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Aspects Relating to the Influence of Climate Conditions and Mineral Fertilisation on Maize Yield

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ABSTRACT

Monitoring climate conditions reveals changes such as the increase in annual average temperatures and the uneven distribution of rainfall. Therefore, focusing on new technological solutions or improvements to existing ones is essential, ultimately resulting in enhanced quantitative and qualitative yields. This study examines the influence of nitrogen and phosphorus fertilization applied according to the current water reserves at different soil depths under the climatic conditions at the Agricultural Research and Development Station in Turda during the studied years. In the three experimental years, two doses of N were applied, namely N-100 kg/ha and N-200 kg/ha using the same dose of phosphorus 40 kg/ha, respectively, phosphorus fertilization was applied in the autumn before plowing to be incorporated into the soil, and the nitrogen dose was applied at the same time as sowing. Climate conditions remain an important factor in crop determination, which is apparent from the data presented in Table 1 where 2023 recorded the best conditions for maize crop development compared to the other years studied, with a yield increase of over 1000 kg/ha, with very significant positive differences, compared to the average of the experimental years. In 2022 and 2024, close quantitative yields are recorded, but with negative differences of up to 750 kg/ha compared to the year's average, in 2022.

1. Introduction

Maize is an exhaustive crop; therefore, its productivity depends on several factors, such as water management, soil quality, availability of mineral fertilizers, thermal regime, and precipitation. (David et al., 2012).

As the world's highest-yielding crop, maize is important for food security, however, maize yield is increasingly facing serious constraints related to the water resources crisis (Jiuxiao et al., 2024).

2. Literature review

Monitoring climate conditions reveals changes such as the increase in annual average temperatures and the uneven distribution of rainfall. Therefore, focusing on new technological solutions or improvements to existing ones is essential, ultimately resulting in enhanced quantitative and qualitative yields. (Şimon et al., 2023).

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Compared to other areas in Romania, the Transylvanian Plain has some specific characteristics that can create problems in maize cultivation: a poor precipitation regime, especially in July; excess heat regime and a relatively shorter interval without frost; hilly relief; soils with different particularities, even from one soil to another (Chețan et al., 2023)

The cultivation of maize in the Transylvanian Plateau depends entirely on the amount of water coming from precipitation and the water reserve in the soil (Chetan et al., 2022), thus, to have satisfactory results in terms of yield and quality, monitoring of climatic parameters and soil water supply is of real importance (Șimon et al., 2023).

Sandu and Mateescu (quoted by Sin and Popescu, 2015), present that for maize crop, according to climate forecasts of air temperature rise, the vegetation period will be shortened by seven days until 2020 and by 12 days until 2050 and yield will decrease by 14% by 2020 and 21% by 2050, respectively, depending on the water shortage in the soil, especially in the filling phase of the grains.

Aggressive temperatures in poor precipitation conditions in water-critical phenophase significantly impact the production components, regardless of the chosen hybrid, the company said, even when using high-performance technologies for growing corn (Popa et al., 2023).

Research by Hera and Borlan (1980) showed that for every 1,000 kg of grain plus related secondary production, corn extracts from the soil: 18-28 kg N, 9-14 kg P_2O_5, and 24-26 kg K_2O.

Following the studies conducted by Deac et al., (2017), it states that the fertility of the land is constantly decreasing. Globally, 62% of the soil surface has low or very low fertility, 27% moderate fertility, and only 11% high fertility.

At the level of our country, the situation of soil fertility is: 52% of arable land has low or very low fertility, 20.7% has moderate fertility and 27.3% are considered soils with very high fertility (Simon et al., 2022).

Fertilizers with N and the nitrogen supply are achieved through basic fertilization with primarily complex type assortments NP, NP + and NPK, NPK +, less or even limited from simple fertilizers with N. The nitrogen requirement of the plants is differentiated by the species and the phenophase of the vegetation. Fertilizers with P currently have an application almost exclusively from type complexes NP; NP+; NPK; NPK+, considered to affect soil and plants compared to previous applications (which were achieved by superphosphates), considered primarily determinants of the multi-year P reserves in the soil (Ceclan et al., 2022).

