Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 2, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDY OF THE EARLY - PRODUCTION RELATIONSHIP IN MAIZE HYBRIDS GROWN AT CARACAL, ROMANIA

Iulia Oana ŞTEFAN[1], Gabriela PĂUNESCU[2], Ramona Aida PĂUNESCU[2], Aurel-Liviu OLARU[1], Marin ȘTEFAN[1]

[1]University of Craiova, 13 A.I. Cuza Street, 200585, Craiova, Dolj County, Romania
[2]Agricultural Development Research Station Caracal, 106 Vasile Alecsandri Street, 235200, Caracal, Olt County, Romania

Corresponding author email: iulia.oana.stefan@gmail.com

Abstract

Choosing maize hybrids is one of the most important decisions a farmer makes each year, the yield potential, disease resistance and herbicide/pest resistance being the main factors that need to be addressed and balanced. Also, a key factor in the choice of the maize hybrid is its earliness. In stress environments, stable genotypes are valuable for their predictable and consistent yields. In the period 2020-2023, on the chernozem from Caracal located in South Romania, an assortment of maize hybrids was tested, the precocity-production relationship being studied. The obtained results showed that in years favorable to maize cultivation, hybrids from the FAO groups 260-340, 340-390 and 400-460 can be grown on the black soil from Caracal in South Romania with similar results. If there are also unfavorable years, considering that we cannot know from the beginning what the weather will be like, it is preferable to cultivate hybrids from the FAO groups 260-340 and 350-390.

Key words*: maize, hybrid, precocity, FAO group.*

INTRODUCTION

Maize crops are of particular importance, as maize kernels are used for human consumption, as animal feed and also as raw material in industry. According to FAO data, approximately 21% of world production is used in human food, 72% in animal feed and 7% as raw material in the food industry (Stoica, 2020).

Maize earliness refers to the period between the date of sowing and the date of harvest, this being a key factor in the choice of the maize hybrid. It is important to consider the early ripening period and soil conditions in the region. The later the maize hybrid, the longer its growing period. The degree of maturity of maize (*Zea mays* L.) hybrids, usually grown in central and northwestern Romania, varied from FAO 100 to 400 (Haș et al., 2012). Late stock normally shows too much moisture at harvest and then presents storage problems. This severely limits the scope of germplasm that can be used in a breeding program located in the area. Selection for early flowering and low moisture at harvest adapts the material to areas requiring earlier maize (Ortiz et al., 2008).

Obtaining maize hybrids which, among other characteristics, must also be early is an important concern of maize breeders. Early maize must grow faster and mature earlier in cooler conditions than late maize to produce mature kernels in a shorter time. Early maize grows faster, especially in the spring when the weather is cool. The maturity zones are based on the useful degrees (GDU) accumulated during the frost-free period: GDU = [Max Temp (≤ 30ºC) + Min Temp (≥ 10ºC)]/2 – 10ºC.

In northern and premontane areas, due to limited thermal resources, precocity is necessary to reach maturity (Cristea, 2004; Căbulea et al., 1999). In southern areas, earliness is used to alleviate the moisture stress of late drought by sowing earlier and earlier.

Maize can be grown under different environmental conditions, but nevertheless, its production is strongly influenced by genotypes, technologies (rotation, earliness and sowing date) and their interaction (Ali et al., 2017). Maize is sensitive to drought at almost all growth stages, but is most sensitive during the flowering period (Spitkó et al., 2014). Thus, when a water deficit occurs at flowering, there

