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RESEARCH ON MAIZE YIELD POTENTIAL BY MATURITY GROUP UNDER CONDITIONS AT ARDS BRĂILA

Alin Ionel GHIORGHE[1], Daniela TRIFAN[1], Emanuela LUNGU[1], Ioana Andreea GORGOVAN[1], Marian BRĂILĂ[1], Luxița RÎȘNOVEANU[1], Gabriela Alina CIOROMELE[1, 2], Nicoleta AXINTI[1, 2], Andreea CHIRIAC[2]

[1]Agricultural Research Development Station Brăila, km 9 Viziru Street, Brăila, Romania
[2]"Dunărea de Jos" University of Galaţi, 47 Domnească Street, Galaţi, Romania

Corresponding author email: chiriac.andreea25@yahoo.com

Abstract

In the current conditions of changing climatic conditions, especially in South-East Romania, it is necessary that the choice of maize hybrids is made correctly, depending on the maturity group, in order to obtain satisfactory yields and thus counteract the effect of climate change. The aim of this research was to study the yield and productive capacity of a set of maize hybrids of different maturity groups in the context of climate change. The field experiment was conducted in the 2023 and 2024 growing seasons on a vermic soil of chernozem with an average humus content of 2.4-3.1% in the upper horizons and only 1.6% in the transition horizon, total nitrogen content of 0.14-0.25% at the test site of the Agricultural Research and Development Station (ARDS) Brăila - Chiscani Experimental Center where a large number of maize hybrids from different maturity groups are tested annually.

Key words*: maize, FAO maturity groups, grain yields hybrids.*

INTRODUCTION

Maize (*Zea mays* L.) is, along with rice and wheat, one of the most widespread cereal crops in the world.In the European Union, maize is the second-most cultivated crop after wheat. In 2024, maize was cultivated on 8.8 million ha for grain maize and in Romania the cultivated area was 2.2 million ha. (EUROSTAT, 2024).

Maize is a major global agricultural crop of strategic importance in international agri-food systems, both directly for human consumption and indirectly as an essential source of animal feed. In recent decades, world production of this cereal has increased significantly, driven by growing global demand, as well as by improvements in productivity per unit area and the expansion of cultivated areas. Maize currently ranks first among cereals in terms of total volume produced and is expected to become the most widely grown agricultural crop in terms of area in the next ten years (Erenstein et al., 2022).

Climate change has led to lower yields for the main agricultural crops. A number of effects of climate change on crop yields have been observed in Eastern Europe, with generalized yield losses of -24.5% in maize (Ray et al., 2019).

The climatic changes continue to differ under different scenarios until 2100 and beyond. Thus under the RCP 4.5, RCP 6.0 and RCP 8.5 scenarios global temperature change is projected to exceed 1.5°C-2°C (IPCC, 2014).

Climate change and maize crop management practices have had an effect on cropping systems in South-Eastern Europe, including Bulgaria, Croatia, Hungary, Romania and Serbia, allowing earlier planting and the cultivation of early maturing hybrids to avoid unfavorable weather conditions, especially during flowering (Buhiniček et al., 2021).

Choosing the right maize maturity for a particular region to achieve higher yields in the future is not straightforward and is not just a matter of prevailing expectations of climate change. Also, management effects might play a more important role in maize phenology and yield formation compared to climate change, not only under sub-optimal growing conditions often found in South-Eastern Europe (Zdunić et al., 2022).

In a 10-year analysis it was concluded that the correlation between the length of the growing season and grain moisture at harvest is positive and significant. The highest grain yield was in the medium-early FAO 500-600 maturity group

but the best combination of high grain yield and low moisture at harvest was in the early FAO 300-400 maturity group (Vulchinkov et al., 2013). Under climate change, there are shifts in maize maturity groups, particularly over the last 10 years, from extremely early and early-maturing maize to more hybrids in the intermediate and late-maturing groups, as rising average temperatures and warmer autumns have meant yield increases can be achieved and early frosts have been pushed later, from late September to early to mid-October (Haraga and Ion, 2022).
The objective of this research is to highlight the productive capacities, adaptation potential and grain moisture at harvest of maize hybrids from different FAO groups tested in the trials conducted at the Agricultural Research and Development Station Braila.

MATERIALS AND METHODS

The study was conducted during 2023 and 2024 to evaluate the adaptability to local conditions of 12 maize hybrids of different maturity groups, FAO 300-340 (DKC4109, DKC4391), FAO 350-390 (DKC4728, DKC4709, DKC4712, DKC4897, DKC4908, DKC5092), FAO 400-440 (DKC5016, DKC5404) and FAO 450-490 (DKC5810, DKC5812).

