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ECONOMIC AND TECHNICAL EFFICIENCY ANALISYS OF THE SPRAY IRRIGATION SYSTEM FOR CORN, BARLEY AND WHEAT CROPS

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Abstract

The paper aimed to analyze the economic and technical efficiency of the spray irrigation system for maize, barley and wheat cultivated in the North-East part of Romania. In order to obtain stable and marketable products, it is necessary to optimize the amount of water indispensable for plant growth and fruiting, even when there is no water from natural precipitation or when plants cannot grow due to a lack of groundwater. In the North-East Region of Romania, by using local water sources and implementing modern irrigation techniques, it is possible to fully satisfy the water needs of plants, contributing to the improvement of irrigation efficiency. Thus, a profitable, sustainable and environmentally friendly agriculture can be achieved. The main production costs for the agricultural year 2022-2023 were about 4,000 lei for the non-irrigated maize crop and about 5,000 lei in the case of irrigation systems. For the production of wheat, increases of cca. 1,000 lei were recorded for the irrigated crop, compared to the non-irrigated one, similarly recorded in the case of the barley crop. This is mainly due to the increase in the cost of inputs price, the increase of water price and the fuel used for irrigation electricity generators. On average, the results obtained for the three investigated crops show that grain corn produces a higher profit per hectare when it is cultivated in an irrigated system (10,600 lei/ha) than when it is cultivated in a non-irrigated system (4,400 lei/ha). For the wheat crop, a profit of 3,500 lei/ha was recorded in the irrigated regime compared to the crop in the non-irrigated regime, where the profit was 20 lei/ha. Moreover, in the case of barley, a profit of 5,480 lei/ha was recorded in the irrigated system compared to the non-irrigated one.

Key words: *spray irrigation, technical and economic efficiency, maize, barley, wheat, North-Eastern Romania*

INTRODUCTION

Most of the irrigated agricultural area is found in developing countries, followed by developed countries and then least developed countries. Of this total area, 71.7% is located in the developed areas of Oceania and Asia, 15.6% in North and South America, 7.8% in Europe and 4.9% in Africa [6].

Currently, only about 20% of agricultural land is irrigated, but this portion produces 40% of global production and 60% of total cereal production [6]. The sources of water used for irrigation are purified wastewater, groundwater and rivers. The irrigation sector in Romania has experienced an involution, going from the development of important facilities between 1970-1975 to 1989, when the area equipped for irrigation was approximately 3.1 million hectares with 375 large irrigation systems [6]. After 1989, land fragmentation, poor infrastructure management and lack of investment led to a significant deterioration of the irrigation sector. By 2004, only 50% of the area equipped with irrigation systems had functional installations, a percentage that decreased to 45% in 2013 [6]. As for the effectively irrigated areas, they represented only 11% of the total of 2004 and decreased to 5% by 2013 [12]. In the post-1990 period in Romania, with political changes and restructuring of public institutions, the land reclamation sector was significantly affected from an organizational point of view (management, design, implementation and exploitation), as well as from a research point of view [6].

Romania's accession to the European Union has brought a particularly important contribution to the irrigation infrastructure in Romania. Starting with the multi-annual financial envelope 2007 – 2013, the first grants funds were allocated for the modernization of the irrigation infrastructure. Until 2024, most Water User's Associations in Romania have benefited from investments of 1 million Euros amount for the modernization of this infrastructure. European policies do not only target the irrigation segment as a means of ensuring quality food on markets at affordable prices. There are other levers also, such as the financial stimulation of optional crop insurance. Accessing thesefunds is a major opportunity for farmers in Romania, regardless of the size of the farmthey manage, which is why it is imperative toknow and understand the role of the Common Agricultural Policy byfarmers who undertake the organization of thecomplete activity for agricultural farms [8]. However, crop irrigation brings a specific benefit, demonstrated by this paper as well, being a much more efficient method than simply issuing insurance policiesfor crops against drought.

As it is known, water deficits can be compensated by adding the necessary amount of water to the active soil layer, during or outside the vegetation season. These approaches are meant to ensure stable and reliable agricultural production, taking into account the improvement or maintenance of soil quality by applying other appropriate agricultural techniques. The selection of the most suitable irrigation method, whether it is flood irrigation, furrow or strip irrigation, sprinkler irrigation, drip irrigation or sub-irrigation, is influenced by the particularities of the soil, the terrain and the crop type, each of these methods presenting both specific benefits and disadvantages.

