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EFFICIENCY OF MAIZE AND SUNFLOWER CROPS UNDER THE IMPACT OF DROUGHT IN BRAILA COUNTY, ROMANIA

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Abstract

The main objective of the research is to evaluate the efficiency of crops under the influence of drought. In the development of agriculture, a challenge is to obtain high yields under the action of climatic factors. During the research, numerous other secondary objectives were achieved, and starting hypotheses were established, which are verified at the end of the article. The objective of the research falls within the current guidelines of PAM 8, which aims at the efficiency of water use in Romania. The research is located at the Brăila county level, we aimed to evaluate the efficiency of the most vulnerable crops (maize, sunflower) under the impact of water shortage. The study was analyzed over the last 33 years, and the results suggested that the potential of crops is proven by the contribution to the turnover of over 8% that it has in the county's economy. Further research is needed to elaborate on these findings in other counties to have a comprehensive nationwide diagnosis for stakeholders.

Key words: *maize, sunflower, efficiency, drought*

INTRODUCTION

Given the high-frequency nature of weather variables relative to yield and other agricultural outcomes, researchers are faced with a unique model selection problem in assessing climate change impacts. If farmers do not respond to climate change in a way that is meaningfully different from how they respond to weather shocks, then using weather fluctuations to identify climate impacts could be perfectly justified [2].

Drought assessment involves analyzing and measuring the impact of drought on various aspects such as the environment, agriculture, economy, and society in general. The present research looks at some key aspects that are considered in the evaluation, as follows:

Monitoring of meteorological indicators, at the level of Brăila county, after 1990, including here, the significant decrease in precipitation amounts, an increase in temperatures and soil moisture;

Monitoring the behavior of crops under the influence of groundwater levels, the flow of rivers and lakes;

Soil moisture and agricultural productivity monitoring [10].

Analysis of the impact of the drought on agricultural production, especially those most sensitive to these changes (corn, sunflower, soy), behaviors that can have serious consequences on the food and economic security of this county. Impact on ecosystems: Drought can affect biodiversity and the natural habitat of various species.

Ecosystem impact assessment is crucial for environmental conservation.

Drought can have significant economic effects, including lower agricultural production, higher food prices, lower farm incomes, and losses in other economic sectors affected by water shortages.

The social impact is assessed by the degree of damage to rural and urban communities, causing migration, lower living standards, and increased social tensions.

It is also important to develop and implement drought adaptation and mitigation measures to reduce vulnerability and improve the resilience of communities and the environment to this type of extreme events [12].

Climate change presents an unparalleled difficulty to human society, and the magnitude of its effects depends on how well the world understands the need for appropriate concessions. As the effects of climate change intensify, both actual and alternative expenses will increase, affecting the population's health and economic prosperity. The primary societal obstacle is the incorporation of sustainable measures into economic development. Plants adapt to climatic conditions through physiological, biochemical, and morphological changes, demonstrating their adaptive potential to survive and thrive in changing climates [1].

We aim from the outset to connect recent work that traces the link between climate change, including changes in precipitation regimes, and the frequency of extreme weather events that can have a significant impact on agricultural production. Farmers can take steps to adapt to climate change, such as using more water-efficient farming techniques, choosing more drought-resistant crops, or developing more advanced irrigation systems.

In conclusion, climate plays a crucial role in determining the success or failure of agricultural production, and farmers and agricultural communities must be prepared and consider adaptation strategies to cope with climate change.

The main objective of the article is to identify the efficiency of crops sensitive to drought in Brăila County under the impact of climate indicators. Achieving this goal requires a data set that identifies the influence of key indicators that leave their mark on crops (maize and sunflower). Along with this, the research aims at **several objectives**, presented below, in the form of O1-O4 [10].

O1 Determining the effect of drought on the efficiency of corn cultivation in Brăila county
O2 Determining the effect of drought on the efficiency of sunflower cultivation in Brăila county
O3 Economic evaluation of the reasons why Brazilian farmers choose crops for the development of their businesses;
O4 Economic assessment of the reasons why the farmers recognize that certain environmental factors can influence the production of certain crops.

