medical or cosmetic field [5, 26].

Geraniums (*Pelargonium* spp.) represent a popular category of ornamental potted plants (indoor or outdoor, depending on the season and conditions), with a high market share (eg 25% in the French market) [11].

The composition of bioactive compounds, with biological and biotechnological effects, has made geraniums of interest for various studies in the pharmaceutical and medicinal field [20, 24, 29].

Due to the large number of species and varieties, the large distribution area, the geraniums show high ecological plasticity expressed by adaptation to various eco-climatic conditions [15, 18, 32, 33]. The relationship of geraniums has been studied in relation to different growing substrates, water regime, and nutrient conditions, or stressors [1, 7, 22, 30].

The biomass accumulation, the content of nutrients, certain reports in the process of plants growth and development, morphological, floral and biochemical parameters under the influence of the substrate and the conditions of geraniums growth were evaluated [1, 36].

Geranium propagation is suitable both by "*in vitro*" techniques (micropropagation), and by vegetative propagation (based on stem cuttings or leaves) [5, 11, 16, 26].

For a wide category of cultivators and lovers of ornamental plants, an accessible method of geraniums propagating is the vegetative one, based on stem or leaf cuttings, with the observance of some procedures for obtaining quality plants.

In order to stimulate the rooting process of the cuttings, the influence of different substances with biostimulatory role was evaluated [6, 23, 26].

Usually in the case of the vegetative propagation process based on cuttings, it is a combination of factors that contribute to obtaining good results. Thus, geranium propagation (*Pelargonium graveolens* L. Herit) was studied in relation to planting time, the position of cuttings (basal, middle, terminal - on source plant shoots), and treatments with rooting bioregulators, and it was found that the terminal cuttings treated with 750 ppm IBA, respectively the middle and basal cuttings treated with 1,000 ppm IBA, ensured good results in vegetative propagation [6].

The rooting substrate, biostimulating substances (rooting hormone), the planting depth of the cuttings (1.5 - 3 cm), the propagation season (summer, autumn), the type of cuttings (stem, leaf-bud cuttings) also influenced vegetative propagation process [26].

Eco-physiological factors in the period of root development (rooting process), it was also found to have an important role in obtaining quality plants by vegetative propagation in geraniums [8, 13, 14].

Recent concerns have focused on optimizing geraniums cultivation technologies by reducing fertilizers and expensive organic components in growing substrates, as well as environmental protection considerations [1].

Of importance is the hydric regime of the plants, in different systems and techniques of geraniums cultivation, associated both with the cultivation substrate and with the cultivation conditions (pots, open space) in order to ensure optimal water plants [4].

Studies on the resistance and also the response of geranium plants to diseases and pests are also of interest, in order to evaluate early aspects and formulate appropriate recommendations and treatments [9]. Imaging techniques in leaves studies are useful for the rapid, non-destructive evaluation of some aspects associated with the attack of diseases or pests, for the purpose of prophylactic and appropriate intervention [12].

The present study investigated the influence of some biostimulatory substances, in the vegetative propagation, by cuttings, of the geranium plants.

MATERIALS AND METHODS

The geraniums, *Pelargonium peltatum*, represented the biological material, used for the purpose of vegetative propagation based on cuttings of shoots (Photo 1). The cuttings were harvested and planted on February 20, 2019.

The geranium cuttings were uniform, 10 cm long, and with a pair of leaves on the upper part (Photo 2).

The experiment took place in protected conditions (greenhouse) within the Didactic and Research Base of the University of Life Sciences "King Mihai I" from Timisoara, Romania (Photo 2).

Ten products with biostimulatory effect were tested, along with a control variant: V1 (control, water treatment), V2 (Radifarm, 0.2%), V3 (Radistim, powder - cuttings treatment at planting), V4 (Ecopan-1, 1.5%), V5 (Legume extract 1, 1.5%), V6 (Aromatic plant extract, 1.5%), V7 (Legume extract 2, 1.5%), V8 (Ecopan-2, 1.5%), V9 (Bionat Plus, 1.5%), V10 (Dill essential oil, 1/50), V11 (GMO Essential oil, 1/100).

On each experimental variant, initial treatments were made for cuttings, with biostimulator substances, in the specified concentrations.

After treatment, the cuttings were planted on the rooting substrate. During the experimental period, at intervals of 7 days, foliar treatments were performed on each experimental variant (except variant V3), with the same concentrations of biostimulator products.

The rooting substrate used was Gramoflor, Cultivo 1 F.

Photo 1. Geranium plant, *Pelargonium peltatum*; plant from the cuttings source group
Source: original photo taken by authors.

(a) (b)

Photo 2. Aspects of the vegetative multiplication process; (a) - sample of geranium cuttings; (b) - geranium cuttings to rooting on experimental variants
Source: original photo taken by authors.

The substrate was based on peat (100% peat), fine-grained (0 - 10 mm), acid reaction (pH = 5.2 - 6.0), humidifying agent 1 L / m^3, content of organic matter 85 - 95%, content of nutrients in the form of macroelements (N = 140 mg, P_2O_5 = 160 mg, K_2O = 180 mg) and trace elements, according to the product presentation [31].

Specific to the vegetative propagation process, the roots number (RN) and the roots length (RL) in cuttings were evaluated on each experimental variant.

The experiment was established on February 20, 2019. Periodic evaluations of the cuttings evolution (destructive sampling of cuttings) were made, regarding the emission of roots and their growth, under the influence of the applied biostimulators and growth substrate. The determinations have been made on March 6 (T1), on March 13 (T2), on March 20 (T3), and on April 2 (T4) respectively. In order to evaluate the cuttings evolution, in the vegetative propagation process, in relation to the applied treatments, the results were compared to the T1 determination.

The recorded experimental results were analyzed by appropriate mathematical and statistical methods (Anova test, regression analysis, PCA, cluster analysis), and for the safety of data and results appropriate statistical safety parameters were used (p, R^2, Coph. corr., and Coefficient of variation, CV). Excel, PAST software [17], and Wolfram Alpha (2020) [34] were used for data analysis and processing.

RESULTS AND DISCUSSIONS

Treatments with the biostimulator products on geranium cuttings have differentiated the rooting (formation and growth of roots) in order to plants vegetative propagation. The values recorded for the roots number (RN) and the roots length (RL), at the moments of determination (T1, T2, T3 and T4), are presented in Table 1.

The roots number (RN) and the roots length (RL), as quantifiable parameters of the vegetative propagation process in geraniums, evolved differently during the study period (moments of determination T1 to T4) in relation to the experimental variants, respectively the biostimulator treatments.

At the T1 evaluation (March 6), it was not found the start of the rooting process (RN-T1 = 0, RL-T1 = 0). Starting with T2 (March 13), the rooting process of the cuttings was found to have started, and variable values were recorded for the number of roots (RN) and the length of the roots (RL), in relation to the experimental variants.

The ANOVA test highlighted the presence of the variance in the experimental data set, and statistical safety (F >Fcrit, p <0.001, for Alpha = 0.001) (Table 2). The distribution of the values of the RN and RL parameters, in the form of Matrix plot, is presented in Figure 1.

Table 1. Data on the vegetative propagation of geranium cuttings under the influence of biostimulator treatments

Trial	Determination periods and values of RN and RL parameters							
	March 6, 2019		March 13, 2019		March 20, 2019		April 2, 2019	
	RN-T1	RL-T1 (cm)	RN-T2	RL-T2 (cm)	RN-T3	RL-T3 (cm)	RN-T4	RL-T4 (cm)
V1	RN-T1=0	RL-T1=0	1	0.40	6.5	0.46	8.5	11.10
V2			4	0.20	14.5	0.58	18.5	14.70
V3			7.5	0.40	19	0.78	11.5	14.80
V4			3.5	0.40	4.6	0.50	5	15.80
V5			4	0.40	7.2	0.70	10	12.20
V6			3	0.50	4.5	0.63	5.5	16.10
V7			3	0.18	4.2	0.49	5	12.51
V8			3.5	0.65	6.2	0.82	7.5	11.50
V9			1	0.25	3.7	0.48	8	13.80
V10			3	0.65	4.2	0.90	4.5	17.20
V11			1.6	0.10	4.5	0.41	8.5	14.20
SE			±0.54	±0.06	±1.49	±0.05	±1.21	±0.60

Source: original data from the experiment.

Table 2. ANOVA test, single factor

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1526.937	5	305.3873	38.20116	2E-17	4.756521
Within Groups	479.6514	60	7.99419			
Total	2006.588	65				

Source: original data from the calculation.

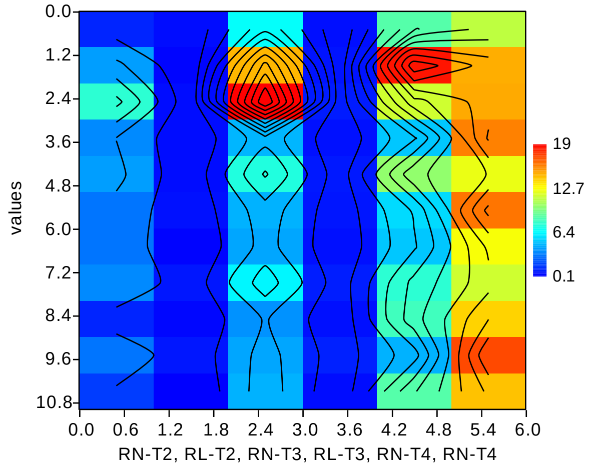

Fig. 1. Matrix plot for the RN and RL parameter distribution during the study period, *Pelargonium peltatum*

Source: iriginal graphic diagram, generated based on experimental data.

The correlation analysis between RN and RL parameters, in relation to the determination moment (T), evidenced strong, positive correlations, in statistical safety conditions ($p < .01$), between RN-T3 and RN-T2 ($r = 0.795$), between RL-T3 and RL-T2 ($r = 0.801$), and between RN-T4 and RN-T3 ($r = 0.756$) respectively (Table 3).

Table 3. Correlation table between RN and RL parameters at the evaluation moments

Categories		RN-T2	RL-T2	RN-T3	RL-T3	RN-T4	RL-T4
RN-T2	Pearson's r	—					
	p-value	—					
RL-T2	Pearson's r	0.214	—				
	p-value	0.528	—				
RN-T3	Pearson's r	0.795**	-0.082	—			
	p-value	0.003	0.811	—			
RL-T3	Pearson's r	0.576	0.801**	0.293	—		
	p-value	0.064	0.003	0.381	—		
RN-T4	Pearson's r	0.331	-0.374	0.756**	-0.032	—	
	p-value	0.32	0.257	0.007	0.926	—	
RL-T4	Pearson's r	0.227	0.150	0.038	0.245	-0.137	—
	p-value	0.502	0.659	0.911	0.468	0.689	—

* p < .05, ** p < .01, *** p < .001

Source: own data obtained from the calculation.

The variability of the studied parameters (RN, RL) was evaluated during the study period, based on the coefficient of variation (CV) and the graphical analysis. The root number (RN) parameter showed a higher variability compared to the root length (RL) parameter, at the three moments of determination, during the study period.

The values of the coefficient of variation were, in the case of the root number (RN) parameter, CVRN-T2 = 56.3311, CVRN-T3 = 68.9189, and CVRN-T4 = 47.8505, respectively. The coefficient of variation presented different values for root length (RL), according to determination moment (CVRL-T2 = 48.3304; CVRL-T3 = 26.8891; CVRL-T4 = 14.1539). The highest value of CV was recorded at T3 determination moment for RN parameter, and at T2 determination moment for RL parameter, respectively. The results obtained show that the two parameters, root formation (RN) and root growth (RL) in geranium cuttings are different. Graphic analysis provides similar results, in the form of Diversity profiles (Figure 2).

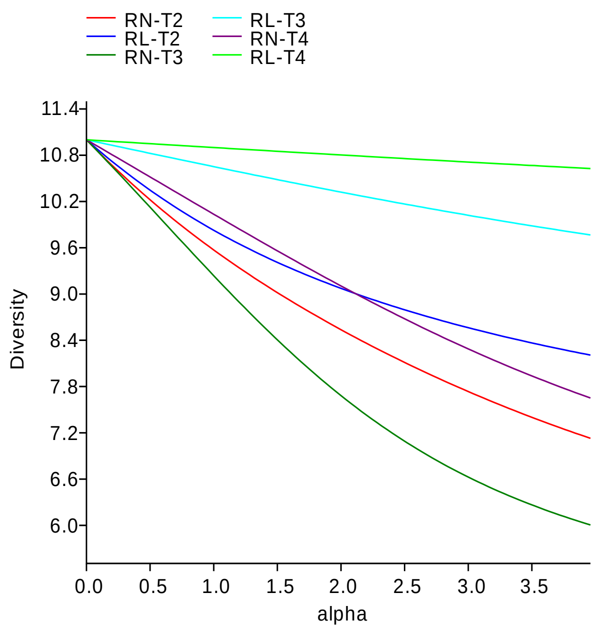

Fig. 2. Diversity profiles of RN and RL parameters in relation to the evaluation moment (T)

Source: original graphic diagram.

According to PCA (correlation matrix) was obtained the diagram shown in Figure 3, which shows the distribution of experimental variants (given by biostimulator treatments) in relation to biometric parameters (RN and RL, at different T moments) as biplot. PC1 explained 42.128% of variance, and PC2 explained 33.487% of variance. It was found the independent positioning of a group of four variants (V1, V7, V9 and V11) and the association of the other variants according to the considered parameters, and with various affinity levels.

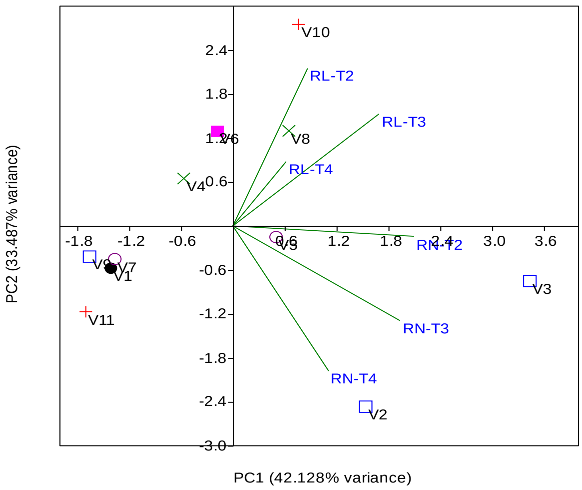

Fig. 3. PCA diagram
Source: original figure

Cluster analysis facilitated to obtaining the dendrogram in Figure 4, in statistical safety conditions (Coph. corr. = 0.972). In the dendrogram obtained, the experimental variants grouped according to the degree of similarity for generating the results in the two parameters considered (RN, RL) and the time moments (T). The formation of two distinct clusters was found. A C1 cluster comprises two variants (V2, V3) which in the PCA analysis showed high affinity for RN. Cluster C2 comprised two sub-clusters, C2-1 and C2-2, with several variants each. The highest level of similarity in the generation of results at evaluated parameters (RN, RL) and time T, was recorded between variants V4 and V6 (SDI = 0.7918), followed by variants V9 and V11 (SDI = 1.1989). The set of values for the calculated SDI is presented in Table 4.

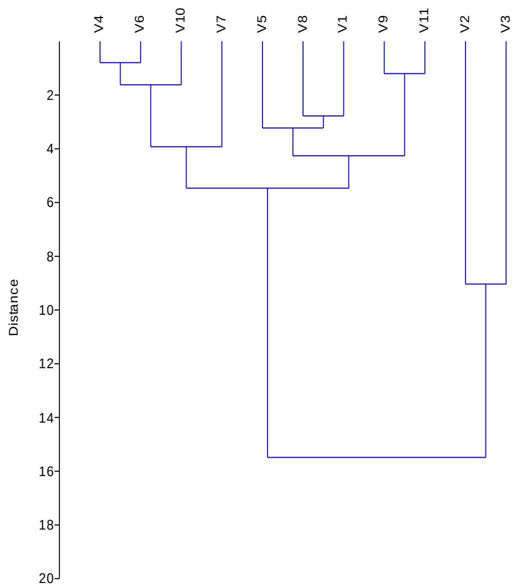

Fig. 4. Variant grouping dendrogram based on Euclidean distances
Source: original figure, obtained based on experimental data

At the T4 moment for determining the parameters RN and RL, it was estimated that geranium cuttings can be planted on more fertile substrates, for growth to obtain plants for ornamental and commercial purposes.

Table 4. SDI values in relation to the experimental variants and biometric parameters in geranium, in the study conditions

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V1		13.6390	14.8760	6.6484	3.6066	6.4837	4.8557	2.7735	3.9247	7.9219	3.7500
V2	13.6390		9.0327	16.7860	11.4820	16.4940	17.1510	14.1650	15.3850	17.5970	14.3540
V3	14.8760	9.0327		16.3310	12.6690	16.3770	16.9390	14.3800	17.0210	17.1500	15.9580
V4	6.6484	16.7860	16.3310		6.7089	0.7918	3.3590	5.2407	4.4814	1.6860	4.3044
V5	3.6066	11.4820	12.6690	6.7089		6.6155	5.9320	2.8402	5.2802	8.0841	4.4129
V6	6.4837	16.4940	16.3770	0.7918	6.6155		3.6538	5.3253	4.0330	1.5477	3.8443
V7	4.8557	17.1510	16.9390	3.3590	5.9320	3.6538		3.4424	3.8625	4.7576	4.1435
V8	2.7735	14.1650	14.3800	5.2407	2.8402	5.3253	3.4424		4.2797	6.7636	3.9065
V9	3.9247	15.3850	17.0210	4.4814	5.2802	4.0330	3.8625	4.2797		5.3288	1.1989
V10	7.9219	17.5970	17.1500	1.6860	8.0841	1.5477	4.7576	6.7636	5.3288		5.2529
V11	3.7500	14.3540	15.9580	4.3044	4.4129	3.8443	4.1435	3.9065	1.1989	5.2529	

Source: original data, obtained from the calculation

Regression analysis was used to assess the growth ratio and the level of RN and RL at T4 moment, depending to the values of the two parameters from previous moments (T2 and T3), during the studied period.

The better the values of the roots of the cuttings (RN and RL) from the first stages of propagation, the more developed the roots were at the time of planting (T4).

This leads to the appreciation that the biostimulators with favorable influence at the start of the cuttings by vegetative propagation will confer an advantage and will ensure the obtaining of vigorous plants, under practical aspect (propagation process), ornamental and commercial.

From the regression analysis, equation (1) was obtained which described the variation of RN-T4 in relation to RN-T2 and RN-T3, in statistical safety conditions (R^2 = 0.992, p <0.001).

Graphically distributed RN values were represented as 3D model (Figure 5), and on isoquants format (Figure 6).

$$\mathrm{RN-T\,4} = ax^2 + by^2 + cx + dy + exy + f \quad (1)$$

where: RN-T4 - roots number at the T4 moment
x – RN-T2, roots number at the T2 moment;
y – RN-T3, roots number at the T3 moment;
a, b, c, d, e, f – coefficients of the equation (1);
a= -1.59861945; b= -0.16582312;
c= 1.82859570; d= 1.64152727;
e= 0.81829463; f= 0.

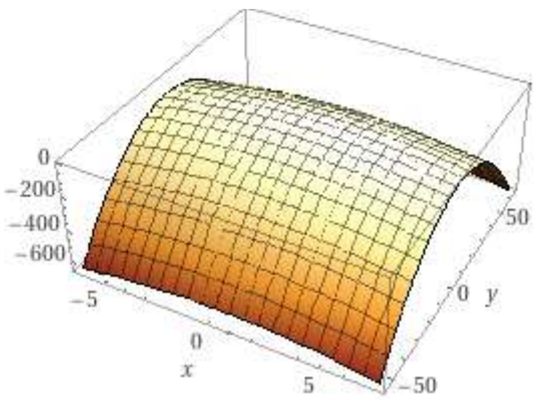

Fig. 5. 3D model of variation of RN-T4, depending to RN-T2 (x-axis) RN-T3 (y-axis)
Source: original graph generated based on experimental data.

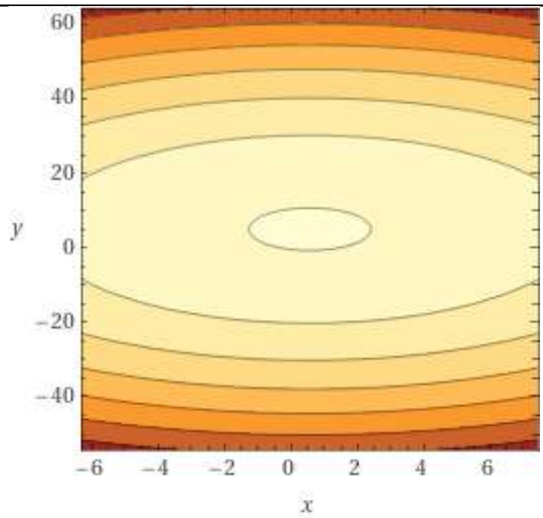

Fig. 6. Model in the form of isoquants regarding the variation of RN-T4 depending on RN-T2 (x-axis) RN-T3 (y-axis)
Source: original graph generated based on experimental data.

To describe the variation of RL-T4 in relation to RL-T2 and RL-T3, the regression analysis has facilitated to obtaining the equation (2), in statistical safety conditions (R^2 = 0.981, p <0.001). Graphically distributed RN values were represented as 3D model (Figure 7), and on isoquants format (Figure 8).

$$\mathrm{RL-T\,4} = ax^2 + by^2 + cx + dy + exy + f \quad (2)$$

where: RL-T4 - root length at the T4 moment;
x – RL-T2, root length at the T2 moment;
y – RL-T3, root length at the T3 moment;
a, b, c, d, e, f – coefficients of the equation (2);
a= -29.44934422; b= -61.31811298;
c= -19.50434508; d= 55.47547725;
e= 66.96517294; f= 0.

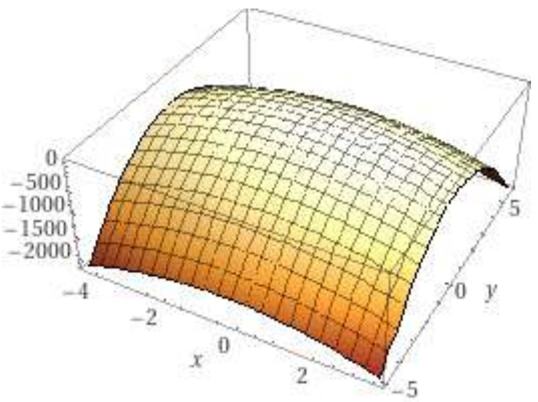

Fig. 7. 3D model of RL-T4 variation, depending to RL-T2 (x-axis) RL-T3 (y-axis)
Source: original graph generated based on experimental data.

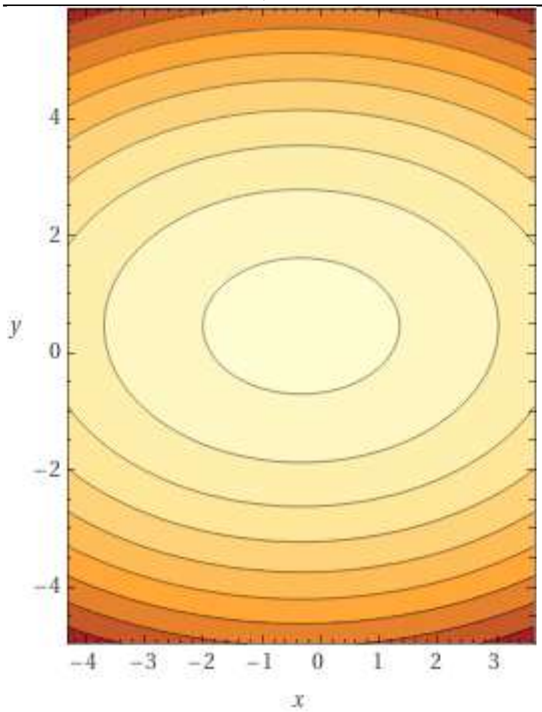

Fig. 8. Model in the form of isoquants regarding the variation RL-T4 depending on RL-T2 (x-axis) RL-T3 (y-axis)
Source: original graph generated based on experimental data.

The differences regarding RN and RL were calculated on the experimental variants, at the T4 moment, in relation to the average values of the experiment. The recorded values (positive and negative) are presented in Figure 9.

For the cultivation of plants on artificial nutrient media, different components of organic, organomineral or mineral type are used, in singly or in a mixture, or in the form of nutrient solutions can be used [28].

For rooting cuttings, light-textured substrates are recommended to facilitate root growth and development. Sand is an accessible substrate, but mixtures with other organic components (eg peat, coconut) ensure better results in the rooting process.

Pholo et al. (2013) [26] reported very good results by using a mixed substrate with sand and coconut, planting cuttings at 3 cm depth, and appropriate treatments with rooting biostimulators.