Other researchers have also researched and found the major importance that irrigation has on the crops that occupy the largest share of arable land in Romania, such as those researched in this paper.Luca et al found that following investigations over a three-year period (2009-2011), it can be said that the additional water intake determined an increase in profit in each of the three experimental years, regardless of the variety cultivated [3].

Rusu and Simion (2015) conclude that the rehabilitation of irrigation systems had a positive effect on the development of competitive/intensive agriculture: land consolidation, increase in cultivated areas, increase in the share of crops with high economic value and increase in agricultural productivity [10].

[9] studied the yields in irrigated and non-irrigated systems as in the study case of Braila County, Romania.

[5] researched the influence of irrigation on the structure of crops on arable land.

Analyzing the evolution of crop yields per unit of land area in Romania compared to other countries, [4] concluded that smaller production level is caused, among other factors, by the lack of irrigations.

Other authors studied the both the technical and economic efficiency of the use of irrigations [13, 2, 7].

In this context, the purpose of this research was to assess the economic and technical efficiency of the spray irrigation system compared to the non-irrigated system for maize, barley and wheat cultivated in the North-East part of Romania.

MATERIALS AND METHODS

The study was conducted in the North-East region of Romania, during 2022-2023, on corn, winter wheat and winter barley crops. The main objective was to analyze the economic efficiency of using the sprinkler irrigation system, compared to the non-irrigated practice, in terms of water consumption, production costs and obtained profits.

In terms of location choice and climatic conditions the experiment was conducted in the forest-steppe area of the Moldavian Plain, a region with semi-arid climatic characteristics, which presents precipitation deficits during the growing season. The areas selected for the study were representative in terms of soil structure, typical for the region. A carbonate chernozem soil, loamy-sandy, with an average root depth of 80 cm for corn and 50 cm for wheat and barley.

In terms of irrigation system and technical parameters, for the comparative analysis, two sprinkler irrigation systems were used: a linear displacement system for corn and a center pivot system for wheat and barley. The systems were adjusted to ensure a constant water application rate of 20 l/m² on the irrigated area. The duration of irrigation application was 5 days for the corn crop and 7 days for the wheat and barley crops based on scientific literature and past experience.

Determination of water consumption was an important purpose within the research, the water consumption being estimated using the Thornthwaite method for calculating potential evapotranspiration (ETP) and optimal actual evapotranspiration (OET). ETP was calculated based on the average monthly temperature and the annual thermal index of the area, applying the formula specific to the region. In addition, the correction coefficient (kφ) specific to each crop and climatic zone was taken into account. The irrigation water requirement was determined for each crop individually, depending on weather conditions and soil characteristics.

As for the calculation and monitoring methods, for each crop, the soil absorbed water quantity was determined, based on gravimetric methods of measuring soil moisture. Measurements of the soil water reserve (IR – Initial Reserve and FR – Final Reserve) were also made, both during and out of the growing season, using parameters such as bulk density and water retention capacity. The total amount of water required for each crop was calculated by adding the water inputs from precipitation and the irrigation system, corrected for evaporation and infiltration factors.

In terms of production costs and profitability determination, production costs were estimated for both regimes (irrigated and non-irrigated) based on input costs such as seeds, fertilizers, fuel for electricity generators, costs of mechanization works and maintenance of the irrigation system. The productions obtained for each crop were analyzed per hectare, and profitability was calculated based on the difference between the income from the sale of the crop and the total production costs. Financial analyses were also performed to evaluate the profitability of the irrigation system compared to the non-irrigated system and the summary results were included in the paper.

The data obtained were statistically analyzed to compare the economic performances of the two irrigation regimes. The average water consumption and yield for each crop were compared, and significant differences were highlighted. The analysis was performed using standardized calculation methods and agricultural statistics software.

All the research assumed tenths of site visits by the authors which made advanced monitorization and analysis of both relevant technical parameters and economical-accounting eloquent financial documents of the economic agent.

RESULTS AND DISCUSSIONS

Economic sustainability is a result of efficient crop management, irrigation system selection, proper crop rotation, and crop yield [11].