The assumptions from which the research started are presented for each objective and are established based on previous studies, specialists, or empirical reports.

I1. Objective 1 *assumes that maize yields have performed somewhat better, reaching peaks of over nine tonnes/hectare in 2018 and a low of 1.2t/ha in 2008. Farmers' challenges are marked by summer drought, farmers in the area of Brăila County face the adverse effects of climatic conditions, encountering significant difficulties for the beginning of the vegetation of crops. Both autumn-sown crops face unprecedented challenges due to months of very low rainfall and unusually high temperatures for this period, but especially spring crops whose vegetation cycle overlaps with extremely dry periods.*

I2. Objective 2*, starts from the hypothesis that sunflower production varied between one ton and almost two tons per hectare, being affected by the reduced amounts of precipitation. These conditions emphasize the importance of adapting agricultural practices to individual plots and the need to assimilate premium genetics supported by advanced technology for a successful harvest.*

The lack of rains at an optimal level during the period of establishment of autumn crops, associated with the current absence of snow and unusually high temperatures, which lead to the evaporation of the water reserve from the soil, are reasons for concern in Brăila County. Precipitation levels vary nationally, with Brăila being one of the most affected counties, and there is even a risk of crops returning. Farmers are therefore advised to choose maize and sunflower hybrids that can withstand drought conditions in the coming spring and summer months and ensure satisfactory yields.

I3. *Objective 3,* Determining farmers to cultivate corn or sunflowers, shows that for one hectare of land cultivated with corn, not irrigated, with an average production of 5-6 tons/hectare, a farmer reaches an income of 2,000 euros, from which remains with a profit of around 600 euros/hectare, after deducting expenses. The price of corn in 2022 was 340 euros/ton.

"The whole process, from establishing a crop to harvesting, varies between 1,000 and 1,400 euros/hectare, without irrigation. The variation of 400 euros depends on what technology the farmer applies, and what investments he has made. 2022 was a special agricultural year because the drought deeply affected Brăila counties, some farmers had their harvests almost completely affected [13].

I4. Objective 4 starts from the hypothesis that specialists emphasize the importance of the pillars of innovation and sustainability in the dynamic landscape of agriculture, local farmers face a series of environmental challenges that require the assimilation of practices and technologies adapted to these conditions. Thus, they offer farmers the solutions with the highest tolerance to drought and heat, ensuring a significant increase in productivity, regardless of the climate impact, through the efficient use of limited water resources.

In this context, the number one choice among Romanian farmers is corn and sunflower hybrids, recognized for their tolerance to extreme environmental conditions.

These hypotheses have been established empirically.

MATERIALS AND METHODS

To achieve this objective, the research focused on exploring statistical data from Brăila County and using the regression function for crop efficiency and farm management performance.

Using FAO data, in the context of the global report on the Sustainable Development Goals (SDGs), we tried to identify what are the opportunities to further increase the efficiency of water use in agriculture, the world's largest user of water. Romania falls within the current recommendations for accelerating the achievement of the SDG target of sustainable water use.

Since in the last four years, there have been major changes in soil and air temperatures much higher than the multi-year averages for the period 1991 - 2020, the crops mentioned above have been affected in the sense of diminishing them, in varying degrees up to calamity, they have subject to compensations granted by the Government.

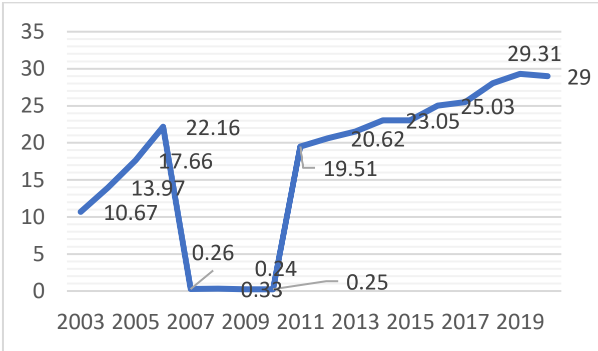

Fig. 1. Efficiency of water use in agriculture $/m3 in Romania after 2003
Source: [5].

