

MODERN MAIZE CULTIVATION TECHNOLOGIES IN THE CONTEXT OF CLIMATIC CHALLENGES

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Abstract

Maize is one of the most important agricultural crops globally due to its high productivity and various applications in food, feed and industry. The study was carried out in the area of gleic soils in the west of Romania and aimed to optimize the tillage system and test the performance of some maize hybrids in the context of climate change, comparing two tillage – minimum and conventional tillage systems – in terms of the impact on average production. The results obtained show that the minimum tillage system led to an increase in average production by 1,117 kg/ha compared to the conventional system. In the dry year 2022, the difference was 603 kg/ha, and in 2023, more climatically favorable, the difference was more pronounced, reaching 1,608 kg/ha. The technology of maize cultivation in a minimum tillage system and the adaptability of hybrids are the viable solution for increasing the harvest in unfavorable climatic conditions.

Key words: corn hybrids, yield performance, sustainable agriculture.

INTRODUCTION

Climate change is one of the greatest challenges for global agriculture, affecting maize production through temperature variations, water deficits, and increased frequency of extreme weather events (Lal, 2020). Maize (*Zea mays* L.), being one of the most widely cultivated crops worldwide, requires technological and genetic adaptations to cope with changing climatic conditions (Edmeades et al., 2017). Recent studies highlight that high temperatures and water deficits significantly reduce maize yields, affecting both quality and quantity of production (Cairns et al., 2013; Zhang et al., 2021). In semi-arid regions, the impact of climate change is particularly severe, necessitating the implementation of effective adaptation strategies (Tsubo et al., 2003). Erenstein et al. (2022) analyze global maize production trends and emphasize the need for investments in research and development to enhance drought resistance. Similarly, Schulz et al. (2020) suggest using intercropping techniques to optimize yields and conserve soil biodiversity. To combat the effects of climate change, researchers have developed multiple strategies, including genetic selection for drought tolerance, improved nitrogen

management, and optimized planting dates (Chițu et al., 2024; Srivastava et al., 2018). The *Drought Tolerant Maize for Africa (DTMA)* program by CIMMYT (2020) demonstrates the success of genetic improvement in developing drought-tolerant maize hybrids. Additionally, Gheith et al. (2022) showed that efficient nitrogen application strategies enhance maize productivity and nitrogen use efficiency. FAO (2019) highlights the importance of climate-smart agriculture, promoting techniques such as mulching and efficient irrigation systems. Roman et al. (2011) analyze modern maize cultivation technologies and propose the use of hybrids adapted to changing climatic conditions. Intercropping, the simultaneous cultivation of maize with other plants, has proven beneficial for conserving soil moisture and improving soil fertility (Mousavi & Eskandari, 2011). For example, studies by Dawo et al. (2007) and Batugal et al. (1990) highlight the advantages of intercropping maize with legumes for yield enhancement and soil quality improvement. Nitrogen fertilization plays a crucial role in increasing maize crop productivity. Wei et al. (2019) demonstrated that plant density and the amount of nitrogen applied influence maize kernel filling parameters. Furthermore, Congreves et al. (2021) proposed redefining

nitrogen use efficiency to support sustainability in agriculture. Oraby et al. (2005) investigated the response of ten maize hybrids to different nitrogen fertilization levels, concluding that optimized nitrogen application improves yields under varying soil conditions. Additionally, Hu et al. (2020) demonstrated that split nitrogen application throughout the growing season increases maize yield in arid conditions.

Analysis of climate change effects across different geographical regions shows that impacts vary depending on local climatic conditions. For example, studies conducted in Romania by Smuleac et al. (2020) revealed difficulties in water accessibility for agricultural production in the Banat Plain. In Asia, Habib-ur-Rahman et al. (2022) identified key challenges and opportunities for the region's agriculture, emphasizing the necessity of effective adaptation policies. Climate change significantly impacts maize production, necessitating the implementation of effective adaptive strategies. Research suggests that genetic improvement, optimized nitrogen management, intercropping, and the adoption of sustainable agricultural practices can help maintain and improve agricultural yields under changing climate conditions (Lal, 2020; FAO, 2019). Therefore, it is essential for farmers, researchers, and policymakers to collaborate in implementing the most effective climate change adaptation solutions to ensure global food security (Erenstein et al., 2022).