Irrigation water management, over a given period of time, determines how much and when water is used for the crop benefit. Accordingly, the following are taken into account: the irrigation rate, the precise timing of irrigation, the time intervals between irrigations, the number of irrigations. The water requirements of crops are threshold variables and depend on the water deficit. This is determined by climatic and hydrogeological conditions, the physical properties of the soil and the water requirements of the crop during the cold period of the season or the vegetation period [1]. The number of irrigations depend on the crop requirements and thus usually one to 5 irrigations can be performed. In the presented analysis, on average, 1-2 irrigations were performed, each with 400 - 600 m3/ha. Potential evapotranspiration (ETP) in m³/ha was calculated using the Thornthwaite method, applying the following formula:

$$\mathrm{ETP} = 160 \cdot \left(\frac{10 \cdot \mathrm{tn}}{\mathrm{I}}\right)^{\mathrm{a}} \cdot k\varphi \quad (1)$$

where:

t_n- the average temperature of the month being calculated ETP, în °C,

I –annual heat indexa=0.000000675· I^3 - 0.0000771·I^2+0.01792·I+0.49239

K_φ- the correction coefficient depending on the latitude of the location, the annual thermal index of the area, this being obtained by adding the monthly thermal indices, was calculated using the formula:

$$I = \sum_{n=0}^{n^1=12} \ln ....(2)$$

where the dermal index equals $\left(\frac{t}{5}\right)^{1.154}$.

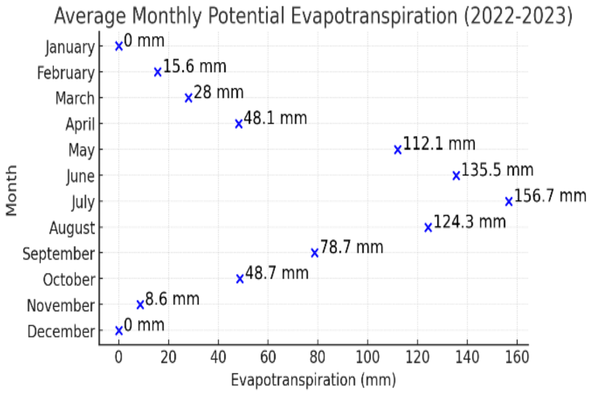

Fig. 1. Monthly average of evapotranspiration potential in 2022-2023
Source: own analysis, determination and centralization.

For Fig. 1 ETP (evapotranspiration) is calculated by adding the monthly values according to the collected and centralized data in Table 1, ETP=24+188+524+980+1,299+1,485+1,333+827+460+162 = 7,272 m^3/ha.

Table 1. Potential evapotranspiration (ETP m^3/ha)

Calculation elements	Month of the year									
	2	3	4	5	6	7	8	9	10	11
Monthly thermal indices (in)	0.16	1.31	3.76	6.66	9.1	10.4	10.1	6.95	4.00	1.48
Annual thermal index I	53.92									
Mean monthly air temperature (tn)	1.5	6	12	17.5	21.5	23.5	23	18	12.5	6.5
Correction coefficient (kφ)	0.81	1.02	1.13	1.28	1.29	1.31	1.21	1.04	0.94	0.79
eA Exponent	1.33									
ETP m3/ha	24	188	524	980	1,299	1,485	1,333	827	460	162

Source: own analysis, determination and centralization

The optimal real evapotranspiration (ETRO) is obtained by multiplying the calculated ETP value andk_φ, known as the correction coefficient for ETP, specific to each crop and natural area in Romania. The irrigation water requirement for a specific crop structure is determined proportionally, based on the water requirement for each crop in particular. ETRO = k_φ. ETP (m3/ha). ETRO – water consumption of a cultivated soil, when the soil moisture varies between field capacity and the minimum threshold, in the optimal range for obtaining an efficient economic yield. This value can be determined by experiments or by calculations. For the three analysed crops (maize, wheat and barley), the average water consumption is presented in Table 2.