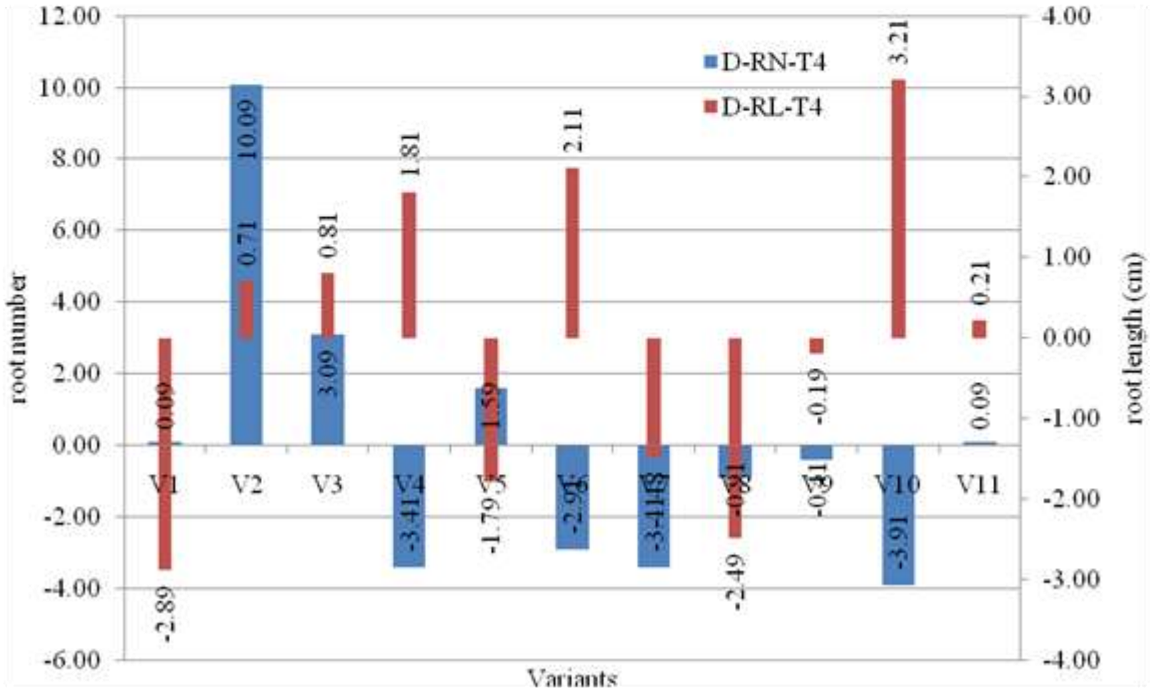

Fig. 9. Graphic distribution of differences regarding RN and RL on experimental variants, T4 moment, in relation to the average value of the experiment, vegetative propagation in geranium
Source: original graph generated based on experimental data.

In the context of environmental protection, some studies have used organic waste (eg compost of tea, leaf residues, sand, organomineral sediment, coco peat etc.) to make substrates for vegetative propagation of geranium (*Pelargonium peltatum*), with good results for multiplication and plant growth [1]. Plant growth, as a whole process, as well as the sequential variation of some vegetative or floral parameters in geranium, in relation to certain influencing factors, have been described by different linear models (eg dry mass of flowers), logarithmic models (eg dry mass of roots and shoots) in relation to phosphorus, or of linear models (eg biomass of roots, stems, leaves) in relation to integral daily light - DLI [8, 36]. The allocation of morphometric or biomass indicators, according to the plants development status, are important to understand and describe plants relationship with different habitat elements or growing conditions, and can generate model patterns of behaviour and plant response, or different intervention measures [10].

The results and models obtained, based on this study, described the geranium seedlings evolution (RN, RL parameters) according to the time under the influence of different biostimulating substances, but under the same peat-based substrate conditions.

CONCLUSIONS

The biostimulating substances tested differentially influenced the rooting process of geranium seedlings, *Pelargonium peltatum*, in the vegetative propagation. In terms of the roots number (RN), variants V2 (18.5 ± 1.21) and V3 (11.5 ± 1.21) were highlighted, and in terms of root length (RL), variants V6 (16.10 ± 0.60 cm) and V10 (17.20 ± 0.60 cm) were highlighted.

Strong correlations were recorded between RN-T2 and RN-T3, RN-T3 and RN-T4, which shows the importance of the processes that determine the emission of roots as quickly as possible in the rooting process of geranium cuttings, *Pelargonium peltatum*. Also, strong correlations were recorded between RL-T2 and RL-T3.

Mathematical models described the variation of the RN and RL parameters, at the end of the multiplication process (T4), in relation to different intermediate stages, in statistical safety conditions.

Based on PCA and Cluster analyses, the grouping and association diagrams of the studied variants were obtained, according to the affinity degree, and the similarity level to the evaluated RN and RL parameters.

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FINANCING OF SCIENTIFIC WORK IN AGRICULTURAL UNIVERSITIES OF UKRAINE

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Abstract

The purpose of this article is to analyze the commercialization of the results of scientific work of agricultural universities of Ukraine and the formation of their ratings according to these indicators. Data from the Ministry of Education and Science of Ukraine for the years 2018–2020 were used to achieve the goal. The research was carried out in three stages: analysis of absolute indicators of commercialization (amounts of earned funds based on the results of scientific work) using the ABC method; analysis of relative indicators of commercialization (amount of earned funds based on the results of scientific work per one scientific-pedagogical worker); formation of ratings of agricultural higher education institutions of Ukraine according to absolute and relative indicators of commercialization of scientific work. The following results were obtained: during the analyzed period, agricultural higher education institutions of Ukraine improved the overall effectiveness of scientific activity. In 2019, 7 higher education institutions, and in 2020, 11 higher education institutions increased the absolute financial indicators of their scientific work, compared to the previous year. In 2019, 8 higher educational institutions, and in 2020, 11 higher educational institutions increased the relative financial indicators of their scientific work, compared to the previous year. According to the rating of agricultural higher education institutions of Ukraine, four leaders were identified according to these indicators. It is expedient to study and implement their experience in attracting funds for financing scientific work in other 12 agricultural higher education institutions of Ukraine.

Key words: *funding, research activities, special fund, agricultural universities, Ukraine*

INTRODUCTION

Scientific research in the agricultural sector of any country contributes to the breeding of new varieties of plants and breeds of animals, the development of new equipment and technologies, the emergence of new methods and theories. However, for the successful conduct of scientific works and the provision of scientific services, appropriate funding is necessary. In particular, agricultural universities of Ukraine finance their scientific activities both from budget funds (general fund) and from their own funds (special fund). It is worth noting that the financial effectiveness of scientific activities in higher education institutions (hereinafter – HEIs) is different: not only the sums of funds earned by universities differ, but also the amount of funds allocated to one scientific-pedagogical worker (hereinafter – SPW). In 2019, the Cabinet of Ministers of Ukraine by its resolution approved the formula for the distribution of state budget expenditures for higher education among HEIs based on indicators of their educational, scientific and international activity. Among other things, it should stimulate HEIs to develop science, partnership with business and diversify funding sources. However, in connection with military operations on the territory of Ukraine, the effect of this resolution is suspended until December 31, 2023 [1].

Over the past five years, a large number of publications have been devoted to the financing of science in the academic field. Scientists from different countries have studied the following aspects: Chandran V. G. R. *et al.* (2021) – selective research funding policy in Malaysian universities [2]; Fu Y. (2022) – the influence of state funding on scientific innovation in Chinese universities [3]; Haake U. and Silander C. (2021) – ways of applying performance-based research funding systems in new universities and university colleges in Sweden [4]; Hoenig B. (2018) – the impact of European funding on universities [5]; Ito S.

and Watanabe T. (2020) – a multilevel analysis of research management and external funding specialists in Japanese universities [6]; Kundu O. and Matthews N. E. (2019) – the role of philanthropic funding in university research [7]; Lee Y. H. (2021) – the role of research funding in scientific productivity in Korean universities [8]; Muizniece L. (2021) – university autonomy and commercialization of state-funded research on the example of Latvia [10]; Pereira-Puga M. and Sanz-Menendez L. (2020) – development of tools for financing university research in Galicia (Spain) [12]; Pourdeyhimi B. (2021) – funding of university research by industry in the USA [13]; Stenbacka R. and Tombak M. (2020) – competition between universities and firms in basic research and university funding policy [14]; Totska O. L. (2022a) – financial aspects of scientific activity of HEIs in the regions of Ukraine and strategizing of commercialization of its results [15]; Wohlrabe K. *et al.* (2019) – an analysis of the effectiveness of German universities whose strategies for the future were awarded within the framework of the Excellence Initiative [19].

However, in the mentioned publications, the authors did not focus their attention on the financing of science in agricultural HEIs. Therefore, the purpose of this article is the analysis of the commercialization of the results of the scientific work of agricultural HEIs of Ukraine and the formation of their ratings according to these indicators.

MATERIALS AND METHODS

Data from the Ministry of Education and Science (hereinafter – MES) of Ukraine for the years 2018–2020 were used to achieve the goal [9].

The analysis of absolute indicators of commercialization of scientific activity was carried out using the ABC method. It is related to a statistical regularity called the Pareto Rule “20 by 80” (for many phenomena, 20% of the causes cause 80% of the effects). In our case, agricultural HEIs of Ukraine are divided into three groups:

A – HEIs with a large amount of financial income from scientific work (about 80% of the total amount);

B – HEIs with average level of commercialization of scientific activity (about 15%);

C – HEIs with little or no amount of financial income from scientific work (about 5%).

In addition, with the help of rating assessment, agricultural universities of Ukraine are divided into six zones based on absolute and relative indicators of incomes to the special fund based on the results of scientific activity.

Note that in agricultural studies, Totska O. (2022d, 2022c, 2022b) used the ABC-analysis method to classify EU countries by the volume of purchases of Ukrainian grain crops/ fats and oils of animal or vegetable origin [18]; agricultural products by the value of export / import in Ukraine-Romania trade [17]; the method of rating research – to determine the position of each region of Ukraine according to selected financial and quantitative indicators of labor in agriculture [16].

RESULTS AND DISCUSSIONS

Analysis of absolute indicators of financial effectiveness of scientific activity of agricultural HEIs of Ukraine

Indicators of commercialization of the results of scientific work of agricultural HEIs for 2018–2020 include:

1) funds received as a result of scientific and scientific-technical works under international cooperation projects;

2) funds received as a result of scientific and scientific-technical works under business contracts;

3) funds received as a result of the provision of scientific services.

They are shown in Table 1. In it, indicators in hryvnias were converted into euros at the official rate of the National bank of Ukraine (average for the period):

2018: 1 euro = 32.14 UAH;

2019: 1 euro = 28.95 UAH;

2020: 1 euro = 30.79 UAH [11].

Table 1. The amount of incomes to the special fund based on the results of the scientific work in the agricultural HEIs of Ukraine (euro)

No	Name of the higher education institution	2018	2019	2020	Total revenue for three years	The share of revenues in the total amount, %	The accumulated share of revenues in the total amount, %	ABC group
1	Nat. Un-ty of Life and Environmental Sciences of Ukraine (NULESU)	318,508	446,071	316,536	1,081,115	38.88	38.88	A
2	Mykolaiv Nat. Agrarian Un-ty	213,613	120,921	175,340	509,875	18.34	57.22	A
3	Dnipro State Agrarian and Economic Un-ty	95,101	85,530	105,201	285,832	10.28	67.50	A
4	Sumy Nat. Agrarian Un-ty	105,051	79,687	91,966	276,704	9.95	77.45	A
5	Vinnytsia Nat. Agrarian Un-ty	24,331	22,406	142,911	189,649	6.82	84.27	B
6	Bila Tserkva Nat. Agrarian Un-ty	11,274	30,034	61,108	102,415	3.68	87.95	B
7	Poltava State Agrarian Un-ty	7,307	15,006	47,150	69,463	2.50	90.45	B
8	Dmytro Motornyi Tavria State Agrotechnological Un-ty	16,537	13,256	30,099	59,892	2.15	92.61	B
9	Lviv Nat. Agrarian Un-ty	25,415	9,243	20,669	55,327	1.99	94.60	B
10	Odesa State Environmental Un-ty	18,915	20,535	11,435	50,886	1.83	96.43	C
11	Kherson State Agrarian and Economic Un-ty	11,560	16,494	14,537	42,591	1.53	97.96	C
12	Uman Nat. Un-ty of Horticulture	11,209	11,597	13,482	36,288	1.31	99.26	C
13	Separ. subdiv. NULESU “Berezhany Agotechnical Institute”	1,438	6,820	-	8,258	0.30	99.56	C
14	Separ. subdiv. NULESU “Nizhyn Agrotechnical Institute”	-	-	7,795	7,795	0.28	99.84	C
15	Odesa State Agrarian Un-ty	-	-	4,412	4,412	0.16	100.00	C
16	Luhansk National Agrarian Un-ty	-	-	-	-	0.00	100.00	C
Together		860,259	877,602	1,042,640	2,780,502	100.00		

Source: Author’s calculation based on data from the MES of Ukraine and the National bank of Ukraine [9; 11].

The analysis of the dynamics of absolute indicators shows that during 2018–2020, agricultural universities of Ukraine improved the overall effectiveness of scientific activity from 860.3 to 1,042.6 thousand euros. In particular, in 2019, 7 HEIs, and in 2020, 11 HEIs improved the financial indicators of their scientific work, compared to the previous year.

According to Table 1, group A included four universities (NULESU, Mykolaiv Nat. Agrarian Un-ty, Dnipro State Agrarian and Economic Un-ty, Sumy Nat. Agrarian Un-ty), which in 2018–2020 received from 276.7 to 1,081.1 thousand euros. Their accumulated share in the total amount of incomes was 77.45%.

Group B united five universities (Vinnytsia Nat. Agrarian Un-ty, Bila Tserkva Nat. Agrarian Un-ty, Poltava State Agrarian Un-ty, Dmytro Motornyi Tavria State Agrotechnological Un-ty, Lviv Nat. Agrarian Un-ty) with revenues in the amount of 55.3 to 189.6 thousand euros. In the total amount of incomes, their contribution was 17.15%. The difference between the bottom income position in the previous group (276.7 thousand euros) and the top one in this one (189.6 thousand euros) amounted to 87.1 thousand euros.

Group C included the remaining 7 HEIs (Odesa State Environmental Un-ty, Kherson State Agrarian and Economic Un-ty, Uman Nat. Un-ty of Horticulture, Separ. subdiv. NULESU “Berezhany Agotechnical Institute”, Separ. subdiv. NULESU “Nizhyn Agrotechnical Institute”, Odesa State Agrarian Un-ty, Luhansk Nat. Agrarian Un-ty). Their income to the special fund was either less than 51 thousand euros or absent. Their accumulated share in the total amount of incomes was 5.40%. The difference between the lower income position in the previous group (55.3 thousand euros) and the upper one in this group (50.9 thousand euros) was small and amounted to 4.4 thousand euros.

In the analyzed period, agricultural HEIs received funds from 4.4 to 1,081.1 thousand euros based on the results of scientific activity. One HEI (Luhansk Nat. Agrarian Un-ty) did not receive such funds.

The results of the ABC-analysis of agricultural HEIs of Ukraine according to the absolute indicators of commercialization of the results of scientific work for 2018–2020 are shown in Fig. 1.

Group of HEIs	Number of HEIs	Share of HEIs, %	Revenues, thousands of euros	Revenues share, %
A	4	25.00	2,153.5	77.45
B	5	31.25	476.7	17.15
C	7	43.75	150.2	5.40
Together	**16**	**100.00**	**2,780.5**	**100.00**

Fig. 1. The results of the ABC-analysis of agricultural HEIs of Ukraine according to the absolute indicators of commercialization of the results of scientific work for 2018–2020

Source: Formed by the author based on Table 1.

Therefore, according to the results of scientific activity in 2018–2020, 94.6% of the earned funds were accumulated in the special fund accounts of 56.25% of agricultural HEIs of Ukraine.

Analysis of relative indicators of the financial effectiveness of the scientific activity of agricultural HEIs of Ukraine

Universities of Ukraine, including agricultural universities, have different absolute indicators of commercialization of the results of scientific work and the number of SPW. In view of this, it is advisable to also investigate the relative indicators of the financial performance of the scientific works and services performed by them.

To do this, we will build Table 2, in which we will display the amount of incomes to the special fund in 2018–2020 based on the results of scientific activity for one SPW by main place of work. On the basis of these indicators, we will calculate the average volume of incomes for each HEI for three years.

Table 2. The amount of incomes to the special fund based on the results of scientific work per SPW by main place of work in agricultural HEIs of Ukraine (euro)

No	Name of the higher education institution	2018	2019	2020	Average revenue for three years
1	Mykolaiv Nat. Agrarian Un-ty	606.85	343.53	498.13	482.84
2	Dnipro State Agrarian and Economic Un-ty	275.66	249.36	321.72	282.24
3	NULESU	234.71	351.24	261.60	282.52
4	Sumy Nat. Agrarian Un-ty	243.74	184.89	238.87	222.50
5	Vinnytsia Nat. Agrarian Un-ty	69.12	70.91	437.04	192.36
6	Odesa State Environmental Un-ty	95.05	114.72	68.07	92.61
7	Bila Tserkva Nat. Agrarian Un-ty	29.98	79.88	162.52	90.79
8	Poltava State Agrarian Un-ty	22.48	46.17	145.08	71.24
9	Dmytro Motornyi Tavria State Agrotechnological Un-ty	58.85	45.55	103.08	69.16
10	Kherson State Agrarian and Economic Un-ty	53.52	76.36	67.30	65.73
11	Lviv Nat. Agrarian Un-ty	74.97	28.88	71.27	58.38
12	Separ. subdiv. NULESU “Nizhyn Agrotechnical Institute”	-	-	136.75	45.58
13	Uman Nat. Un-ty of Horticulture	35.03	36.24	45.70	38.99
14	Separ. subdiv. NULESU “Berezhany Agotechnical Institute”	17.76	87.44	-	35.07
15	Odesa State Agrarian Un-ty	-	-	31.29	10.43
16	Luhansk Nat. Agrarian Un-ty	-	-	-	-

Source: Author’s calculation based on data from the MES of Ukraine [9].

Analysis of the dynamics of relative indicators shows that during 2018–2020, agricultural universities of Ukraine also improved the performance of individual employees, as in 2019, 8 HEIs, and in 2020, 11 HEIs improved their activities, compared to the previous year. In general, during the analyzed period, the average volume of incomes per SPW of the agricultural HEIs ranged from 10.43 to 482.84 euros (with the exception of Luhansk Nat. Agrarian Un-ty).

Ranking of agricultural HEIs of Ukraine by absolute and relative indicators of funding of scientific research

We will build Table 3 on the basis of the indicators of the total amount of incomes from the results of scientific activity for three years and the average amount of incomes from the results of scientific activity for three years per SPW in agrarian HEIs.

Table 3. Ranking of HEIs of Ukraine by the total and average amount of incomes per SPW by main place of work to a special fund based on the results of scientific and scientific-technical works and the provision of scientific services for 2018–2020

Name of the higher education institution	Rating of HEIs 1	Rating of HEIs 2
NULESU	1	2
Mykolaiv Nat. Agrarian Un-ty	2	1
Dnipro State Agrarian and Economic Un-ty	3	3
Sumy Nat. Agrarian Un-ty	4	4
Vinnytsia Nat. Agrarian Un-ty	5	5
Bila Tserkva Nat. Agrarian Un-ty	6	7
Poltava State Agrarian Un-ty	7	8
Dmytro Motornyi Tavria State Agrotechnological Un-ty	8	9
Lviv Nat. Agrarian Un-ty	9	11
Odesa State Environmental Un-ty	10	6
Kherson State Agrarian and Economic Un-ty	11	10
Uman Nat. Un-ty of Horticulture	12	13
Separ. subdiv. NULESU "Berezhany Agotechnical Institute"	13	14
Separ. subdiv. NULESU "Nizhyn Agrotechnical Institute"	14	12
Odesa State Agrarian Un-ty	15	15
Luhansk Nat. Agrarian Un-ty	16	16

Source: Author's calculation based on the data of Tables 1 and 2.

As you can see, the ratings of HEIs in terms of absolute and relative indicators are approximately the same. The largest discrepancy is observed for Odesa State Environmental Un-ty (10 and 6 ranking positions, respectively).

The rating matrix of zoning of agricultural HEIs of Ukraine is shown in Fig. 2. On it, agricultural HEIs of Ukraine are divided into six zones:

zone 1 – high level (both rating positions from 1 to 4) – NULESU, Mykolaiv Nat. Agrarian Un-ty, Dnipro State Agrarian and Economic Un-ty, Sumy Nat. Agrarian Un-ty (25.00% of HEIs);

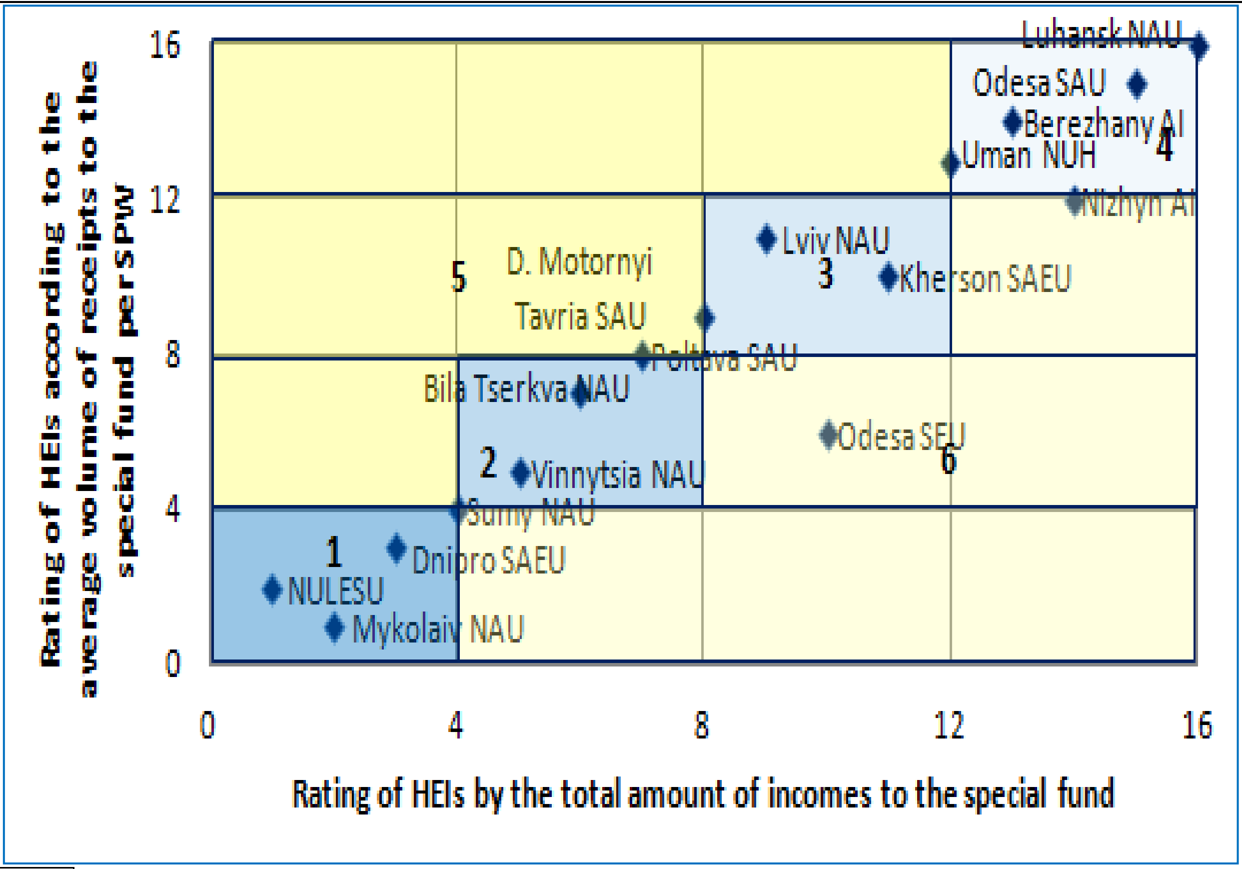
zone 2 – level above the average (both rating positions from 4 to 8) – Vinnytsia Nat. Agrarian Un-ty, Bila Tserkva Nat. Agrarian Un-ty, Poltava State Agrarian Un-ty (18.75%);

zone 3 – level below the average (both rating positions from 8 to 12) – Dmytro Motornyi Tavria State Agrotechnological Un-ty, Lviv Nat. Agrarian Un-ty, Kherson State Agrarian and Economic Un-ty (18.75%);

zone 4 – low level (both rating positions from 12 to 16) – Uman Nat. Un-ty of Horticulture, Separ. subdiv. NULESU "Berezhany Agotechnical Institute", Separ. subdiv. NULESU "Nizhyn Agrotechnical Institute", Odesa State Agrarian Un-ty, Luhansk Nat. Agrarian Un-ty (31.25%);

zone 5 – zone of imbalance with a higher level of the total volume of receipts to the special fund of HEIs – does not include HEIs (0%);

zone 6 – zone of imbalance with the highest level of the average volume of receipts to the special fund of HEIs per SPW at the main place of work – Odesa State Environmental Un-ty (6.25%).



Zone 1 – high level;

zone 2 – above average level;

zone 3 – below average level;

zone 4 – low level;

zone 5 – an imbalance zone with a higher level of revenues to the special fund of HEI;

zone 6 – an imbalance zone with a higher level of incomes to the special fund of HEI for one SPW by main place of work.

Fig. 2. Rating matrix of zoning of agricultural HEIs of Ukraine.
Source: Author’s development based on Table 3.

CONCLUSIONS

The analysis of the dynamics of indicators of the financial effectiveness of the scientific activity of the agricultural HEIs of Ukraine for 2018–2020 shows that the agrarian universities of Ukraine improved the overall effectiveness of the scientific activity from 860.3 to 1,042.6 thousand euros. In addition, in 2019, 7 HEIs, and in 2020, 11 HEIs improved the absolute financial indicators of their scientific work, compared to the previous year; in 2019, 8 HEI and in 2020, 11 HEIs improved the relative financial indicators of their scientific work, compared to the previous year. One of the factors of such revitalization can be approved by a resolution of the Cabinet of Ministers of Ukraine, the formula for the distribution of state budget expenditures for higher education among HEIs based on the indicators of their educational, scientific and international activity.

According to the conducted ABC-analysis, in 2018–2020, the largest amount of funds (from 276.7 to 1,081.1 thousand euros) based on the results of scientific activities went to the special fund of four universities – NULESU, Mykolaiv Nat. Agrarian Un-ty, Dnipro State Agrarian and Economic Un-ty, Sumy Nat.

Agrarian Un-ty. Their accumulated share in the total amount of incomes was 77.45%.

According to the ranking of agricultural HEIs of Ukraine by the total and average volume of incomes per SPW by main place of work to a special fund based on the results of scientific and scientific-technical works and the provision of scientific services for the years 2018–2020, these same universities fell into zone 1 with a high level as an absolute, as well as the relative indicator. For HEIs of Ukraine that did not enter this zone, it is recommended to study the best practices of four leading agricultural universities in the field of commercialization of the results of scientific work.