Figure 1 shows how in Romania different intervals of efficiency were registered, as the economy registered different stages in its evolution.

Decreases in water withdrawals can result from structural changes in a country's economy, such as industrial relocation, that create increases in virtual water imports.

As previously explained, the indicator can provide an overview of the change in water use efficiency globally from 2003 to the present (latest validated data available 2019). Globally, water use efficiency increased from USD 17.18/m3 in 2015 to USD 18.89/m^3 in 2018 worldwide representing an increase of 10% [8].

However, global values hide regional differences.

To determine the effect of the drought on agricultural production in Brăila County, we used the data set of the type:

Precipitation Index (SPI) – Standardized Precipitation Index: This index standardizes the amount of precipitation in Brăila County and the period, allowing the evaluation of the drought in statistical terms. The Crop Rainfall Index is a measure of the amount of rainfalls over a given period and in a given geographical area, relative to the water needs of the crops during that period.

Moisture Deficit Index (PDSI): This is an indicator that assesses soil moisture deficit based on precipitation and potential evapo transpiration. PDSI can be used for regional or national drought monitoring. Soil moisture deficit refers to the difference between the amount of water available in the soil and the amount of water needed to meet plant requirements. It is a measure of how much water is lacking in the soil to support plant growth and development optimally.

Optimum real evapotranspiration (ETRO) is a method of estimating the water consumption of crops and represents the water consumption that allows photosynthesis to take place corresponding to obtaining an economically efficient harvest. It was indirectly established based on the formula:

$ETRO = k\_p \cdot ETP$.................................(1)

where:

ETRO isthe actual optimal evapotranspiration, in m^3/ha

k_p – coefficient characteristic of the analyzed plants, grown in the pedoclimatic zone

ETP – potential evapotranspiration, established by the Thornthwaite method in m^3/ha.

Water consumption during the vegetation period was obtained by adding up the monthly products for which this indicator was determined.

ETRO is determined for each crop and the resulting values are used to calculate the water balance and to determine the water requirement.

These meteorological indicators are used by meteorologists, environmental agencies, and authorities responsible for drought monitoring and management, helping to identify and address water scarcity issues and impacts on the environment and communities.

SPI values (March – September) for Brăila county, lower than -0.8 indicate periods of at least moderate meteorological drought, with values lower than -1.6 indicating at least extreme drought for the two time intervals. Droughts during this period are very significant for agricultural production in particular, as most annual crops end their lifecycles within them.

The prevailing pedoclimatic conditions associated with the Black Sea basin have been favorable to cereal growing in these regions since ancient times.

Today, Romania is recognized worldwide as an important grower, producer, and exporter of maize. In 2021, it was ranked 3rd in terms of area under maize cultivation, with 2,554,680 hectares and a production of 14,820,690 tonnes [3].

The examination of maize production and area in Romania reveals several key findings. Maize remains the predominant crop, cultivated across approximately 2.5 million hectares, representing 47.6% of the area dedicated to cereals and 30.8% of the total cultivated area. Regional distribution shows South Muntenia, South East, and North East as the primary regions for maize cultivation. While there was a slight decrease in maize cultivation area in 2021 compared to 2011, macro-regions experienced varied changes, with notable increases in Macro-regions 1, 2, and 3, but a significant decrease in Macro-region 4. Despite fluctuations in cultivation area, maize production increased by 26.5% between 2011 and 2021 [6].