is a delay in spike growth and then silk emergence (Edmeades, 2013).
In stress environments, stable genotypes are valuable for their predictable and consistent yields. However, such stability would be less valuable in a less stressed environment, where genotypes through their adapted responses could produce higher yields, taking advantage of favorable environmental conditions (Kusmec et al., 2018). Genotype is the hereditary makeup of an individual and its performance is based on the ecosystem in which it is placed (Andorf et al., 2019).
Choosing maize hybrids is one of the most important decisions a farmer makes each year. Yield potential, disease resistance and herbicide/pest resistance are the main factors that need to be addressed and balanced. Another important factor is relative maturity. A hybrid can take more advantage of the available heat units and produce more, contrary to what its earliness group foreshadowed (Stefan et al., 2018).
Growers may choose hybrids of different relative maturity for various reasons. Michigan State University recommends choosing a hybrid with varying relative maturity to use flowering and pollination as a drought shield and to vary harvest dates. Usually, not all hybrids from the same FAO group are chosen because sometimes the spring or summer can be particularly cool or a frost can set in earlier.
Silva et al. (2022) evaluated seven maize hybrids from different seed companies/ marketers to study the effect of water and nitrogen deficit on grain yield and yield components. The hybrids tested were DK619, Lerma, NK703, Rio Cisnes, Rio Maipo, Rio Negro and Rio Trancura. Hybrids were arranged in randomized blocks with 4 replicates. Plot size was 18 m^2 (four rows spaced 0.75 m x 6 m long). The main differences in production showed that the influence of the environment (SE=1,054 kg/ ha) was greater than that caused by the hybrid (SE=240 kg/ha). Production varied between 12,802 and 16,572 kg/ ha. Differences in grain yield were associated with biomass ($r = 0.89$; $p = 0.008$) and number of grains/m^2 ($r = 0.70$; $p = 0.080$). Water stress and nitrogen stress caused a 72% and 57% decrease in production compared to the production from the non-stress environment (Silva et al., 2022).
Based on the results recorded in the United States (Kansas), Araya et al. (2017) concluded that maize production will decrease in the coming years, on average by 18-33%. The shortening of the maize vegetation period (9-18% reduction in days to maturity), due to high temperatures, could cause a decrease in production.
Studies carried out in Turda recommended earlier sowing as a technological measure to reduce the influence of high temperatures, considering that in this way the plants would more effectively use the existing water reserve in the soil, from the first months of the year (Haș et al., 2021).

MATERIALS AND METHODS

In the period 2020-2023, on the chernozem from Caracal in South Romania, numerous maize hybrids from globally recognized seed producing companies were tested - BASF, Biocrop, Corteva, Donau Saat, KWS, Lidea, MAS Seeds, Saaten Union, Syngenta and with vegetation periods placed in almost all FAO earliness groups.
From a climatic point of view, the years 2020, 2021 and 2023 were favorable for maize cultivation, but the year 2022 was extremely dry and the hybrids placed in the FAO 400-490 group and above FAO 500 had extremely low productions.
The precocity-production relationship was studied through the lens of correlations between production and humidity at harvest, production and classification in the FAO group, production and its coefficient of variability within the FAO groups, but also by calculating the differences in production using the Newman-Keuls test.

RESULTS AND DISCUSSIONS

For the period in which the climatic conditions were favorable for maize cultivation, the Newman-Keuls test shows distinctly significant differences between the productions of hybrids belonging to the FAO 150-250 group and all other groups, between the FAO group greater than 460 and the hybrids from the FAO 260-340 groups, 350-390 and 400-450, but does not show any difference between the productions

of the hybrids from the FAO 260-340 group and the 350-390 and 400-450 groups, nor between the 350-390 and 400-450 groups (Table 1).

For the period in which the values from the year 2022 were also entered in the production average, a year in which the climatic conditions were extremely unfavorable, the Newman-Keuls test allows a different interpretation. Distinctly significant differences were recorded between the yields of hybrids belonging to the FAO group greater than 460 and all other groups, as well as between the FAO 150-250 group and hybrids from the FAO 260-340 and 400-450 groups. The production differences in hybrids belonging to the 150-250 group and those from the 350-390 group, on the one hand, and those between the FAO 350-390 and FAO 400-450 groups, on the other hand, are significant. There was no difference between the yields of the hybrids in the FAO 350-390 group and the FAO 260-340 group, but also between the FAO 260-340 and 400-450 groups (Table 2).

Table 1. Presentation of the results of the Newman-Keuls test for maize tested at Caracal – average of the years 2020, 2021 and 2023 (unfavorable year excluded)

Experienced FAO Group	Experienced FAO Group				
	FAO 150-250 (48.64 q/ha)	FAO > 460 (58.00 q/ha)	FAO 260-340 (70.37 q/ha)	FAO 350-390 (70.41 q/ha)	FAO 400-450 (73.63 q/ha)
FAO 150-250 (48.64 q/ha)	0	9.36**	21.73**	21.77**	24.99**
FAO > 460 (58.00 q/ha)		0	12.37**	12.41**	15.63**
FAO 260-340 (70.37 q/ha)			0	0.04*ns*	3.26*ns*
FAO 350-390 (70.41 q/ha)				0	3.22*ns*
FAO 400-450 (73.63 q/ha)					0

*p < .05, * * p < .01

Table 2. Presentation of the results of the Newman-Keuls test for maize tested at Caracal - average of the years 2020-2023 (unfavorable year included)