For a more in-depth study of the field of funding of scientific work in HEIs, it is advisable to conduct a comparative analysis of incomes from the scientific activity of agricultural universities of Ukraine and the world.

We hope that the end of the war in Ukraine will restore the effect of the Decree of the Cabinet of Ministers of Ukraine on the distribution of state budget expenditures for higher education among HEIs based on the indicators of their educational, scientific and international activity. And this will be an additional incentive for agricultural universities to diversify the sources of funds for financing their scientific activities.

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DETERMINATION OF THE PROBABILITY OF FAVORABLE TRENDS IN THE EXPORT-IMPORT OF TOURIST SERVICES OF UKRAINE WITH EU COUNTRIES: FINANCIAL BACKGROUND

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Abstract

The purpose of this article is to analyze the dynamics of financial indicators of export-import of travel-related services between Ukraine and the EU, to identify their favorable trends in the short term. Data from the State Statistics Service of Ukraine for 2014–2021 on the annual volumes of foreign trade in services of Ukraine with the countries of the world, dynamics of foreign trade in services by types were used for the analysis. To identify favorable trends in indicators, a probabilistic forecasting method is used, the basis of which is the use of the Poisson distribution law. The obtained results indicate that the largest recipients of Ukrainian tourist services in the analyzed period were the following EU countries: Cyprus, France, Germany, Italy, Poland (more than 1 million US dollars annually). At the same time, tourism services worth more than 10 million US dollars were imported to Ukraine annually from Cyprus, Germany, Greece, Malta (except for the indicator from Greece for 2020). Bulgaria, Cyprus and Finland have the highest probability of a favorable trend (>0.65) for 1 year for the financial indicators of the export of tourist services from Ukraine; Lithuania, Portugal, and Romania – for indicators of import of tourist services to Ukraine. It will be possible to compare the obtained results with the actual data in May-June 2023, when the State Statistics Service of Ukraine will publish statistical information for 2022. However, a war on the territory of Ukraine may prevent the predictions from coming true.

Key words: *export, import, tourist services, Ukraine, EU countries*

INTRODUCTION

The EU is one of Ukraine's important trading partners, particularly in the field of tourism services. According to the data of the State Statistics Service of Ukraine (2023a, 2023b), the share of travel-related services exported from Ukraine to EU countries in the total export of tourist services of Ukraine in 2014–2021 annually exceeded 11% and was 14.28% on average. At the same time, the share of travel-related services imported from the EU to Ukraine in the total amount of tourism services imported to Ukraine annually exceeded 32% and averaged 39.94% [9; 10]. Considering the significant potential of cooperation between Ukraine and the EU in the field of tourism, it is expedient to predict its favorable trends in the future.

Analysis and forecasting of tourism indicators in the EU countries was carried out by a number of scientists: Grigoras M. A. *et al.* (2018) – the indicators of tourism in the Brasov County (Romania) were analyzed from the point of view of tourist inflow and accommodation in the period 2007–2016, and a forecast was made for 2017–2021 [1];

Gunter U. (2018) – predicted future trajectories of real tourism exports and relative prices for tourism exports in the EU-15 were analyzed [2];

Gunter U. *et al.* (2022) – demand forecasting was carried out in selected EU countries in terms of total outbound travel expenses (import of tourist goods) [3];

Ivanovic Z. *et al.* (2018) – applied the financial portfolio theory to tourism demand in Croatia and constructed the optimal mix of foreign inbound tourists [4];

Mavrommati A. *et al.* (2021) – the determinants of tourism demand were investigated for a statistically significant sample of eleven European countries for 1996–2015 [5];

Popescu A. (2016) – analyzed the relationship between tourist accommodation opportunities in terms of the number of units and the number of tourist flows in terms of arrivals to Romania and its 8 micro-regions in the period 2007–2015 [6]; Popescu A. (2021) – analyzed to what extent the Covid-19 pandemic affected tourist flows in Romanian tourism in 2020 compared to 2019 and the forecast for 2020 [7]; Popescu A. and Plesoianu D. (2017) – trends in tourism in Maramures county (Romania) were analyzed, a forecast of the number of tourist arrivals and overnight stays for the period 2017–2021 was made [8]; Tindeche C. *et al.* (2018) – monitoring of EU tourism policy, EU regional policy and sustainable development policy was carried out [11]. In addition, we note publications on the analysis and forecasting of Ukraine's foreign economic activity: Totska O. (2022c, 2022d, 2022a, 2022b) – financial aspects of trade in agricultural products between Ukraine and Romania [14]; Ukrainian export of grain crops, fats and oil to European Union countries [15]; predictive modeling of foreign trade between Ukraine and Romania by separate groups of goods of the agro-industrial complex [12]; forecasting the export value of agricultural products of Ukraine based on fuzzy sets [13]. The purpose of this article is to analyze the dynamics of financial indicators of export-import of travel-related services between Ukraine and the EU, to identify their favorable trends in the short term (since there is a war in the country, which increased the risks for foreign tourists, and also affected number and well-being of Ukrainians).

MATERIALS AND METHODS

Data from the State Statistics Service of Ukraine for 2014–2021 on the annual volumes of foreign trade in services of Ukraine with the countries of the world, dynamics of foreign trade in services by types were used for the analysis [9; 10].

To identify favorable trends in indicators, a probabilistic forecasting method is used, the basis of which is the use of the Poisson distribution law. The essence of this method is that first in the studied time series, the fluctuations of the series are marked with pluses and minuses: a "+" sign is written if the next level is greater than the previous one; and "–" if vice versa. At the same time, the initial observation is also assigned a "–" sign. Then build a table of favorable trends (Table 1) and calculate their average length according to the formula:

$$\bar{\tau} = \frac{\sum \tau_i f_i}{\sum f_i}, \qquad (1)$$

where:

τ_i – the value of the *i*-th favorable trend, years;

f_i – frequency of its repetition.

Table 1. Favorable trends

Type of trend	The magnitude of the favorable trend, years, τ_i	Frequency of repetitions, f_i
– –	0	
–+–	1	
–++–	2	
–+++–	3	
–++++–	4	
–+++++–	5	
–++++++–	6	
–+++++++–	7	
–++++++++–	8	

Source: Yeleiko V. I. (1988) [16].

The intensity of interruption of favorable trends is calculated using the obtained average value according to the formula:

$$\lambda = \frac{1}{\bar{\tau}}. \qquad (2)$$

The probability of a favorable trend is determined based on the Poisson distribution law according to the formula:

$$P = e^{-\lambda t} = \left(e^{-1}\right)^{\lambda t}, \qquad (3)$$

where:

e^{-1}=0,3679,

t – number of periods.

All formulas are taken from [16].

RESULTS AND DISCUSSIONS

Analysis and determination of favorable trends in the export of travel-related services from Ukraine to EU countries

To analyze the dynamics of financial indicators of the export of tourist services from Ukraine to EU countries, Table 2 was created.

Table 2. Export of travel-related services from Ukraine to EU countries, thsd. USD

Country	2014	2015	2016	2017	2018	2019	2020	2021
Austria	798.9	931.1	597.4	903.6	908.5	1,757.9	214.2	474.7
Belgium	970.8	1,082.7	1,240.9	1,482.5	1,370.5	1,184.8	254.9	412.3
Bulgaria	1,100.4	1,046.7	705.4	1,098.7	1,302.5	1,469.6	1,536.3	2,336.1
Croatia	140.1	267.6	205.1	282.2	107.6	200.0	75.2	108.4
Cyprus	4,785.0	1,764.2	1,498.6	2,819.2	5,234.0	5,763.8	6,602.5	6,743.2
Czechia	1,434.2	1,197.2	595.5	447.6	671.9	801.1	318.0	5,945.7
Denmark	627.1	322.5	449.1	506.3	759.9	660.9	168.2	410.9
Estonia	1,417.2	1,031.2	351.5	752.5	703.2	664.5	205.7	766.7
Finland	492.7	505.8	581.2	634.5	657.7	678.1	287.1	383.5
France	2,209.4	1,875.4	1,828.4	2,216.8	3,742.0	4,549.2	2,048.9	2,904.8
Germany	3,900.0	2,756.3	3,392.3	4,429.7	6,445.7	6,147.3	3,655.5	5,716.7
Greece	1,234.6	2,033.6	2,360.7	2,735.5	2,368.0	1,659.8	482.1	799.6
Hungary	555.4	729.7	622.3	449.7	804.3	805.9	359.1	655.5
Ireland	728.5	455.7	367.6	374.8	345.3	436.0	562.6	1,166.3
Italy	1,087.7	1,044.7	1,177.8	1,538.8	1,912.8	5,515.4	3,604.9	4,502.3
Latvia	1,064.6	819.9	3,877.9	1,305.4	1,069.9	1,122.3	592.5	618.7
Lithuania	264.0	234.8	402.3	1,301.8	1,124.9	1,737.8	529.7	863.4
Luxembourg	44.4	56.9	38.0	113.9	217.9	174.0	35.1	168.7
Malta	116.2	46.9	58.1	145.5	229.1	402.0	116.7	1,349.8
Netherlands	1,028.7	866.9	763.2	1,077.3	1,704.4	1,941.0	947.7	1,825.2
Poland	7,073.6	7,676.8	5,615.2	6,775.9	8,768.4	10,295.6	3,473.3	4,390.1
Portugal	167.4	69.9	134.3	168.6	344.0	287.4	144.3	256.9
Romania	341.2	436.0	449.4	800.8	630.8	990.1	718.9	1,645.0
Slovakia	195.9	267.2	275.1	324.8	306.8	474.4	234.9	499.2
Slovenia	234.0	128.4	78.3	162.7	180.5	208.7	175.0	239.5
Spain	836.5	822.6	1,087.0	1,900.7	2,116.7	1,525.7	1,747.8	2,265.6
Sweden	719.0	456.3	602.4	1,012.6	1,152.4	1,157.9	529.8	820.4
EU 27	33,567.4	28,926.9	29,355.0	35,762.4	45,179.6	52,611.1	29,620.6	48,269.0
World	228,049.1	200,937.0	205,236.3	242,748.2	298,855.4	334,952.5	263,445.8	343,482.8
Share of EU 27	14.72	14.40	14.30	14.73	15.12	15.71	11.24	14.05

Source: Created by the author based on data from the State Statistics Service of Ukraine (2023a, 2023b) [9; 10].

According to Table 2, in 2014–2021, most tourist services (more than 1 million US dollars annually) were exported from Ukraine to the following EU countries: Cyprus, France, Germany, Italy, Poland.

The least tourist services (less than 350,000 US dollars annually) were exported to Croatia, Luxembourg, Portugal and Slovenia.

The total export of Ukrainian travel-related services to the EU increased in all years except 2015 (after the beginning of the occupation of the territory of Ukraine in 2014) and 2020 (during the Covid-19 pandemic).

To identify favorable trends in export indicators, Table 3 was constructed. Note that in Table 3, for better visualization of the data, positive fluctuations of the series are highlighted in blue, negative – in yellow. According to Table 3, the longest positive trends in the dynamics of export indicators were observed for such countries as Italy, Malta, Sweden (for 4 years) and Bulgaria, Cyprus, Finland (for 5 years), as well as for the total indicators for the EU and the world (for 4 years).

In the short-term perspective (1 year), the following EU countries have the highest probability of a favorable trend (>0.65) for the indicators of the export of tourist services from Ukraine: Bulgaria, Cyprus, Finland.

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Table 3. Fluctuations in export levels of travel-related services from Ukraine to EU countries

Country	2014	2015	2016	2017	2018	2019	2020	2021	The frequency of repetitions of a favorable trend, f_i						$\bar{\tau}$	λ	P
									0 years	1 year	2 years	3 years	4 years	5 years			
Austria	-	+	-	+	+	+	-	+		2		1			1.67	0.60	0.55
Belgium	-	+	+	+	-	-	-	+	1	1		1			1.33	0.75	0.47
Bulgaria	-	-	-	+	+	+	+	+	1					1	2.50	0.40	0.67
Croatia	-	+	-	+	-	+	-	+		4					1.00	1.00	0.37
Cyprus	-	-	-	+	+	+	+	+	1					1	2.50	0.40	0.67
Czechia	-	-	-	-	+	+	-	+	1	1	1				1.00	1.00	0.37
Denmark	-	-	+	+	+	-	-	+	2	1		1			1.00	1.00	0.37
Estonia	-	-	-	+	-	-	-	+	2	2					0.50	2.00	0.14
Finland	-	+	+	+	+	+	-	+		1				1	3.00	0.33	0.72
France	-	-	-	+	+	+	-	+	1	1		1			1.33	0.75	0.47
Germany	-	-	+	+	+	-	-	+	2	1		1			1.00	1.00	0.37
Greece	-	+	+	+	-	-	-	+	1	1		1			1.33	0.75	0.47
Hungary	-	+	-	-	+	+	-	+	1	2	1				1.00	1.00	0.37
Ireland	-	-	-	+	-	+	+	+	1	1		1			1.33	0.75	0.47
Italy	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
Latvia	-	-	+	-	-	+	-	+	2	3					0.60	1.67	0.19
Lithuania	-	-	+	+	-	+	-	+	1	2	1				1.00	1.00	0.37
Luxembourg	-	+	-	+	+	-	-	+	1	2	1				1.00	1.00	0.37
Malta	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
Netherlands	-	-	-	+	+	+	-	+	1	1		1			1.33	0.75	0.47
Poland	-	+	-	+	+	+	-	+		2		1			1.67	0.60	0.55
Portugal	-	-	+	+	+	-	-	+	2	1		1			1.00	1.00	0.37
Romania	-	+	+	+	-	+	-	+		2		1			1.67	0.60	0.55
Slovakia	-	+	+	+	-	+	-	+		2		1			1.67	0.60	0.55
Slovenia	-	-	-	+	+	+	-	+	1	1		1			1.33	0.75	0.47
Spain	-	-	+	+	+	-	+	+	1		1	1			1.67	0.60	0.55
Sweden	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
EU 27	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
World	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55

Source: Created by the author based on Table 2.

Analysis and determination of favorable trends in the import of travel-related services from EU countries to Ukraine

To analyze the dynamics of financial indicators of the import of tourist services from the EU countries to Ukraine, Table 4 was created.

According to Table 4, in 2014–2021, tourism services from Cyprus, Germany, Greece, and Malta worth more than 10 million US dollars were imported to Ukraine annually (except for the indicator from Greece for 2020); from Denmark, Ireland, Luxembourg – in the amount of less than 1 million US dollars (except for the indicator from Denmark for 2019).

The total amount of imports of European travel-related services to Ukraine increased in all years except 2015, 2016 and 2020.

To identify favorable trends in import indicators, Table 5 was constructed. Note that in Table 5, for better visualization of the data, positive fluctuations of the series are also highlighted in blue, negative fluctuations in yellow. According to Table 5, the longest positive trends in the dynamics of import indicators were observed for such countries as Czechia, Italy, Malta, Poland, Spain (for 4 years) and Lithuania, Portugal, Romania (for 5 years), as well as for the total indicators for the world (for 4 years).

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Table 4. Import of travel-related services from EU countries to Ukraine, thsd. USD

Country	2014	2015	2016	2017	2018	2019	2020	2021
Austria	4,041.4	2,614.4	3,794.9	4,765.3	4,601.0	4,568.4	2,694.3	3,316.7
Belgium	1,953.8	1,149.7	1,753.9	1,943.0	2,733.4	2,246.2	1,747.7	2,238.8
Bulgaria	3,540.4	5,952.3	5,575.1	4,771.1	7,021.5	10,882.9	4,014.4	37,666.9
Croatia	2,046.0	1,901.0	3,534.9	4,118.2	4,154.1	3,965.7	2,983.2	7,828.3
Cyprus	195,384.5	78,419.3	32,004.9	57,558.9	94,623.8	161,122.0	64,457.3	137,440.1
Czechia	4,479.5	3,579.7	3,755.4	5,053.0	6,305.4	9,296.3	4,701.8	4,651.8
Denmark	559.7	370.1	771.8	692.0	895.7	1,944.8	695.3	912.6
Estonia	2,644.6	3,901.2	3,358.1	4,724.6	5,140.6	4,123.6	1,931.6	2,405.8
Finland	2,079.6	1,993.3	2,034.8	2,087.5	2,287.6	2,087.8	944.1	1,078.2
France	9,400.8	7,732.1	4,689.8	6,258.0	8,263.5	10,291.7	4,173.2	6,827.3
Germany	17,442.1	10,174.2	10,399.3	20,205.1	19,461.8	17,679.5	12,528.9	12,732.6
Greece	23,245.0	14,923.3	13,460.9	11,388.7	19,243.9	27,673.9	2,888.5	30,516.6
Hungary	2,612.3	2,138.0	2,038.5	4,104.2	3,618.8	4,286.4	2,120.4	3,805.5
Ireland	146.2	162.7	135.2	359.3	191.0	394.1	119.8	179.0
Italy	8,858.0	8,049.2	9,773.6	11,176.8	17,019.7	20,904.3	7,494.4	8,061.8
Latvia	959.0	5,771.6	13,645.5	13,589.8	11,909.7	10,175.3	1,928.8	1,432.5
Литва	1,131.0	1,671.2	2,560.6	2,643.9	2,728.5	3,965.3	1,558.6	1,656.0
Luxembourg	64.3	103.1	130.8	83.6	103.9	139.3	32.7	50.1
Malta	82,090.7	75,218.9	83,793.5	101,804.4	136,787.2	154,797.4	100,285.4	211,153.1
Netherlands	2,162.2	2,384.7	2,345.2	2,923.1	2,999.9	4,049.0	2,273.9	2,983.7
Poland	11,555.1	8,128.2	9,856.6	12,392.2	15,984.5	23,367.2	18,529.4	26,441.6
Portugal	323.1	376.9	390.8	1,091.0	1,465.3	1,609.6	556.3	853.6
Romania	500.5	660.6	849.4	1,457.3	1,913.4	2,099.0	1,089.1	1,470.8
Slovakia	2,397.7	1,788.7	1,263.2	1,390.7	1,688.4	1,458.5	695.5	1,051.0
Slovenia	870.6	725.8	853.9	915.0	1,537.8	1,249.8	466.2	614.4
Spain	14,049.5	8,618.4	11,145.9	12,234.9	16,196.0	21,497.1	4,534.7	12,636.7
Sweden	997.4	628.5	741.2	638.3	1,155.8	770.0	845.3	1,021.0
EU 27	395,534.6	249,136.9	224,657.9	290,369.6	390,032.0	506,644.8	246,291.0	521,026.0
World	681,021.7	597,645.5	603,216.5	794,973.9	990,392.9	1,299,287.9	702,922.3	1,598,761.7
Share of EU 27	58.08	41.69	37.24	36.53	39.38	38.99	35.04	32.59

Source: Created by the author based on data from the State Statistics Service of Ukraine (2023a, 2023b) [9; 10].

According to Table 5, in the short term (1 year), the following EU countries have the highest probability of a favorable trend (>0.65) for the indicators of the import of tourist services to Ukraine: Lithuania, Portugal, Romania.

CONCLUSIONS

The financial indicators of the export of Ukrainian travel-related services to the EU during 2014–2021 increased annually, except for 2015 and 2020. The decrease in indicators was influenced by the occupation of part of the territory of Ukraine in 2014, in particular the Autonomous Republic of Crimea, and the pandemic Covid-19. The largest recipients of Ukrainian tourist services were the following EU countries: Cyprus, France, Germany, Italy, Poland (more than 1 million US dollars annually).

The financial indicators of the import of travel-related services to Ukraine from the EU during the analyzed period also grew annually, except for 2015, 2016 and 2020. In particular, tourism services were imported to Ukraine from Cyprus, Germany, Greece, Malta annually in the amount of more than 10 million US dollars (except for the indicator from Greece for 2020).

Table 5. Fluctuations in the level of import of travel-related services from EU countries to Ukraine

Country	2014	2015	2016	2017	2018	2019	2020	2021	The frequency of repetitions of a favorable trend, f_i						$\bar{\tau}$	λ	P
									0 years	1 year	2 years	3 years	4 years	5 years			
Austria	-	-	+	+	-	-	-	+	2	1	1				0.75	1.33	0.26
Belgium	-	-	+	+	+	-	-	+	2	1		1			1.00	1.00	0.37
Bulgaria	-	+	-	-	+	+	-	+	1	2	1				1.00	1.00	0.37
Croatia	-	-	+	+	+	-	-	+	2	1		1			1.00	1.00	0.37
Cyprus	-	-	-	+	+	+	-	+	1	1		1			1.33	0.75	0.47
Czechia	-	-	+	+	+	+	-	-	2				1		1.33	0.75	0.47
Denmark	-	-	+	-	+	+	-	+	1	2	1				1.00	1.00	0.37
Estonia	-	+	-	+	+	-	-	+	1	2	1				1.00	1.00	0.37
Finland	-	-	+	+	+	-	-	+	2	1		1			1.00	1.00	0.37
France	-	-	-	+	+	+	-	+	1	1		1			1.33	0.75	0.47
Germany	-	-	+	+	-	-	-	+	2	1	1				0.75	1.33	0.26
Greece	-	-	-	-	+	+	-	+	1	1	1				1.00	1.00	0.37
Hungary	-	-	-	+	-	+	-	+	1	3					0.75	1.33	0.26
Ireland	-	+	-	+	-	+	-	+		4					1.00	1.00	0.37
Italy	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
Latvia	-	+	+	-	-	-	-	-	1		1				1.00	1.00	0.37
Lithuania	-	+	+	+	+	+	-	+		1				1	3.00	0.33	0.72
Luxembourg	-	+	+	-	+	+	-	+		1	2				1.67	0.60	0.55
Malta	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
Netherlands	-	+	-	+	+	+	-	+		2		1			1.67	0.60	0.55
Poland	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
Portugal	-	+	+	+	+	+	-	+		1				1	3.00	0.33	0.72
Romania	-	+	+	+	+	+	-	+		1				1	3.00	0.33	0.72
Slovakia	-	-	-	+	+	-	-	+	2	1	1				0.75	1.33	0.26
Slovenia	-	-	+	+	+	-	-	+	2	1		1			1.00	1.00	0.37
Spain	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55
Sweden	-	-	+	-	+	-	+	+	1	2	1				1.00	1.00	0.37
EU 27	-	-	-	+	+	+	-	+	1	1		1			1.33	0.75	0.47
World	-	-	+	+	+	+	-	+	1	1			1		1.67	0.60	0.55

Source: Created by the author based on Table 4.

According to the probabilistic method of forecasting, the basis of which is the use of the Poisson distribution law, the following favorable trends of financial indicators for 1 year were revealed: Bulgaria, Cyprus and Finland have the highest probability of a favorable trend (>0.65) for indicators of the export of tourist services from Ukraine; Lithuania, Portugal, and Romania – for indicators of import of tourist services to Ukraine. It will be possible to compare the obtained results with the actual data in May-June 2023, when the State Statistics Service of Ukraine will publish statistical information for 2022. However, a war on the territory of Ukraine may prevent the predictions from coming true.

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AN EXPERIMENTAL MODEL FOR ASSESSING THE LEVEL OF DIGITIZATION IN BEEKEEPING

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Abstract

A mathematical model has been developed to assess the digitization of the beekeeping sector. For this purpose, the summarized results of questionnaire surveys of 37 apiaries located in the regions of Plovdiv and Pleven municipalities in Bulgaria were used. For evaluation on the degree of digitization of the apiaries we took under consideration only what software and hardware products are used. The results showed a low degree of digitization of the studied apiaries - in 27 out of 37 studied apiaries there were no data about the use of software and hardware applications, and the average level of digitization for the studied apiaries according to the model we developed was within 8-9 %. A survey on the awareness of those employed in the beekeeping about some basic digital products for collecting, storing and distributing information and their willingness to use them in the future was also conducted. It was found that between 21% and 35% of the respondents were not familiar with the basic digital products. Far more worrying was that between 50 % and 70% of respondents stated that they were familiar with the listed digital products, but did not intend to use them in the near future.

Key words: *beekeeping, digitization, mathematical model, questionnaire surveys*

INTRODUCTION

Bees are an important factor in the ecosystem of our planet due to their role in pollinating a large number of plant species. This made the Food and Agriculture Organisation of the United Nations to pronounce them the most significant factor influencing the yields of agricultural production for the last 50 years [3]. In this context, a large part of the efforts of the bodies involved are aimed at protecting the bee population, with the products of the beekeeping industry remaining in the background, despite their critical importance for the economy and their proven benefits for human health.

The decline of honey bee colonies is an unusual phenomenon that appeared at the beginning in the 2000s [12]. Several factors are connected with mortality in bees. These are pesticides, *Varroa destructor* mite, genetic strains, reduction of the habitats, the population of Asian hornet and viruses. Electromagnetic fields also affect the health of the honey bees. Despite the fewer studies, increased aggressiveness and reduction of the ability for development was demonstrated when the bees were exposed at low frequency electromagnetic fields comparable to those found around power lines [10]. However, it is still difficult to prove the causal relationship between the above factors and the reduced bee population, and to predict future consequences.

These reasons made one of the least intensified branches of agriculture an object of interest for the digitalization that is increasingly entering the livestock sector [8].

Precision beekeeping arose in response to the need to manage beekeeping in an optimal way. It includes technology and statistical methods to help beekeepers understand what is happening inside their hives without opening them and thus disturbing the colony.

The embedding of sensors in hives and the processing of the data provided by them gives the beekeeper real-time information about the status of the hives based on the relevant variables. The main investigated parameters in the hive are temperature, weight, humidity, sound and CO_2 [2].

In a study of the economic aspects of the digitization of agriculture [13] the authors proposed an active investment policy regarding IT technologies in the sector based on the construction of large holding companies with relevant structural units, as well as free financial resources, including possible active state participation in this process. Another study [7] showed that digitization was not effective without full strategic planning and gave examples of a digital business model of an agricultural enterprise, where the financial resources necessary for step-by-step digitization can be obtained at the expense of staff reduction.