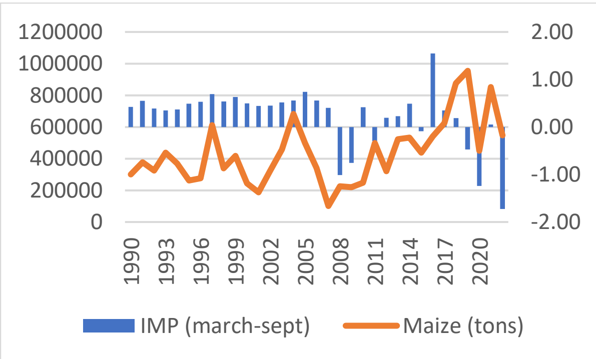

Fig. 2. The evolution of corn production and SPI in Brăila County from1990 to2022
Source: [4, 13].

Toillustratetheeffect of drought on agriculturalproduction in Brăila County, weusedthe linear regression model for theproduction of sunflower, andgrain corn, as dependent variables.

The regression function was used to assess the sensitivities and resistance of crops to drought and to quantify the effects of drought on crop production (Fig. 2).

However, agriculture suffers from these seasonal events. Thus climatological factors trigger lower-than-normal precipitation and/or a late end to the dry season.

SPI is important to farmers because the amount and distribution of rainfalls can significantly influence the yield and quality of the maize crop. From the analysis of the SPI Index for the Braila area in the period 1990-2022, the frequency of droughts varied from 3% extreme drought, 6% moderate drought, and 87.8% normal years - mild drought for the period March-September (Fig. 3).

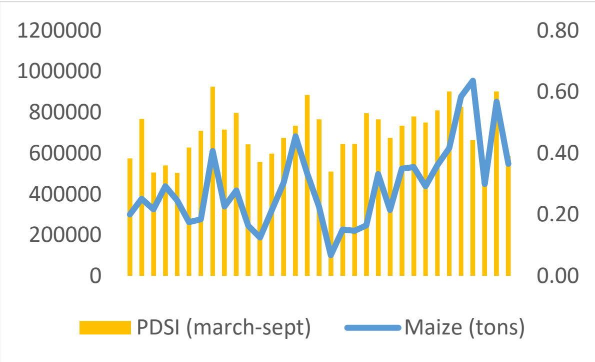

Fig. 3. The evolution of corn production and PDSI in Brăila County from1990 to2022
Source: [4, 13].

The water consumption for the corn crop reached an average value of 703.4 mm/m^2 in the period 1990-2022, and the amount of precipitations during the entire vegetation period was 289 mm (Fig. 4).

In the last 33 years, corn was harvested on average from an area of 89 thousand cultivated hectares within Brăila county, the reported average production being almost 2.4 tons/ha.

From the analysis of these data, it can be concluded the dependence of this agricultural crop on irrigation, complete the difference between the cumulative precipitations during the vegetation period and the calculated crop consumption.

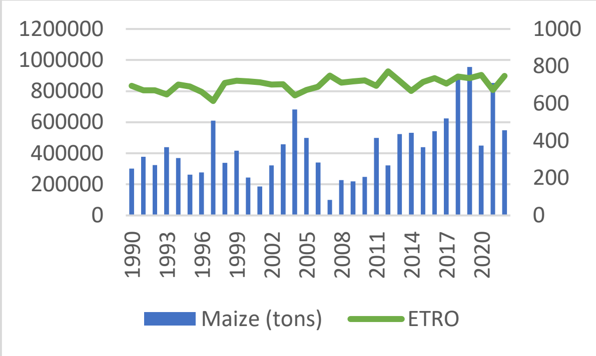

Fig. 4. The evolution of corn production and ETRO in Brăila County from1990 to 2022
Source: [13].

The dynamics of sunflower production and SPI is shown in Fig. 5.

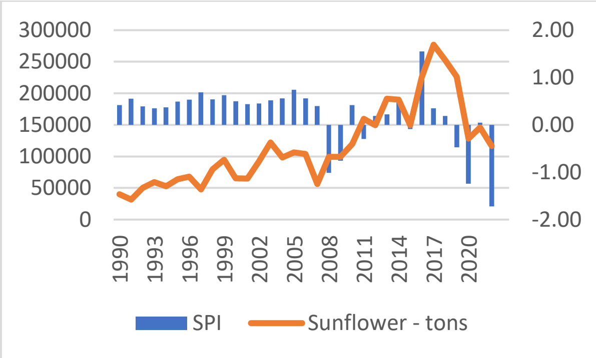

Fig. 5. The evolution of sunflower production and SPI in Brăila County in the period 1990-2022
Surce: [4, 13].