3. Material and methods

The research aimed to know the influence of Nitrogen and phosphorus fertilization application according to the momentary water reserve found at different depths in climatic conditions in the area of SCDA Turda in the experimental years studied.

The research was executed during 2022-2024, within the experimental fields from the Agricultural Research and Development Station (SCDA) Turda, Romania, the soil type is defined as chernozem clay (SRTS 2012; 2012+), the pH is in the neutral limits - low alkaline, high humus content, and, the phosphorus regime in its mobile forms, occurs with low values in the deep and medium horizons in the surface ones, and the soil supply with potassium is good (Ceclan et al., 2022).

In the three experimental years, two doses of N-100 kg/ha and N-200 kg/ha were applied using the same dose of phosphorus 40 kg/ha, phosphorus fertilization was applied in autumn before plowing to be incorporated into the soil, and the nitrogen dose was applied after sowing. The sowing was 65,000 germinable grains/ha three years with the crop rotation of the soy-grass autumn-corn. The biological material used was the Turda 344 hybrid, a semi-early hybrid created by SCDA Turda. The results obtained from the study were rigorously analyzed using the variance analysis method. We confidently determined the least significant difference (LSD) at three crucial significance levels: 5%, 1%, and 0.1%.(ANOVA, 2015).

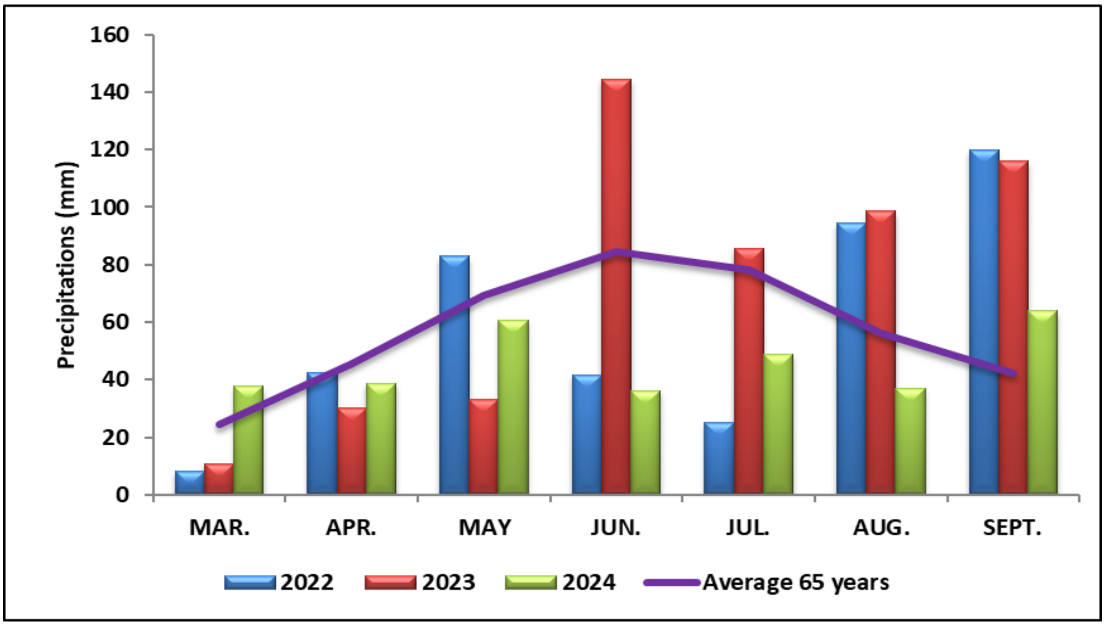

Figure 1. Average rainfall at ARDS Turda 2022 - 2024
Source of primary data: Turda meteorological station
(longitude: 23°47'; latitude 46°35'; altitude 427 m)

The rainfall regime was differentiated from year to year, in April and the rainfall approached the multiannual average except for 2023, when the deficit was much more pronounced. In July, when water consumption is high in two of the three years, rainfall was in deficit compared to the multiannual average, considering that in June, the same in the two there was a deficit for years.