MATERIALS AND METHODS

The research was carried out in the southwest of Timiș County, between the Bega Canal and the Timiș River, near the border with Serbia. The data regarding the monthly average temperatures during the experiment period are presented in Figure 1. From the analysis of the data, it can be seen that for the months of January, February and March the monthly average of temperatures in 2023 was higher than that of 2022, in April the monthly average in this period was very close, April was almost similar. Large temperature differences were recorded in May-July, where temperatures in 2022 were much higher compared to the same period in 2023. In the other months, there were no significant differences, except for October and

December, which were warmer for 2022. Correlation coefficient: 0.96, which indicates a very strong relationship between the annual temperatures of 2022 and 2023. This means that the temperature patterns were similar between the two years.

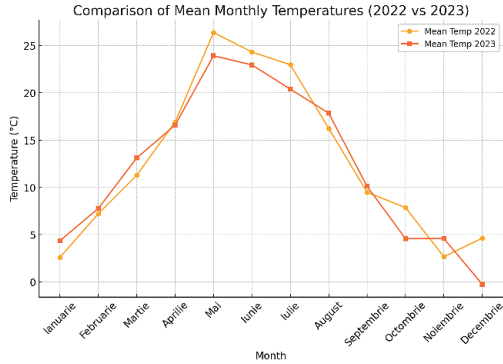


Figure 1. Comparison of the average monthly temperatures during the experimentation period

The correlation between the air temperature and the BBCH stage requirement for maize is shown in Figure 2.

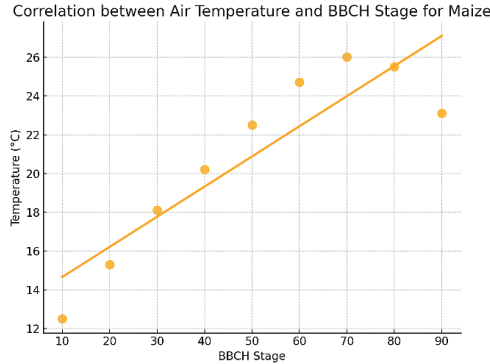


Figure 2. Correlation between monthly average temperatures and BBCH stage requirement for maize

The correlation coefficient is 0.90, which shows a strong correlation between air temperature and the BBCH stage, indicating an increase in temperature as the corn advances in development.

The average monthly rainfall recorded during the experimental period is shown in Figure 3. In January, April and September, higher amounts of precipitation were recorded for 2022 compared to 2023. In March, June and July we had a rainfall deficit for 2022, and in 2023 the

monthly average rainfall was enough for the plants not to suffer water stress. A very large difference in the average rainfall is observed, in 2022 the average being 108.8 mm lower than in 2023. The correlation between the monthly rainfall during the experimental period and the BBCH stage of maize development is shown in Figure 4.

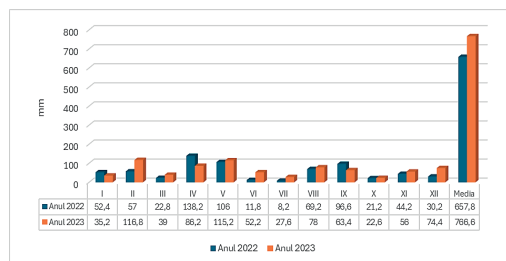


Figure 3. Average monthly rainfall recorded during the experimental period

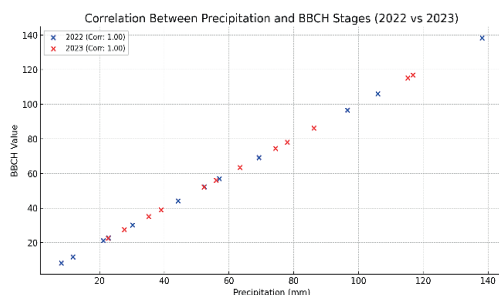


Figure 4. Correlation between the monthly rainfall during the experimental period and the BBCH stage of maize development

BBCH stage 00-19 - March - April (emergence and beginning of vegetative development). In 2022 there was higher rainfall in April, which favoured a good start of the crop, and in 2023 rainfall was lower in April, which led to a later emergence and a more difficult start. BBCH stage 20-39 -May - June (vegetative growth), due to less rainfall in this interval of 2022, water stress was recorded, while in 2023 the better distributed rainfall in May and June favoured plant growth.