One of the first attempts to study the possible ways for implementation of the apiary digitalization was made by Zacepins et al. [15]. Their developments were entirely focused on the construction of integral schemes and the definition of the main concepts to carry out digitalization in the apiaries. However, clarifying the degree of entering of the digital applications (the use of a personal computer, data processing programs, social networks, websites, e-mail, cloud-based platforms, etc.) in the apiary were not considered. Some authors consider different models for a smart beehive emphasizing on the analysis and data collection and equipment costs [4] or focus their efforts on constructing regression models to predict the internal variables of the hives [9].

The assimilation of digital technologies, which beekeepers already use in their activities to help collect and store information, is a natural process related to the wide invasion of these technologies in all spheres of human life [8; 11]. A study presenting the entering of digital technologies in beekeeping, according to the results obtained and the factors that influence them, can provide the basis of the strategy on which a future digitization in beekeeping would develop. Hence, the aim of our study is to test a model of a unified evaluation system of the use of digital technologies in small and medium-sized bee farms (up to 1,000 beehives), by summarizing the information from the questionnaire surveys for each farm.

MATERIALS AND METHODS

Mathematical and statistical functions of the Microsoft Office Excel package were used to assess the digitization of the enterprise. Logical operators were also used when necessary.

Surveys

Surveys were conducted on 37 apiaries in the Pleven and Plovdiv municipalities where the most of the apiaries in the country are located. The data collected concerned the number of hives in the apiary, the age of the staff, what digital products they know for collecting, storing and transferring information, whether they currently use them and, if not, whether they intend to use them in the future.

Development of a mathematical model to assess the level of digitization of a bee farm

The structure of an enterprise in beekeeping, as in most other production enterprises, generally includes 5 departments that perform different independent functions (logistics, consulting, production, administration and sales). The need for digitization is evident for every department in the enterprise, due to the requirement for continuous transfer of data between different departments for more efficient management and quick decision-making when critical situations arise. We have chosen a 6-point digitization scale as a model for assessing the degree of digitization (Table 1).

The digitalization model of the apiary can be represented as a one-line matrix, with the coefficients in each cell representing the level of digitalization for the corresponding department.

$$(a1 \quad a2 \quad a3 \; a4 \quad a5) \qquad .... \quad (1)$$

In the model that we propose, the degree of digitalization is presented in %, as each of the departments in the enterprise (respectively, each of the coefficients in the matrix) participates with an equal share compared to all the others and is % of the maximum possible digitalization estimate. Since the enterprises have different degree of production volume, it is quite possible, especially for smaller enterprises, that some of the departments are missing or their functions have been taken over by other departments.

Table 1. Evaluation table for the degrees of digitization of information and their code

Numerical code of the degree of digitalization	Available software and hardware products used as a marker for positioning in the corresponding degree of digitization of information
X	Missing unit
0	Lack of digitization - Does not use software and hardware applications
1	Availability of specialized simplified software for data processing and storage - excel/access file, which is used to store information
2	Transfer of data by using the possibilities of the Internet using e-mail to forward the accumulated information to another interested person within or outside the farm
3	Using passive Internet-based platforms (e. g. WordPress) where the accumulated information is uploaded, stored and/or displayed.
4	Using active Internet-based platforms (Gmail Spreadsheet, Dropbox and/or similar) where accumulated information is uploaded, stored and shared, enabling multiple accounts to work simultaneously on the same work document.
5	Using cloud-based software platforms serving all available primary documentation and storing all available information on farm activities. It can use both a cloud space rental/hosting service and its own private cloud.
6	Full automation and digitization of the farm - lack of subjective factor in the collection, processing and transfer of information.

Source: Authors' original model.

We have tried that the absence of departments does not affect the degree of digitization of the enterprise. For example if the presented model is missing two of the departments out of the possible maximum of 5 departments, the degree of digitization will only be estimated for the existing 5 – 2 = 3 departments. Mathematically, this can be expressed as follows:

$$S = 100 \times \sum_{i=1}^{n} \frac{a_1 + \cdots + a_n}{a_{max} \times n} \quad \text{..................(2),}$$

where:
S - degree of digitization of the entire model expressed (%);
a - degrees of digitization for the corresponding department;
a_{max} maximum possible degree of digitization (in our case 6);
n - existing number of departments in the enterprise.

An example of the assessment of the degree of digitization for an apiary is shown in Table 2. In the table, the numerical value is an estimate of the corresponding degree of digitization, the letter x means that the relevant department does not exist as a structure in the enterprise and the last cell on the right is the total estimate of the degree of digitization for the entire apiary.

Table 2. Example model of estimation of the digitalization in the apiary apiary

Departments	**L**	**C**	**P**	**A**	**S**	**TEDL**
Estimates	x	4	0	6	5	62.50%

Legend: L-Logistics, C-Consultancy /R&D, P-Production, A-Administration, S-Sales, TEDL-Total estimation of the Digitalization Level
Source: Authors' original model.

RESULTS AND DISCUSSIONS

Table 3 shows the results of surveys carried out on the degree of digitization of 37 apiaries located in the Pleven and Plovdiv regions. The results showed a low level of digitization of the studied apiaries.

Table 3. Total estimation of the digitalization level in the apiaries

№	Association	Apiary code	Age	Number of beehives	Degree of digitalization according to the departments					TEDL
					L	C	P	A	S	
1	Plovdiv	2	57	10	0	0	0	0	0	0.00%
2	Plovdiv	1	55	10	0	0	0	0	3	10.00%
3	Plovdiv	9	60	10	0	0	0	0	0	0.00%
4	Plovdiv	3	55	50	0	0	0	0	0	0.00%
5	Plovdiv	11	35	50	5	5	5	5	5	83.33%
6	Plovdiv	6	32	100	0	0	0	0	0	0.00%
7	Plovdiv	7	37	100	0	0	0	0	3	10.00%
8	Plovdiv	10	40	100	0	0	0	0	0	0.00%
9	Plovdiv	8	47	100	0	0	0	0	0	0.00%
10	Plovdiv	4	45	200	0	0	0	0	3	10.00%
11	Plovdiv	5	28	200	0	0	2	0	3	16.67%
12	Plovdiv	15	55	200	0	0	0	0	0	0.00%
13	Plovdiv	16	50	200	0	0	0	0	0	0.00%
14	Pleven	19	65	10	0	0	0	0	0	0.00%
15	Pleven	16	52	10	0	0	0	0	0	0.00%
16	Pleven	14	70	10	0	0	0	0	0	0.00%
17	Pleven	12	44	10	0	0	0	0	0	0.00%
18	Pleven	21	48	50	0	0	0	0	0	0.00%
19	Pleven	20	55	50	0	0	0	0	0	0.00%
20	Pleven	18	55	50	0	0	0	0	0	0.00%
21	Pleven	17	51	50	0	0	0	0	0	0.00%
22	Pleven	13	62	50	0	0	0	0	0	0.00%
23	Pleven	11	33	50	0	0	0	0	0	0.00%
24	Pleven	15	42	100	0	0	0	0	0	0.00%
25	Pleven	3	66	100	0	0	0	0	0	0.00%
26	Pleven	14	41	200	0	0	0	0	3	10.00%
27	Pleven	10	63	200	0	0	0	0	0	0.00%
28	Pleven	9	62	200	0	0	0	0	0	0.00%
29	Pleven	8	50	200	0	0	0	0	0	0.00%
30	Pleven	7	44	200	0	0	0	0	3	10.00%
31	Pleven	6	60	200	0	0	0	0	0	0.00%
32	Pleven	13	45	200	0	0	0	0	0	0.00%
33	Pleven	12	40	500	0	0	0	0	0	0.00%
34	Pleven	5	26	500	5	4	5	5	3	73.33%
35	Pleven	4	30	500	0	0	0	0	0	0.00%
36	Pleven	2	33	500	4	4	4	4	3	63.33%
37	Pleven	1	38	1000	0	0	2	0	3	16.67%
Mean:			47.86	169.46	0.378	0.351	0.486	0.378	0.865	8.20%

Legend: L-Logistics, C-Consultancy /R&D, P-Production, A-Administration, S-Sales, TEDL-Total estimation of the Digitalization Level

Source: Authors' original model.

Only 10 out of a total of 37 studied apiaries declared that they were currently using digital products for collecting, storing and transferring information. The overall estimate for the level of digitization according to our model is 8.20%. In our opinion, one of the main reasons for this low value, is that a large number of beekeepers are afraid to invest in applications, partly because of ignorance, partly because they estimate the costs as unprofitable. Attempts to evaluate the cost have been made by Zacepins et al. [14], who estimated their Raspberry Pi-based system for monitoring of 20 colonies at US$140. Another Raspberry Pi-based system with audio and video surveillance costs US$106 [5]. In their case, the system was placed in an urban area where internet and power were available via cables. In another study [1] it was found that a weight, temperature, and humidity data collection system was estimated to cost about US$35 per beehive, with Wi-Fi access. These costs are relatively high and the owners of the smaller apiaries prefer to save them.

The analysis of the digitization by departments showed that the Sales and Production sectors have the highest degree of digitization. This is not surprising, since the first is directly related to the realization of the products, and the second is decisive for the protection of the health of the bee colonies, and usually the investments are directed preferentially in these two sectors. In the surveys, we examined several factors affecting the degree of digitalization, the first being the number of beehives. We found that as the number of hives increased, the degree of digitization also increased and reached over 30% for apiaries with more than 300 hives, which is almost 4 times more than the average level (Fig.1). This is in agreement with another study [6], showing that small business representatives were less inclined to invest in digitization.

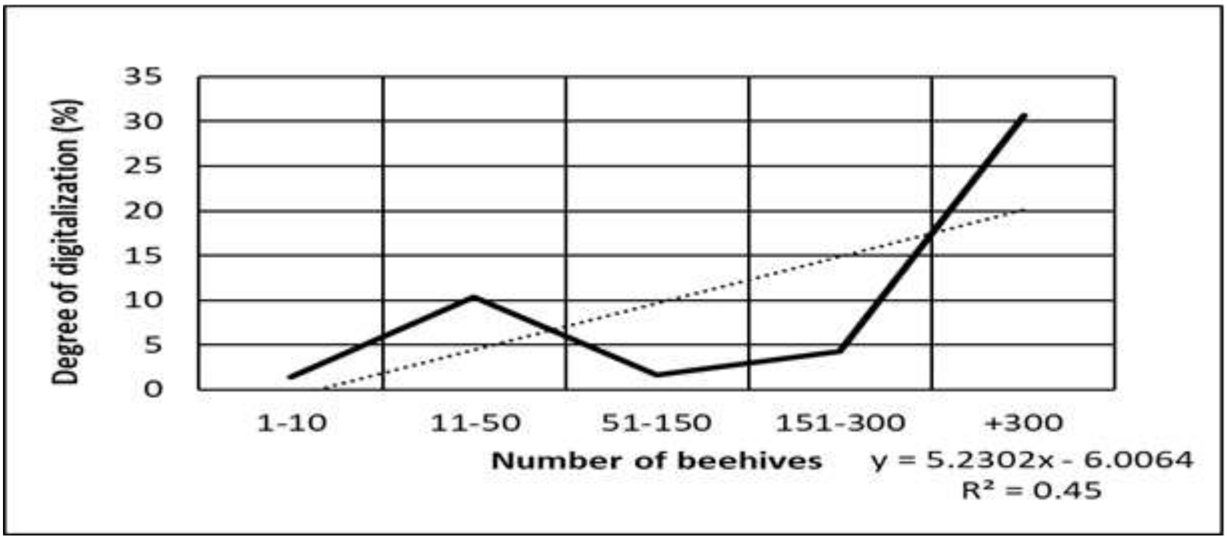

Fig. 1. Relationship between the degree of digitization on the number of hives in the apiary
Source: Authors' original model.

The second investigated factor was the age of the apiary owners. Expectedly, younger beekeepers up to the age of 40 were more likely to use digital products in the management of apiaries. The reasons, on the one hand, are probably the higher awareness of the benefits of introducing modern technologies, as well as the expected longer period of return of the investments.

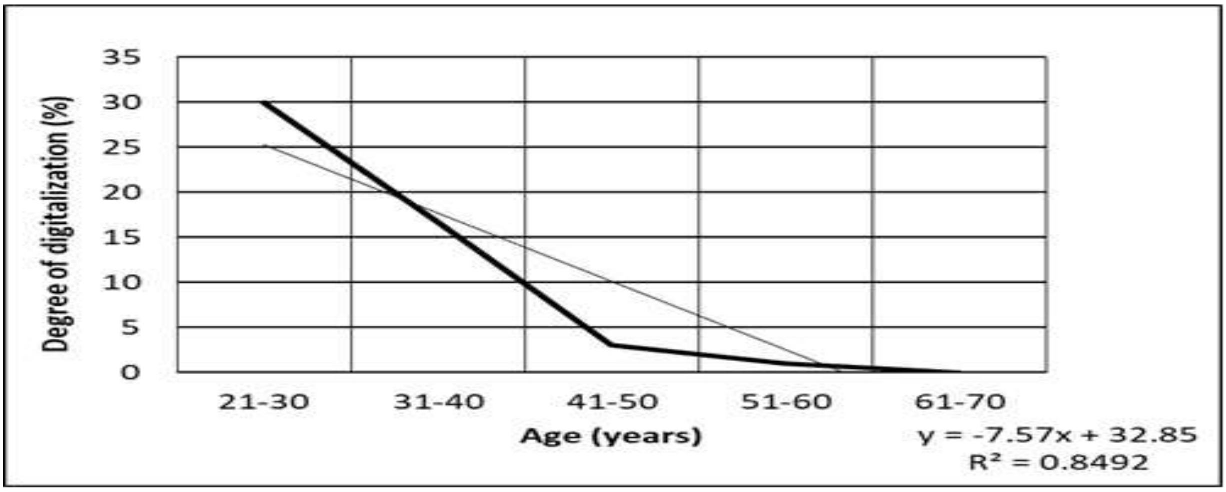

Fig. 2. Relationship between the degree of digitalization and the age of the beekeeper
Source: Authors' original model.

The survey also contained questions regarding the awareness of those employed in beekeeping regarding some basic digital products for processing, storing and transferring information. The results are presented in Table 4.

Table 4. Awareness of bee farm owners about some basic products for processing, storage and transfer of information

Awareness code	Digital products for information transfer					
	SHSP	Facebook	Wordpress	Google drive	Dropbox	CL
0	21.62%	29.73%	35.14%	35.14%	37.84%	29.73%
1	8.11%	18.92%	13.51%	5.41%	0.00%	5.41%
2	70.27%	51.35%	51.35%	59.46%	62.16%	56.76%
3	0.00%	0.00%	0.00%	0.00%	0.00%	8.11%

Legend: 0 – not informed about the product; 1-knows and used the product; 2 – Knows the product but does not use it and is not willing to use it; 3 – Knows the product, does not use it but is willing to use it; SHSP – Specialized hardware and software in the production; CL-Cloud based platform.
Source: Authors' original model.

It was found that between 21 and 35% of respondents were not familiar with basic digital products, which is a relatively high percentage. A far more worrying result is that between 50 and 70% of people stated that they were familiar with the listed digital products, but had no intention of using them in the near future. This is probably due to factors such as the high cost of the digital products, the unstable economic environment in recent years, the high risks of losing bee colonies and the level of awareness of the people participating in the surveys.

CONCLUSIONS

The results of the model we developed to assess the level of digitization of the beekeeping sector in Bulgaria showed low values within 8-9%. In 27 out of 37 studied apiaries, there was no data about the use of software and hardware applications for processing, storing and transferring information. The sample used in the study is small. However, we believe that the model largely reflects the overall picture of the beekeeping sector in animal husbandry, because the investigated apiaries according to the number of hives are in a large range from 10 to 1000. The prospects in the near future in this direction are not particularly favourable mainly due to economic reasons and the serious risks of dying bee colonies due to external factors.

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RESEARCH ON THE ADOPTION OF SOIL ANALYSIS APPLICATIONS IN AGRICULTURAL ENTITIES

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Abstract

The main purpose in agricultural production is to get the highest yield from the unit area. The prerequisite for obtaining high efficiency is the right fertilizer consumption. The basic element of obtaining the highest income from production is balanced fertilization. Factors such as the type, amount and time of use of the fertilizer directly affects yield. Thus, in order for the producer to use fertilization in a balanced method, it is necessary to give the soil an appropriate amount and type of fertilizer by making a soil analysis. This research aims to determine the tendencies of the producers in Bursa to have soil analysis performed. For this purpose, a face-to-face survey was conducted with 388 producers. The data obtained were analyzed and interpreted with SPSS 25.0. 38.9% of the producers are between the ages of 36-45. Educational status is only literate at the rate of 66.8%. According to the test results, 82.2% of the producers do not use soil analysis for their lands. It is seen that the producers who have soil analysis have the analysis done to learn the fertilizer need of the crop they will plant the most and they trust the results of the analysis. It has also been observed that the producers do not have sufficient information about soil analysis. This is due to the low level of education of the producers. The increase in the trainings that will raise the awareness of the producers and free soil analysis will encourage the producers to analyze. The main thing is that this factor, which directly affects production, such as soil analysis, should be made compulsory for all producers.

Key words*: *fertilizers, soil analysis, yield, agricultural production

INTRODUCTION

The most important aim of agricultural policies is to increase the efficiency in agricultural production. Sustainable methods are used to increase agricultural efficiency and ensure the continuity of production. Especially the increase in the population rate carries the agriculture sector to a more important position [3]. There is a linear relationship between the agricultural sector and the population. The increase in the population requires an increase in the yield obtained from the unit area. Agricultural production is very important not only for the agricultural sector, but also for other sectors. Along with a 1% increase in agricultural production, a 1.5% increase occurs in non-agricultural sectors [40].

Provided that all these conditions remain constant, the world population according to the United Nations; It is estimated to be 8.6 billion in 2030, 9.8 billion in 2050 [25] and 11.2 billion in 2100 [37]. The fact that the world population will increase at this level puts agricultural lands at risk [9]. For this reason, sustainable use of agricultural lands is at the top of the measures to be taken against population growth in the coming years [17, 29, 39]. In addition, the wrong and unconscious use of agricultural lands threatens the agricultural sector. Also, [28] pointed out the importance of systematic fertilizer application for preserving and/or increasing soil fertility, as a sustainable development measure.

Excessive fertilization, spraying and irrigation reduce soil fertility [1]. Fertilization and irrigation are the most effective factors that reduce the dependence of agricultural activities on natural conditions. For this reason, fertilizer production and consumption is one of the main signs of agricultural development of a country, as well as increasing the yield obtained from the unit area [23].

Fertilizer Use in Agriculture

Chemical fertilizers basically consists of three types: nitrogen (N), phosphorus (P) and potassium (K) [14,18]. Mostly nitrogenous chemical fertilizers are used in all countries, including Turkey. Since 1950, global fertilizer use has increased by 800% [30].

During agricultural production various damages are done to the environment [11]. Chemical fertilizers, in particular, is an issue that needs to be thoroughly planned and studied. Damages in agricultural production are not short-term, but long-term and permanent [3]. Excessive fertilizing pollutes the environment, soil, underground and surface waters and causes harmful accumulations in plants. If the fertilization is not used enough, the nutrients in the soil and the plant are reduced [24]. Doubling the amount of agricultural production activities until the 1990's is directly related to the 6.9 times increase in nitrogen fertilizers and 3.5 times the increase in phosphorus fertilizers [34].

It has been known since ancient times that productivity is increased by fertilization in plant production [4]. Despite this, the widespread use of chemical fertilizers in Turkey dates back to the 1970s [2]. Production and consumption of chemical fertilizers is quite problematic in Turkey. Therefore, contrary to the expected increase in product yield as a result of fertilization, environmental problems are observed [26]. Although the tendency of producers to use chemical fertilizers increases, their habits of making their own fertilizers reduce product yield and increase costs [8].

With the increase in industrial and agricultural production, pesticide, heavy metal and fertilizer residues in the soil are also increasing [10]. These residues in the soil are absorbed by plants over time and indirectly harm consumer health. In addition to human health, environment is also affected negatively, and plants and animals are also affected by this situation [41]. In order for the correct fertilization to take place, the type of fertilizer, the amount of fertilizer and the fertilizer content that the plant needs should be determined by soil analysis.

Table 1 shows the chemical fertilizer consumption data between 2015 and 2021 in Turkey. Consumption of nitrogen fertilizers is higher than phosphorus and potassium fertilizers. The year with the highest nitrogen fertilizer consumption is 2020, phosphorus fertilizers in 2016 and potassium fertilizers in 2021. The year with the highest total consumption of N-P-K is 2020.

Table 1. Chemical fertilizer consumption in Turkey by years (tons) (ten thousand)

Fertil-izer	2015	2016	2017	2018	2019	2020	2021
N	148.7	189.6	176.5	152.8	168.3	205.3	178.7
P	25.5	34.6	33.0	27.7	29.1	33.3	27.7
K	10.9	9.8	10.4	9.6	9.7	9.5	12.8
N-P-K Total	185.1	234.1	219.8	190.1	207.1	248.1	219.2

Source: [35].

Soil Analysis

Soil analysis is a method that shows which plant nutrients the soil needs by taking samples 1-2 months before planting or fertilizing [9,15]. The samples taken are analyzed in the laboratory. It has been proven by scientific studies that soil analysis provides many benefits to the producer, environment and economy [12, 19, 21, 27]. This analysis prevents unnecessary nutrient loadings to the soil, the plants are not fed poorly and the product quality is increased. Choosing the wrong type of fertilizer and using the fertilizer at the wrong time reduces the expected yield of the product [15]. In Taşpınar and Ertek [32], which studied the sustainability of soil and water usage of farmers in Konya province in Turkey, it has been observed that 100% of the farmers participating in the research conducted did not have soil analysis.

Producers are not sufficiently aware of the benefits of soil analysis. According to the research of Kucukkaya and Ozcelik [15] soil analysis in wheat production reduces costs and increases the income of the enterprise. Celik and Urhan [6] stated that many elements, especially N, P, K, are at low levels in their research in the Keles district of Bursa province. In the research, the results were obtained that the local producers did not have soil analysis and unconsciously consumed fertilizer.

There is no obligation for producers to have soil analysis. According to the research conducted by Guldal and Ozçelik [8] one of the reasons why producers do not have soil analysis is that they do not have to have an analysis done. Not being aware of the soil analysis subsidies, insufficient subsidies and not trusting the results of the analysis are among the other reasons for not having the analysis done.

In this research, it is aimed to determine the tendencies of the producers in Bursa to have soil analysis. Analysis that are directed by the data obtained from the farmers have been performed and the results were interpreted.

MATERIALS AND METHODS

Bursa province, which is the research area, is located in the northwest of Turkey and southeast of the Sea of Marmara. Bursa province is the 4th largest province of Turkey and its population was announced as 3,147,818 as of 2021 [35]. Bursa, which has a total area of 11,027 km^2, has 17 districts in total [5,16]. Bursa has a very high agricultural potential. Agricultural soils have high pH and lime and low organic matter contents [36]. Within the scope of the research, a face-to-face questionnaire was applied to 388 farmers in the rural areas of Bursa province Keles and Orhaneli.

While preparing the survey questions, previous studies on similar topics were examined and the questions were adapted to the current research. The prepared questionnaire was tested by conducting a pilot study with a focus group of 12 people. Data from farmers participating in the pilot study were not included in the study. In the research, primary data was obtained from producers in March and April 2022 and statistical data from the Ministry of Agriculture and Forestry were used. The data than was analyzed with SPSS 25.0. In order to test the reliability of the research data, Cronbach's Alpha analysis was performed and α=0.82 was obtained. Research data is in the high reliability group [33]. Frequency analysis and Chi-square test were used in the analysis of the data.

The following formula was used to calculate the sample size (n).

$$n = [z^2 * p * (1 - p) / e^2] / [1 + (z^2 * p * (1 - p) / (e^2 * N))]$$

For 95% confidence level (α), z = 1.96, p = ratio (expressed as decimal), N = population size, e = margin of error [7, 20].

z = 1.96, p = 0.5, N = 3,147,818, e = 0.05 n = [1.962 * 0.5 * (1 - 0.5) / 0.052] / [1 + (1.962 * 0.5 * (1 - 0.5) / (0.052 * 3,147,818))] n = 384.16 / 10,001 = 384.113, and 388 people were surveyed in the research.

RESULTS AND DISCUSSIONS

In this part of the research, the data obtained from the producers and the analysis results are included. The results of the analysis were compared with the results of the previous researches.

Demographic indicators

When the demographic data of the producers are examined, 38.9% are in the 36-45 age range and 29.9% are in the 56-65 age range. The ratio of producers with 3-5 people in the household is 47.6% and 34.6% for those with 6-8 people (Table 2).

Table 2. Demographic indicators

Age	**N**	**%**
25-35	39	10,1
36-45	151	38,9
46-55	56	14,4
56-65	116	29,9
65+	26	6,7
Total	338	100,0
Household size	N	%
1-2	24	6,2
3-5	185	47,6
6-8	134	34,6
8+	45	11,6
Total	388	100,0
Education	N	%
Literate	259	66,8
Primary Education	75	19,3
High School	37	9,5
University	17	4,4
Total	388	100
Marital Status	N	%
Married	341	87,9
Single	47	12,1
Total	388	100,0

Source: Own results.

When the marital status is examined, the number of married producers is 341 and the number of single ones is 47. Majority of the producers (66.8%) are only literate, 19.3% are primary school graduates and 4.4% are university graduates.

Table 3 shows the Chi-square test results for the status of producers having soil analysis and their agricultural production areas.

Table 3. Status of producers having soil analysis

Agricultural production area (da)	Soil Analysis			**Chi-Square (X^2)**
	Yes	No	Total	
20	16	22	38	56,270
21-50	8	134	142	
51-100	22	133	155	
101-200	15	23	38	
201+	8	7	15	
Total	69	319	388	

Source: Own results.