Experienced FAO Group	Experienced FAO Group				
	FAO > 460 (25.36 q/ha)	FAO 150-250 (32.30 q/ha)	FAO 350-390 (37.67 q/ha)	FAO 260-340 (41.08 q/ha)	FAO 400-450 (42.43 q/ha)
FAO > 460 (25.36 q/ha)	0	6.94**	12.01**	15.72**	17.07**
FAO 150-250 (32.30 q/ha)		0	5.37*	8.78**	10.13**
FAO 350-390 (37.67 q/ha)			0	3.41*ns*	4.76*
FAO 260-340 (41.08 q/ha)				0	1.35*ns*
FAO 400-450 (42.43 q/ha)					0

*p < .05, * * p < .01

We can conclude that in the years favorable for maize cultivation, hybrids from FAO groups 260-340, 350-390 and 400-460 can be grown on the Caracal chernozem with similar results. If there are also unfavorable years, considering that we cannot know from the beginning what the weather will be like, it is preferable to cultivate hybrids from the FAO groups 260-340 and 350-390.

Research on new maize hybrids that differ significantly in characteristics related to earliness such as anthesis, silking, anthesis-silking intervals as well as those related to physiological maturity (grain filling period and rate of their filling) were also studied by other researchers (David, 2008; Ibraheem and Abdel-Moneam, 2015; Borozan et al., 2021).

The most productive maize hybrids were those placed in the FAO 400-450 group, whose average in 2020 was 8097 kg/ha. At the opposite pole were the hybrids from the FAO > 460 group whose average production was 338 kg/ha (Figure 1).

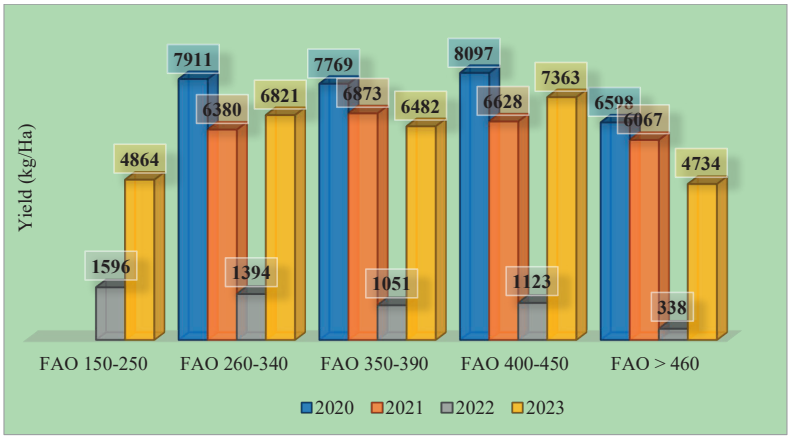

Figure 1. Average yields of maize hybrids tested at Caracal according to FAO group and year of testing

The largest weight is the productions over 6000 kg/ha registered in all FAO groups except 150-250. In three of the groups, namely FAO 260-340, FAO 350-390 and FAO 400-450, in 3 years out of the 4 tests, the aforementioned productions were recorded.

The extremes of the coefficients of variability were: 3.3% for productions in the FAO group 150-250 and 76.8% for productions in the FAO group over 460, both in the year 2022.

The coefficient of determination shows us that 33% of the variability of the coefficient of variability is the consequence of the changes in the yields of the maize hybrids (Figure 2).

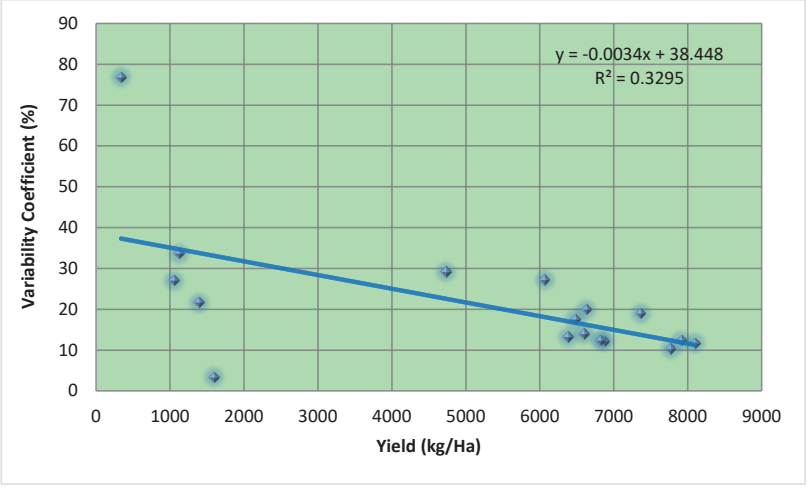

Figure 2. The relationship between the production of maize hybrids - production variability coefficient

In the case of the relationship between the production of maize hybrids and the humidity at harvest in 2021, the coefficient of determination shows us that 56% of the variability of humidity is given by the variability of the productions of maize hybrids (Figure 3). In the year 2023, this coefficient of determination is lower, so that 43% of the

variability of moisture at harvest is closely related to the variability of the productions obtained on the chernozem from Caracal (Figure 4).