BBCH stage 50-69 -July - August (flowering, pollination and berry formation), very low rainfall in July 2022 influenced pollination and grain formation and implicitly the grain production yield. In 2023, there was more rainfall in July, which favoured a better grain yield. In conclusion, 2023 benefited from a more

favourable distribution of rainfall, which explains a higher BBCH in certain months compared to 2022, therefore a better growth and development with direct implications on the level of production.

The type of soil on which the study was carried out was gleiosol with a clay-clay to clayey texture, with a grainy to polyhedral structure, high humus content with a moderate - low acidic pH. Among the negative qualities to be noted is the degree of compaction. Under these conditions, soil loosening works are mandatory, in order to improve the aero-water regime. The experiments were bifactorial, in which *factor A* represented the tillage, with two graduations and *factor B* the hybrid cultivated with 7 graduations. Graduations of *factor A - tillage*: a1 - tillage in the "minimum tillage" system; a2 - tillage in the "conventional system". The tillage of the soil in the minimum tillage system was: after harvesting the wheat, when the soil moisture allowed, the scarification work was done directly at a depth of 50-70 cm and with a distance between the arms of the scorer of 70 cm. The work was carried out on both diagonals, thus ensuring the loosening of the soil and the destruction of the hardpan. After ensuring good humidity, a work was carried out with the tiger, at a depth of 20 cm, through this work the stubble was incorporated into the soil.

In the variant (2) in which the conventional system was applied, the works carried out were as follows: the first disc harrow work for the destruction of the stubble and the conservation of water in the soil, the second work was the plough work at a depth of 25 cm., the third work - disc cultivator + rotary harrow for the preparation of the seedbed.

Factor B represented the maize hybrid, using 7 hybrids, with different vegetation periods, as follows: the Torino hybrid of the FAO 320 group; the DKC4391 hybrid of the FAO 340 group; the P9537 hybrid of the FAO 350 group; the DKC 5092 hybrid; the DKC 5182 hybrid of the FAO 400 influenza; the P0170 hybrid of the FAO 450 group and the Fabio hybrid of the FAO 460 group.

The hybrids taken in the study are new products produced by Bayer, Syngenta and Corteva companies. Fertilization was carried out with 126 kg/ha N, 65 kg/ha P₂O₅ and 84 kg/ha K₂O. The sowing density was 72,000 germinating

seeds/ha, the sowing was done at a distance of 70 cm between the rows and 5 - 6 cm deep.

RESULTS AND DISCUSSIONS

The results presented in the paper were calculated according to the calculation method for bifactorial experiments, with 3 repetitions. For a better example of the influence of the soil tillage system in conditions of water stress and atmospheric heat, we present the results obtained per experimental year.

Table 1. Shows the harvest results obtained in 2022

Factor B Hybrid	Factor A - systems of works		Average Yield kg/ha
	A1-minimum tillage kg/ha	A2- conventional kg/ha	
Torino	4033	3523	3778
DKC4391	6662	5819	6240
P9537	4945	3730	4337
DKC5092	6610	5830	6220
DKC5182	4462	4800	4631
P0170	5332	5025	5178
Fabio	6977	6071	6524
X	5574	4971	5272

Average Factor A

Systems of works	Yield kg/ha	%	Difference kg/ha	Significance
A1	5574	100		
A2	4971	89	-603	000
DL5%=157 DL1%=261 DL0.1%=488				

Average Factor B

Hybrid	Yield kg/ha	%	Diff. kg/ha	Significance
Torino	3778	100		
DKC4391	6240	165	2462	XXX
P9537	4337	115	559	XXX
DKC5092	6220	165	2442	XXX
DKC5182	4631	122	853	XXX
P0170	5178	137	1400	XXX
Fabio	6524	172	2746	XXX
DL5%=151 DL1%= 212 DL0.1%=300				

From the data presented in Table 1, it can be seen that the harvests obtained for all the experimented hybrids were lower than the potential of these hybrids, ranging from 4033 kg/ha at Turin to 6972 kg/ha at Fabio in the tillage minimum tillage system and between 3523 kg/ha and 6071 kg/ha at the same hybrids cultivated in the conventional system. On average, on the 7 hybrids researched, the harvest was

5574 kg/ha in the minimum tillage system and 4971 kg/ha in the conventional one.