Table 2. The average water consumption for maize, wheat and barley

Calculation elements	Month of the year								Total
	3	4	5	6	7	8	9	10	
ETP m^3/ha	188	524	980	1,299	1,485	1,333	827	460	7,096
Maize									
k_φ	-	0.86	1.05	0.86	1.31	1.07	0.92	-	
ETRO=ETP· k_φ m^3/ha	-	450	1,029	1,117	1,945	1,426	761	-	6,728
Winter wheat									
k_φ	2.71	1.55	1.20	0.91	-	-	-	-	
ETRO=ETP· k_φ m^3/ha	509	812	1,176	1,182	-	-	-	-	3,679
Winter barley									
k_φ	2.71	1.55	1.20	0.91	-	-	-	-	
ETRO=ETP· k_φ m^3/ha	509	812	1,176	1,182	-	-	-	-	3,679

Source: own analysis, determination and centralization.

The determination of water consumption for the crops of grain maize, winter wheat and winter barley in the conditions of North-East Region of Romania is done using the Thornthwaite method.

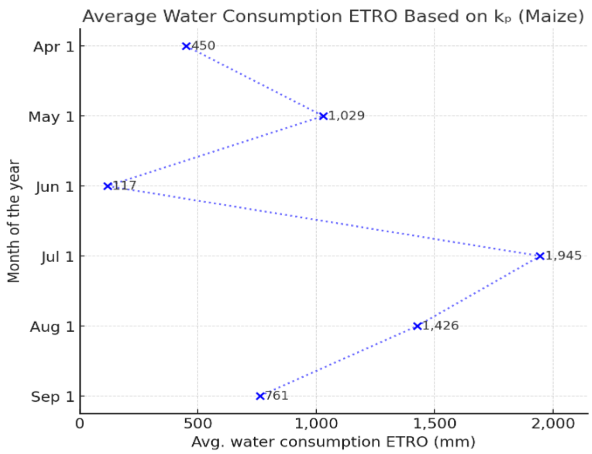

Fig. 2. Average water consumption ETRO based on k_φ (maize)
Source: own analysis, determination and centralization

As it can be seen, the maximum water consumption coincides with the months of maximum corn growth (June-July).
The decrease in consumption towards the end of the vegetation cycle (August-September) indicates a maturation of the crop.
The following Figure 3 shows the evolution of average water consumption (ETRO) for wheat crops depending on the month of the year, more precisely in the period March - June.

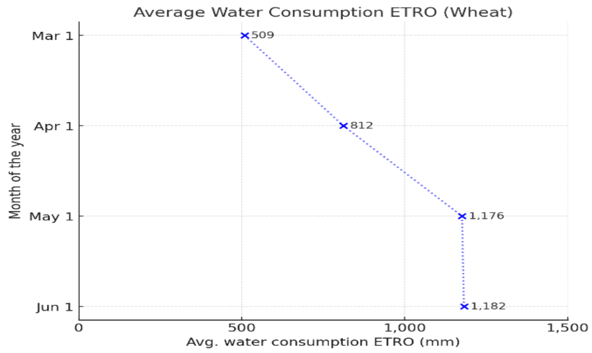

Fig. 3. Average water consumption ETRO based on k_φ (wheat)
Source: own analysis, determination and centralization

As it can be seen, the maximum water consumption is recorded in the months of May and June, coinciding with the critical phases of development. Irrigation is essential in April and May, when any water deficit can negatively affect the final production.

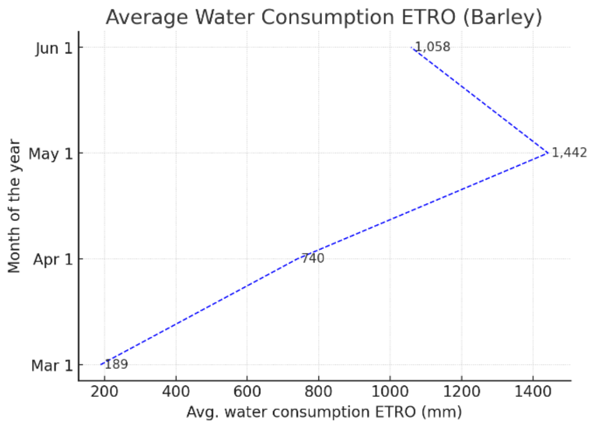

Fig. 4. Average water consumption ETRO based on k_φ (barley)
Source: own analysis, determination and centralization

From Fig. 2, 3 and 4 it can be seen that in maize there was an average water consumption that varied from one month of vegetation to another, but in wheat and barley, on average, the water consumption was the same. In all three studied crops the average water consumption was calculated according to the correction coefficient.
The total amount of water in the soil during April 1 – August 31 for the grain maize crop is obtained by adding the monthly average of water consumption i.e. 6,796 m³/ha. The total amount of water absorbed from the soil during March 1 – June 31 for the winter wheat and winter barley crops is 3,679 m³/ha.