The study and field experiments were organized in the Experimental Center Chiscani of ARSD Braila on a carbonate vermic chernozem soil with an apparent density ranging from 1.19 g/cm^3 in the worked horizon (Ap) to 1.44 g/cm^3 in the other soil horizons.

Regarding the chemical characteristics of the soil profile in the experimental perimeter of SCDA Brăila, the content of mobile phosphorus, with values ranging from 41 ppm to 62 ppm, the soil falls into the medium and is well supplied with phosphate. Mobile potassium supply is medium, with values ranging from 98 ppm to 108 ppm, and the humus content in the worked layer is 3.04%. (Trifan et al., 2021).
The pre-planting crop was fall wheat. The applied technological elements included ploughing, one disc tillage, base fertilization with complex fertilizers 200 kg/ha NPK 20.20.20.0 and urea phase fertilization 100 kg/ha. Sowing was carried out on 24.04.2023 and 16.04.2024, respectively. Crop maintenance was carried out by applying treatments in vegetation to control weeds and pests and applying two irrigation rules totalling 800 mc/ha.
The production capacity and quality elements such as hectoliter weight HM (kg/hl) and thousand kernel weight TKW (g) were followed. Analysis of variance (ANOVA) was performed to examine differences and a Fisher's protected least significant difference (LSD) test was used to determine the significance of the differences among the variants results and control (p-values 0.05, 0.01, and 0.001).

RESULTS AND DISCUSSIONS

The analysis of the rainfall regime of the agricultural year 2022-2023 allows us to state thatoverall, the analyzed period can be characterized in terms of normal rainfall, but with uneven rainfall distribution during the agricultural year, alternating dry periods with periods better supplied with rainfall. Rainfall totaled 439 mm with a deficit of 3 mm compared to the multi-year monthly average of 442 mm. Thermally, the agricultural year was warmer than the multi-year average by 2.1°C. From October 2022 through September 2023, there were positive deviations from the multi-year monthly average in every month except April and May which were cooler than the multi-year monthly average by 0.8°C and 0.1°C respectively (Table 1).

Table 1. The main climatic elements of agricultural year 2022-2023

Climatic elements		Month values												Total/ Average
		X	XI	XII	I	II	III	IV	V	VI	VII	VII	IX	
Precipitation (mm)	Agricultural year 2022-2023	6	31	20	64	7	13	66	40	26	106	55	5	**439**
	Normal	30	33	36	28	27	26	35	48	62	46	39	32	**442**
	Deviation ±	**-24**	**-2**	**-16**	**36**	**-20**	**-13**	**31**	**-8**	**-36**	**60**	**16**	**-27**	**-3**
Air Temperature (^{0}C)	Agricultural year 2022-2023	13	8.1	2.9	4.4	1.4	7.9	10.4	16.6	21.6	24.7	24.7	20.9	**13.1**
	Normal	11.5	5.6	0.6	-2.1	-0.2	4.7	11.2	16.7	20.9	22.9	22.1	17.3	**10.9**
	Deviation ±	**1.5**	**2.5**	**2.3**	**6.5**	**1.6**	**3.2**	**-0.8**	**-0.1**	**0.7**	**1.8**	**2.6**	**3.6**	**2.1**

Source: Meteorological Station of Braila

The analysis of the rainfall regime of the agricultural year 2023-2024 allows to state that overall, the analyzed period can be characterized from the normal rainfall point of view, the rainfall totaled 471 mm with a positive deviation of 29 mm compared to the multi-year monthly average of 442 mm (Figure 1).

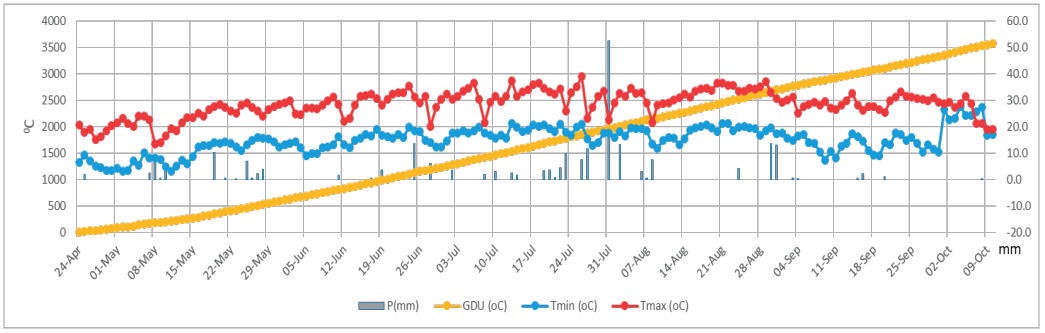

Figure 1. Presentation of climatic conditions and the sum of degrees of useful temperature during the vegetation period for maize, at ARDS Braila, in 2023