Temperatures recorded during the experimental years are above the multiannual average except for April 2023 and September 2022. This fact indicates a warming of the temperatures felt by the plants during the vegetation period, as characterization only the months of March and September of 2022 are with low temperatures, april 2022 and 2023, March 2024 are characterized as normal in terms of recorded temperatures, all the others being above average characterized from warm to warm.

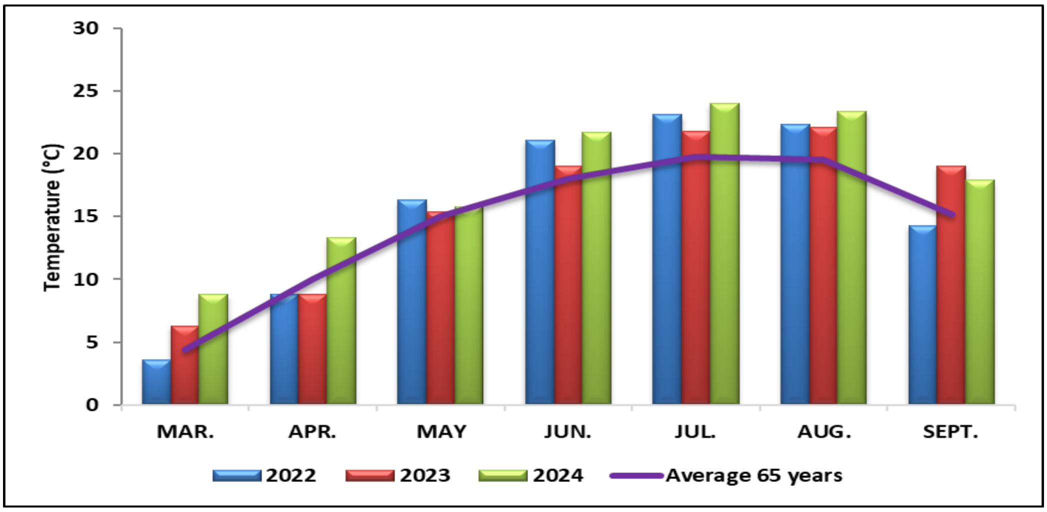

Figure 2. Average temperature at ARDS Turda 2022 - 2024
Source of primary data: Turda meteorological station
(longitude: 23°47'; latitude 46°35'; altitude 427 m)

The climate data recorded during the study period and presented in this paper come from the ARDS Turda Meteorological Station, located at the longitude coordinates: 23°47'; latitude 46°35'; altitude 427 m.

3. Results and discussions

The first vegetative phases of maize can develop properly according of water needs because in the spring months, the water reserve of the three years rarely reaches the minimum range.

Șimon et al. (2022) state, the lack of rainfall from the vegetation period of the crop is an important factor in the realization of the harvest, the momentary reserve of water from the soil accumulated from rains before the period of development of crops, can sustain it to overcome water stress, water stress, especially in conditions where the rainfall in the vegetation period is lower and if the evapotranspiration does not reach high levels.

