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OPTIMIZING DRIP IRRIGATION YIELD IN GRAIN MAIZE CULTIVATION IN EASTERN ROMANIA

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Abstract

Maize cultivation stands as a vital pillar in Eastern Romania's agriculture, significantly contributing to food security and the local economy. In the face of climate change and increasing production demands, optimizing irrigation methods becomes crucial. This article explores the impact and advantages of drip irrigation on the yield of maize crops in the region. Modern technology allows for the customized configuration of drip irrigation systems, considering the specific needs of maize cultivation and local conditions. By providing water at the right time and in optimal quantities, drip irrigation significantly contributes to the increase in maize crop yield. Drip irrigation in maize cultivation in Eastern Romania represents an efficient and sustainable solution for optimizing agricultural yield. Through the adoption of these modern technologies, farmers can ensure increased and sustainable production, contributing to the prosperity of the region

Key words: *drip irrigation, uniform water distribution, crop efficiency, water provision, sustainable solution.*

INTRODUCTION

The growth of the global population, along with increased demands for food and energy, has led to a rising need for higher global production of maize (*Zea mays* L.). However, environmental factors such as high temperatures and drought have continued to reduce maize production in many regions over the past decades, and this decline is expected to worsen in the context of climate change (Meeks et al., 2013). The development of maize hybrids capable of performing efficiently under heat and drought conditions is a crucial objective for ensuring agricultural progress in the future. These traits include, but are not limited to, shortening the anthesis-silking interval (ASI), delaying leaf senescence, increasing root depth and density, osmotic adjustment, a high number of leaves, reduced plant height, performance under limited nitrogen conditions, seedling vigor, and the presence of epicuticular wax (Betran et al., 2003; Ludlow et al., 1990; Wan et al., 2000; Meeks et al., 2013). These objectives are a priority in breeding programs globally, including in Romania. Drought tolerance is recognized as a complex trait, which significantly complicates the development of effective methods for selection, breeding, and evaluation. Maize is an exceptionally valuable species due to its high production potential, wide diversity of uses as food and feed, as well as a raw material for industrial processes. Cultivated on large areas globally, including in Romania, maize plays a crucial role in the development of a modern and efficient agricultural market. Market and consumer demands drive research in maize breeding, directing it towards the creation of increasingly higher-performing hybrids in terms of production capacity (Sarca et al., 1996).

Maize (*Zea mays* L.) is a highly important forage plant due to its high dry matter yield and quality characteristics that support optimal animal production (Roth et al., 1995). The yield and quality of maize forage are determined by a complex interaction of environmental, agricultural, and genetic factors. It is well established that maize grain and forage yields decrease in the presence of drought and soil water deficit (Hajibabaei & Azizi, 2012). Maize (*Zea mays* L.) exhibits a high grain yield potential, primarily influenced by the genetics of the cultivated hybrid and environmental factors that affect plant development (Ion et al., 2014). The production capacity of the plants is determined by yield factors, which play a crucial role in its formation (Ion et al., 2013). Distinct reactions of the hybrids to water stress at various stages of crop development have been observed (Mandache et al., 2012). Research on water consumption related to maize irrigation is a major objective, considering the importance of this crop in providing plant material (Popa, 2021). Globally, drought and desertification affect approximately 47% of arid lands, with varying degrees of aridity. In recent years, there has been a trend of expanding drought-affected areas in most regions of the country, accompanied by a reduction in water resources available for irrigation (Huma, 2004). Given that Romania is a member of the European Union and is facing the challenges of a market economy and the global financial crisis, achieving high and stable yields, along with economic efficiency and environmental protection, has become an urgent necessity. For southeastern Romania, an average irrigation rate of 800-1500 m^3/ha is recommended. The lack of irrigation during the period of maximum water consumption by maize plants can have a significant impact on grain yield (Jinga I. & Cătălina, 2000). Drip irrigation plays a significant role in the proposed solutions for the water crisis. Average daily evapotranspiration will increase by approximately 6% if the average air temperature rises by 2°C and by about 15% at an average temperature above 5°C (Nitu et al., 2023). Drip irrigation "has the potential to double crop yields, including for most vegetables, cotton, sugarcane, and vineyards" (Postel, 2000). Drip irrigation, an advanced and water-efficient method, ensures that plant roots are maintained in optimal moisture conditions over extended periods, thus favoring both physiological activity and crop development (Yan et al., 2022). Other studies have indicated that drip irrigation helps reduce salt ion levels in the soil near the dripper, creating a favorable environment for plant growth in the root zone and mitigating the negative effects of soil salinization on crop development (Zhang et al., 2019). The objective of establishing an irrigation schedule is to accurately determine the volume and optimal timing of water application to crops (Sałata et al., 2022), based on at least one parameter from the soil-plant-atmosphere system (Kang et al., 2021). The selection of an appropriate irrigation scheduling strategy is crucial for supporting plant physiological processes and, consequently, for maximizing yield (Kumar Jha et al., 2019). Additionally, efficient irrigation scheduling contributes to reducing water and energy consumption (Souza & Rodrigues, 2022). On the other hand, over-irrigation or under-irrigation, resulting from an inadequate or poorly designed irrigation plan, has generally led to reduced grain production and decreased efficiency in the use of irrigation water (Irrigation Water Productivity), as well as issues such as land flooding, soil salinization, and elevated groundwater levels (Yohannes et al., 2019; Almeida et al., 2022; Quiloango-Chimarro et al., 2022).

