STUDY OF PLANT DENSITY IN MAIZE PRODUCTION IN 2021

Péter JAKAB * [1], Péter VARGA[1], Melinda TAR[1]
[1] Institute of Plant Sciences and Enviromental Protection, Faculty of Agriculture, University of Szeged, Hódmezővásárhely, Hungary
**Corresponding author: jakab.peter@szte.hu*

Abstract: *The main goal of these study was to examining the effect of plant density of maize hybrids on yield and income. The experiment was set up in Óbecse (Serbia) used by in a split-plot design with four replications and four plant densities (65,000, 70,000, 75,000, 80,000 plants ha^{-1}) in 2021. The soil was calcareous chernozem. Its nitrogen and phosphorus content was very good, and potassium content was good. The studied hybrids were: KWS Kashmir (FAO 400), KWS Kollegas (FAO 480), KWS Don Juan (FAO 440) and Pioneer 0164 (FAO 430). 2021 was moderately dry year. The amount of rainfall was lower by 98.6 mm than the long term average in the vegetation period of maize. The results were processed and statistically evaluated using the software Microsoft Excel 2016 and IBM SPSS Statistics Version 29.0.0.0. The Pioneer0164, KWS Don Juan, and KWS Kashmir hybrids reached their maximum yield and the highest income at a plant density of 65,000 plants/ha. On the other hand the KWS Kollegas hybrid resulted the highest yield (7866 kg/ha) at a plant density of 80,000 plants/ha, and consequently, the highest income as well. The results indicate, that maize hybrids have varying optimal and econimically viable plant densities, therefore, it is advisable to use hybrid-specific cultivation techniques.*

Key words: *maize, plant density, yield amount, income*

INTRODUCTION

The order of cultivated plants according to their sowing areas has been wheat-rice-corn for long decades. In the past decades, changes took place. The sowing area of corn increased very dynamically, thus, after wheat (~210-220 million ha) it became the second (~165 million ha), while rice (~160 million ha) became back to the third most important crop. Due to the dynamic increase of its sowing area and yield average, corn is the grain crop produced in the largest volume (~850-900 million tons) in the world, preceding wheat and rice. Its dynamic increase is due to its enormous yield potential (C_4 plant) and broadening utilization (SZÉLL, 2004; NAGY *et* SÁRVÁRI, 2005; NAGY, 2007; PEPÓ *et* SÁRVÁRI, 2011; PEPÓ and CSAJBÓK, 2013; NAGY, 2021).

Nowadays maize has a wide range of applications, being produced for food, feed and industrial purposes. Thanks to continuous improvements in the germplasms and to competition between breeding companies, the yield potential of the species is clearly increasing, but when grown under the continental climate characteristic of Hungary the increasing frequency of extreme environmental conditions means that the yield averages have risen only slightly and exhibit great instability. The primary goal of modern maize production is sustainability, in which a wise choice of genotypes and technologies plays an outstanding role. The plant density, a component of the maize production technology, which has been widely studied, but is still not exploited sufficiently in farm practice. It has a great influence on the success of maize production, especially when weather conditions are unpredictable. This contributes to the fact that farmers are often reluctant to change their choice of hybrids. Consequently, higher plant density is not always justified, but there is nevertheless a chance of obtaining higher yields from hybrids with better yield potential, based on knowledge of the growing area, a wise choice of genotype and the rational use of production technologies. This question has long been the subject of research and a large body of information is available, both in Hungary and abroad. However, this information is not always comprehensible to maize growers, so the results, however good, are rarely translated into practice (KÖNCZÖL, 2018).

The optimum plant density depends on the genotype of hybrids, on agro ecological conditions, on the effects of crop year, on the water- and nutrient supply and on the intensity of maize production. A 10 thousand plants/ha change in stock density can increase yields by 1.5-2 t/ha, but over the optimum level yields are reduced. There are big differences among the plant density of different maize hybrids. There are hybrids sensitive to higher plant density and there are wide and narrow optimum plant density hybrids. Concerning the fact that the frequency

of drought crop years increased and the usage of fertilizers dropped in the last years we suggest that the optimum plant density is 68-72 thousand/ha in the case of 200-300 FAO hybrids and 60-65 thousand/ha in 400-500 FAO hybrids (SÁRVÁRI, 1995; PÁLOVICS and SÁRVÁRI, 2006). Among different components responsible for low grain yield, plant density and selection of unsuitable cultivars are of high importance (BISWAS *et al.*, 2020; YAO *et al*., 2016; BATTAGLIA *et al.*, 2019). According XU *et al.* (2017) plant density increasing from 67,500 to 90,000 plants/ha causes significantly grain yield increasing by 7%.