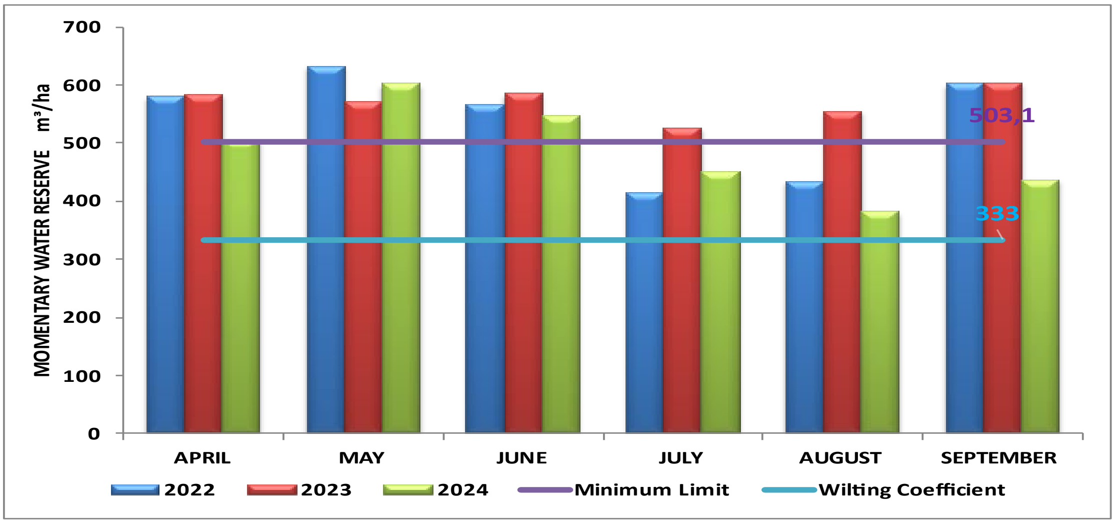

Figure 3. The momentary reserve of water on the depth 0-20 cm (m^3/ha)
Source: Original

On the depth of 0-20 cm, the momentary water reserve is above the minimum limit throughout the vegetation period in all years studied except for the months of July, August from 2022 and 2024 and September from 2024, but not to pass below the threshold of the wilting coefficient at which plants cease their physiological processes (figure. 3).

Popa et. all (2021) concluded that in addition to the amount of rainfall in the vegetation period and the water supply in the soil is a decisive factor for yield, thus, monitoring the water supply in the soil, even before the crop starts, is very important because all stages of development depend on precipitation and soil, taking into account that in the research perimeter is the only source of water.

Figure 4 illustrates a significant decrease in momentary water supply, nearing the minimum limit. Notably, in July and August of 2022 and 2024, as well as September 2024, water supply values fell below this threshold. June 2023 also recorded momentary water reserves close to the wilting point at a soil depth of 0-50 cm.

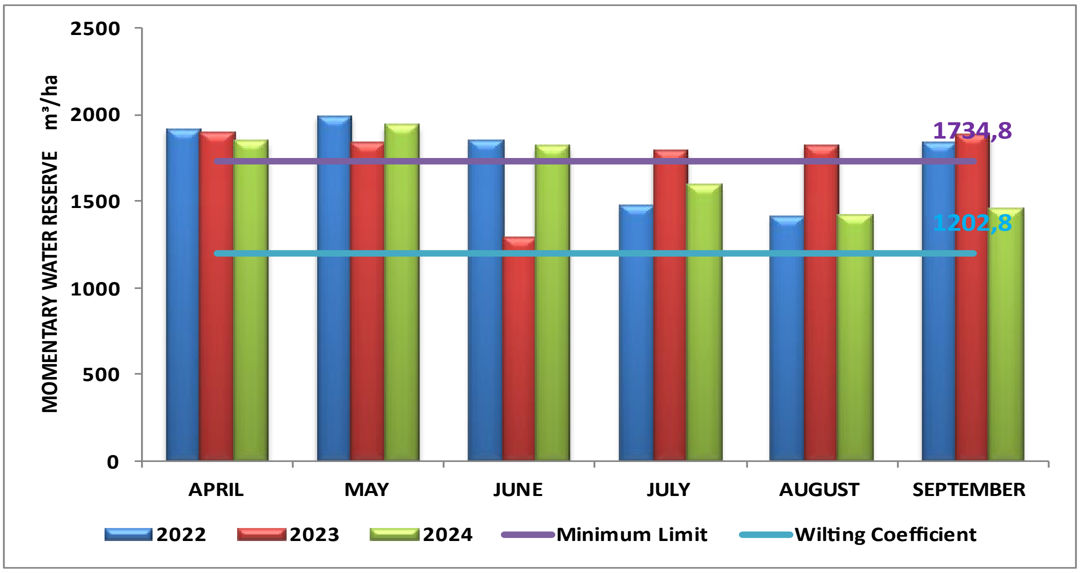

Figure 4. The momentary reserve of water on the depth 0-50 cm (m^3/ha)

Source: Original

Values close to maize crop requirements were recorded only in the first months of the growing season when water consumption was quite low.