The initial soil water reserve (IR), available to crops during the vegetation period is located in a limited soil layer, determined by the depth at which the root system develops or by the soil conditions. Outside the growing season, the accumulation layer from which water can be accessed by plants is taken into account. In soils with a water regime independent of the groundwater level, such as in the forest-steppe zone, this reserve can be a maximum of 500 m³/ha.
The field water capacity reserve (WCR) is calculated as follows:

WCR=H*BD*FC...............................(3)

where:
BD – bulk density in t/m3,
CC – field water capacity in % g/g,
H – depth for which the soil water reserve is considered (cm).
In the case of wilting coefficient (WC), the unit % g/g provides a measure of the intensity of wilting, indicating how much mass (usually water) was lost from the plant structure as a result of this process. And for field water capacity (FC), "g/g" means "grams of water per gram of soil", that is, the mass of water retained in the soil compared to the total mass of the soil, and "%" indicates that this ratio is expressed as a percentage, to show the proportion of water retained by the soil compared to the total mass of the soil. The final soil water reserve (FR) is the amount of water remaining in the soil at the end of the growing season or during autumn. In the forest-steppe area, this value generally exceeds 800 m³/ha.
The water reserve corresponding to the wilting coefficient (WCR) is calculated according to the formula:

WCR=$H*DA*CO$................................(4)

where: SWR - soil water reserve at the beginning of the growing season, expressed in m³/ha.
The calculation formulas for the initial and final soil water reserves are presented in Table 3, which contains the values (FR) for the final reserve and the initial reserve (IR), at a depth

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of H=150 cm, noted in m^3/ha, for the forest-steppe.

Table 3.FR and IR valuesof soil water

Zone	FR	IR	Winter precipitation storage coefficient (c)
Forest-steppe	R_{CO}+800	R_{CC}-500	0.5

Source: own analysis, determination and centralization

The water from precipitation during the growing season (GS) for a given month is equivalent to the total amount of precipitation recorded in that month (including amounts less than 5 mm). In calculating this amount of precipitation, water losses through runoff to the soil surface are not taken into account, and infiltration is taken into account only when the soil reaches its water retention capacity at the specified depth, allowing for runoff only for amounts of water exceeding this capacity, after deducting the actual optimal evapotranspiration. PV is equal to 10 times the thickness h in mm of the precipitation layer, with an 80% supply, according to Table 4 and Fig. 5.

Table 4. Precipitation during the growing season is supplied by 80%

Calculation elements	UM	Month of the year							Total
		3	4	5	6	7	8	9	
Precipitations (Pv) supplying 80%	m^3/ha	350	300	390	470	290	230	300	2,330

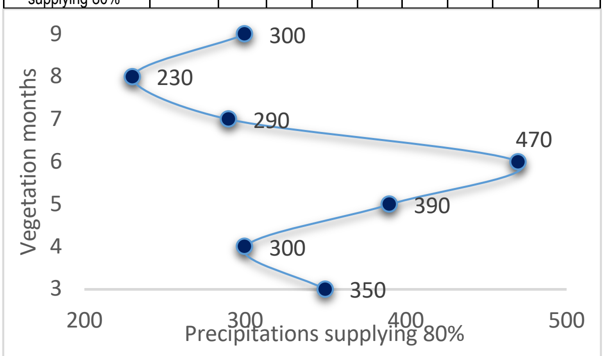

Fig. 5. Precipitation (Pv) supplying 80% (m3/ha)
Source: own analysis, determination and centralization.

From Fig. 5 it can be seen that the rainiest months were May and June, with quantities between 390 m^3/ha and 470 m^3/ha.