Sunflowers are grown in many countries because of their remarkable ecological adaptability. Over 45 million tonnes of sunflower seeds are produced worldwide, a considerable rise from previous years. However, there have been significant geographical variations in the growth of global sunflower production [7].

Farmers in Romania will grow sunflowers on the long term because it has both technical and economic advantages [11]. The sunflower is part of the group of mesophytic plants, with a medium resistance to drought. Sunflower achieved a high performance of 3,041 kg/ha in 2018 and the lowest of 1,858 kg/ha in 2020 [9]. The weakest crop years for these two crops were 2020, but 2018 favored maize and sunflower.

The sunflower is part of the group of mesophytic plants, with a medium resistance to drought. After sunrise, the need for water

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increases progressively, with a maximum consumption during flowering and fruiting.
Regarding sunflowers, in Brăila County total production (on average) was 116,000 tons in the last 33 years. The sunflower yield reported in Brăila County was 2.9 tons/ha (Fig. 6).

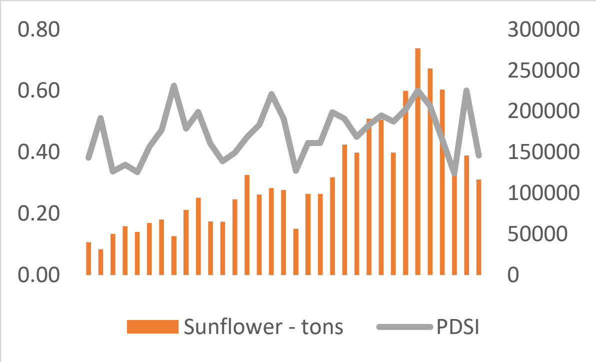

Fig. 6. The evolution of sunflower production and PDSI in Brăila County in the period 1990-2022
Surce: [4,13].

It turns out that sunflower is a basic crop in this area, but the prolonged droughts of the last 20 years that have hit Romania also affect sunflower production, which has decreased by approximately 30% (Fig. 6).
In the following figures, we study the dispersions in the analysis of the efficiency of the program and sunflower crops under the impact of the drought using th etwo indicators, taking into account the climatic conditions but also the crop's response to these conditions at the Brăila county level.

RESULTS AND DISCUSSIONS

Climate change is expected to affect agriculture, drought will occur more often, start earlier, and last longer. Higher temperatures and less precipitation are expected to reduce crop yields, although more extreme weather events are likely to increase crop yield volatility.
In the following figures, we study the dispersions used in the analysis of the efficiency of corn crops under the impact of drought using the two indicators, taking into account the climatic conditions but also the crop's response to these conditions at the level of Brăila county.

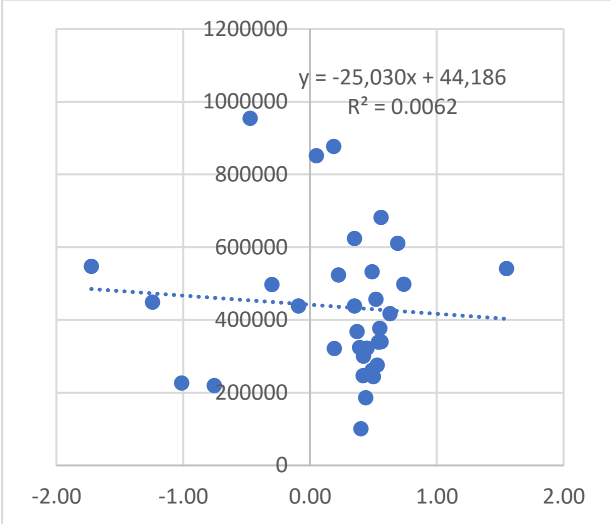

Fig. 7. Dispersion relationship between corn production and SPI in Brăila county during 1990-2022
Source: processingbytheauthors.