Even though the water reserve in the superficial soil layer is quite small at certain times, the fact that maize has a well-developed root system helps to extract the water necessary for physiological processes and deeper layers.

On the depth of 0-100 cm Figure 5, the momentary water reserve decreases below the minimum limit during the vegetation period except for May 2022, where the water reserve is above the minimum value. Still, instead, the wilting coefficient is not reached in any experimental year studied.

The observations conducted between 2022 and 2024 indicate that there has been a low level of soil water supply in recent years, raising concerns about the need for measures to improve water availability for crop plants.

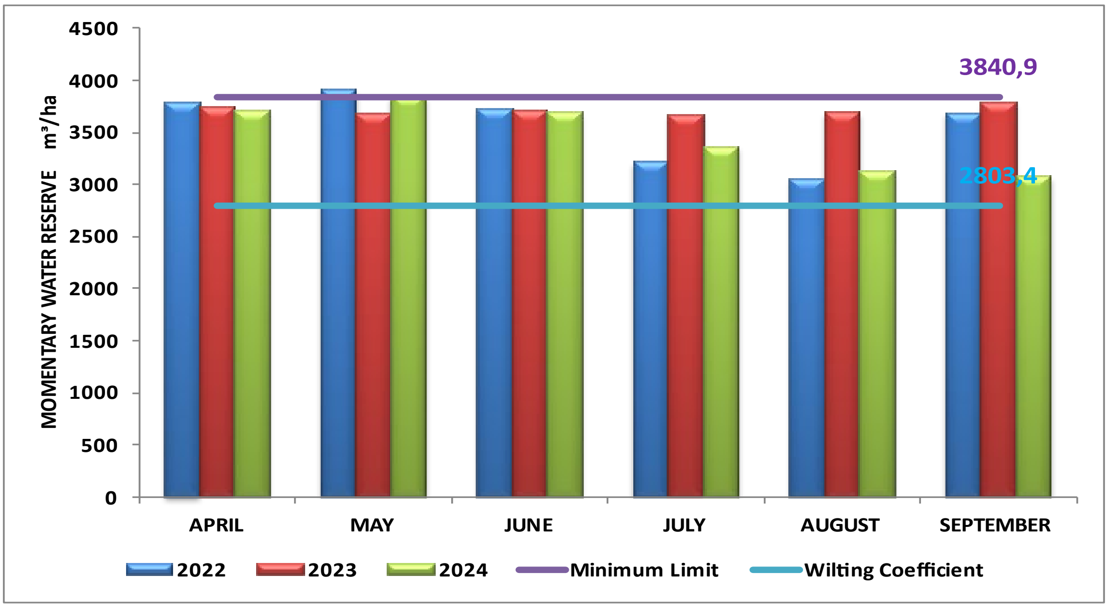

Figure 4. The momentary reserve of water on the depth 0-100 cm (m^3/ha)

Source: Original

From sowing to harvesting, maize is subjected to many pressures, biotic and abiotic, these factors together form an ecosystem (Popa et al., 2021).

Climate conditions remain an important factor in crop yields, which is apparent from the data presented in Table 1 where presented that 2023 recorded the best conditions for crop development maize compared to the other years studied, with a yield increase of over 1000 kg/ha, with very significant positive differences, compared to the year's average. In 2022 and 2024, close quantitative yields were obtained, but with negative differences of up to 750 kg/ha compared to the year's average, in 2022.