MATERIALS AND METHODS

To achieve the objectives of the research, a bifactorial experiment of the 2 x 2 type with three replications was set up in Constanta County during the 2022-2023 period. Factor A was represented by two maize hybrids, a1 - P9889 and a2 - P0217, and factor B by the cultivation technology with the following levels: b1 - non-irrigated, b2 - irrigated at 50% I.U.A with ½ m = 200 m^3/ha $N_{90}P_{45}$, b3 - irrigated at 50% I.U.A with m = 400 m^3/ha $N_{180}P_{90}$ (Table 1).

Table 1. Experimental Variants

Factor A	Factor B		
a_1 - P9889	b_1 - non-irrigated	b_2 - irrigated 50% I.U.A at 0-40 cm with ½ m=200m^3/ha $N_{90}P_{45}$	b_3 - irrigated 50% I.U.A at 0-80 cm, with m=400 m^3/ha $N_{180}P_{90}$
a_2 - P0217			

The research was conducted in an area with flat microrelief, without groundwater contribution during the vegetation period.

Irrigation was applied at different stages of vegetation, with the objective of maintaining soil moisture above 50% of Pmin. IUA, regardless of the irrigation method used. In

calculating the drip irrigation rate, it was essential to know the distance between emitters and the distance between drip lines in order to determine the percentage of wetted soil (P).
m brut = 1/ηc • H • Da • (CC-pmin) • P (m^3/ha)
m brut= drip irrigation norm;
H= irrigation depth;
Da= soil bulk density;
CC= field water capacity;
Pmin. = minimum soil moisture threshold;
P = percentage of moistened soil;

$$P = 100\ \frac{Su}{dp * dc}\ \%$$

For calculating the irrigation rate, the weighted average values of the physical and hydro-physical indices of the soil from Constanta County were used, corresponding to the active layers of 0.8 m and 0.4 m. The irrigation rates were calculated for depths of 0.8 m and 0.4 m.
mbrut = 1/0.95 • 100 • 0.8 • 1.38 • (26.45 – 19.69) • 0.50 = 396 ≈ 400 m^3/ha
mbrut =1/0.95 • 100 • 0.4 • 1.38 • (26.9 – 19.75) • 0.50 = 209 ≈ 200 m^3/ha
Climatically, Constanta County is characterized by a transition between dry steppe and sub-humid forest climates. The year 2022 was marked by a significant warming in January and February. Starting from September, the average monthly temperatures approached the multiannual average. Therefore, from a thermal perspective, 2022 can be considered excessively warm, with an annual average temperature of 12.7°C, exceeding the multiannual average by 2.1°C. The lowest multi-year average temperature is recorded in January at -2.6°C, while the highest multi-year average temperature occurs in July, reaching 22.4°C (Figure 1). Regarding the annual average temperature, the year 2023 showed a minimal variation of just 0.2°C compared to the multi-year average of 10.6°C, thus it can be considered a drought year in terms of temperature (Figure 2). In 2022, the precipitation regime was deficient from the very beginning, with a significant deficit starting in the first month of the year. During the period from January to July 2022, precipitation levels were approximately 50% below normal, characterizing this period as extremely dry. During the warm season, precipitation decreased by approximately 32.5% compared to the multi-year average for this region. Thus, from the perspective of the precipitation regime, the year 2022 can be classified as a drought year, marked by prolonged extreme drought throughout almost the entire growing season of spring crops (Figure 3).