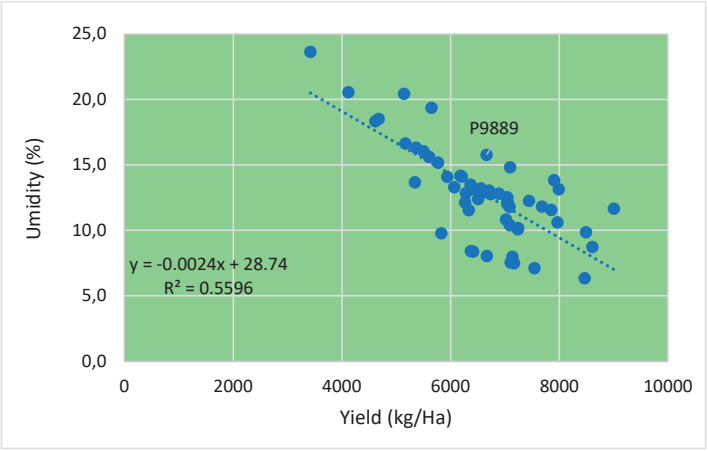

Figure 3. The relationship between the production of maize hybrids and the humidity at harvest in 2021

The correlations clearly show that in 2 of the 4 years tested, the relationship of yield with moisture at harvest was strongly negative. The later the hybrid was (high moisture at harvest) the less productive it was and vice versa.

In the year 2021, the points representing the values of the obtained productions are almost uniformly distributed along the line representing the linear equation. The hybrid Corteva P9889 stood out, which at a high humidity (15.8%) obtained a relatively increased production (6661 kg/ha).

In the year 2023, the hybrid Corteva P9911 presented a positive deviation from the line showing the correlation, which, although it recorded a high moisture at harvest (17.8%), also had a high production (8040 kg/ha) (Figure 4). With such a production, it was expected that the hybrid would belong to an FAO group above 400, more precisely FAO 410.

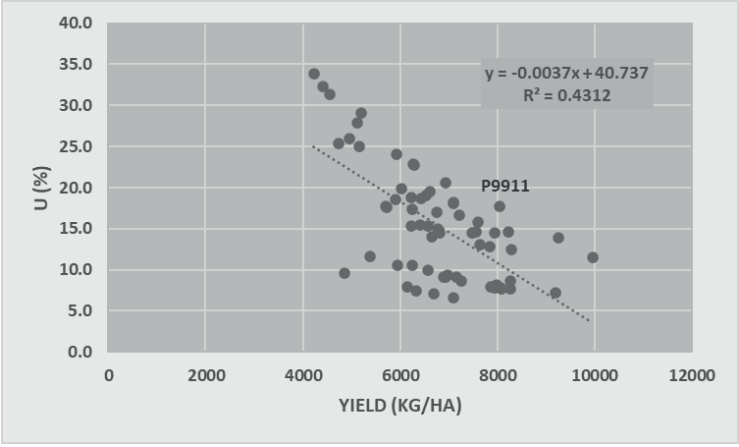

Figure 4. The relationship between the production of maize hybrids and the humidity at harvest in 2023

CONCLUSIONS

In years favorable to maize cultivation, hybrids from the FAO groups 260-340, 350-390 and 400-460 can be grown on the Caracal black soil with similar results. If there are also unfavorable years, considering that we cannot know from the beginning what the weather will be like, it is preferable to cultivate hybrids from the FAO groups 260-340 and 350-390.

The extremes of the coefficients of variability were: 3.3% for productions in the FAO group 150-250 and 76.8% for productions in the FAO group over 460, both in the year 2022. The variability was so diversified, from very stable to unstable, which suggests that it is extremely difficult to choose a performing hybrid with productive stability for the Caracal chernoziom. Following the correlations between yields and humidity at harvest, two maize hybrids from Corteva (P9889 and P9911) were highlighted which, although they showed high humidity, also recorded high yields. They thus broke the particularly strong but negative relationship in the sense that a hybrid with high moisture at harvest has a low yield.