Table 1. Influence of climatic conditions on maize yield, ARDS Turda 2022-2024

Variant	kg/ha	%	+/-	Significance
Years average (Control variant c.v.)	6425	100,0	0,0	c.v.
2022	5668	88,2	-757	00
2023	7768	120,9	1343	***
2024	5838	90,9	-586	0
LSD (p 5%) 454; LSD (p 1%) 645; LSD (p 0.1%) 934				
Notes: *** = significant at 0.1% probability levels, positive superior values; ”00”, ”0” = significant at 5% and 1% probability levels, negative inferior values; ns= not significant.				

Among the factors that influence agricultural crop yields, climatic conditions are the most difficult to control and are the major limiting factors for maximum production. Water stress, excessive rainfall, extreme temperatures, and low light can significantly reduce crop yield (Avila et al., 2022).

Fertilization of maize crops is imperative to obtain satisfactory yields both qualitatively and quantitatively. The use of fertilizers as a source of nutrients is essential for crop yields (Ceclan et al., 2024).

Of the macronutrients, it is well known that nitrogen significantly influences the growth and development of plants. Knowing the physiological mechanisms that contribute to the absorption and use of nitrogen is especially important to increase the efficiency of using this chemical element (Agapie et al., 2021).

Regarding the influence of fertilization on grain yields (table 2), maize uses very good chemical fertilizers, has high productive potential, and, consumes large amounts of nutrients, especially nitrogen and potassium, so increasing the nitrogen dose also brings an increase in yield, thus registering increase of over 700 kg/ha, with very significant positive statistical differences compared to the control variant.

Table 2. Influence of the level of fertilization on maize yields, ARDS Turda 2022-2024

Dose	kg/ha	%	+/-	Significance
$N_{100}P_{40}$ Control variant	6055	100,0	0,0	c.v.
$N_{200}P_{40}$	6794	112.2	739	***
LSD (p 5%) 269; LSD (p 1%) 373; LSD (p 0.1%) 514				
Notes: *** = significant at 0.1% probability levels, positive superior values;				

From Table 3 of the influence of experimental factors on the grain yields, it follows that the climatic conditions remain an important constituent in establishing the yield in the area of ARDS Turda thus, the yield obtained in the experimental year 2023 was significantly higher at both doses of fertilization years 2022 and 2024, recording yield increases of 1196 kg/ha and 1490 kg/ha, respectively, both variants being statistically assured as very significant positive to the control variant.

Table 3. Interaction of experimental years x the level of fertilization on maize yields, ARDS Turda 2022-2024

Variant	kg/ha	%	+/-	Significance
Years Average x $N_{100}P_{40}$ Control variant	6055	100,0	0,0	c.v.
2022 x $N_{100}P_{40}$	5371	88,7	-685	0
2023 x $N_{100}P_{40}$	7252	119,8	1196	***
2024 x $N_{100}P_{40}$	5544	91,5	-512	ns
Years Average x $N_{200}P_{40}$ Control variant	6794	100,0	0,0	c.v
2022 x $N_{200}P_{40}$	5965	87,8	-829	00
2023 x $N_{200}P_{40}$	8285	121,9	1491	***
2024 x $N_{200}P_{40}$	6133	90,3	-661	0
LSD (p 5%) 561; LSD (p 1%) 790; LSD (p 0.1%) 1125				
Notes: *** = significant at 0.1% probability levels, positive superior values; ”000”, ”00” = significant at 0.1% and 1% probability levels, negative inferior values; ns= not significant.				

5. Conclusions

The momentary water reserve decreases with increasing sampling depths, so the depth of 0-100 cm is located below the minimum limit throughout the vegetation period, but without exceeding the wilting coefficient at which plants begin to reduce physiological processes, often irreversibly.

Analysis of results indicates that climatic conditions significantly influence maize yield in the experimental years studied.

A key factor in increasing maize yield is the use of mineral fertilizers, particularly nitrogen fertilizers, while climatic conditions can influence the effectiveness of these fertilizers.

Acknowledgements

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