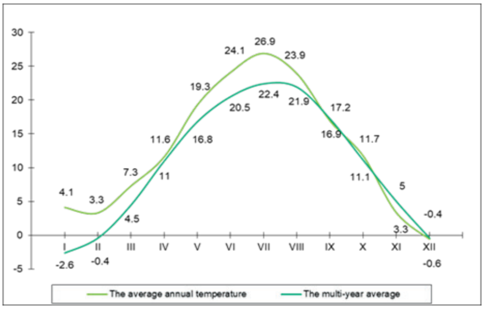

Figure 1. Monthly average air temperature recorded in the year 2022 and the multi-year average at the Constanta meteorological station

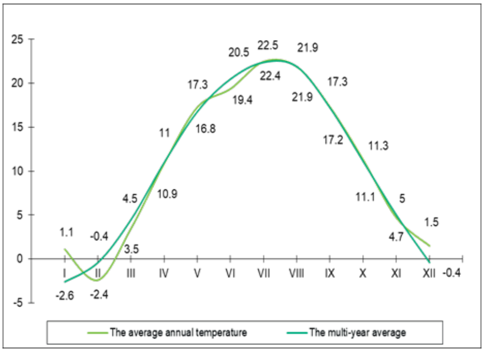

Figure 2. Monthly average air temperature recorded in the year 2023 and the multi-year average at the Constanta meteorological station

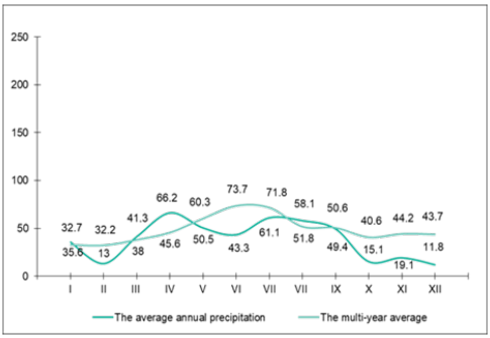

Figure 3. Monthly average precipitation recorded in the year 2022 and the multi-year average at the Constanta meteorological station

The year 2023 can be classified as a drought year, characterized by an extended drought period between May and August. During the cold season, precipitation decreased by 37% compared to the multi-year average for this period, while in the warm season, a reduction of 10% was observed (Figure 4).

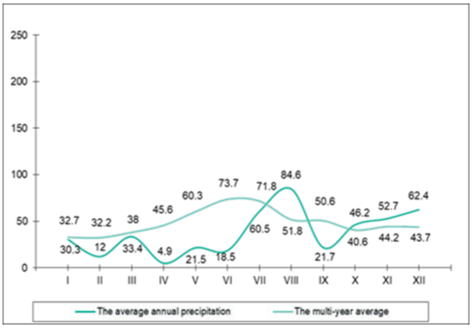

Figure 4. Monthly average precipitation recorded in the year 2023 and the multi-year average at the Constanta meteorological station

RESULTS AND DISCUSSIONS

The P0217 hybrid achieved a higher yield, with 76.17 q/ha, compared to the P9889 hybrid, which had a yield of 66.61 q/ha. The yield difference between the two hybrids is 9.56 q/ha, statistically ensured to be very significant (Table 2).

Table 2. The influence of maize hybrids on the average yield

Factor A	Production (q/ha)	Difference from Ct	Significance
a_1 - P9889	66.61	Ct	
a_2 - P0217	76.17	9.56	***

DL 5% 0.8
DL 1% 1.1
DL 0.1% 1.6

The yield obtained under non-irrigated conditions was 35.07 q/ha, serving as the reference level (Ct) for comparison. The introduction of irrigation combined with a fertilization regimen increased the yield to 69.70 q/ha, resulting in a production increase of 34.69 q/ha compared to the non-irrigated condition. Doubling the irrigation rate and intensifying fertilization further increased the yield to 109.33 q/ha, leading to a highly significant yield increase of 74.27 q/ha compared to the non-irrigated condition (Table 3).

Table 3. The effect of different cultivation technologies on the average yield of the two maize hybrids

Factor B	Production (q/ha)	Difference from Ct	Significance
b_1 - non-irrigated	35.07	Ct	
b_2 - irrigated 50% I.U.A at 0-40 cm with ½ m=200m³/ha $N_{90}P_{45}$	69.70	34.69	***
b_3- irrigated 50% I.U.A at 0-80 cm, with m=400 m³/ha $N_{180}P_{90}$	109.33	74.27	***

DL 5% 0.7
DL 1% 0.9
DL 0.1% 1.3

The interaction of factors reveals that irrigation and fertilization significantly increase yield compared to non-irrigated crops. The transition from non-irrigated (b1) to irrigated at 50% IUA at 0-80 cm depth with 400 m³/ha of water, along with the application of $N_{180}P_{90}$ fertilizers (b3), resulted in a highly significant yield increase of 69.92 q/ha. The application of irrigation at 50% IUA at 0-40 cm depth with a rate of 200 m³/ha, combined with a fertilization regime of $N_{90}P_{45}$ (b2), led to a statistically significant yield increase of 33.95 q/ha compared to the control variant. For the P0217 hybrid, the results showed a highly significant yield increase under the influence of irrigation and fertilization.