An evaluation of the SPI, based on rainfalls records over the last thirty years, using the regression function, shows that the dispersion relationship between the indicators is negative, indicating a percentage of 0.6% of the variability of production to rainfall in this crop from Braila (Fig. 7).
The relationship between the two factors is negative, which shows an un even distribution of precipitations throughout the growing season that affected corn production. Also, poorly drained soils led to excessive water accumulation in the roots, which negatively affected plant growth.
From the SPI evaluation, it can be seen that maize shows a high degree of vulnerability to high temperatures and lack of precipitations, and consequently yields are low. High evapotranspiration from the grain filling period limits production potential. In drought-prone areas, SPI is an effective indicator for evaluating the effects of drought on maize productivity (Fig. 8).
An evaluation of PDSI, using linear regression, based on soil moisture index records over the last thirty years, the dispersion shows that this indicator describes 26% of the variability of the production of this crop in Brăla, and ETRO contributes 1.3% to the variability production, (Figures 7 and 8).

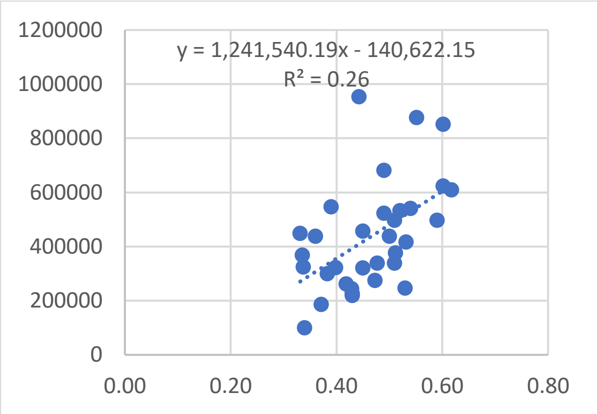

Fig. 8. Dispersion between maize production and PDSI in Braila county in the period 1990-2022
Source: processing by the authors.

Figure 9 shows a small dispersion of only 1.3% between evapotranspiration and maize production, indicating inefficient water use over the past 33 years, and poor crop management.
The amount of water available for evapotranspiration is strongly influenced by temperature, humidity, wind, and precipitation.

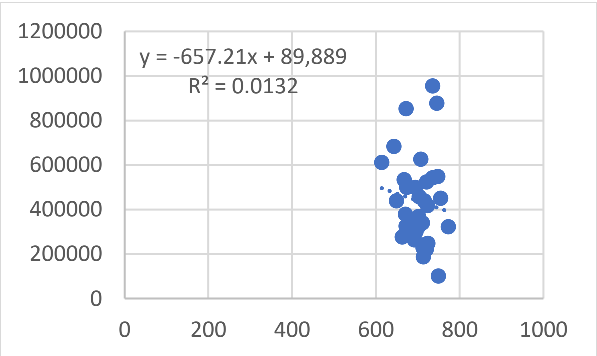

Fig. 9. Dispersion between corn production and ETRO in Brăila County during 1990-2022
Source: processing by the authors.

In Brăila County, the high temperatures and dry weather of recent years have left their mark on the evapotranspiration of the corn crop. The soil's ability to hold water and release it gradually can influence the availability of water to plants. Moreover, the small dispersion of 1.3%, but the function is negative, shows us a weak efficient management of irrigation in the county, which failed to ensure the optimal amount of water necessary for the growth and development of corn (Fig. 10).