MATERIALS AND METHODS

Our experiment was carried out in 2021 in Óbecse (Serbia). The soil of the experiment was calcareous chernozem in good agricultural state. The soil was almost neutral, medium in nitrogen, and well supplied in phosphorus and potassium. The experimental treatments were set up in split-plot design with four repetitions. The size of the plots was 630 m^2. The forecrop was winter wheat. During the nutrient supply, 170 kg/ha of NPK fertilizer (7:20:20) was applied in the autumn of 2020. In the spring of 2021, 170 kg/ha of nitrogen fertilizer was applied before the seedbed preparation. Sowing took place on April 25, 2021. Post-emergence weed control was carried out after sowing. The experiment was harvested on October 18.

2021 was moderately dry year. The amount of rain was lower by 98.6 mm than the average in the vegetation period of maize *(Table 1)*

The statistical tests were performed using one-factor analysis of variance, based on the method of Sváb (1986).

Result date were processed and statistically evaluated using the software Microsoft Excel 2016 and IBM SPSS Statistics Version 29.0.0.0.

Table 1

Distribution of precipitation in the vegetation period of maize (Óbecse, 2021)

Month	Precipitation (mm)	Long-term average precipitation (mm)	Deviation from average (mm)
April	34.5	31.7	2.8
May	64	84	-20
June	5	64	-59
July	100	60.7	39.3
August	43	47.2	-4.2
September	7	64.5	-57.5
Total	**253.5**	**352.1**	**-98.6**

RESULTS AND DISCUSSIONS

Examining the results of the year 2021, it can be observed that the Pioneer 0164, KWS DonJuan, and KWS Kashmir hybrids responded to an increase in plant density with a decrease in yield. However, these results were not statistically significant. In contrast, the KWS Kollegas hybrid yielded the lowest (6688 kg ha^{-1}) at a plant density of 70,000 plants ha^{-1}, while achieving its maximum yield (7866 kg ha^{-1}) at a plant density of 80,000 plants ha^{-1}. The latter result was statistically significant (*Table 2*).

(Table 2).

Examining the yield of different hybrids within the plant densities, it can be determined that KWS Kashmir had the highest yield at plant densities of 65,000, 70,000, and 75,000 plants per hectare (7740, 7622, and 7468 kg/ha). At a plant density of 80,000 plants per hectare, the yield of KWS Kollegas proved to be the highest (7866 kg/ha).

Table 2

The effect of plant density ont he yield of maize hybrids

Hybrid	**Yield (kg/ha)**			
	65,000 plants/ha	**70,000 plants/ha**	**75,000 plants/ha**	**80,000 plants/ha**
Pioneer 0164	7248^{Ab}	6910^{Aab}	6649^{ABab}	6327^{Aa}
KWS Kollegas	7228^{Aa}	6688^{Aa}	7026^{ABa}	7866^{Ba}
KWS Don Juan	7239^{Aa}	6804^{Aa}	6488^{Aa}	6533^{Aa}
KWS Kashmir	7740^{Aa}	7622^{Aa}	7468^{Ba}	7418^{ABa}

For each hybrid (rows), values marked with different lowercase letters and for each plant density (columns), values marked with different uppercase letters significantly differ at the $p<0.05$ significance level.

As the plant density increases, the cost of seed per hectare also increases. The highest seed cost was observed for the KWS Don Juan hybrid at every plant density. The lowest seed cost was calculated for the KWS Kashmir and KWS Kollegas hybrids.

The Pioneer0164, KWS Don Juan, and KWS Kashmir hybrids reached their maximum yield and consequently the highest income at a plant density of 65,000 plants/ha. In contrast, the KWS Kollegas hybrid had the highest yield (7866 kg/ha) at a plant density of 80,000 plants/ha, and consequently, the highest income as well *(Table 3).*

Table 3

The effect of different plant densities on the income (Ft/ha)

Hybrid	**Plant density (thousand/ha)**	**Yield (kg/ha)**	**Income (Ft/ha)**	**Cost of sowing seed (Ft/ha)**	**Income - Cost of sowing seed (Ft/ha)***
Pioneer 0164	80	6327	454 467	65 600	388 867
Pioneer 0164	75	6649	477 587	61 500	416 087
Pioneer 0164	70	6910	496 345	57 400	438 945
Pioneer 0164	65	7247	520 552	53 300	467 252
KWS Kollegas	80	7886	566 451	62 400	504 051
KWS Kollegas	75	7026	504 677	58 500	446 177
KWS Kollegas	70	6687	480 327	54 600	425 727