It follows that the harvest in the conventional system represented only 89% compared to the minimum tillage, returning a difference of -603 kg/ha, statistically ensured as very significantly negative.

From the analysis of the behaviour of the hybrids, on average on the two agrofunds, the lowest harvest of 3778 kg/ha was recorded in the Turin hybrid (FAO 320), the earliest of the cultivated ones.

In the hybrids of the groups between FAO 340 and 370, average harvests of over 6000 kg/ha were recorded, in the hybrid DKC 4391 and the hybrid DKC 5092, and in the hybrid P 9537, the harvest was only 4337 kg/ha. The semi-late hybrids of the 400 - 500 group achieved harvests of 4631 kg/ha at the DKC 5182 hybrid, 5178 at P0170 and 6524 at Fabio.

The average harvests on the two systems compared to the Turin harvest are higher with very significant differences.

The results obtained this year highlight the importance of the soil tillage system that allows water to be stored and reduces its loss from the soil through repeated mechanical works. Also, the good behaviour of 3 hybrids that exceeded 6000 kg/ha and can be considered tolerant to the harsh climatic conditions of this year is highlighted, in which in the critical months of the vegetation period only 11.8 mm of precipitation were recorded in June and 8.2 mm of precipitation in July and maximum temperatures of over 30°C were also recorded in the mentioned period.

In conclusion, the results of the dry year in which the development of important vegetation phases were carried out in conditions of water and heat stress, due to the application of technologies favourable to the crop, still obtained acceptable results.

This year was favourable for the corn crop, the rainfall during the vegetation period of 86.2 mm in April, 115.2 mm in May, 52.2 mm in June, 27.6 mm in July and 78 mm in August explains that the harvests were on average on cultivated hybrids of 9783 kg/ha in plots worked in the minimum tillage system and 8175 kg/ha in the conventional system. The harvest difference of -1608 kg/ha in favour of the minimum tillage system is very significantly negative.

Table 2. Shows the harvest results for 2023

Factor B Hybrid	Factor A - systems of works		Average yield kg/ha
	A1- minimum tillage kg/ha	A2- conventional kg/ha	
Torino	9209	7733	8471
DKC4391	10095	8025	9060
P9537	9624	7824	8724
DKC5092	9419	8116	8767
DKC5182	9917	8117	9017
P0170	10185	8702	9443
Fabio	10036	8708	9372
X	9783	8175	8979

Average Factor A

Systems of works	Yield kg/ha	%	Difference kg/ha	Significance
A1	9783	100		
A2	8175	83	-1608	000
DL5%=76 DL1%=126 DL0.1%=237				

Average Factor B

Hybrid	Yield kg/ha	%	Diff. kg/ha	Significance
Torino	8471	100		
DKC4391	9060	106	589	XXX
P9537	8724	102	253	XX
DKC5092	8767	103	296	XXX
DKC5182	9017	106	546	XXX
P0170	9443	111	972	XXX
Fabio	9372	110	901	XXX
DL5%=146 DL1%= 206 DL0.1%=290				

The highest harvests of over 10,000 kg/ha were recorded in hybrids DKC4391 (10,095 kg/ha), P0170 (10,185 kg/ha) and Fabio hybrid (10,036 kg/ha) grown in the minimum tillage system (Table 2). It should be noted that in the conventional system there were no harvests higher than 8,708 kg/ha.

This year's results show that corn is a crop that capitalizes, in normal years, on the productive potential of the area. Better productivity is obtained if in the minimum system of works the basic work is presented by scarification at a depth of 70 cm, the favourable effect of this work being maintained in years 2 and 3 compared to the date of execution.

The average harvest on the two systems shows that the best results are obtained by cultivating the hybrids DKC 4391 (9060 kg/ha), DKC5182 (9017 kg/ha), P0170 (9443 kg/ha) and Fabio (9372 kg/ha).