From a thermal point of view, the agricultural year was very warm compared to the multiannual average by 3.5°C (Table 2). On the whole, the analyzed period can be characterized as normal in terms of rainfall, but with an uneven rainfall distribution during the agricultural year, alternating dry periods with periods better supplied with rainfall.

Table 2. The main climatic elements of agricultural year 2023-2024

Climatic elements		Month values												Total/ Average
		X	XI	XII	I	II	III	IV	V	VI	VII	VII	IX	
Precipitation (mm)	Agricultural year 2023-2024	3	124	23	16	**0**	40	26	35	47	33	17	107	**471**
	Normal	30	33	36	28	27	26	35	48	62	46	39	32	**442**
	Deviation ±	**-27**	**91**	**-13**	**-12**	**-27**	**14**	**-9**	**-13**	**-15**	**-13**	**-22**	**75**	**29**
Air Temperature (^{0}C)	Agricultural year 2023-2024	15.9	8.1	3.6	0.4	**7.4**	8.2	16.8	16.6	24.3	26.5	25.2	20.0	**14.4**
	Normal	11.5	5.6	0.6	-2.1	-0.2	4.7	11.2	16.7	20.9	22.9	22.1	17.3	**10.9**
	Deviation ±	**4.4**	**2.5**	**3**	**2.5**	**7.6**	**3.5**	**5.6**	**-0.1**	**3.4**	**3.6**	**3.1**	**2.7**	**3.5**

Source: Meteorological Station of Brăila.

In the 2023 agricultural year, the maize crop experienced a vegetation period of 169 days, from sowing to harvest. During this period, the total accumulation of Growing Degree Units (GDU) reached 3567 °C, a value considered favorable for the full development of even semi-late and late hybrids. In contrast to the favorable thermal regime, the rainfall regime proved to be below the physiological requirements of the crop. The total precipitation accumulated over the entire vegetation period was only 233 mm, with an uneven distribution and extended periods of both atmospheric and soil drought. This water deficit is particularly critical during pollination and grain filling, potentially leading to a reduction in the number of kernels per ear and the weight of 1000 kernels.

Although the thermal conditions in 2023 provided excellent premises for a high-performing maize crop, the significant precipitation deficit represents a major limiting factor for yield, highlighting the importance of adopting adaptation measures such as the use of drought-tolerant hybrids and the application of irrigation.

In 2024, the maize crop underwent a vegetation period of 177 days from sowing to harvest, characterized by a high thermal regime and a slight improvement in rainfall compared to the previous year (Figure 2). The total GDU accumulated during this interval was 3741 °C, exceeding the value recorded in 2023, indicating an increased thermal accumulation. The rainfall regime recorded a total of 320 mm of precipitation, significantly higher than the previous year (+87 mm), yet still below the optimal requirement for maize under non-irrigated conditions.

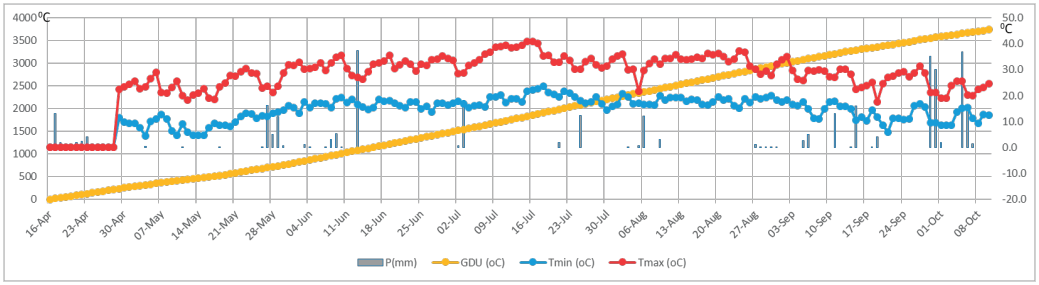

Figure 2. Presentation of climatic conditions and the sum of degrees of useful temperature during the vegetation period for maize, at ARDS Brăila, in 2024

Grain yield

The climatic conditions in 2023 were favorable especially for late maturing hybrids in the FAO 450-490 group allowing very good yields (Table 3).