KWS Kollegas	65	7228	519 187	50 700	468 487
KWS Don Juan	80	6533	469 265	69 760	399 505
KWS Don Juan	75	6487	465 961	65 400	400 561
KWS Don Juan	70	6803	488 659	61 040	427 619
KWS Don Juan	65	7238	519 905	56 680	463 225
KWS Kashmir	80	7418	532 834	62 400	470 434
KWS Kashmir	75	7468	536 426	58 500	477 926
KWS Kashmir	70	7619	547 272	54 600	492 672
KWS Kashmir	65	7739	555 892	50 700	505 192

CONCLUSIONS

We can conclude, than 2021 was moderatly dry year for maize and the distribution of precipitation was unfavourable for maize. In most cases the yield of the examined mize hybrids was higher in lower plant density (65-70 thousand/ha). The correlation between yield and plant density was significant only Pioneer 0164 hybrid. We established in our experiment, that the examined maize hybrids react differently on the change of plant density and distribution of rain.

These results support the findings of Sárvári et al. (2005), PEPÓ *et al*. (2007), and MURÁNYI and PEPÓ (2014). According to their results, determining the optimal plant density requires knowledge of the ecological, agronomic requirements, and biological characteristics of the specific maize hybrid. It has been determined that for most of the maize hybrids included in the study, cultivation with lower plant densities was more economical.

BIBLIOGRAPHY

BATTAGLIA, M., LEE, C., TOMASON, W., MULLEKOM, J.V.(2019). Effects of corn row width and defoliation timing and intensity on canopy light interception. Crop Science, 59 (4), 1718-1731.

BISWAS, S., SAHA, A., DEBNATH, S., CHATTERJEE, S. (2020). Performance of maize genotypes in *kharif* under varying planting density and nutrient levels in new alluvial zone of West Bengal. Multilogic in Science IX. (XXXII), 477-478.

NAGY, J. (2007). Kukoricatermesztés. Budapest; Akadémiai Kiadó.

NAGY, J. (2021). Kukorica. A nemzet aranya – Élelmiszer, takarmány, bioenergia. Budapest; Szaktudás Kiadó.

NAGY, J., SÁRVÁRI M. (2005). Kukorica. In: Antal J. ed.: Növénytermesztéstan 1. A növénytermesztés alapjai. Gabonafélék. Budapest; Mezőgazda Kiadó.

KÖNCZÖL, P. (2018). Effect plant density on the yield and yield components of maize hybrids. Thesis of doctoral (PhD) dissertation. University of Debrecen.

MURÁNYI, E., PEPÓ, P. (2014): Különböző genotípusú kukoricahibridek tőszám sűríthetőségének vizsgálata csernozjom talajon. Agrártudományi Közlemények. 56. 87-92.

PÁLOVICS, B., SÁRVÁRI, M. (2006): Tőszám hatása a kukoricahibridek termésére. Debrecen; Agrártudományi Közlemények. Különszám.

PEPÓ, P., CSAJBÓK, J. (2013). Integrated crop production I. University of Debrecen, Service Sciences Methodology Centre.

PEPÓ, P., SÁRVÁRI M. (2011): Gabonanövények termesztése. Debrecen; Debreceni Egyetem.

PEPÓ, P., ZSOMBIK, L., BERÉNYI S. (2007): A kritikus agrotechnikai tényezők elemzése a kukoricatermesztésben. Agrofórum Extra, 17. 5-6.

SÁRVÁRI, M. (1995): A tőszám szerepe a fajtaspecifikus kukorica-termesztési technológiában. Növénytermelés. 44. 3. 261-270.

SÁRVÁRI, M. (2005): Összefüggés a tőszám, vetésidő, és a kukorica termésbiztonsága között. Agronapló, 9. 4. 30-32.

SVÁB, J. (1986). Biometriai módszerek a kutatásban. Budapest; Mezőgazdasági Kiadó.

SZÉLL, E. (2004): Gabonafélék In: Jolánkai M. ed. Szántóföldi növények vetőmagtermesztése és kereskedelme. Budapest; Mezőgazda Kiadó.

XU, C., HUANG, S., TIAN, B., REN, J., MENG, Q., WANG, P. (2017): Manipulating planting density and nitrogen fertilizer application to improve yield and reduce environmental impact in Chinese maize production. Frontiers in Plant Science, 8 (1234), 1-11.

YAO, H., ZHANG, Y., YI, X., ZHANG, X., ZHANG, W. (2016): Cotton responds to different plant population densities by adjusting specific leaf area to optimize canopy photosynthetic use efficiency of light and nitrogen. Field Crops Research, 188, 10-16.