According to the results of the chi-square test, the relationship between the groups was significant at the p=0.006, p<0.05 level. 134 of the producers with an agricultural production area of 21-50 decares and 133 of the producers with an agricultural production area of 51-100 decares do not have soil analysis. Of the 15 producers with a production area of 201 da and above, 8 have soil analysis and 7 do not. Regardless of the size of the agricultural production area, 82.2% of the producers do not have soil analysis. It is thought that it is unnecessary to have soil analysis done due to both the education level of the producers and their traditional approaches.

Kart and Gul [13] stated that only 10.4% of the producers they interviewed had regular soil analysis. They have determined that there is a positive relationship between the size of the farm and the soil analysis of the producers. As the size of the enterprises increases, the rate of soil analysis also increases. In the current study, there is no relationship between the increase in the size of the farm and the situation of having soil analysis. It is thought that the different results obtained between the studies are due to the difference in the number of samples. In the research of Uyak and Dogan [37], 74% of the producers do not have soil analysis. 67% of those who have a soil analysis have a soil analysis only once every 3 years. 80% of the producers stated that the tools and equipment used were not sufficient. In Ozden et al., [22] research, only 15.63% of the enterprises have soil analysis done.

According to the results of the research, one of the reasons why the enterprises have such a small percentage of soil analysis is that the laboratories are established in urban areas. For this reason, producers are not willing to have soil analysis. The rate of soil analysis in all studies is quite low. Although that are many studies that soil analysis increases product yield, producers do not have soil analysis.

Table 4. Reasons of producers for soil analysis and their trust in the results

Reasons for soil analysis	**Producers trust in the results**			**Chi-Square (X^2)**
	Yes, I trust the results	No, I don't trust the results	Total	
To get diesel-fertilizer support, due to obligation	21	4	25	18,661
To find out the fertilizer requirement of the crop that will be planted	37	7	44	
Total	58	11	69	

Source: Own results.

Chi-square test was applied to determine the reasons of the 69 producers who had soil analysis and whether they trusted the soil analysis results. According to the chi-square test, the relationship between the groups was significant at the p=0.001, p<0.05 level. As a result of the test, it was determined that the producers who had soil analysis performed both because of the necessity to get diesel-fertilizer support and to learn the fertilizer need of the product they would plant, trusted the soil analysis results.

Tanriverdi and Celik [31] in their research, determined that 90.48% of the farms that they have interviewed have had soil analysis done. It was stated that 85.71% of these farm enterprises had soil analysis after the subsidies have been offered and 54.76% of them reported increased yields after soil analysis. The rate of farms suggesting soil analysis to other businesses is 52.6%.

Yuzbasioglu [42] stated that only 23.82% of the producers benefit from fertilization subsidies and the reason for having soil analysis is to benefit from these subsidies. The reason for the low number of producers benefiting from the subsidy is that they are not aware of these government subsidies. The reasons for the producers who did not have soil analysis done was mainly because they rely on their own experience, their land is small and they do not know how to take soil samples.

In the studies that were examined, it is seen that the producers are not aware of the subsidies and soil analysis. Similar results were obtained in the present study. Also this study shoes that producer that have soil analysis trust to the results of the analysis. Thus, producers should be made more aware of the benefits of soil analysis and the subsidies offered.

CONCLUSIONS

Agriculture is a sector that faces many risks and uncertainties. In addition to these risks and uncertainties, the uncontrolled production of products reduces product yield and causes irreversible damages to the environment. For this reason, the nutrients needed by the soil should be determined before production and production should be made in this direction. Soil analysis helps determine the current situation of the soil and the plants and what they need for a healthier and sustainable production cycle. In this study, it has been aimed to determine the status of the producers in Bursa province to have soil analysis.

According to the results of the research, only 17.8% of the producers have had soil analysis performed. Producers who had soil analysis, on the other hand, stated that they trusted the results of the soil analysis. In this case, producers rely on soil analysis but do not have a deterrent to analyze. Manufacturers, who see analysis as unnecessary, continue with the production method they are accustomed to and oppose innovations. The main reason for this situation is the low level of education of the producers. Soil analysis should become mandatory for all producers. Producers consider soil analysis to be costly. In addition, they consider soil analysis unnecessary because they rely on their own experience.

In many studies, it has been stated how much the world population will increase in the future. Research shows that the needs of the population in the coming years can only be met with sustainable systems. Despite the daunting results of the researches, agricultural lands are still not adequately protected today. The inadequacy of the measures taken at present is also obvious. In particular, policy makers need to take measures to protect agricultural lands and encourage correct fertilization. In this direction, free soil analyzes will enable producers to use the right fertilizer at the right time and in the right amount.

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FARMERS WATER USAGE PREFERENCES AND THEIR ATTITUDE TOWARDS EXCESSIVE IRRIGATION

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Abstract

One of the biggest risks that the world will face by 2050 is water scarcity. This problem is not only the main problem of underdeveloped and developing countries, but also of developed countries. Considering that the agricultural sector uses 70% of the global fresh water drawn from rivers, lakes and other sources, water waste in agricultural areas should be prevented and water should be used effectively. This research aims to determine the water usage preferences of the producers in the agricultural sector where water usage is the highest. For this purpose, a face-to-face survey was conducted with 412 producers residing in the rural areas of Bursa, Turkey. The data obtained as a result of the survey were analyzed with SPSS 25. 0. When the analysis results are examined; It is seen that 36.2% of the producers determine the amount of water they will use for irrigation according to their estimations, they have very little (50.2%) information about the useful water capacity of the soil, and 47.8% do not use drip irrigation, but they plan to use it. Although studies have been carried out to prevent water waste, the expected benefit has not been achieved. Extension service should be provided to the producers that excessive irrigation does not increase the yield.

Key words: *water use, producer preferences, water scarcity, drip irrigation*

INTRODUCTION

Water is one of the most important natural resources that living things need to survive [12]. People settled and lived in areas where they had access to throughout them. Water is a renewable resource and not infinite [37].
The negative effects of climate change are becoming more evident day by day. Changes in precipitation cycles, permanent droughts [7, 22] and more frequent natural disasters cause irreversible damage to water sources [36]. These problems occurring in water resources directly affect other resources [43]. These increasing symptoms also have negative consequences in agriculture, which is a main sector [17]. Problems such as climate change and drought, which have natural results, require more efficient use of water used in agriculture [8]. Research performed on the subject does not offer encouraging scenarios for the future. Therefore, water management in agriculture is a very important issue [7]. Kara and Yereli [17] stated in their research that consumer behaviors should be analyzed in subjects such as water management, food safety and nutrition in order to determine the impact levels of climate change on sectors.
According to the research conducted by the United Nations Economic Commission for Europe (UNECE) in 2020, with the rapid increase in population in 2050, the demand for food will increase by 50% , the demand for water by 55% [18] and the energy demand by 80% [35]. FAO reported that agricultural lands are an important issue in terms of global environmental change and food supply problems [11] These resources must be protected in order to meet the basic vital needs of people [1, 30]. States are responsible for preserving, developing water resources and also for distributing these to individuals [4]. The priority for the use of water can be ranked as; drinking-consumption, necessity for animals to survive, use in agricultural areas, use in energy and industry, use in trade, tourism and fishing [2].
70% of the world's water is used in agriculture [13, 26, 27, 39]. Since the global climate crisis directly affects the agriculture sector,

the rate of water used in agriculture is increasing [14]. In this case, the distribution of water between sectors also differs. In addition to the climate crisis, the unconscious use of water is another factor that causes the water crisis [42]. The use of wrong irrigation systems, technological inadequacies, transmission and distribution problems and infrastructure problems increase the waste of water [4]. Turkey is located in the semi-arid/semi-humid middle latitude region. As in other countries in this region, sometimes arid climate is seen periodically, and sometimes humid climate characteristics are observed [21, 29]. Agricultural production in arid and semi-arid areas is directly dependent on water [9]. The precipitation rate is not high. Therefore, the amount of water used in agriculture should be used adequately and effectively [10].

Table 1. Amount of water withdrawn from Turkey's water resources and usage areas (billion m3/year, %)

Years	2012	2014	2016	2018	2020
Irrigation	41.55	35.85	43.06	43.95	44.0
Thermal power plants	6.40	6.53	8.61	7.87	8.28
Municipalities	4.94	5.23	5.83	6.19	6.49
Manufacturing industry	1.79	2.20	2.12	2.68	2.60
Villages	1.04	0.43	0.38	0.39	0.42
Mining	0.11	0.21	0.23	0.24	0.27
Organized industrial zones	0.14	0.14	0.15	0.16	0.18
Total	55.96	50.59	60.38	61.48	62.24

Source: Ministry of Environment, Urbanization and Climate Change, 2022 [28].

When the water usage areas in Turkey are examined (Table 1), it is seen that agricultural irrigation has the highest share like other developing countries. In the agriculture sector, 1% savings amount corresponds to 6.6% water consumption in industry and 4.9% in drinking water consumption [41].

Excessive Irrigation and Water Holding Capacity of the Soil

Farmers do not have enough information about the relationship of the plant with water and soil. Excessive use of water does not only harm the plant, but also has negative effects on the environment. Farmers who do not have enough information tend to use excessive water as they are traditionally accustomed to [10]. There are some factors that should be considered in order to determine the correct irrigation method. Determining the properties of the soil is one of these factors. Soil analysis is very useful to determine soil structure and needs [40].

[16] stated in their study that half of the agricultural lands of Osmaniye province contain high levels of Na, and therefore salinization is observed in the soil, while the remaining soils have low levels of P. According to the research, balanced fertilization and drip irrigation system should be used in agricultural soils in this region. Drip irrigation system is seen as superior to other irrigation systems [6], due to the fact that it can irrigate large areas with limited water, its water application efficiency is high, it requires less labor, and it needs low energy [7]. In addition, weed, disease and pest reproduction rates are low in drip irrigation method [15].

The water holding capacity of the soil is very important in order to store the water in the soil and to provide the water needed by the plant [31]. Water holding capacity is defined as the difference between field capacity and wilting point [24]. Organic materials are components that bind the grains in the soil, reveal nutrients to plants, and control the movements of water in the soil. In this way, the water holding capacity of the soil also increases. The effect of organic materials on increasing the water capacity of the soil is not effective in increasing the water resources [38].

MATERIALS AND METHODS

This research was carried out in Bursa province in June and July 2022. Bursa province is Turkey's 4th largest city and is located in the south of the Marmara region. As of 2021, the population of Bursa was announced as 3,147,818 [34]. Research data were obtained by using face-to-face survey method with 412 producers.

The research consists of two parts. In the first part, previous studies were examined and the literature part of the research was formed. In the second part, analyzes were made using the research data and the results of the analysis

were interpreted. Necessary literature research was carried out while forming the survey questions. While some of the questions were taken from previous studies, the rest were prepared uniquely for this study. The prepared survey questions were finalized by pre-interview with 15 people and approved by an expert academician. The obtained data were analyzed with SPSS 25.0 (Statistical Package for the Social Sciences). Frequency analysis and Chi-square test were used in the analysis of the data.
The following formula was applied to obtain the sample size [23, 32]:

$$n=(z)^2 p(1-p)/d^2 \quad (1)$$
$$n=(1.96)^2/(4(0.05)^2)=384.16$$

n: sample size,
z: level of confidence according to the standard normal distribution (for a level of confidence of 95% (1.96),
p**=** sampling proportion (0.5),
d**=** tolerated margin of error (0.05)

When the above formula is applied, the 412 participants in the current study has been deemed to be sufficient.

RESULTS AND DISCUSSIONS

In this part of the research, the demographic characteristics of the producers, their knowledge about irrigation, their knowledge about over-irrigation and soil capacity were analyzed. Analysis results were analyzed and compared with previous studies and interpreted.
Table 2 shows the demographic information of the producers. When this information is examined, it is seen that the producers are mostly between the ages of 36-45 and their marital status is married. The number of households of 133 producers is 6-8 people. When the farmers' education levels were examined, it is seen that 274 people can only read and write. According to agricultural production data, 34.5% of the producers have been producing for 6-10 years and 40.3 % of the producers stated that their production areas was between 51-100 decares.

Table 2. Demographic information of producers

Age	**N**	**%**
25-35	40	9.7
36-45	156	37.9
46-55	62	15.0
56-65	126	30.6
66+	28	6.8
Total	412	100
Household size	**N**	**%**
1-2	26	6.3
3-5	129	31.3
6-8	133	32.3
8+	124	30.1
Total	412	100
Education	**N**	**%**
Not literate	10	2.4
Literate	274	66.5
Primary school	81	19.7
High school	39	9.5
University	8	1.9
Total	412	100
Marital status	**N**	**%**
Married	363	88.1
Single	49	11.9
Total	412	100
Experience in agriculture	**N**	**%**
1-5	51	12.4
6-10	142	34.5
11-20	104	25.2
21+	115	27.9
Total	412	100
Arable area owned	**N**	**%**
1-20	41	10.0
21-50	148	35.9
51-100	166	40.3
101- 200	41	10.0
201+	16	3.8
Total	412	100

Source: Own results.

In Table 3 producers' knowledge about irrigation can be seen. Regarding irrigation, 267 of the producers who received technical information support from agricultural engineers stated that they rarely consulted for support and 298 of them stated that they did not attend any seminar or meeting on irrigation and fertilization.
Producers get information about irrigation mostly from provincial and district agriculture directorates (40.7%) and television programs (31.3%).
More than half of the producers can only read and write. The low level of education prevents them benefiting from more information channels.

Table 3. Information status of producers about irrigation

Status of receiving technical information support on irrigation	**N**	**%**
Yes	97	23.5
Very rare	267	64.8
No	48	11.7
Total	412	100
Status of participation in training meetings on irrigation	**N**	**%**
Yes	114	27.7
No	298	72.3
Total	412	100
Information sources about irrigation	**N**	**%**
Provincial Directorates of Ministry of Agriculture and Forestry	168	.
Private institutions	17	
From journals/books about agriculture	98	
TV Programs	129	
Total	412	
Method for determining the amount of water	**N**	**%**
Checking the moisture at the roots	132	32.0
Calculation	131	31.8
Estimation	149	36.2
Total	412	100
State of knowledge about the water holding capacity of the soil	**N**	**%**
Yes	74	18.0
Very little	207	50.2
No	131	31.8
Total	412	100
Drip irrigation usage	**N**	**%**
Yes	97	23.5
No but I'd like to	197	47.8
No because it's expensive	101	24.5
Hard to manage	17	4.2
Total	412	100

Source: Own results.

36.2% of the farmers determine the amount of water used for watering the field according to their estimates. The producers, who are afraid to change their habits from the past, make irrigation according to their own wishes. The number of producers who have information about the water holding capacity of the soil is 74. 207 manufacturers have very little information. There are 97 producers using the drip irrigation method. On the other hand, 197 producers stated that they did not use it, but that they intend to use it in the future. 101 producers do not use drip irrigation because it is expensive. [3] concluded in their research that 63% of the farmers prefer the drip irrigation method because it is easy. [25] stated in their research that the initial installation of the drip irrigation system is costly, but it increases fruit yield from the first year.

Manufacturers do not abandon the traditional production methods they have adopted and see new production systems as unnecessary costs. Although it is known that the drip irrigation system increases the product yield, the producers still do not prefer this system. For individuals who spend their free time mostly in coffeehouses, the trainings to be given here and the information to be published in mass media such as television will be beneficial.

Table 4. Excessive irrigation conditions of producers

The situation of using the appropriate irrigation method	**Producers belief that more irrigation causes more yield**						**Chi-Square (X^2)**
	Yes		No		No idea		
	N	%	N	%	N	%	
Yes	179	83.6	89	65.4	38	61.3	86,797
No	35	16.4	47	34.6	24	38.7	
Total	214	100	136	100	62	100	

Source: Own results.

Table 4 shows the Chi-square test results of the questions "The more irrigation is applied, the more the belief in yield increase" and "The situation of using the appropriate irrigation method". According to the test results, 83.6% of the producers who have the perception that the more irrigation is done, the more the yield will increase, think that they are irrigating appropriately. The rate of those who do not have the perception that the more irrigation is done, the more yield will increase and think that they are doing proper irrigation is 65.4%.

Excessive irrigation in agriculture causes soil salinization and erosion as well as reducing crop yield. Producers are not aware of the adequacy of their irrigation. [19] stated in their research that producers do not pay the real cost of the water they use and therefore they tend to over-irrigate. 31.1% of the producers participating in the research believe that excessive irrigation increases the crop yield. According to [5] research, producers commonly believe that over-irrigation will increase yields.

For this reason, much more water is used than is needed. In the studies reviewed, it is seen that there are similar results with the current study.

Although the studies are in different regions, producers have a similar perception towards water use.

Table 5 shows the Chi-square test results of "Knowledge about the water holding capacity of the soil?" and "Having knowledge about the harms of watering the soil too much?". According to the test results, only 17 of the producers who have knowledge about the useful water capacity of the soil think that adding too much water to the soil is harmful. 66.3% of the producers, who have little knowledge about the useful water capacity of the soil, state that giving too much water to the soil is partially harmful. According to the research of [33], 59% of the producers do not have information about the water holding capacity of the soil. The rate of those with very little knowledge is 4%. Producers do not have enough information about the amount of water their soil needs.

Table 5. Information status of producers about soil capacity

The state of having knowledge about the harms of watering the soil excessively	Knowledge about the water holding capacity of the soil						Chi-Square (X^2)
	Yes		Very little		No		
	N	%	N	%	N	%	15,083
Yes	17	22.9	25	12.1	17	13.0	
Partially	49	66.3	117	56.5	73	55.7	
No	8	10.8	65	31.4	41	31.3	
Total	74	100	207	100	131	100	

Source: Own results.

They should be informed about the damages caused by excessive irrigation not only to the crop but also to the soil and the environment. The measures that will be taken are very important in reducing water scarcity, which is one of the most important problems of the future [20].

[8] in their research, farmers were asked whether over-irrigation is harmful, and 61% of the farmers answered that over-irrigation is not harmful. In the same study, it was stated that the scarce water resources in the region should be used more efficiently and water should not be given more than the water holding capacity.

Similar results were obtained in the present study in comparison with the studies reviewed. Producers do not use water resources effectively and water waste continues in the agricultural sector.

CONCLUSIONS

All of the future research about the subject focuses on water scarcity and the negative consequences that will occur with it. Water scarcity, which poses a great threat to future generations, shows its effects today as well. Despite this, water waste continues in the agricultural sector, where water use is the highest. This unconscious use of water in the agricultural sector also poses a risk to other sectors.

When the results of the analysis are examined, it is seen that the producers believe that the more they irrigate, the more yield they will get. Producers are not aware of the damage caused by excessive irrigation and think that they use the most appropriate irrigation. In addition, producers who believe that excessive watering of the soil is not harmful, do not have enough information about the water holding capacity of the soil.

The education level of most of the producers is literate. The number of producers with a high level of education is quite low. For this reason, it would be useful to provide information about irrigation systems in the mass media that producers follow. Producers often spend their free time in coffee houses. Trainings and informing in coffeehouses are more efficient for producers. Producers who think that excessive irrigation will increase the yield are not aware of the damage they cause to the environment. Although it has been determined in many studies that the use of water at the required rate increases the efficiency, producers do not prefer systems that provide sufficient water use, such as drip irrigation. The research was carried out within the borders of Bursa province, located in the south of the Marmara region. The region is an important region in terms of Turkey's agricultural potential, as well as one of our leading provinces in terms of education level.

The current research, if applied more comprehensively in other geographical regions, will shed light on establishing a model for Turkey.

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AGROPHYTOCENOTIC RELATIONSHIPS OF CULTIVATED AND WEED PLANTS AT THE LEVEL OF COMPETITION AND ALLELOPATHY

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Abstract

The purpose of the research is to study the relationship between cultivated and weed plants at the level of competition and allelopathy, which will allow us to substantiate a systematic approach to regulating the number of weeds. Species composition of weed vegetation was determined by an instrumental method. The number and biomass of weed plants were counted by the quantitative weight method of Vasilyev et al.(2005). Allelopathic properties of the most common weeds in crops were determined by the method of Grodzinsky (1965). As a result of this research it was found that on average rotational crops remove 103.6 kg/ha of nitrogen, 51.5 kg/ha of phosphorus, and 96.9 kg/ha of potassium. The main species of weeds of field crops remove 124.1, 12.9 and 18.9 kg/ha of nitrogen, phosphorus and potassium, respectively, mainly due to such species as Loliumtemulentum L., Galiumaparine L., Cirsiumarvense L., Ambrosia artemisifolia L. and Chorisporatenella (Pall.) DC. At the same time most of the studied species of weeds have high allelopathic activity. Particular attention should be paid to Loliumtemulentum L., since its grains have the fungus Stromatiniatemulenta, which produces the alkaloid temulin. In high concentrations it has an inhibitory effect on the germination of test-culture seeds. Thus, the growth index at the concentration of the tested solution 1:50 is 0.34, and at 5:50 – 0.16; similar indices were found under the action of Centaureacyanus L. and Taraxacum officinale L. This research suggests that winter wheat agrocenoses contains both allelopathically active species and species to which the plants are tolerant. This is of practical value since it allows a differentiated approach to the system of integrated weed control measures, in particular to the choice of herbicides aimed at destroying allelopathic active weed species. This study was aimed to study the relationships between cultivated and weed plants at the level of competition and allelopathy.

Key words: *field crops, weeds, allelopathic properties, competition*

INTRODUCTION

Weeds are an independent ecological group of plant origin. The source of weed vegetation is natural vegetation. Weeds have separated from natural vegetation by natural selection. As a result, many representatives of weeds have changed their biological features and become closer to cultivated plants. These changes have taken place under the influence of environmental conditions. Weeds need the same life factors as cultivated plants. Therefore, they are competitors of cultivated plants and drastically reduce yields [1, 6, 31].

Weed populations are almost ubiquitously present in the structure of agrocenoses, forming a total weed component with a specific species composition for each field as well as the number of individual weed species, the potential stock of their seeds and vegetative reproduction organs in the soil [23]. Formed in the process of the old land cultivation history, modern populations of weed plants have acquired a complex of well-known properties that allow them to successfully withstand intensive anthropogenic impacts. Consequently, the place of the weed component in the structure of agrophytocenosis is determined by natural, environmentally relevant laws [24].

The history of land cultivation shows that among the numerous natural phenomena that have a negative impact on agriculture, the most tangible in reducing the yield are weeds. As a result of competition with cultivated plants, weeds significantly affect the balance of nutrition elements, physical properties of soil, water-air, as well as heat and light conditions of agrophytocenosis.

The relationship between cultivated and weed plants in agrophytocenosis is formed at two levels. The first is competition in the struggle of plants for light, water and nutrients, and at a higher level, the biochemical mutualism of plants, which is called allelopathy [28, 3, 25, 2, 10].

Emphasized that despite the successful modification of weed management in Iran, more research is needed to further explore and test the best thresholds for each risk level in the weed population control matrix using more weed species [26].

Growing season during different stages of crop development weeds remove from the soil 2.7-14.8 kg/ha nitrogen, 2.2-20.1 kg/ha phosphorus, 6.7-39.0 kg/ha potassium, 1.7-4.5 kg/ha calcium and 0.9-3.1 kg/ha magnesium. The relationship of which nutritional elements were removed depended on the type of weed and its vegetative mass [22].

In field rotation the optimal system of weed control resulted in two times less weed infestation during three rotations and helped to decrease the amount of nutrients taken out by weeds: nitrogen by 4-6 times, phosphorus by 4.5-5.0 times, and potassium by 4.0-5.5 times. At the same time, the consumption of nitrogen increased by 23-25%, phosphorus by 20-23% and potassium by 17-21% [17]. According to Junusov, K.K. (2015) [15] in corn crops, the greatest removal of nutrients from monocotyledonous weeds came from *Echinóchloa crus-gálli L.,* andfrom the dicotyledonous plants *Matricaria perforate L.* and *Chenopodium album L. N*otes that weed plants are reservoirs of the most harmful species of parasitic nematodes. Data on the use of 112 insects, 3 fungi, 1 mite and 1 nematode as hosts established for biological weed control in Hawaii, the continental USA and the Caribbean show that the risk to local flora can be reliably estimated by plant introductions [20].

Found inhibitory effects of spring rape seeds on both seed germination and root development of *Sonchusarvensis L.* (by 46.1 and 75.7%, respectively) and *Convolvulusarvensis L* (by 21.2 and 92.8%, respectively). Seeds of weeds had an insignificant influence on the germinating ability of spring rapeseeds (84 to 93.7% decrease). The effect of glucosinolates and erucic acid in rapeseeds on the germination of weed seeds was not established. The obtained data allow us to speak about the complex allelopathic relationships between spring rapeseed and weed plants during joint germination in the form of negative influence at the biochemical level, which can be observed in natural communities as well [21].

[33] pointed out that different rates of mineralization of plant residues of weeds lead to the fact that the inhibitory allelopathic effect is more pronounced in the initial periods of transformation of plant residues in *Sonchus arvensis L.* and *Convolvulu sarvensis L.* Plant weeds of the Poacea family containing cellulose decompose at a slower rate and inhibit the test winter wheat crop after mineralization for 30 days [7].

Aspects of allelopathy can be used for practical purposes of weed control, and that allelopathic components of the rhizosphere can be studied more directly through plant genomics [4].

Similar data are described by [11, 13, 27].

In modern agriculture our understanding and views of the role of weeds in agro-ecosystems are changing. The focus has been on "destruction" and "eradication". However, this is being replaced by the concept of regulating the number of weeds. This concept is based not only on the threat of increasing pollution of agro-ecosystems with herbicides, but also the consideration that weeds are a threat not due to their species diversity or presence in the crop, but by their high numbers. Therefore, instead of costly and virtually unrealistic elimination of weeds, it is more economically feasible to prevent their mass growth and reduce their numbers to a safe level.