Table 3. Production results of maize hybrids in 2023

Maize hybrids	Yield 2023 kg/ha	%	Diff. by control	Significance
FAO hybrids 300-340				
DKC 4109	10984	92.2	-935	-
DKC 4391	11980	100.5	60	-
FAO hybrids 350-390				
DKC 4728	9603	80.6	-2316	°°°
DKC 4709	7877	66.1	-4042	°°°
DKC 4712	9236	77.5	-2683	°°°
DKC 4897	12253	102.8	333	-
DKC 4908	9644	80.9	-2275	°°°
DKC 5092	17004	142.7	5084	***
FAO hybrids 400-440				
DKC 5016	11666	97.9	-253	-
DKC 5404	9826	82.4	-2093	°°
FAO hybrids 450-490				
DKC 5810	15206	127.6	3286	***
DKC 5812	17758	149.0	5838	***
Average (control)	**11919**	100.0	Mt.	
LSD 5%=1227.82kg/ha; LSD 1%=1672.69 kg/ha; LSD0.1%=2248.05 kg/ha				

The results confirm the need to choose hybrids according to their adaptability to climatic variations and their capacity to efficiently capitalize on available resources. The late hybrids (FAO 450-490), DKC 5812 and DKC 5810 benefited significantly from the high rainfall (106 mm in July and 55 mm in August) and high temperatures in July and August, obtaining yields of 15206 kg/ha and 17758 kg/ha, respectively.

The hybrid DKC 5092 of the FAO 350-390 group made efficient use of climatic and technological resources and obtained a very good yield and a significant difference compared to the average of the experiment.

The poorer results of early and intermediate hybrids can be explained by the drier period in May and June during generative development.

The climatic conditions of 2023-2024, with consistently high temperatures and extremely high deviations in June-August ranging from 3.1-3.6°C and precipitation deficits in April-August, put pressure on late hybrids (especially DKC 5810 and DKC 5812), significantly reducing their yields compared to the first year of testing. The climatic conditions were favorable to the intermediate hybrids FAO 350-390, DKC 4728, and DKC 4897, which obtained the highest yields of 12506 kg/ha respectively 12546 kg/ha, statistically assured results compared to the average yield of the experiment (Table 4).

Table 4. Production results of maize hybrids in 2024

Maize hybrids	Yield 2024 kg/ha	%	Diff. by control	Significance
FAO hybrids 300-340				
DKC 4109	11088	109.8	991	**
DKC 4391	9133	90.5	-964	°
FAO hybrids 350-390				
DKC 4728	12506	123.9	2408	***
DKC 4709	8004	79.3	-2093	°°°
DKC 4712	7883	78.1	-2214	°°°
DKC 4897	12546	124.2	2248	***
DKC 4908	9926	98.3	-171	-
DKC 5092	9767	96.7	-330	-
FAO hybrids 400-440				
DKC 5016	9703	96.1	-394	-
DKC 5404	12003	118.9	1906	***
FAO hybrids 450-490				
DKC 5810	9533	94.4	-564	-
DKC 5812	9075	89.9	-1023	°°
Average (control)	**10097**	100.00	Mt.	
LSD 5%=725.04 kg/ha; LSD 1%=987.74 kg/ha; LSD0.1%=1327.49 kg/ha				

From the FAO 400-440 group, the hybrid DKC 5404 stood out with a yield of 12003 kg/ha with a positive difference that was very semi-significant compared to the average of the experiment.

The choice of hybrids for drought-prone areas should focus on those with better water and heat stress adaptability, such as DKC 5404, DKC 4728, and DKC 4897, which have demonstrated

stability and performance even under extreme climatic conditions.

Values of **the hectolitre mass (HM)** for the analyzed maize hybrids are presented in Table 5. Results confirm that 2023 was generally favorable for maize development, allowing most hybrids to achieve high hectolitre mass values. The best hectolitre mass results were achieved by the intermediate hybrids in the FAO 350-390 group, in particular DKC 4728 (75.46 kg/hl) and DKC 4709 (76.03 kg/hl). The above-average hectoliter mass of most hybrids indicates favorable climatic conditions during the ripening and grain-filling period in 2023.