Crop differences are statistically assured as very significant, except for the P9537 hybrid, where the difference is distinctly significant. In

conclusion, in the climatically favourable years of all 7 cultivated hybrids, harvests of over 9,000 kg/ha were obtained in the minimum tillage cultivation system, which shows their good productive biological potential.

Table 3 summarizes the yield results obtained in 2022-2023.

The synthesis of the results presented allows the conclusion to be drawn regarding the behavior of the investigated hybrids in different climatic conditions.

Under the given conditions, the differences between the two systems of works are obvious. Thus, in the minimum tillage system, the hybrids managed to achieve economically efficient harvests between 6,600 kg/ha and 8,507 kg/ha.

Table 3. Summary of harvest results from the 2022-2023 experimental cycle

Factor B Hybrid	Factor A - systems of works		Average yield kg/ha
	A1- minimum tillage kg/ha	A2- conventional kg/ha	
Torino	6621	5628	6124
DKC4391	8378	6922	7650
P9537	7284	5777	6530
DKC5092	8011	6972	7491
DKC5182	7189	6458	6823
P0170	7758	6863	7310
Fabio	8507	7389	7948
X	7678	6572	7125

Average Factor A

Systems of works	Yield kg/ha	%	Difference kg/ha	Significance
A1	7678	100		
A2	6572	85	-1117	000
DL5%= 114 DL1%=189 DL0.1%=354				

Average Factor B

Hybrid	Yield kg/ha	%	Diff. kg/ha	Significance
Torino	6124	100		
DKC4391	7650	124	1526	XXX
P9537	6530	106	406	XXX
DKC5092	7491	122	1367	XXX
DKC5182	6823	111	699	XXX
P0170	7310	119	1186	XXX
Fabio	7948	129	1824	XXX
DL5%=107 DL1%=150 DL0.1%=212				

Under conventional system cultivation, the separation of harvests for the investigated hybrids was between the limits of 5,628 kg/ha and 7,389 kg/ha. The average difference

between the harvest of hybrids grown in the minimum tillage system and the conventional one is -1117 kg/ha, a very significantly negative difference, with harvests of over 8,000 kg/ha in the minimum tillage working system were the hybrid Fabio with 8,507 kg/ha, DKC 4391 with 8,378 kg/ha and DKC 5092 with 8,011 kg/ha. It should be noted that on average over the two years no hybrid was below 6,700 kg/ha. In the conventional working system, the Fabio hybrid with the highest harvest was 7,389 kg/ha, and the Turin hybrid with the lowest harvest, with 5,628 kg/ha. It should be noted that 4 of the 7 hybrids were with harvests between 6,000 and 7,000 kg/ha.

The analysis of the average harvests on the two working systems shows that 4 hybrids recorded harvests between 7,300 and 7,900 kg/ha. The entire assortment of hybrids researched motivates the continuation of research in the coming years, because the average level of harvests exceeds 6,000 kg/ha, proving that they have a high biological potential.

CONCLUSIONS

The research carried out in the area of gleic soils in the west of the country, on corn cultivation, aimed to make a contribution to the adaptation of the tillage system and the testing of new corn hybrids, in the conditions of climate change that negatively affects harvests. The researches regarding the tillage carried out in two variants - the tillage in the "minimum tillage" system and the tillage in the conservative system, on average over the two experimental years, showed the superiority of the minimum tillage system in which the average harvest, on the 7 hybrids taken in the study, was higher by 1,117 kg/ha. The harvest differences between the two working systems were only 603 kg/ha in the dry year 2022 and 1,608 kg/ha in 2023, more climatically favourable due to the rainfall that fell both in terms of quantity and monthly distribution, but without being enough for the corn needs. With reference to the behaviour of the 7 hybrids studied (Torino, DKC4391, P9537, DKC 5092, DKC 5182, P0170, Fabio) the average harvest in the two experimental years was 7678 kg/ha in the minimum tillage system and 6572 kg/ha in the conventional tillage system.

The work presented is highly topical due to the serious climatic deviations felt more and more in recent decades with effects on harvests and respectively on ensuring people's nutrition.

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