In table 5, are the values of the physical and hydro physical indices for carbonate chernozems from the Moldavian Plain, where we encounter a sandy loamy texture. WCR at a depth of 150 cm has the value:

WCR=H*BD*CO=150*1.37*8.9=1,829 m^3/ha;

FR is equal to:

FR = WCR +800=1,829+800=2,629 m^3/ha; WCR is calculated using the relationship: WCR =H*DA*FC =100*1.37*23.1=3,165 m^3/ha.

Thus, IR is equal to:

IR = WCR – 500=3,165–500=3,665 m^3/ha. The irrigation norm (M) is the amount of water required to irrigate a cultivated area of one ha. It is expressed in m^3/ha and is calculated as follows:

M=ETRO+ FR – IR – VP.....................(5)

Using the previously calculated values, M is determined as follows:

- corn: M=ETRO+FR – IR–VP=5,967 m^3/ha+2,629 m^3/ha–3,665 m^3/ha–2,330 m^3/ha=3,601 m^3/ha;
- wheat: M=ETRO+FR – IR–VP=3,679 m3/ha+2,629 m^3/ha–3,665 m^3/ha–1,510 m^3/ha=2,133 m^3/ha;
- barley: M=ETRO+FR – IF–VP=3,679 m^3/ha+2,629 m^3/ha–3,665 m^3/ha – 1,150 m^3/ha=2,133 m^3/ha.

Table 5.Physical and hydrophysical indices – carbonate chernozem

Soil grouo	Physical-geographical unit	Texture	Depth h (cm)	Aparent density (t/m^3)	Wilting coefficient WC (% g/g)	Field Capacity FC (% g/g)
Carbonate chernozem	Moldavian Plateau	Sandy clay loam	50 100 150	1.32 1.36 1.37	10.7 9.6 8.9	25.7 24.4 23.4

Source: own analysis, determination and centralization.

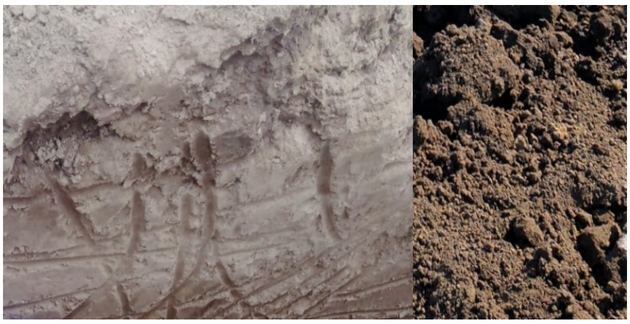

Fig. 6.Studied soil profile, sandy clayey loam texture
Source: author's photo and analysis.

Figure 6 shows the soil profile with a sandy loam texture, according to the data presented in Table 5.

The irrigation norm during the growing season represents the amount of water applied at one watering for a crop on an area of one ha. The sum of the watering rates forms the irrigation rate. H, where the roots are mainly located, is

80 cm for the corn crop and 50 cm for the wheat and barley crops.

The watering norms for the three crops are calculated according to the minimum threshold values: for corn 1,000 m^3/ha, for winter wheat and winter barley 675 m^3/ha.

Thus, for corn crops, approximately 4 irrigations are required, and for winter wheat and winter barley crops, an average of 3 irrigations are required. The irrigation rate is adjusted: for corn 867 m^3/ha, for wheat and barley 711 m^3/ha. For the analyzed irrigation systems, the duration of irrigation application is 5 days for the linear displacement sprinkler for corn crops, with a rate of 20 l/m², and for the center pivot sprinkler irrigation system, the duration of irrigation application is 7 days for wheat and barley crops.

Humidity determination is carried out by the gravimetric method and thus irrigation application for the analyzed crops takes place when the soil water reserve decreases and its value approaches the minimum threshold.

The amount of water distributed, application times and duration of irrigation in the agricultural years 2022 and 2023 are presented in Tables 6 and 7.