Developed a biological method of accelerated suppression of weeds under forest belts based on creating an agrosteptic cover under them - an analogue of floristic rich steppe (meadow) phytocenoses - with extremely saturated axes of ecological niches with perennial virgin grasses, whose competitive power for food elements, moisture and light is significantly higher than that of weeds [9].

According to Mazirov and Arefieva (2014) [18] the content of phenolic substances in the rhizosphere of both annual and perennial weed species (Cirsiumarvense, Sonchusarvensis) increases when tillage is minimized. Boreshnavard (2017) [5] noted that a bean planting scheme can significantly reduce weed populations. Demirak (2018) [8] studied the effect of using olive mill waste and thyme oil for weed control in sequential extraction of Cd, Zn and Cu into the soil as an alternative to herbicides.

Ivashov (2016) [14] recommended the following species of weed plants for biogeochemical monitoring of agroecosystems in terms of their pollution with heavy metals under the conditions of Priamurye: *Amaranthus albus L., Menthaarvensis L., Matricāriachamomīlla L., Sonchusoleraceus L., Polygonumlapathifolium L.,* and *Trifoliumhybridum L.*

This research studied the relationships between cultivated and weed plants at the level of competition and allelopathy, which will make it possible to substantiate a systematic approach in the regulation of weed numbers. In modern agriculture our understanding and views of the role of weeds in agro-ecosystems is changing. The concept of "eradication" and "elimination" is being replaced by the concept of weed control. The basis for this concept is not only the threat of increasing pollution of agro-ecosystems with herbicides, but also the consideration that weeds are a threat not because of their species diversity or presence, but because of their high numbers. Therefore, instead of costly and virtually unrealistic weed eradication, it is more economically viable to prevent weeds from massive spreading and to reduce their numbers to a safe level. In our opinion, the study of allelopathic interactions between cultivated and weed plants can make a significant contribution to the rational regulation of the number of weed plants and the development of rational measures to control them.

MATERIALS AND METHODS

The research was conducted under conditions of the unstable moisture zone of the Central Caucasus in a perennial stationary experiment in eight-field grain-plough rotation with the following crop rotation: pea-oat mixture (fallow) - winter wheat - winter barley - corn for silage - winter wheat - pea - winter wheat - sunflower during 2002-2020. The total area of the plot was 108 m², and the recorded area was 66 m². The experiment was repeated three times. The total area of the experimental plot was 6.4 ha. Mechanical treatment consisted of disk hoeing, no-tillage and cultivation. Pesticides were used for pest control.

In the experiment the following measurements were made: under field conditions plant samples were taken and nutrient removal was determined, under laboratory conditions the allelopathic activity of cultivated and weed plants taken at the flowering phase was determined and the growth index was calculated.

Species composition of weed vegetation was determined by an instrumental method. The number and biomass of weed plants were counted by the quantitative weight method of Vasilyev *et al.*(2005) [12].. Allelopathic properties of the most common weeds in crops were determined by the method of Grodzinsky (1965) [32]. The roots and the above-ground parts (stems + leaves + inflorescences) of weeds were crushed separately and kept for 24 hours at room temperature in a 1:10 water to weight ratio (10 g of weeds per 100 ml of water). Twenty winter wheat seeds were placed in Petri dishes with filter paper, pre-soaked in distilled water for 2 hours. The filter paper was moistened with equal amounts of weed extracts. Seeds which germinated on water-moistened filter paper served as a control. Laboratory germination of seeds was determined in accordance with the State Standard 12038- 84. The vegetation experiment to determine the allelopathic activity of decomposing plant residues of weeds was carried out in 0.5 l vessels filled with calcined sand with the addition of 10 g of crude weight of weed plants.

Winter wheat seeds were sown at two times: immediately after plant residues were incorporated and after 30 days, during which the sand with plant residues was moistened. Plants grown in vessels with sand served as a control.

Biometric indicators of winter wheat were recorded 20 days after sowing. Variants of the experiments were repeated four times.

RESULTS AND DISCUSSIONS

Contents of main nutrients in cultivated and weed plants

The data we obtained indicated that the concentration of nutrients in weeds was at the same level as in cultivated plants, and in some cases it exceeded it.

Nitrogen plays the leading role in growth processes. Increased nitrogen nutrition contributes to enhanced growth of vegetative organs, and the formation of a powerful assimilating apparatus. Lack of nitrogen leads to inhibition of growth, and subsequently to a decrease in yield and quality. In our studies, we found that in the flowering phase, the relative nitrogen content in winter wheat was 2.64%, in winter barley - 2.36%, and in sunflower - 2.6%, There was a somewhat lower nitrogen content in the green mass of pea with oats and corn for silage (Figure 1).

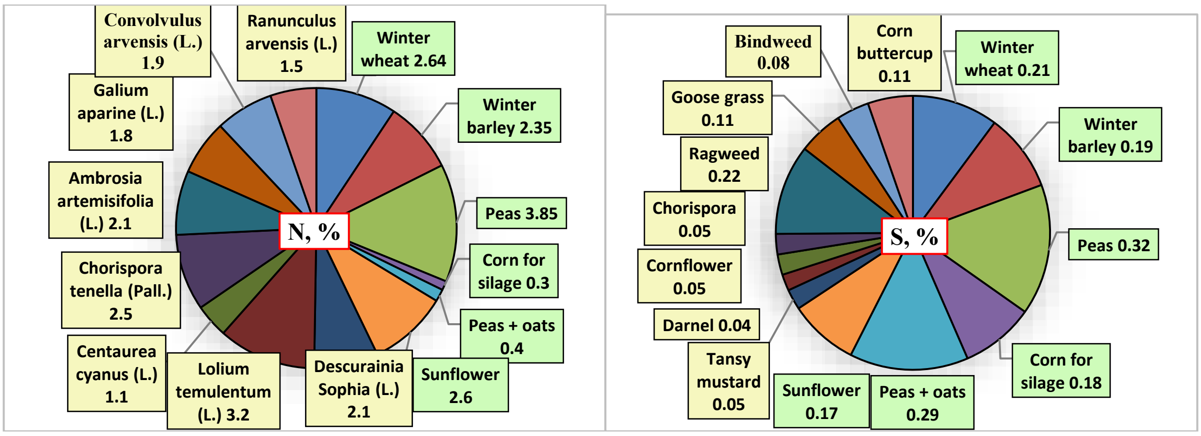


Fig. 1. Relative content of nitrogen (N) and sulfur (S) in green mass of cultivated and weedy plants, %.
Source: Own primary data.

The nitrogen content in weeds was similar. For example, *Loliumtemulentum L.* contained 3.2%, *Chorisporatenella (Pall.) DC)* - 2.5, *Ambrosia artemisifolia L.* and *Descurainia Sophia L.* - 2.1% nitrogen. Weed plants also contained a relatively high amount of sulfur - from 0.17 to 0.05%.

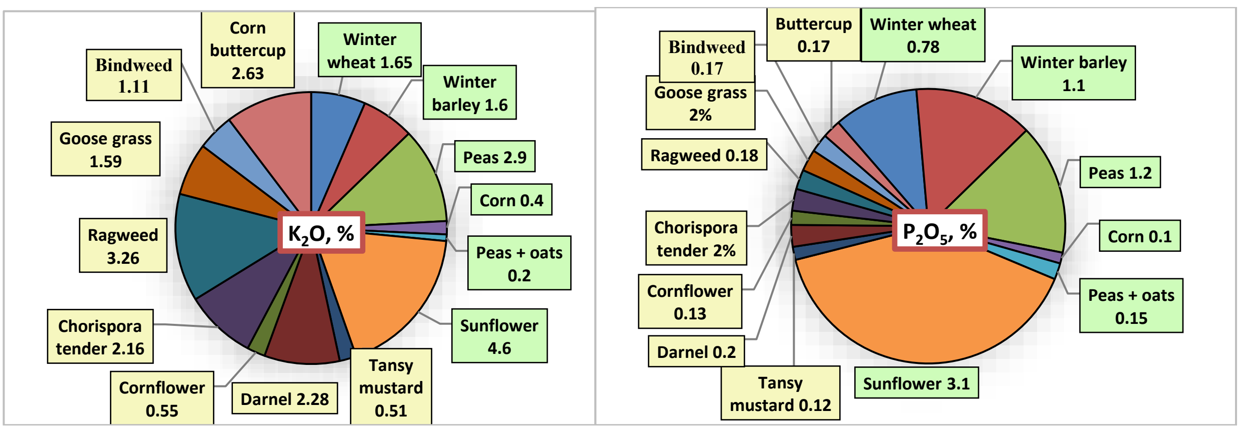


Fig. 2. Relative content of potassium (K_2O) phosphorus and phosphorus (P_2O_5 in the green mass of cultivated and weedy plants, %.
Source: Own primary data.

In plants most of the sulfur is in the composition of proteins (sulfur is part of the amino acids cysteine, cystine and methionine) and other organic compounds - enzymes, vitamins, mustard and garlic oils.

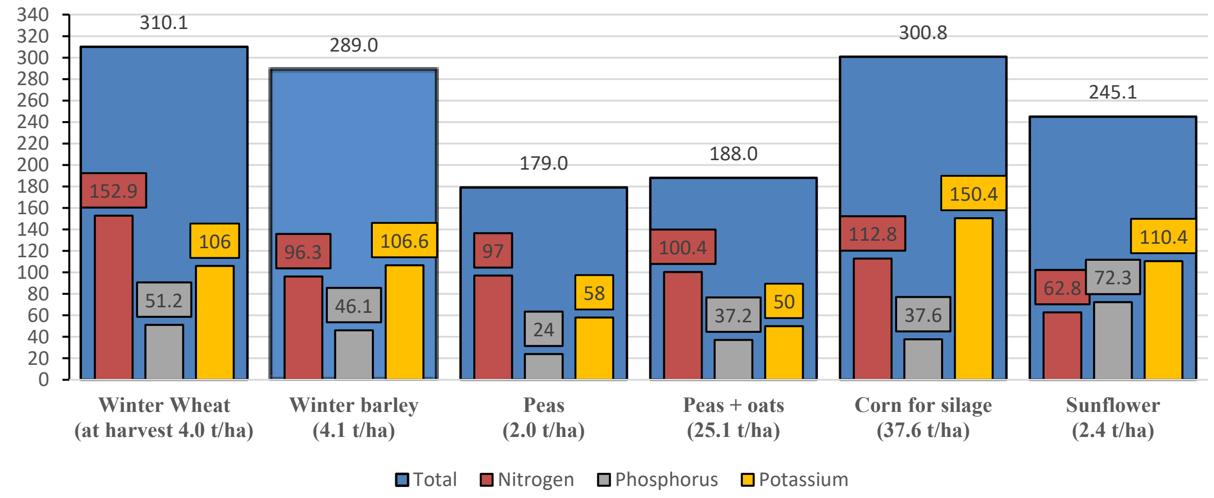
Sulfur is involved in nitrogen and carbohydrate metabolism of plants, respiration and synthesis of fats.

The physiological role of phosphorus and potassium is to participate in the synthesis and movement of organic compounds, energy exchange, especially intensive during the formation of reproductive organs and the formation of spare substances in the marketable part of the crop. If the phosphorus content in weeds is quite low in comparison with cultivated plants, the potassium content is two to three times higher (Figure 2).

Nutrient removal by cultivated and weed plants

The data show that weeds growing in the agrophytocenosis remove significantly more nutrients than the cultivated plants, even with their good development. This is demonstrated in the works of Struve (1926) [26], Bell (1970) [3], Rice (1978) [29], Ballare and Casal (2000) [2], and Einhelling and Rasmussen (2003) [10]. The data analysis presented in Figure 3 shows that on average rotation crops take out 103.6 kg/ha of nitrogen, 51.5 kg/ha of phosphorus, and 96.9 kg/ha of potassium.

a)



b)

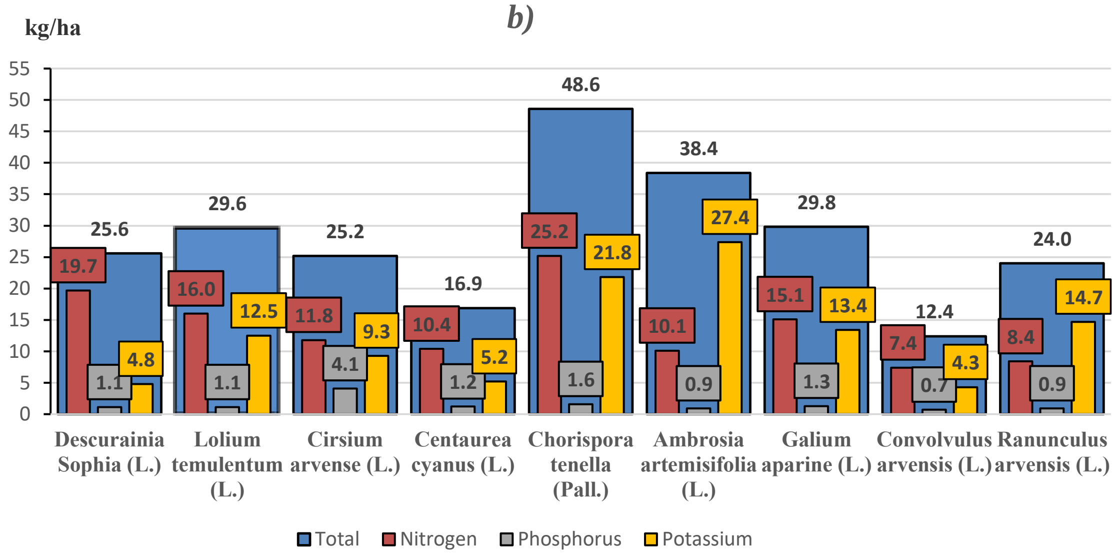


Fig. 3. Nutrient removal, kg/ha: a) by cultivated plants, b) by weeds.
Source: Own primary data.

The main species of weeds of field crops remove nitrogen, phosphorus and potassium, respectively, 124.1, 12.9 and 18.9 kg/ha, mainly due to such species as Lolium temulentum L., Galium aparine L., Cirsium arvense L., Ambrosia artemisifolia L. and Chorisporatenella (Pall.) DC.

Consequently, weeds are competitors to cultivated plants in the struggle for life factors, in particular for the elements of nutrition. Consuming from the soil a significant amount of basic nutrients - macro-, microelements, organogenes, they deprive the cultivated plant of the opportunity to fully use nutrients to form a quality crop.

Allelopathic mechanisms of mutual influence of cultural and weed components of agrophytocenosis

Trofimova*e al*. Nesmeyanov Shayev (2019)[29] demonstrated that the highest allelopathic activity among the weed species under study was in *Galiumaparine L., Avenafatua L., Agrimóniaeupatória L., and Cyclachaenaxanthiifolia (Nutt.) Fresen*. Cruciferous weeds have a high inhibitory effect on the germination processes of winter wheat due to their high biochemical activity, e.g.: *Lolium temulentum L., Galium aparine L., Cirsium arvense L., Ambrosia artemisifolia L., Descurainia Sophia L., Chorisporatenella (Pall.) L., Convolvulusarvensis L., Ranunculus arvensis L., Centaureacyanus L., Descurainia Sophia L.,* and*Cirsiumarvense L*. High allelopathic activity of the donor plant under study, oil radish, has been found. Khramchankova and Mileika A. (2020) [16] revealed the dependence of lichen allelopathic action on weeds on the amount of applied lichenomass. According to Om H. *et al*. (2002)[19] green fertilizers of sunflower and wheat reduced the population of Phalaris minor by 100% under laboratory conditions and by 42% and 15%, respectively, under field conditions, indicating the inhibitory role of allelochemicals. Tursumbekova (2014) [30] noted that regardless of the species of cereal crops, the greatest inhibitory effect on seed germination was seen in *Chenopodium album L.* aqueous extracts, and on the growth of germinal roots and coleoptiles - *Thlaspiarvense L.* We found that the extract of *Stellaria media (L.) Vill.* from the above-ground parts had the least allelopathic effect on seed germination of all cereal crops.

The data presented show that the removal of nutrients with the crop by cultivated plants was close to the removal of these elements by weeds. However, it is not always appropriate to estimate the full picture of the degree of harmfulness and yield reduction of crops due to competition with weeds. In addition to competition between cultivated and weed plants for nutrients, moisture, light, and space, there are also allelopathic interactions.

The share of influence of different factors in the self-organization of agrophytocenosis is understood differently. Together with the recognition of competition for resource consumption, a significant factor in the organization of agrophytocenoses is chemical interference, i.e., allelopathy.

However, some questions about the degree of allelopathic influence of monocotyledonous and dicotyledonous weeds on the cultivated plant remain unclear.

Our laboratory studies showed that there was a high degree of allelopathic effect of weeds which was manifested in the inhibition of germination processes of the test crop, as well as in slowing the rate of germination, growth and development of winter wheat. The degree of action of weed extracts on the germination of the test crop (radish seeds) depended on the type of weeds and the concentration of the extract. Allelopathic activity of aqueous extracts of weed plants at a concentration of 1:50 was most significant with respect to seed germination of the test crop.

Extracts of these plants had a pronounced inhibitory effect which began with minimal concentrations. At a 1:50 weight ratio of the weed and water, 16 to 21% of radish seeds germinated. With increasing solution concentration, the inhibition ranged from 90 to 80% compared to the control (Figure 4).

Most of these species belong to the Asteraceae family, the peculiarity of which is that the cell sap of these plants contains substances of a glycosidic nature - taraxacin and taraxacerin, rubber-like substances. Dandelion roots contain triterpenes -

taraxerol, taraxasterol. Triterpenes are derived components of essential oils, plant hormones and enzymes of a terpene nature.

It has been found that essential oils and their components affect not only seed germination but also the growth of seedlings and their organs, cause deeper changes in photosynthesis, respiration and other processes.

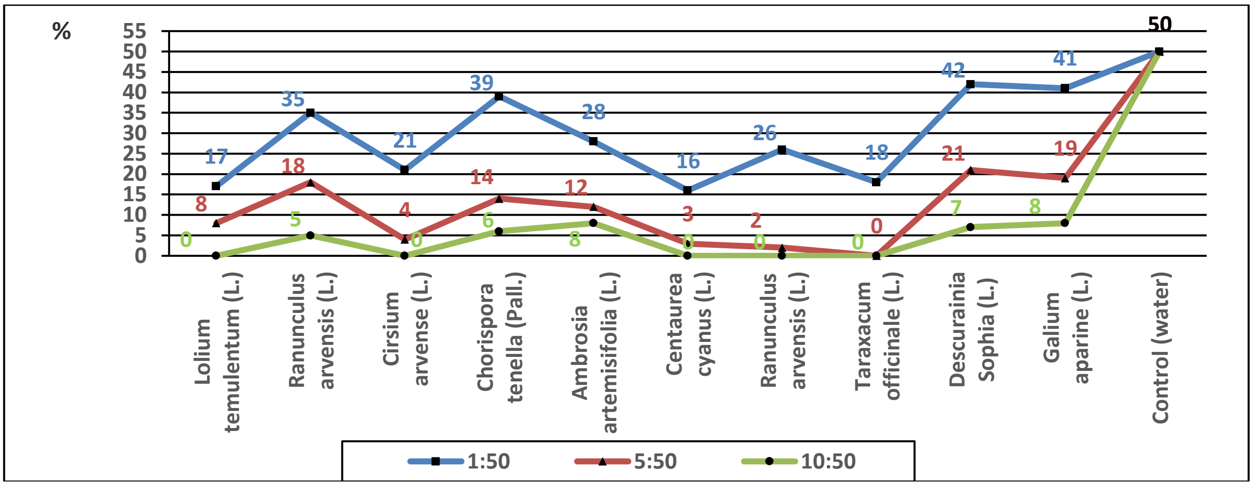


Fig. 4. Allelopathic properties of weed plants(germinated seeds of the test crop, %)
Source: Own primary data.

At a 10:50 weight ratio of weed to water, the suppression is 100%. Particular attention should be paid to the intoxicating weed *Lolium temulentum L.*, in the grains of which there is a fungus *Stromatinia temulenta*, which produces the alkaloid temulinum. At high concentrations, it has an inhibitory effect on the germination of test-culture seeds. Thus, the growth index at the concentration of the tested solution 1:50 is 0.34, and at the concentration 5:50 – 0.16. Similar indices were obtained under the action of blue cornflower and dandelion. The latter had a more powerful inhibiting effect as seen by the fact that already at the ratio of the weed and water 5:50 no germination processes of the test-culture were observed.

Such species as *Descurainia Sophia L. and Chorisporatenella (Pall.) DC*. slow down the germination of the test crop to a lesser extent. The growth indices of the test cultures exposed to *Descurainia Sophia L*. extracts of the concentrations studied were 0.84, 0.42 and 0.14, respectively (Figure 5).

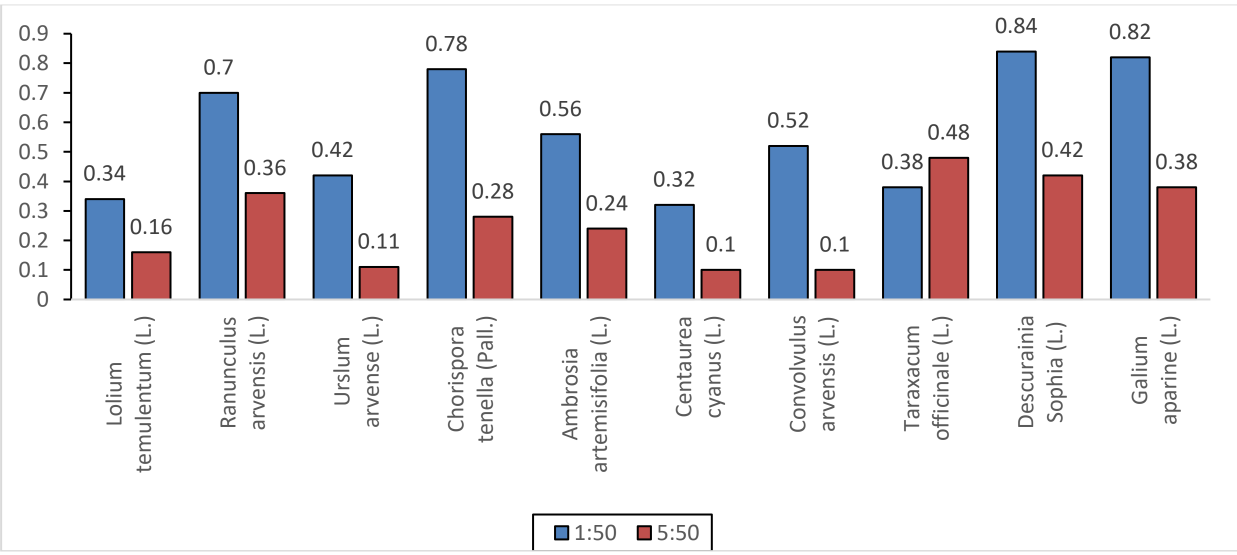


Fig. 5. Growth indices of the test crop under the influence of aqueous extracts of weed plants
Source: Own primary data.

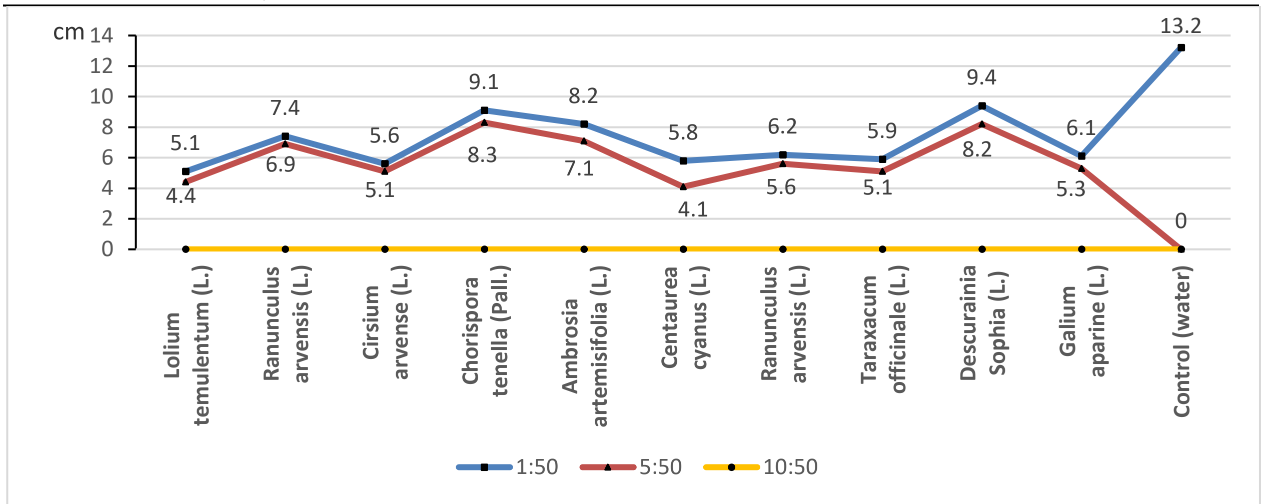


Fig. 6. Allelopathic effects of weed plant extracts on the growth of winter wheat (length of aboveground parts, cm)
Source: Own primary data.

As a result of the *Chorisporatenella* extract impact, the growth indices were 0.78, 0.28 and 0.12, i.e., at solution concentration 1:50 their effect was close to control. In order to determine the degree of influence of extracts from weed plants on growth processes of winter wheat we germinated the seeds of the crop in aqueous extracts of weed species under study. We found a negative lifetime effect of monocotyledonous and dicotyledonous weeds on wheat seedlings. When the ratio of aqueous extracts was 10:50, the processes of germination of winter wheat grains were absent, that is, the concentration of physiologically active substances that inhibit the processes of germination of winter wheat increased when the weediness of crops was high. Under the action of aqueous extracts of weeds, the growth of the aboveground and root parts of winter wheat was reduced in comparison with the control, which was water. Species of the Asteraceae family are especially active. So, if the length of the aboveground parts of winter wheat plants is 13.2 cm in the control at a 1:50 ratio, then extracts of such weeds as field thistle, blue cornflower, field loosestrife, dandelion, or hollyhock reduce this index by half (Figure 6).