Compared to the non-irrigated variants, irrigation and fertilization according to the b3 technology led to a yield increase of 84.78 q/ha. This result shows that the P0217 hybrid has an increased capacity to respond to irrigation and fertilization strategies, indicating a better adaptation to the optimization of water and nutrient resources (Table 4).

Table 4. The impact of irrigation and fertilization on corn hybrids P9889 and P0217

Factor B	Factor A	Production (q/ha)	Difference from Ct	Significance
b_1 - non-irrigated	a_1 P9889	31.98	Ct	
b_2 - irrigated 50% I.U.A at 0-40 cm with ½ m=200 m³/ha $N_{90}P_{45}$	a_1 P9889	65.93	33.95	***
b_3 - irrigated 50% I.U.A at 0-80 cm, with m=400 m³/ha $N_{180}P_{90}$	a_1 P9889	101.90	69.92	***
b_1 - non-irrigated	a_2 P0217	38.15	6.17	**
b_2 - irrigated 50% I.U.A at 0-40 cm with ½ m=200 m³/ha $N_{90}P_{45}$	a_2 P0217	73.58	41.60	***
b_3 - irrigated 50% I.U.A at 0-80 cm, with m=400 m³/ha $N_{180}P_{90}$	a_2 P0217	116.77	84.78	***

DL 5% 2.8
DL 1% 3.9
DL 0.1% 5.3

In Constanta County, soils can often be deficient in nutrients due to erosion processes and prolonged drought conditions. Adequate fertilization thus becomes vital to ensure a sufficient supply of essential nutrients such as nitrogen (N) and phosphorus (P). Studies have shown that applying a fertilization regime with higher doses, such as N180P90 (variant b3), in combination with irrigation at 50% IUA at a depth of 0-80 cm and a water volume of 400 m³/ha, can lead to very significant yield increases, up to 69.92 q/ha for the P9889 hybrid and 84.78 q/ha for the P0217 hybrid.

The results obtained in variant b3 suggest that the P0217 hybrid has a superior capacity to adapt to irrigation and fertilization compared to P9889, making it an excellent option for east areas affected by drought. This variant has shown that a more intensive irrigation and fertilization strategy can compensate for water and nutrient deficiencies, maximizing yield even in unfavorable climatic conditions. Fertilization and irrigation of corn in the east region of the country are essential for ensuring high productivity, especially in the context of current climatic conditions characterized by drought and extreme temperatures. Experiments conducted on corn hybrids P9889 and P0217 have clearly demonstrated the importance of these agricultural practices.

CONCLUSIONS

Fertilization and irrigation of corn in the eastern region of the country are essential for maintaining and improving agricultural productivity, especially in the context of current climate changes, which bring frequent drought and extreme temperatures. In this region, which includes the counties of Moldova and Dobrogea, corn crops are exposed to climatic conditions that can significantly reduce yields if appropriate agricultural practices are not applied.

In the eastern part of Romania, soils are often subjected to erosion processes and can become nutrient-deficient due to torrential rains followed by periods of drought. This makes fertilization crucial to supplement the lack of essential nutrients, such as nitrogen (N) and phosphorus (P), which are necessary for the optimal development of corn.

Experiments conducted on corn hybrids, such as P9889 and P0217, have shown that applying a more intensive fertilization regime, such as $N_{180}P_{90}$ (variant b3), can lead to significant increases in production. Under current conditions, this fertilization, combined with appropriate irrigation practices, becomes even more important to ensure a constant supply of nutrients, thereby ensuring good crop development.

Irrigation is another essential factor in the eastern region of the country, where precipitation is often insufficient to meet the water needs of corn. Prolonged drought can cause water stress in plants, leading to a significant decrease in production. Experiments have shown that irrigation at 50% IUA (Active Moisture Index) at depths of 0-40 cm and 0-80 cm, together with a water volume of 200-400 m³/ha, can bring major improvements in crop yields.

In conclusion, for the eastern region of the country, characterized by frequent drought and soil erosion, fertilization and irrigation of corn are fundamental agricultural practices for obtaining high and stable yields. Experimental results suggest that the use of intensive fertilization strategies, combined with appropriate irrigation, can compensate for water and nutrient deficiencies, thus maximizing crop yields. The P0217 hybrid, in particular, has proven to be highly adaptable to these conditions, making it an excellent option for farmers in eastern Romania.

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