Table 6. The amount of water distributed and the duration of irrigation during 2022 agricultural year

Description	U/M	Vegetation months						Total	M m^3/ha
		4	5	6	7	8	9		
80% supply	m^3/ha	300	390	470	290	230	300	1,980	3,500
ETP	m^3/ha	524	980	1,299	1,485	1,333	827	6,448	
kφ	m^3/ha	0.86	1.05	0.86	1.31	1.07	0.92	-	
ETRO=ETP· kφ m^3/ha	m^3/ha	450	1,029	1,117	1,945	1,426	761	6,728	
P_v-ETRO	m^3/ha	-150	-639	-647	-1,655	-1,196	-461	-4,718	
R_{CC}	m^3/ha	3,165							
R_{PM}+m/2	m^3/ha	3,288+433=3,721							
R_i	m^3/ha	3,665	4,390	3,751	3,979	4,074	2,785	-	
m	m^3/ha	875	-	875	875 875	-	-	-	
R_f	m^3/ha	4,390	3,751	3,979	4,074	2,875	2,417	-	

Source: own analysis, determination and centralization

Table 7. The amount of water distributed and the duration of irrigation during 2023 agricultural year

Description	U/M	Vegetation months						Total	M m^3/ha
		4	5	6	7	8	9		
80% supply	m^3/ha	300	390	470	290	230	300	1,980	2,133
ETP	m^3/ha	524	980	1,299	1,485	1,333	827	6,448	
kφ	m^3/ha	1.55	1.20	0.91	-	-	-	-	
ETRO=ETP· kφ m^3/ha	m^3/ha	812	1,176	1,182	-	-	-	3,170	
P_v-ETRO	m^3/ha	-512	9,786	-712	-	-	-		
R_{CC}	m^3/ha	3,165							
R_{PM}+m/2	m^3/ha	3,288 + 355 = 3,643							
R_i	m^3/ha	3,665	3,854	3,779	3,778	-	-	-	
m	m^3/ha	711	711	711	-	-	-	-	
R_f	m^3/ha	3,854	3,779	3,778	3,778	-	-	-	

Source: own analysis, determination and centralization.

For the irrigation applications, the first irrigation is applied on April 22; the 2ndirrigation is applied on May 15, and the 3rdirrigation is applied on June 15.

In the studied area, a technical budget was developed for the established crops.

Table 7 presents the economic indicators in irrigated and non-irrigated regimes.

It can be seen that all studied crops have a significant increase in production under irrigated conditions: maize: from 7,000 kg/ha (unirrigated) to 13,000 kg/ha (irrigated) (+85%).Wheat from 2,200 kg/ha to 5,000 kg/ha (+127%).Barley from 2,400 kg/ha → 6,000 kg/ha (+150%).

Table 8. Economic indicators, irrigated and non-irrigated

System	Economic index	Maize	Winter wheat	Barley
Irrigated	Avg. production (kg/ha)	13,000	5,000	6,000
	Avg. production cost (lei/ha)	5,000	4,500	4,500
	Avg. selling price (lei/kg)	1.2	1.6	1.8
	Avg. total profit (lei/ha)	10,600	3,500	6,300
Non irrigated	Avg. production (kg/ha)	7,000	2,200	2,400
	Avg. production cost (lei/ha)	4,000	3,500	3,500
	Avg. selling price (lei/kg)	1.2	1.6	1.8
	Avg. total profit (lei/ha)	4,400	20	820

Source: authors analysis from company primary data.

Total costs per hectare increase in the irrigated system due to additional water and irrigation management costs: Maize: from 4,000 lei/ha to 5,000 lei/ha (+25%).Wheat: from 3,500 lei/ha to 4,500 lei/ha (+29%).Barley: from 3,500 lei/ha to 4,500 lei/ha (+29%).

The cost per kilogram remains relatively constant, suggesting that the increased yield covers the investment in irrigation.

As we can also see, a considerable profit for the corn crop results, but also a small difference in profit for the wheat crop, because this is not a demanding plant, being drought-resistant, and irrigation did not have a major effect on its development.

From Figures 7 and 8, we can observe the days during the vegetation months when the largest amounts of water were allocated by irrigations due to the lack of precipitation, as we can see, 2022 being a drier year than 2023.

As we can see in Fig. 7. And Fig. 8., the highest amounts of water were applied in June and July, indicating a peak requirement during this period.

In August and September, the volumes applied are lower, which may suggest a maturation of the crops and a reduction in water need.