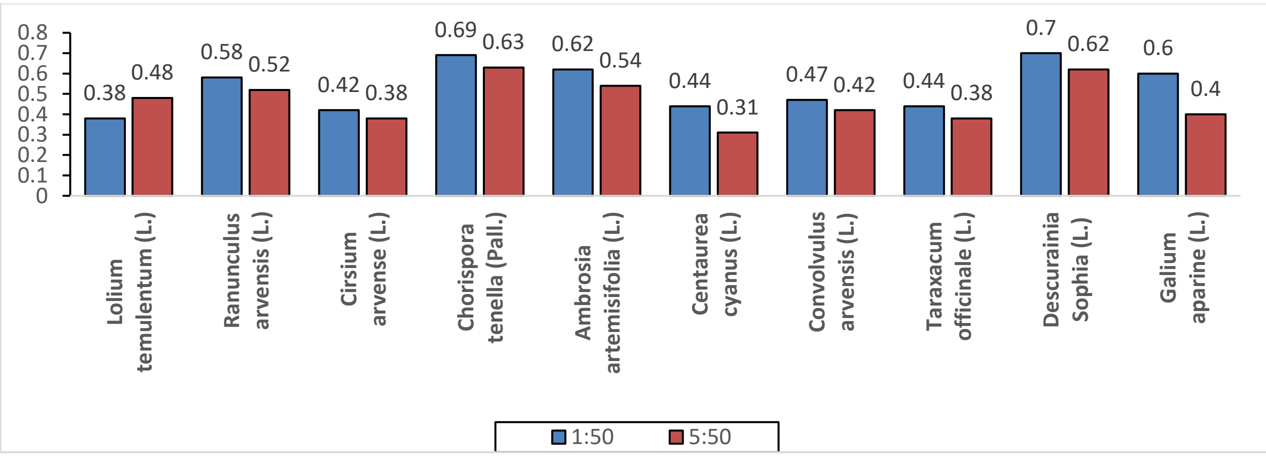


Fig. 7. Growth indices of the aboveground part of winter wheat under the influence of aqueous extracts of weed plants
Source Own primary data.

At the same time, perennial weeds, e.g., dandelion and field thistle, which have a strong root system and had formed flowers at the time of the study, to a greater extent slow the growth of winter wheat.

When the ratio of the weed suspension and water was 5:50 there was a decrease in the length of the aboveground parts from 10 to 30%, but the patterns described above were repeated.

Thus, the growth index of the aboveground part of winter wheat when exposed to a solution of field thistle at a ratio of 1:50 was 0.42, and at 5:50 - 0.38, when exposed to the extract of dandelion medicinal growth indexes were, respectively, 0.44 and 0.38, while the extract of *Chorisporatenella*to a lesser extent inhibited growth of the aboveground parts of winter wheat, growth indices at the above concentrations were 0.69 and 0.63.

Spruce weed intoxicant also contributed to the inhibition of growth of the aboveground parts of the crop, with a ratio of weed and water 1:50 growth index of 0.38 (Figure 7).

The root system of plants suffers to a greater extent from allelopathic active substances of weeds, since the root system first of all absorbs the water solution and all substances in it, including those harmful to the plant, in connection with which its suppression is more intense (Figure 8).

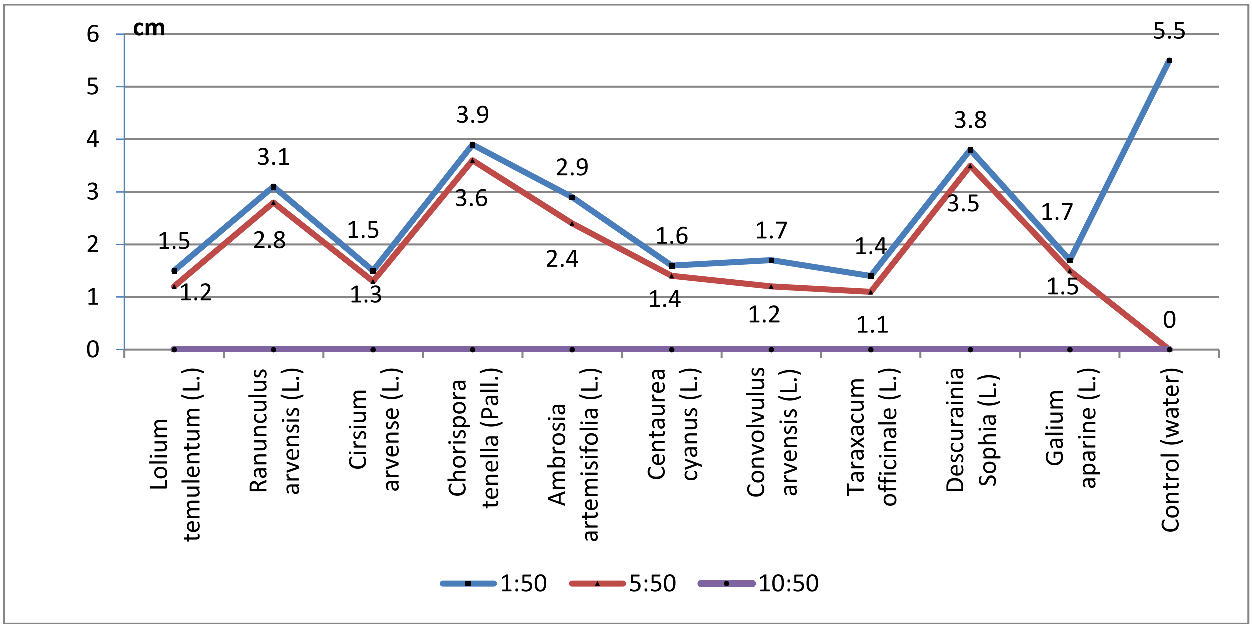


Fig. 8. Allelopathic effects of weed extracts on the growth of winter wheat (root length, cm)
Source Own primary data.

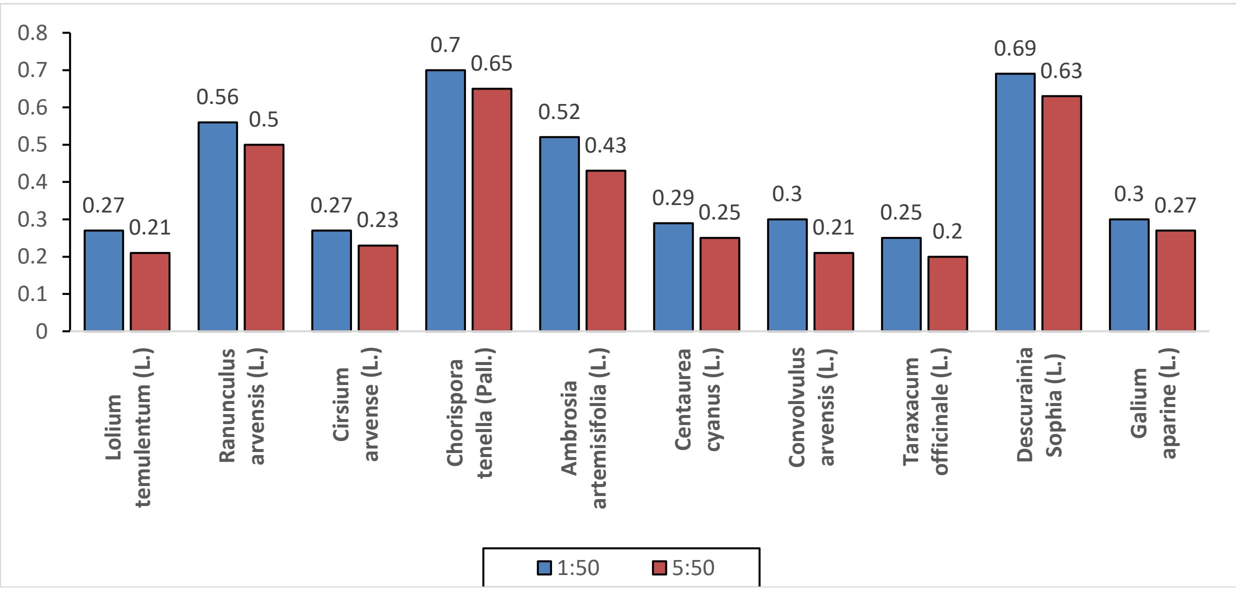


Fig. 9. Root growth indices of winter wheat under the influence of aqueous extracts of weed plants
Source: Own primary data.

Thus, growth indices (Figure 9) under the influence of allelopathically active species ranged from 0.27 to 0.30 at a solution concentration of 1:50 to 0.1-0.2 at 5:50.

Growth indices of less active species were higher: 0.52-0.70 at low concentration and 0.43-0.63 at higher concentration.

CONCLUSIONS

From the above we can conclude that in the agrocenosis of winter wheat, both allelopathic active species and species to which the plants are tolerant grow. This provision is of practical importance, as it allows a differentiated approach to the system of integrated weed control measures, in particular the selection of herbicides, aimed at destroying allelopathic active species of weeds.

Weeds have high allelopathic activity, which manifests itself in the suppression of growth processes of winter wheat. Inhibition of aqueous extracts from weeds ranges from 80 to 90% compared with the control. Most allelopathically active species belong to the Asteraceae family, the feature of which is that the cell sap of these plants contains substances of a glycosidic nature - taraxacin and taraxacerin, rubber-like substances. In the agrocenosis of winter wheat there are weed species to which cultivated plants are tolerant, which is of practical importance because it allows a differentiated approach to the system of protective measures.

ACKNOWLEDGEMENTS

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PHYSICAL MODELING OF WATER EROSION ON SLOPING LANDS IN AGRICULTURAL COMPLEXES

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Abstract

The purpose of the research is to justify the method of physical modeling of sprinkling for the study of water-induced soil erosion. The paper presents technical solutions for the laboratory installation that provide modeling of natural precipitation. The research deals with the method of sprinkling runoff sites based on the criteria of similitude using a portable sprinkler. The results of the experiments to study soil absorbing capacity, removal of chemical elements, cumulative soil washout for various degrees of protective plant cover were obtained. The criteria of similitude allow to use the data obtained during sprinkling run off sites for modeling natural rains. The advantages of the proposed sprinkling plant and examples of its use in the field are presented.

Key words: *sprinkler, soil absorbing capacity, soil erosion, biogenic elements, criteria of similitude*

INTRODUCTION

In order to obtain quantitative data on the negative effects of rain erosion on soils and environment (water bodies, plants), long-term field observations of precipitations are necessary [10, 8].

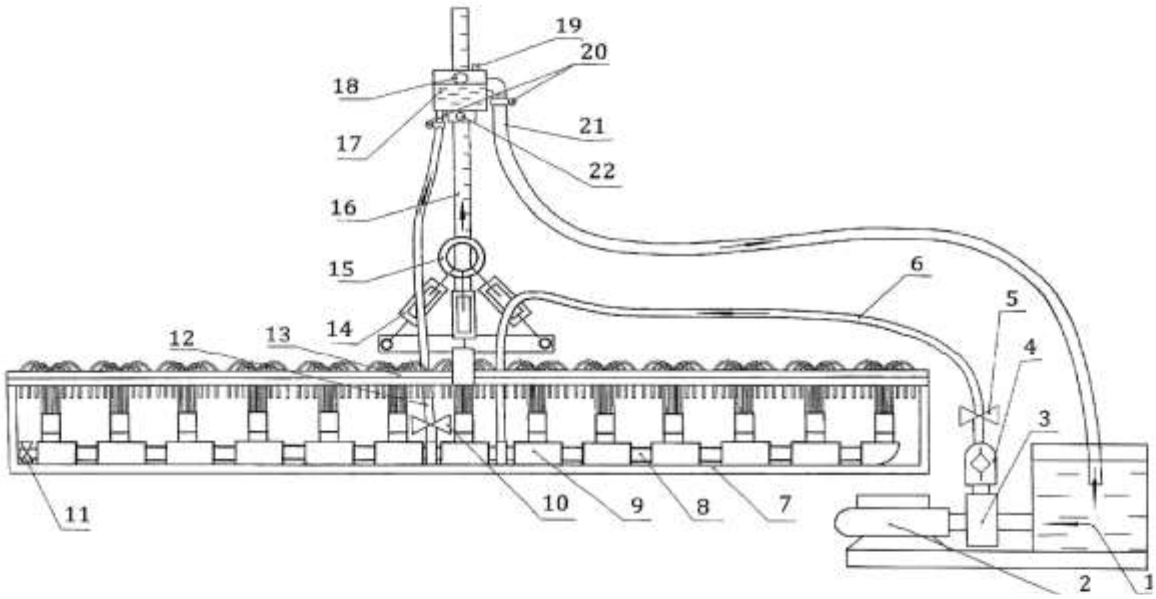

Fig.1. Layout of the portable laboratory and field sprinkler installation
Source: own drawings by patent [25].
Legend: 1-Tank, 2-Engine, 3-Pump, 4-Filter, 5-Valve, 6-Pressure water conduit, 7-Frame; 8-Supply conduit; 9-Tees; 10- Valve; 11- Drain valve; 12-Conduit; 13- Section of horizontal panels; 14-Regulating coupler; 15-Suspension bracket; 16-Vertical bar with a scale; 17-Capacity; 18- Float; 19- Drainage hole; 20- Clamps; 21-Supply; 22-Retainer.

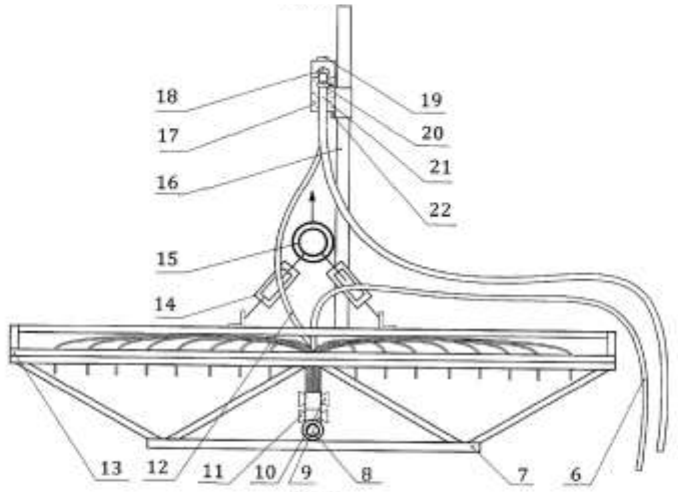

Fig. 2. Sprinkler
Source: own drawings by patent [25].

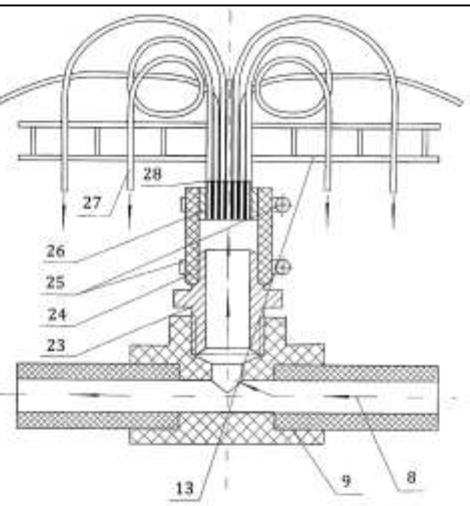

Fig.3. Increased cross-section of sprinkler unit
Source: own drawings by patent [25].

Legend:7- Frame, 8- Delivery conduit, 9-Tees, 10- Bypass valve, 11-Drain valve, 12-Transparnet vertical water conduit, 13-Horizontal plates, 14-Ties, 15-Suspended clip, 16- Vertical bar with a scale, 17-Capacity; 18- Float; 19-Drainage hole; 20- Clamps; 21-Supply; 22-Retainer;23-Nipple; 24-Internal cavity; 25-Clamps; 26- Tubes; 27-Thin flexible tubes; 28-Gauge sleeve.

This type of observations requires topographic survey of the area, soil mapping, equipping the precipitation stations with appropriate apparatus (rain gauges, pluviometers), and laying run off sites [14]. The fragments of terrain under study should have different slope inclination since it strongly affects the erosion development [3, 21].

These arrangements require substantial financial costs and cannot always correspond to the assigned task since it is impossible to get rain with specified properties and on schedule [2, 16].

Using sprinklers to study rain erosion is becoming increasingly relevant [5, 19, 23].

The method of sprinkling runoff sited used in our experiments allows to obtain the required data quickly and at low cost [1].

Laboratory and field sprinkler installation that comprises a water tank, a pump with an engine and filters, pressure and delivery conduits with valves, a frame with sprinklers as a bunch of thin flexible pipes, a vertical bar with an overflow device and a drainage pipe, vertical and return water conduits, T-pipes with nipples, thick flexible pipes and bushings, a suspended clip with ties differs from the existing analogues since it has calibrated bushings fixed in the entrance ends of thin flexible pipes and the return water conduit of larger diameter than the vertical water conduit made of transparent material.

An increase in the diameter is due to gravity flow of liquid caused by the elevation difference in contrast with the transfer tube, where the water is delivered under pressure. The layout of the laboratory installation is shown in Figure 1.

MATERIALSANDMETHODS

The invention relates to agriculture and can be used to simulate natural rain in laboratory and field conditions [25]. The basis of design requirements is high uniformity and stability of rain distribution over the irrigated area. The patent overview of the installation solutions used for sprinkling showed that a common deficiency of these devices is low uniformity of rain distribution over the irrigated area. The water flowing through the nozzles to elastic pipes fills them unevenly. The pipes that are filled first begin to suck out water from the nozzle, creating a vacuum in it and thus preventing the rest of the pipes from filling. The result is a low uniformity of water flow between them. In the proposed installation solution, the pipes are filled from the bottom up as shown in Figures 2 and 3.

In another device, the water supply is through the jails in sprinklers to thin flexible pipes and the distribution is over the entire irrigated area.

The flow area of thin flexible pipes is manufactured with deviations. During installation, they bend unevenly. For these reasons, all thin flexible pipes cannot pass the same amount of water and, as a result, they cannot maintain the same intensity over the entire irrigated area. In addition, the overflow device is made of a transparent material that complicates visual control over the height of the water column and sprinkler intensity. In the known sprinkler installation, the water supply is from the bottom up and, upon completion of works, it is difficult to remove it from the system. The presence of water in the system upon completion of works leads to the deposition of sediment and bacteria growth. This contributes to clog thin flexible pipes and, as a consequence, a decrease in their flow area.

In order to eliminate the listed deficiencies and deal with the problem, the increase in the uniformity and stability of the rain distribution over the area, a laboratory and field sprinkler installation solution is proposed, comprising a water tank, engine, pump, filter, valve, pressure water conduit and sprinkler. It includes a delivery conduit fixed on the frame with tees, a drain valve of the bypass valve and a transparent vertical water conduit, horizontal panels, ties, a suspended cling, a vertical bar with a scale, overflow device with a lock, a drainage hole, a transparent return water conduit and sprinkler units. Each sprinkler unit comprises a vertical thick flexible pipe, clamps, thick seal sleeve and a bunch of thin flexible pipes with calibrated bushings sequentially fixed in the tee. The presence of calibrated bushings at the entrance to thin flexible pipes provides a dosed supply of water into each pipe, i.e. reduces the effect of variation in the cross section of thin flexible pipes on their discharge capacity, which, in turn, ensures more stable operation of the entire sprinkler installation. The overflow device is made in the form of a transparent container with a bright float, transparent water conduits, and drainage hole. In addition, the transparent return water conduit is made from a pipe of larger diameter than a transparent vertical water conduit. This provides good visual control over the operation of the entire hydraulic installation system, and the presence of water in an overflow device allows short-term stable work of the installation even when the engine and pump are shut down. The drain valve provides rapid drainage of residual water from the system upon completion of work.

The overflow device is made in the form of a transparent tank 17 with a bright float 18, a drainage hole 19, clamps 20 and a transparent return water conduit 21 fixed on a vertical bar with a scale 16, a lock 22. In this installation solution, the diameter of a transparent return water conduit 21 is larger than the diameter of the transparent vertical water conduit 12. Sprinkle units (Fig. 3) comprise a nipple 23, vertical thick flexible tube 24, clamp 25, thick seal sleeve 26, a bunch of thin flexible pipes 27 and calibrated bushings 28 sequentially fixed in the tee 9. One end of every thin flexible pipe 27 with densely inserted calibrated bushing 28 is fixed by an adhesive joint in thick seal sleeves 26.

RESULTS AND DISCUSSIONS

Laboratory and field sprinkler installation is as follows. When the engine 2 is turned on, the pump 3supplies water from the tank 1 through the filter 4, the valve 5, the pressure conduit 6 into the delivery conduit 8 with the tees 9 fixed on the frame 7. Water drives the air out of water conduits through the nipples 23 and first enters the inner cavity of vertical thick flexible tubes 24 fixed on clamps 25 with nipples 23. Then the water reaches the lower edges of thick seal sleeves 26 and flows through the calibrated bushings 28 to thin flexible pipes 27. Through them, it is delivered to the entire width of the sprinkler and forms rain drops at the ends fixed in the sections of horizontal panels 13. Excess water through the bypass valve 10 and transparent vertical water conduit 12 rises into the transparent tank 17 of overflow device, raising the float 18. The excess water is discharged into the tank 1 through the transparent return water conduit 21. The drainage hole 19 is made in the upper part of the transparent tank 17. If necessary, the air supply is through it, which prevents suction of water from the system through the transparent return water conduit 21. The rain intensity changes in the installation by moving the overflow device along the vertical bar with a scale 16 when the lock 22 is loose or by full blockade of bypass valve 10. The complete blockage of water flow by bypass valve 10 is used when on turning on the installation excessive pressure is created in the system that contributes to faster air displacement and the inclusion of all thin flexible pipes 27 into operation. For stable operation of the installation, the valve 5 adjusts the water supply so that its small amount discharges through the overflow device and transparent return water conduit 21 to the tank 1, avoiding overflow through the drainage hole 19. For work, the sprinkler is raised to the required height with the suspended cling 15, while its horizontal position is achieved by lengthening or shortening of ties 14. Clamps 20, 25 capture flexible pipes 24 and water conduits 12, 21 and prevent depressurization of the system. A transparent overflow device allows to stabilize the pressure in the system during a short -term stop of the pump station, and vertical and return water pipelines as well as tanks with a bright float made from transparent materials allow visual control of the entire sprinkler installation work in various modes. Transparent return water conduit made as a pipe of a larger diameter allows to achieve stable operation of the installation at enormous pressure surges from the pumping station. The vertical arrangement of the sprinkler unit and water supply from bottom up provide a slow non-turbulent filling of the vertical thick flexible pipe 24, and the water flow through calibrated bushings 28 is dosed individually into each thin flexible pipe 27. Thus, the water flows passing through the thin flexible pipes 27 become even, and the uniformity of sprinkling increases. Upon the work completion, the water from the delivery conduit 8 discharges through the drain valve 11. Thus, the water removal from the system is achieved, sediment formation and bacteria growth hinder during the intervals between sprinklings. The set of essential features of the proposed device provides obtaining a technical result in terms of uniformity and stability of artificial sprinkling. The installation technical solutions have been repeatedly verified and modified for the purpose of convenience and quality of the field experiments. An example of the field operation of the installation is shown in Photo 1 a and b.


a.


b.

Photo 1.Laboratory-field rainfall simulator
Source: Original figure, authors' photo.
Legend: a-measuring the intensity of artificial rain, b-modeling of aerodynamic processes on crops.

As a criterion of similitude for natural rains, the erosion rainfall index AI is used: for different rainfalls, the erosion-hydrological effect is the same if the rainfalls have the same AI index [6, 9].

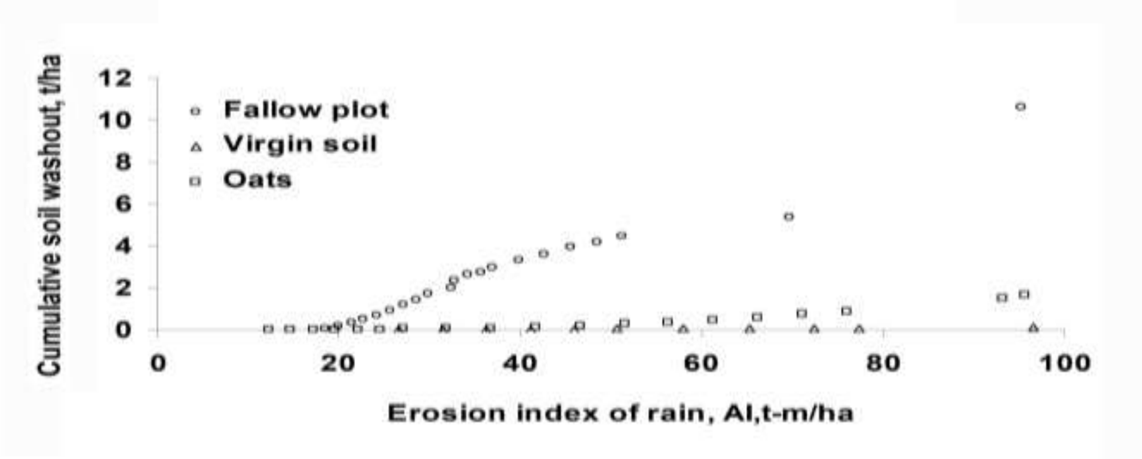

Fig. 4. Dependence of the cumulative soil washout on the erosion rainfall index (for natural rain) with varying degrees of protective soil cover
Source: Original figure generated based on experimental data.