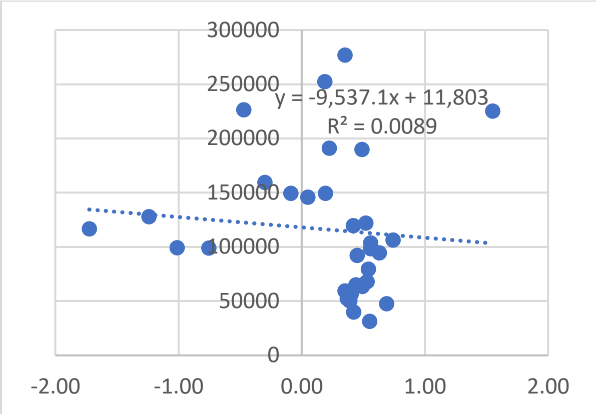

Fig. 10. The dispersion between sunflower production and SPI in Brăila County during 1990-2022
Source: processing by the authors.

Figure 11 shows a positive correlation between soil moisture and sunflower production, the trend is increasing because an adequate level of soil moisture is essential for plant development and growth.

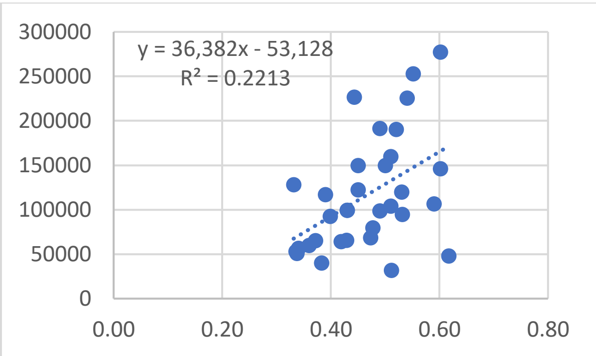

Fig. 11. Dispersion between sunflower production and PDSI in Brăila County during 1990-2022
Source: processing by the authors.

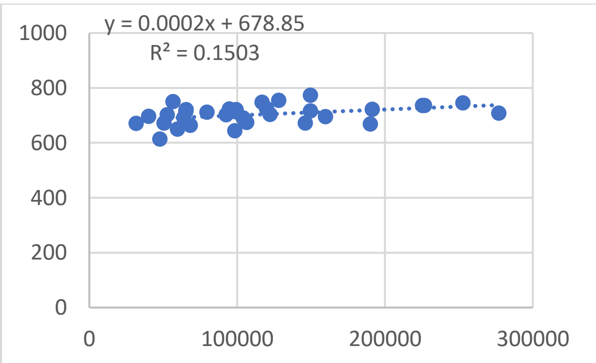

Fig. 12. Dispersion between sunflower production and ETRO in Brăila county during 1990-2022
Source: processingbytheauthors.

In Brăila County (Figure 12), R^2 = 15%, indicating a greater dispersion between evapotranspiration and sunflower production.

This variation is explained by the reduced capacity of water retention in the lands intended for sunflower crops, which were exposed to drought.

Under the influence of high temperatures and dry weather conditions, evapotranspiration increased, increasing the differences between evapotranspiration and agricultural production. This phenomenon can be attributed to a higher plant water requirement in the context of drought, causing additional pressure on available water resources.

The water consumption for the sunflower crop reached an average value of 669.8 mm/m^2 during the period 1990-2022 and the precipitation intake during the entire vegetation period was 289 mm. From the analysis of these data, it can be concluded the dependence of the sunflower culture for irrigation, in the pedoclimatic conditions of Brăila, even if it is known that this culture has better tolerance to drought, to obtain some high production it is necessary for irrigation.

CONCLUSIONS

Periods of drought or flooding can adversely affect plant development and seed production. For example, corn loses 15.6% of its water during sunny periods of the day and 40% of its water during long periods of drought.

Dispersion is usually expressed statistically, using measures such as standard deviation or coefficient of variation. However, it is important to note that there is no "standard" value for the dispersion between environmental indicators and outputs, as this may vary according to local conditions and other context-specific factors.

From the statistical analysis, it was found that there was a negative correlation between the precipitation index and corn production, due to its uneven distribution.

In practice, these values can be determined by analyzing field data or by using agricultural and hydrological models to estimate the relationship between environmental indicators and agricultural production in Brăila County. Such analyses can help farmers and agricultural specialists better understand the water requirements of their crops and optimize water resource management to maximize crop yields.

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