Table 5. Results of hectolitre mass (HM) 2023-2024

Maize hybrids	MH 2023 kg/hl	MH 2024 kg/hl	Average MH hl/kg	Diff. by control kg/hl
FAO hybrids 300-340				
DKC 4109	74.40	69.9	72.15	0.14
DKC 4391	72.83	67.7	70.27	-1.75
FAO hybrids 350-390				
DKC 4728	75.46	71.7	73.58	1.57
DKC 4709	76.03	70.4	73.22	1.21
DKC 4712	71.86	65.30	68.58	-3.43
DKC 4897	72.06	69.3	70.68	-1.33
DKC 4908	74.26	65.2	69.73	-2.28
DKC 5092	72.83	68.00	70.42	-1.60
FAO hybrids 400-440				
DKC 5016	73.9	66.8	70.35	-1.66
DKC 5404	74.36	70.8	72.58	0.57
FAO hybrids 450-490				
DKC 5810	73.23	69.4	71.32	-0.70
DKC 5812	73.6	71.8	72.70	0.69
Average (control)	**73.42**	**70.60**	**72.01**	**Mt.**

The average hectolitre weight for 2024 was 70.60 kg/hl, down on the previous year 73.42 kg/hl. This decrease can be directly correlated to the more stressful climatic conditions in the 2024 season, extremely high temperatures and a pronounced water deficit during specific growing periods.

The hybrids with the best overall stability and performance, demonstrated by the high average MH values over the two years, are: DKC 4728 (73.58 kg/hl) and DKC 4709 (73.22 kg/hl) from FAO 350-390; DKC 5404 (72.58 kg/hl) from FAO 400-440; DKC 5812 (72.70 kg/hl) from FAO 450-490.

In year 2023 the average **thousand-kernel weight** (TKW)was 378.83 g, a very high value, indicating very favorable conditions for the development and filling of the corn grain (Table 6). The semi-late hybrids DKC 5016 with 409.63 g and DKC 5404 with 407.94 g were highlighted. Very good results were also obtained by the late hybrids of the FAO 450-490 group, above the average of the experience, showing the capacity of late hybrids to capitalize on the growing conditions.

Table 6. Thousand-kernel weight (TKW) results 2023-2024

Maize hybrids	TKW 2023 g	TKW 2024 g	Average g	Diff. by control g
FAO hybrids 300-340				
DKC 4109	338.06	218.43	278.46	-31.30
DKC 4391	344.32	245.66	294.99	-14.55
FAO hybrids 350-390				
DKC 4728	327.34	220.52	273.93	-35.61
DKC 4709	317.92	251.16	284.54	-25.00
DKC 4712	301.12	241.34	271.23	-38.31
DKC 4897	328.30	274.26	301.28	-8.26
DKC 4908	339.37	211.40	275.39	-34.16
DKC 5092	381.20	232.62	306.91	-2.63
FAO hybrids 400-440				
DKC 5016	409.63	249.45	329.54	20
DKC 5404	307.94	251.87	279.91	-29.64
FAO hybrids 450-490				
DKC 5810	397.10	253.90	325.50	15.96
DKC 5812	360.56	226.60	293.58	15.96
Average (control)	**378.83**	**240.25**	**309.54**	**Mt.**

In 2024 which was climatically more difficult, the average TKW was 240.25 g, significantly lower compared to 2023, indicating stress conditions such as dry spells, extreme temperatures, which reduced dry matter accumulation in the grain. The best results were obtained by the semi-late hybrids of FAO group 400-440, DKC 5404 with 251.87 g and hybrid DKC 5016 with 249.45 g.

The hybrids with the most stable TKW results for the two test years were the FAO 400-440, DKC 5404 and DKC 5016 hybrids that showed the best adaptability, performance and overall stability under contrasting climatic conditions in the two test years.

CONCLUSIONS

Concerning the yields obtained by the hybrids studied, the year 2023 was particularly favorable for late hybrids, group FAO 450-490, with DKC 5812 and DKC 5810 being the most favorable. The year 2024, with more unfavorable periods for maize crop especially in the generative periods, led to significant yield decreases especially for late hybrids and was more favorable for the semi-late hybrids of the FAO 350-390 group.

The stability of hectolitre mass under variable conditions emphasizes hybrids with good stress tolerance, in particular DKC 4728, DKC 5404, DKC 5812, which should be preferred to ensure consistent yield quality. Concerning TKW values, DKC 5404 and DKC 5016 hybrids

provide good quality stability regardless of climatic conditions.

In the context of current climate change and increased variability of annual climatic conditions, the recommendation is to prioritize the choice of hybrids that combine good yields with stability of physical quality of production (MH and TKW), such as DKC 5404 and DKC 4728, to reduce the risk of economic losses under difficult climatic conditions.

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