The erosion characteristic A is a criterion of similitude for artificial rains. For these two criteria, the equity *A=const AI* is relevant where *const* is a constant value. This equity allows to replace the value *A* with *AI* according to the data obtained during sprinkling [22]. Therefore, with this replacement, the obtained dependences can be used for natural rains [17]. This is the basis of the method of sprinkling runoff sites [13, 16].
Using remote control can allow to calculate the cumulative soil washout depending on the state of the soil (at different degrees of protective plant cover and mulching) [11, 12].
Consider the example from the Laboratory of Soil Protection from Erosion at the Federal State Budgetary Scientific Institution Kursk FANC where an experiment was carried out in sprinkling runoff sites with the oat crops (phenophase of the third new leaf) and virgin soil (about 25 years old), the fallow plot (Photo 1 was used as a control option.
Figure 4 allows to visually detect the dependence of soil washout on the degree of protection.
Soil washout on the fallow plot taken as a control option is several times higher than in options with vegetation [24]. The most favorable conditions for preventing the soil wash out are observed in the virgin soil option[4, 15].
To obtain heavy crop yields in arid zones, it is important to set up the correct soil moisture regime using mechanized watering systems [7, 4]. However, due to the excessive intensity of rainfalls that effects on absorbing capacity, run off occurs. Using the sprinkling method allows to identify the soil absorbing capacity for a particular area and develop standards of watering until runoff occurs. The experimental data of polygon tests are the basis of mathematical models for predicting soil water erosion [18, 20].

CONCLUSIONS

Physical modeling of water erosion on sloping lands in agricultural complexes allows to obtain reliable data on the physical and chemical characteristics of soils.
The design features of the proposed installation solution provide a high accuracy of natural precipitation simulation. The water flow control system allows to calibrate each sprinkler, prevent the formation of air bubbles in the system, and provide the repeatability of polygon experiments. At the stage of filling with water, the system is located on the ground for easy access to the hydraulic control system. Using the sprinkling method allows to quickly obtain relevant data on the soil absorbing capacity, removal of chemical elements in dissolved form, amount of washed out soil caused by rain erosion. Data obtained during the application of sprinkling method can be used for calculating the norms of mechanized irrigation. The proposed rain installation allows for high-quality physical modeling of water erosion on sloping lands in agricultural complexes

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INVESTMENT MANAGEMENT IN THE CULTIVATION OF LAVENDER FOR THE PRODUCTION OF THE ESSENTIAL OIL

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Abstract

The group of authors purposesin this article to analyze the benchmarking of budget in the lavender culture. Group of authors developed the economic-financial budgets for the cultivation of lavender, which can be considered an important source of information for benchmarking. The authors used data from the primary records in agricultural holdings, which practice lavender cultivation. The analysis methods used in the article are benchmarking and budgeting of production for comparing the data and economic efficiency. Based on the research and analysis carried out, strategic conclusions were formulated for the sustainable development of the lavender branch, necessary for the implementation by the actors of the value chains in the sector. The final conclusion of the group of authors boils down to: lavender culture is highly profitable, the production processes are fully mechanized and it is a payment with increased resistance to drought (in dry years the quality of the essential oil is higher), which is extremely important in conditions of climate resilience and it is recommended to be practiced for small farmers to diversify incomes in rural areas.

Key words**:** *budget, profitability, sales income, cost of sales, gross margin, lavender*

INTRODUCTION

Investments are important for the development of the all agricultural sectors in the Republic of Moldova [10, 12]. Some authors pointed out the importance of investments in horticulture, emphasizing the fruit-trees sector [11, 13].
The sector of hetero-oleaginous plants is also a component of domestic horticulture and is one of perspective, because it is profitable, the products enjoy interest on the regional and international markets, the production factors are favorable, support from the authorities / donors and the experience / recorded history facilitate its sustainable development [9].
The post-harvest infrastructure must be developed in such a way that the result of the processing of the raw material hetero-oleaginous plants (lavender) results in the following estimated structure of finished products [8]:
-the largest share is intended for food industry products – 50%;
-30% cosmetology and hygiene products;
-20% for medicine (for which higher growth is expected in the future).
The analysis presented in this article by the group of authors is based on the analysis of the economic aspects of lavender cultivation, which is a branch with great development potential.
The analytical data presented serve as a complex source of information for the main actors of the value chain for lavender, the analysis of the possibilities of optimizing production costs and increasing economic efficiency, which will ultimately ensure high competitiveness of the extractor and its sustainable development through the creation of partnerships among lavender sector clusters.

MATERIALS AND METHODS

The industrial lavender cultivation budget will be analyzed in the conventional and conventional system, which is the activity plan expressed in quantitative units, translated into value units, the calculation of the necessary financial resources that should be invested/spent to achieve the predetermined goals. The budget provides a way of documenting the number of resources that are used to achieve the planned objectives and for managerial control of the activity [5].

For the cultivation of industrial lavender in the conventional system, two budgets will be developed for the area of one hectare, namely:

(1)the investment budget for planting and caring for the lavender until it comes to fruition in the common conventional system for all varieties;

(2)the aggregate budget of incomes and expenses when growing lavender per fruit in the conventional system, where the oil yield was estimated at 70% of the production potential per unit area.

RESULTS AND DISCUSSIONS

For farmers, it is important to select lavender varieties that ensure competitive production, and this can be achieved with the following varieties: Vis Magic – 10; Moldovan – 4; Unique Aroma; Alba – 7, where the planting material is of high quality and performance. In the case of the Chișineovscaia 90 (C90) variety, which is the most widespread and cultivated in the republic, the planting material is of medium quality, and the essential oil is of high quality and the investments per hectare planted with lavender are lower [9]. In Table 1 there are estimated the investments for planting one hectare of lavender in a conventional system with the Chișineovscaia 90 (C90) variety.

The amount of investments for the establishment and care until the entry into the fruit of a hectare of lavender in the conventional circuit constitutes 6,897 Euro, the largest weight representing the cost of the means of production 51.5%.

An important factor in the cultivation of lavender is the profitability of the crop, namely, the gross profit obtained from the operational activity, which for different technologies and varieties of lavender is different, because the biological characteristics and production potential are different. Next, we will analyze the lavender cultivation budgets in the conventional circuit for the following Moldovan varieties, such as: Chișineovscaia 90; Magic Dream – 10; Moldovan – 4; Unique Aroma; White – 7.

The income and expenditure budget for the cultivation of one hectare of industrial lavender in a conventional system for the Chișineovscaia 90 variety is presented in Table 2.

Table 1. The investment budget for planting and caring for lavender until fruiting in the conventional system (area – 1 ha, scheme: 50 cm between plants per row, 160 cm between rows)

Specification	MU	Quantity	Unit price, Euro	Total - 1 year	Total - 2 year	Total - 3 year	Total years II + III	Total (up to fruit entry)	
								Euro	Structure, %
I. The cost of the means of production	**Euro**	**X**	**X**	**2,641**	**486**	**425**	**911**	**3,552**	**51.5%**
Planting material (scheme 1.6x0.5m)	unit	14.286	0.12	1.714			0	1.714	24.9%
Planting material filling the gaps (5% bushes)	unit	714	0.12		86		86	86	1.2%
I'm gaining weight. organic at planting	t	29	20.00	571			0	571	8.3%
Total mineral fertilizers:				190	37	37	74	264	3.8%
Diamophos NPK 10:26:26	kg	200	0.95	190			0	190	2.8%
Microelement - Poly-Feed 19:19:19 + 6 ME	kg	9	4.10		37	37	74	74	1.1%
Chemicals	Euro			132	331	360	690	823	11.9%
Herbicides - glyphosate, 540 g/l, salt	l	10.00	13.23	132			0	132	1.9%
Herbicides - metamitron	l	1.50	48.30		72	72	145	145	2.1%
Herbicides - quizalofop-p-ethyl	l	1.50	23.00		35	35	69	69	1.0%

Insecticide - lambda cyhalothrin	l	0.60	48.91			29	29	29	0.4%
Insecticide - acetamiprid	l	0.60	136.30		82	82	164	164	2.4%
Fungicides - tribasic copper sulfate	kg	5.00	17.94		90	90	179	179	2.6%
Fungicides - sulfur	kg	3.00	5.08		15	15	30	30	0.4%
Fungicides - pyrimethanil	kg	1.00	36.92		37	37	74	74	1.1%
Water (when planting and caring for plantation)	m^3	23	0.20	5	5		5	9	0.1%
Fuel (field travel)	l	20.00	1.42	28	28	28	57	85	1.2%
II. Mechanized services	**Euro**	**X**	**X**	**871**	**405**	**77**	**482**	**1,353**	**19.6%**
Deforestation and weed challenge	ha	1.0	17.7	18			0	18	0.3%
Semi-deep plow (35-40 cm)	ha	1.0	78.7	79			0	79	1.1%
Leveling the clearing plow (2 directions)	ha	2.0	17.2	34			0	34	0.5%
Transport services (sprinkled water - 2 times)	t/km	2.0	1.4	3			0	3	0.0%
Introduction of herbicides (2 times)	ha	2.0	10.4	21			0	21	0.3%
Total cultivation - 2 times	ha	2.0	21.4	43			0	43	0.6%
Transporting planting material	km	200.0	1.4	286			0	286	4.2%
Water transport for planting and irrigation	t x km	228.6	1.4	327	327		327	655	9.5%
Fertilizer transportation services	t/km	3.0	1.4	4			0	4	0.1%
Fertilization by spreading	ha	1.0	13.2	13			0	13	0.2%
Digging strips for planting	ha	1.0	19.7	20			0	20	0.3%
Mechanized cultivation between rows - 3 times	ha	3.00	14.57		44	44	87	87	1.3%
Transport services (sprinkled water)	ha	3.0	1.4	3	4	4	9	11	0.2%
Spraying the fields	ha	3.0	9.8	20	29	29	59	79	1.1%
III. Manual operations	**Euro**	**X**	**X**	**525**	**321**	**350**	**671**	**1,197**	**17.4%**
Picketing the area for planting	pers/day	6.0	15.0	90			0	90	1.3%
Mulching with soil	pers/day	5.0	15.0	75			0	75	1.1%
Planting bushes	pers/day	23.8	15.0	357			0	357	5.2%
Filling in the blanks	pers/day	4.8	15.0		71		71	71	1.0%
Cut the inflorescences	pers/day	6.7	15.0		100	200	300	300	4.3%
Loading and unloading of fertilizers	pers/day	0.2	15.0	3			0	3	0.0%
Weeding between bushes in a row (2 times)	pers/day	10.0	15.0		150	150	300	300	4.3%
IV. Land tax	**Euro**	**1**	**5.5**	**5.5**	**5.5**	**5.5**	**11.0**	**16.5**	**0.2%**
V. Rent land payment	**Euro**	**1**	**150**	**150**	**150**	**150**	**300**	**450**	**6.5%**
IV. Unexpected expenses (%)	**Euro**	**X**	**X**	**210**	**68**	**50**	**119**	**328**	**4.8%**
TOTAL investments (I+II+III)	**Euro**	**X**	**X**	**4,402**	**1,436**	**1,059**	**2,495**	**6,897**	**100.0%**

Source: Calculations of the group of authors [4, 5, 6, 7, 8, 9].

Table 2. The budget for the cultivation of industrial lavender per fruit variety Chișineovscaia 90 in the conventional system (area – 1 ha, scheme 50 cm between plants per row, 160 cm between rows)

Specification	MU	Recommended technology per 1 ha			
		Quantity/rate per hectare	Unit price, Euro	Sum, Euro	Consumption structure, %
I. Net sales	**Euro**		**X**	**3,767.50**	**X**
Essential oil	kg	68.5	55.00	3,767.50	X
II. The cost of the means of production	**Euro**	**X**	**X**	**551.73**	**24.94**
Mineral fertilizers:				177.62	8.03
Diamophos NPK 10:26:26	kg	150.00	1.02	153.66	6.95
Microelement - Poly-Feed 19:19:19 + 6 ME	kg	6.00	3.99	23.96	1.08
Chemicals:				359.92	16.27
Herbicides - metamitron	l	1.50	48.30	72.45	3.28
Herbicides - quizalofop-p-ethyl	kg	1.50	23.00	34.50	1.56
Insecticide - lambda cyhalothrin	l	0.60	48.91	29.35	1.33
Insecticides - acetamiprid	l	0.60	136.30	81.78	3.70
Fungicides - tribasic copper sulfate	l	5.00	17.94	89.70	4.06
Fungicides - sulfur	kg	3.00	5.08	15.23	0.69
Fungicides - pyrimethanil	kg	1.00	36.92	36.92	1.67
Fuel (field travel)	l	10.00	1.42	14.20	0.64
III. The cost of mechanized services	**Euro**	**X**	**X**	**645.30**	**29.17**
Transporting water to sprinkle the fields	ha	5.0	1.4	7.16	0.32
Spraying the fields	ha	4.0	9.83	39.33	1.78
Cultivation between the rows	ha	3.0	14.57	43.70	1.98
Mechanized harvesting of inflorescences	ha	1.0	51.51	51.51	2.33

Harvest transportation	t x km	112.5	1.43	161.10	7.28
Processing services	Euro/kg	68.5	5	342.50	15.48
IV. The cost of manual operations	**Euro**	**X**	**X**	**223.59**	**10.11**
Weeding between the rows (2 times)	pers/day	8.00	15.00	120.00	5.42
Harvest support	pers/day	3.75	15.00	56.25	2.54
Loading and unloading the crop	pers/day	3.00	15.00	45.00	2.03
Loading and unloading of fertilizers	pers/day	0.16	15.00	2.34	0.11
V. Other costs and fees	**Euro**	**X**	**X**	**686.04**	**31.01**
Plantation wear and tear (not allocated to flow)	Euro	X	X	530.54	23.98
Rent land payment	Euro	1.00	150.00	150.00	6.78
Land tax	Euro	1.00	5.50	5.50	0.25
VI. Contingency expenses ((II+III+IV+V)*10%)	**Euro**	**X**	**X**	**105.33**	**4.76**
VII. Variable + fixed consumptions (II+III+IV+V+VI)	**Euro**	**X**	**X**	**2,211.99**	**100.00**
VIII: Gross profit (gross margin) (I-VII)	**Euro**	**X**	**X**	**1,555.51**	**X**
IX: Profitability (VIII / VII*100%)	**%**	**X**	**X**	**70.32**	**X**

Source: Calculations of the group of authors [4, 5, 6, 7, 8, 9, 10].

Note. The proposed budget is a model for entrepreneurs and may vary depending on the production factors and specific conditions of the beneficiary. In "Other costs and taxes" (V) are included the costs for the annual depreciation of the plantation in the amount of 530.54 Euro. Depreciation is calculated from a financial point of view for the recovery of the investments made based on their term of operation, and their value remains under the management of the entrepreneur for the next year.

Examining the data in from Table 2, we conclude that the Chișineovscaia 90 variety lavender culture is profitable in the conventional system, because it allows the annual gross profit to be obtained in the amount of 1,555.51 Euro per hectare (sum of sales revenue – 3,767.5 Euro and cost of sales – 2,211.99 Euro).

The cash flow available at the end of the year for the production of industrial lavender variety Chișineovscaia 90 in the conventional circuit will be 2,263 Euros, which is enough to ensure the need for cash for the next year and the receipt of dividends by the founders (Table 3).

Profitability is the economic category that expresses the ability of the enterprise to obtain profit, which reflects its performance. The achievement of this objective is conditioned by the performance of a profitable activity.

Table 4 presents the main indicators of the economic efficiency of the lavender culture in the conventional system of the Chișineovscaia 90 variety per surface unit.

Table 3. Cash flow when growing industrial lavender Chișineovscaia 90 variety in conventional system

Specification	1	Cash flow by months of the year, Euro											
	Total - area, Euro	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Initial cash flow	**X**	**0**	**0**	**0**	**-2**	**-538**	**-691**	**-1,066**	**-1,476**	**-1,492**	**-1,494**	**2,272**	**2,263**
I. Net sales	**3,768**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3,768**	**0**	**0**
Essential oil	3,768										3,768		
II. The cost of the means of production	**552**	**0**	**0**	**2**	**471**	**62**	**10**	**2**	**2**	**2**	**2**	**2**	**0**
Mineral fertilizers:	178	0	0	0	162	8	8	0	0	0	0	0	0
Diamophos NPK 10:26:26	154				154								
Microelement - Poly-Feed 19:19:19 +	24				8	8	8						
Chemicals:	360	0	0	0	308	52	0	0	0	0	0	0	0
Herbicides - metamitron	72				72								
Herbicides - quizalofop-p-ethyl	35				35								
Insecticide - lambda cyhalothrin	29				29								
Insecticides - acetamiprid	82				82								
Fungicides - tribasic copper sulfate	90				90								
Fungicides - sulfur	15					15							
Fungicides - pyrimethanil	37					37							
Fuel (field travel)	14			2	2	2	2	2	2	2	2	2	
III. The cost of mechanized services	**645**	**0**	**0**	**0**	**38**	**23**	**292**	**278**	**15**	**0**	**0**	**0**	**0**
Transporting water to sprinkle the fields	7				4	4							

Spraying the fields	39				20	20							
Cultivation between the rows	44				15		15		15				
Mechanized harvesting of inflorescences	52						26	26					
Harvest transportation	161						81	81					
Processing services	343						171	171					
IV. The cost of manual operations	**224**	**0**	**0**	**0**	**2**	**60**	**51**	**111**	**0**	**0**	**0**	**0**	**0**
Weeding between the rows (2 times)	120					60		60					
Harvest support	56						28	28					
Loading and unloading the crop	45						23	23					
Loading and unloading of fertilizers	2				2								
V. Other costs and fees	**686**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**150**	**0**
Plantation wear and tear (not allocated to	531												
Rent land payment	150											150	
Land tax	6						6						
VI. Contingency expenses	**105**	**0**	**0**	**0**	**26**	**7**	**18**	**19**	**1**	**0**	**0**	**8**	**0**
VII. Variable + fixed consumptions	**2,212**	**0**	**0**	**2**	**537**	**152**	**376**	**409**	**17**	**2**	**2**	**159**	**0**
VIII: Gross profit (gross margin) (I-VII)	**1,556**												
IX: Profitability (VIII / VII*100%)	**70**												
Final cash flow	**X**	**0**	**0**	**-2**	**-538**	**-691**	**-**	**-1,476**	**-1,492**	**-1,494**	**2,272**	**2,263**	**2,263**

Source: Calculations of the group of authors [4, 5, 6,7, 8, 9, 10].
Note: Depreciation is not calculated in the cash flow, because the money broken down to depreciation remains in the enterprise and is calculated for accounting purposes (calculating profitability).

Table 4. Analysis of the economic efficiency of industrial lavender cultivation, the Chișineovscaia 90 variety in a conventional system

#	The main economic indicators	Calculation formula	MU	Calculation data (area 1 hectare)
1	The investment budget for the establishment of the	Investment budget	Euro	6,946.97
2	Subsidies possible to obtain	Subsidy regulation	Euro	500.00
3	Sales income	Budget per fructification	Euro	3,767.50
4	Cost of sales	Budget per fructification	Euro	2,211.99
5	Annual gross profit	3-4	Euro	1,555.51
6	Profitability of revenues (revenues obtained per 1 leu of	3 / 4 * 100%	%	170.32
7	Economic profitability (profits obtained per 1 leu of	5 / 4 * 100%	%	70.32
8	Cash flow at the end of the year	Budget per fruit	Euro	2,262.57
9	Unit cost	4 / harvest per hectare	Euro / kg	32.29
10	Average selling price	3 / harvest per hectare	Euro / kg	55.00
11	Gross profit (gross margin) of production	10-9	Euro / kg	22.71
12	Investment recovery period (years of fruition)	(1-2) / 5	ani	4.14
13	Investment recovery period (years after planting)	12 + 3 years vegetation period	ani	7.14

Source: Calculations of the group of authors [9, 1, 2, 3].

Table 5. Cumulative economic indices for industrial lavender cultivation, Chișineovscaia 90 variety for a conventional production cycle (area 1 ha)

Specification	Land preparation and planting	Caring for the plantation until it bears fruit		Exploitation of the plantation - the period in full fruition									
Year	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**
Plantation productivity	0%	15%	50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Investment costs	-4,452	-1,436	-1,059										
Annual cost of sales		-98	-328	-1,681	-1,681	-1,681	-1,681	-1,681	-1,681	-1,681	-1,681	-1,681	-1,681
Annual sales revenue	0	565	1,884	3,768	3,768	3,768	3,768	3,768	3,768	3,768	3,768	3,768	3,768
Annual gross profit (gross margin)	-4.452	-970	497	2,086	2,086	2,086	2,086	2,086	2,086	2.086	2,086	2,086	2,086
Subsidies	500												
Cumulative cost of sales	4,452	5,987	7,374	9,055	10,737	12,418	14,099	15,781	17,462	19,144	20,825	22,507	24,188
Cumulative sales revenue	500	1,065	2,949	6,716	10,484	14,251	18,019	21,786	25,554	29,321	33,089	36,856	40,624
Cumulative gross profit (gross margin)	-3,952	-4,922	-4,425	-2,339	-253	1,833	3,919	6,006	8,092	10,178	12,264	14,350	16,436

Source: Calculations of the group of authors.

The culture of conventional lavender of the Chişineovscaia 90 variety allows farmers to record high economic efficiency results, namely: the economic return is 70.3% for the conventional farming system. The average commercial addition to the essential oil is 22.71 Euro/kg, which is beneficial for farmers and for diversifying income sources in rural areas. The cumulative information of the main economic indices in the cultivation of industrial lavender, the Chişineovscaia 90 variety for a full cycle of conventional production are presented in Table 5.

The cumulative profit generated in the conventional industrial lavender culture amounts to 747,015 Euros for a production cycle (13 years a cycle, including 10 years of full fruiting). Therefore, the cultivation of industrial lavender of the Chişineovscaia 90 variety in a conventional system can be recommended to farmers who have relatively small areas and who can ensure optimal conditions for the implementation of modern lavender cultivation technologies in a conventional circuit.

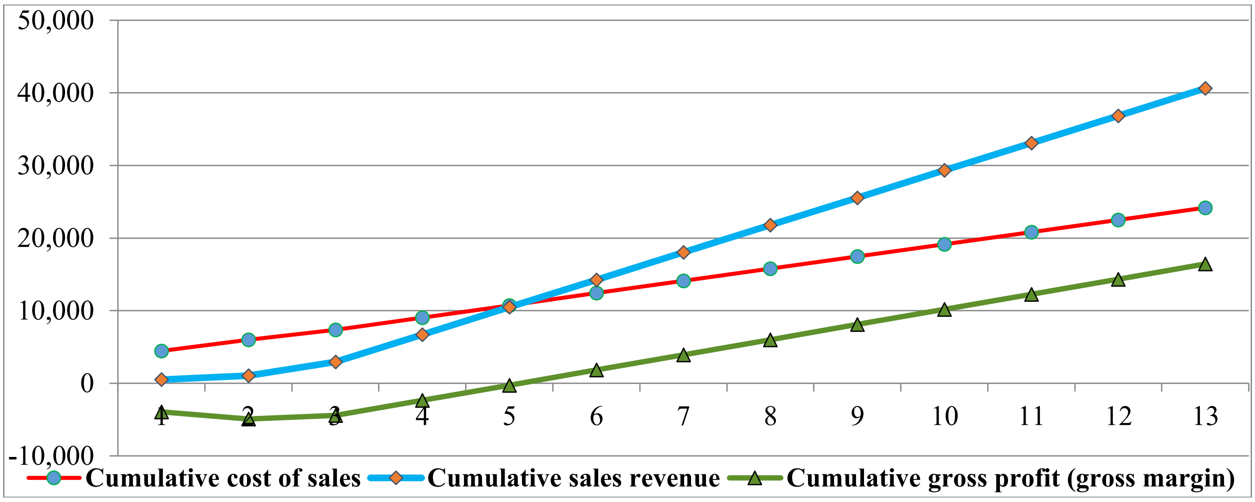

Fig. 1. The evolution of the cumulative economic indices for the cultivation of industrial lavender Chişineovscaia 90 variety for a conventional production cycle (area 1 ha)
Source: Calculations of the group of authors.

The culture of industrial lavender variety Chişineovscaia 90 in the conventional system has a high level of economic efficiency and is advantageous for implementation in agricultural holdings in rural areas of the Republic of Moldova.

CONCLUSIONS

Currently, there is an acute lack of complex / practical / applied information for agricultural producers regarding the efficient and sustainable development of businesses with hetero-oleaginous crops, the modernization of raw material production and processing technologies, the marketing of essential oil, the creation of added value, the ecological system of production and processing, the practical management of the operational management of the business, the competitiveness of the products and the enterprise to ensure the markets.

Public institutions, associations and donors must focus assistance on improvement of the existing framework, which would boost the development of the hetero-oleaginous crops sector (special for lavender) and support this sector in a much more focused / determined way, as it is one of perspective, with enormous unexplored possibilities both economically, social and ecological.

Cultivation of hetero-oleaginous plants for the Republic of Moldova offers farmers opportunities to diversify sources of income and presents a series of advantages:

-Essential oil is obtained from lavender, sought after in the E.U. / USA for industry, food, pharmaceutical, cosmetic, light, etc.;

-Crops with application in industry are promoted (technical plants, hetero-oleaginous plants);
-Competitive products are ensured in terms of quality, with direct reference to consumer protection;
-Establish business relationships between domestic and foreign producers and processors;
-Lavender culture is mechanized and does not require considerable investment;
-Businesses with hetero-oleaginous crops are practiced by small and medium farmers, which is important for providing them with alternatives to income;
-Lavender can also be cultivated in an ecological system and the average purchase price of the essential oil is 20-35% higher if they are certified by international certification bodies;
-Hetero-oleaginous crops are crops with a high level of profitability and allow for much more efficient use of production factors (land, fixed assets, etc.).

The production of hetero-oleaginous crops in an ecological system offers some advantages and is recommended for small farmers for implementation based on the following considerations:
-The cultivation of hetero-oleaginous crops is favored by the pedo-climatic conditions in the given region.
-Both on the domestic and European markets, demand is on the rise.
-The yield / profitability of these crops is very high! This means more money for entrepreneurs.
-The initial investment is small compared to the average profit obtained.

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