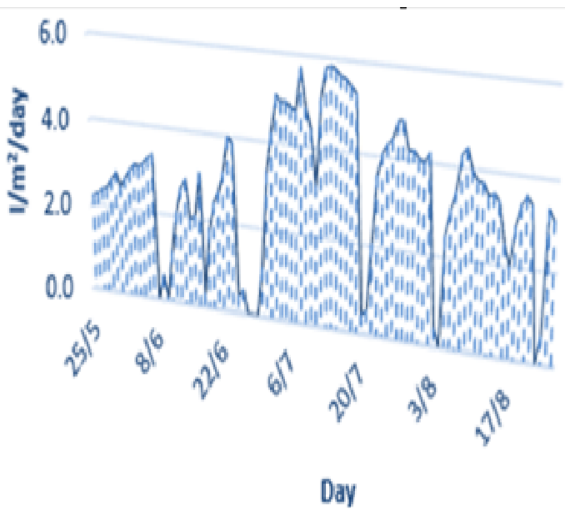

Fig. 7. Irrigated water amount in 2022
Source: primary data analysis and centralization of the water pumping station flowmeter.

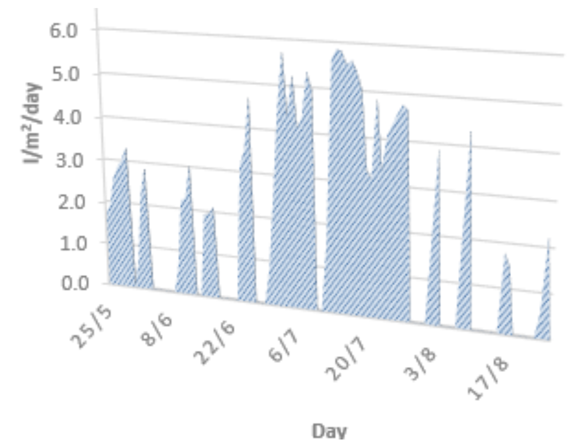

Fig. 8. Irrigated water amount in 2023
Source: primary data analysis and centralization of the water pumping station flowmeter.

CONCLUSIONS

The present paper compares production, costs, and profits for irrigated and non-irrigated systems, providing a clear perspective on the benefits of irrigation.

In terms of irrigation influence on agricultural production we can observe significant increase in production for all crops studied: for corn from 7,000 kg/ha (non-irrigated) to **13,000 kg/ha irrigated, +85%. For winter wheat from 2,200 kg/ha to 5,000 kg/ha, +127%. For barley from 2,400 kg/ha to 6,000 kg/ha, +150%. This increase confirms the importance of water as a limiting factor in agriculture and demonstrates the positive impact of irrigation on crop yield.

In terms of production costs and economic analysis, we can observe that production costs increase with the use of irrigation, but remain justified by the increase in production. For corn from 4,000 lei/ha, non-irrigated to 5,000 lei/ha, irrigated+25%. For wheat from 3,500 lei/ha to 4,500 lei/ha, +29%. For barley from 3,500 lei/ha to 4,500 lei/ha, +29%. The cost per kilogram **remains constant, which indicates that the investment in irrigation is economically sustainable. Wheat is the most affected in the absence of irrigation, with an almost non-existent profit in the non-irrigated regime. This fact emphasizes the need for irrigation to avoid economic losses.

In terms of water management and irrigation needs we observe that water consumption varies depending on the crop and phenological stage, as follows: corn has the highest consumption (6,796 m³/ha, between April-August).Wheat and barley require 3,679 m³/ha (March-June). As stated within the paper, irrigation must be adapted according to evapotranspiration and precipitation. The maximum water consumption coincides with the periods of intensive growth (June-July for corn, May-June for wheat and barley), which requires efficient Water User's Association strategies and organizing for the whole agricultural year.

Irrigation brings a clear increase in production and profit for the analyzed crops, justifying the additional costs of implementing an irrigation system. Wheat is the most vulnerable to water shortages, while corn is the most profitable under irrigated conditions. The study highlights the need to modernize and expand irrigation systems to support efficient and sustainable agriculture in Romania.

Given the recent years that have shown an increasing, unusual degree of drought, with a maximum temperature of 44.5° C during 2024 summer, it is expected that national and European policies will continue to encourage the development of the irrigation system through financial incentives, deductions and other measures.

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