REFERENCES

Ali, S.A., Tedone, L., Verdini, L., De Mastro, G. (2017). Effect of different crop management systems on rainfed durum wheat greenhouse gas emissions and carbon footprint under Mediterranean conditions. *Journal of Cleaner Production, 140*(2).608–621.

Andorf, C., Beavis, W.D., Hufford, M., Smith, S., Suza, W.P., Wang, K., Woodhouse, M., Yu, J., Lübberstedt, T. (2019). Technological advances in maize breeding: past, present and future. *Theor Appl Genet., 132*(3). 817–849.

Araya, A., Kisekkaa, I., Linb, X., Vara Prasadc, P.V., Gowdad, P.H., Riceb, C., Andalese, A. (2017). Evaluating the impact of future climate change on irrigated maize production in Kansas. *Climate Risk Management, 17*. 139–154.

Borozan, P., Musteaţa, S., Spînu, V., Spînu, A., Statnic, M. (2021). Cercetări privind crearea liniilor consangvinizate şi a hibrizilor de porumb timpuriu. *Ştiinţa Agricolă, 1*. 3–11.

Căbulea, I., Grecu, C., Haş, I., Haş, V., Copândean, A., Teban, A. (1999). Crearea hibrizilor de porumb la Staţiunea de Cercetări Agricole Turda în perioada 1983-1997. *Contribuţii ale cercetării ştiinţifice la dezvoltarea agriculturii, VI*. 73–98.

Cristea, M. (2004). *Fiziologia porumbului*. Cap.6, pp. 96-140, în Porumbul – Studiu monografic. Vol. I. Biologia porumbului. Editura Academiei Române. Bucureşti.

David, I. (2008). Cercetări privind cerinţele termice pentru răsărire la unii hibrizi de porumb. *Lucrări Ştiinţifice, vol. 51, seria Agronomie*, 19–24.

Edmeades, G.O. (2013). *Progress in Achieving and Delivering Drought Tolerance in Maize - An Update*. ISAAA: Ithaca, NY.

Haş, V., Haş, I., Copandean, A., Nagy, E. (2012). Turda 248 – hibrid de porumb de perspectivă pentru zona Transilvaniei. *Analele INCDA Fundulea, 80*. 59–68.

Haş, V., Tritean, N., Copândean, A., Vana, C., Varga, A., Călugăr, R., Ceclan, L., Șimon, A., Russu, F. (2021). Effect of climate change on the behavior of some released maize hybrids, created at ARDS Turda. *AN. I.N.C.D.A. Fundulea, LXXXIX*, 1–21.

Ibraheem, F., Abdel-Moneam, M.A. (2015). Classification of some new maize hybrids according to earliness and physiological maturity related traits under low and high nitrogen fertilization conditions. *J. Plant Production, Mansoura Univ., 6* (5). 725–748.

Kusmec, A., De Leon, N., Schnable, P.S. (2018). Harnessing Phenotypic Plasticity to Improve Maize Yields. *Front Plant Sci., 9*. 1377.

Ortiz, R., Sayre, K.D., Govaerts, B., Gupta, R., Subbarao, G.V., Ban, T., Hodson, D., Dixon, J.M., Ortiz, M.J.I., Reynolds, M. (2008). Climate change: can wheat beat the heat? *Agriculture, Ecosystems and Environment, 126*(1-2). 46–58.

Silva, P.S.T, Cassiolato, A.M.R., Galindo, F.S., Jalal, A., Nogueira, T.A.R., Oliveira, C.E.D.S, Filho, M.C.M.T. (2022). *Azospirillum brasilense* and zinc rates effect on fungal root colonization and yield of wheat-maize in tropical savannah conditions. *Plants, 11*. 3154.

Spitko, T., Nagy, Z., Zsubori, Z.T., Halmos, G., Banyai, J., Marton, L.C. (2014). Effect of drought on yield components of maize hybrids (*Zea mays* L.). *Maydica 59*(2). 161–169.

Stoica, C. (2020). Cercetări privind optimizarea producției de semințe de porumb hibrid în exploatațiile agricole din Câmpia Bărăganului. Teză de doctorat. Universitatea ”Dunărea de Jos”, Galați.

Stefan, M., Popescu, Cr., Gheorghe, D. (2018). Researches on the influence of crop rotation and fertilization to the maize cropped on the improved sandy soil from southern part of Dolj County. *18th International Multydisciplinary Scientific Geoconference SGEM 2018, 18*. 427–433.