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RESEARCH ARTICLE

Response of maize plants to seeding rates under conditions of typical black soil

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Abstract

The study of maize plant productivity for hybrids Zorianyi FAO190, Leleka FAO 260, Donor MV FAO 310 with seeding rates of 60-90 thousand seeds per hectare was carried out during 2018-2020 in the North-Eastern Forest Steppe of Ukraine (Sumy district). It was found that such index as number of rows in a cob and number of grains in a row depends more on hybrid characteristics than on seeding rate. With density increase of the crops, occurs a decrease in grain number in a row. Weather conditions have a significant effect on grain number and, accordingly, the yield of maize grain. We can recommend usage of seeding rate of 90.000 seeds per hectare for hybrids Zorianyi, for Leleka 80.000 seeds and 70.000 seeds per hectare for hybrid Donor MV.

Keywords: Maize, Seeding rate, Plant density, Cob, Yield, Productivity, Grains per year, Kernel

Introduction

The task of scientists is currently aimed at working with maize genotypes and selecting density of plant growing, which can provide the highest productivity. (Widdicombe et al. 2002) emphasized that it is better to have plant density of 90 thousand per ha^{-1} for the northern maize zone. But times are changing, global warming is increasingly felt, lack of moisture during growing season increasingly limits normal development of plants. If late-ripening hybrids were in fairly good demand in the forest-steppe zone of Ukraine, now more attention is paid to mid-ripening, mid-early and early-ripening hybrids (Hryhoriv et al. 2020; Zemela et al. 2021; Radchenko et al. 2022). With appearance of new hybrids, appears the need to test their potential under different sowing rates and other regulated factors – fertilizers, tillage methods. (Taran et al. 2018; Lacolla et al. 2023; Sabourifard et al. 2023: Kharchenko et al. 2019) emphasized on significant influence of hybrid in cultivation technology, stressing on importance of taking into account hybrid intensity.

A significant amount of data from field experiments of Canada and USA had been processed by scientists over 14 years, which showed that optimal plant density should be based on FAO, weather, soil conditions and technological operations, and they developed corresponding calculation formula (Assefa et al. 2016, 2018). It is the factor of plant sowing rate that increases maize yield within 8.5%-17%.

It has been proven that the higher plant stand density, the greater leaf area index and efficiency of radiation use (Li et al., 2022). Iranian scientists (Saeidinezhad & Saffari, 2015) indicated that denser maize crops prevent weed growing. Experience of (Silva et al. 2021) appear to be interesting as they found that magnesium content in soil and soil electrical conductivity are among the most important indices for determining optimal density of hybrids. Such a factor as relief should also be taken into account, assessing the nature of the relief, steepness, exposure and length of slopes (Dindaroglu et al., 2022).

Materials and Methods

Field experiment was performed in the fields of the Institute of Agriculture in the Northeast at NAAS of Ukraine and was conducted in 2018-2020. Geographical coordinates of experimental plots N 50.889668, E 34.709948. The experiment is two-factor and laid out by the method of split blocks with three repetitions:

- Factor A–sowing rate (60.000, 70.000, 80.000, 90,000 seeds per ha^{-1}).
- Factor B–hybrids (Zorianyi FAO 190, Leleka FAO 260, Donor MV FAO 310).

Soil of experimental plot is leached low-humus medium-loam black with slight acidic environment reaction. The content of mobile phosphorus is 11.89 mg/100 g of soil; exchangeable potassium is 10.04 mg/100 g of soil according to Chyrikov method. The area of one accounting plot was 25 m^2, three replicates. The height of plants was measured in the phase of milk-wax ripeness, 10 plants from each variant. Plant density was calculated by counting plants per 14.3 linear meters (10 m^2) and converting them per hectare. Obtained results were calculated using Agrostat program.

At the time of sowing maize (May) in the period 2018-2020, air temperature exceeded average long-term indices by 4.3 °C in 2018, by 2.40 in 2019, but in 2020, on the contrary, air temperature was lower by 2.1 °C. Limit of moisture was observed in this spring month in 2018 (precipitation were 34% less than average long-term index) and in 2020 (by 24% less). In 2020, excessive amount of precipitation fell in May, 93.2 mm against 54 mm of long-term average index. Evaluating further development of weather conditions in 2018-2020, it should be noted that 2018 and 2019 were very dry, and 2020 was dry, which we described in detail in our previous articles with another soil cultivation experiment with the same maize hybrids (Petrenko, 2020; Kharchenko et. al., 2021a, Kharchenko et al., 2021b). The lack of moisture was especially felt in August 2019 and 2020.

Results and Discussion

On average over the years of research, among the studied hybrids, height of plants was the highest in the phase of shooting panicles, with sowing rate of 90.000 plants per ha, and was 246 cm for hybrid Zorianyi (Tab. 1). The lowest height of plants for this hybrid was noted in 2020 with sowing rate of 70.000 pcs per ha^{-1}. The highest plant height in 2018 was noted for hybrid Leleka (FAO 260) 262 cm. It should be noted that in 2019-2020 plant height was almost the same, on average, they were 241 cm-235 cm. This can also be observed for hybrid Donor (FAO 310), in 2018 plant height was the highest 262 cm.

Height of cob attachment is also one of important indices when growing maize for grain. As well as sowing rate, weather conditions affected plant height and cob attachment, which make mechanized harvest of maize possible. For hybrid Zorianyi, we have the following indices on average over the years, from 9 cm to 101 cm. For hybrid Leleka, height of beginning attachment was in the range of 92 cm-94 cm in the years of research with sowing rate of 70 thousand pcs and 80 thousand pcs And with the norm of sowing 90 thousand pcs, height of beginning attachment was almost 10 cm higher than for hybrid Zoryanyi. Hybrid Donor with the seeding norm averaged from 101 cm to 105 cm over the years. It can be noted that in 2019, the highest figure was 114 cm for hybrid Donor with sowing rate of 80.000 pcs per ha^{-1}.

Table 1. Influence of seeding rate on the height of plants and attachment of cobs

Factor A Seeding rates pcs ha^{-1}	Factor B - hybrids Plant height/ irst cob height, cm			
	2018	2019	2020	Average 2018-2020
Zorianyi (FAO 190) 70				
80	245/83	249/95	230/95	241/91
90	250/95	247/98	232/93	243/95
Mean	251/103	254/100	235/99	246/101
Leleka (FAO 260) 70	248/94	250/98	232/96	243/96
80				
90	255/90	238/95	238/92	243/92
Mean	263/92	240/95	240/95	247/94
Donor MV (FAO 310)	269/95	245/100	229/100	247/98
	262/92	241/97	235/96	246/95
60	255/98	243/104	250/104	249/102
70	260/102	250/112	248/102	252/105
80	271/104	252/114	252/108	258/109
Mean	262/101	248/110	250/105	253/105

$LSD_{0.05}$ for hybrids 2.7, for seeding rate 1.4, interaction factors A and B 4.02

The seeding rate influenced on the number of grains per row for hybrids, but the number of grain per row were dependent on both factors (Tab. 2). With increase of seeding rate of maize, number of grains per row decreased.

Table 2. Biometric indices of plants for maize hybrids of different ripening groups depending on plant standing density

Factor A Seeding rates pcs ha^{-1}	Factor B - hybrids Number of rows per cob *Number of grain per row, pcs 2018			
		2019	2020	Average 2018-2020
Zorianyi (FAO 190)				
70	16*38	14*34	16*43	15.3*38.3
80	14*36	14*33	14*43	14.0*37.3
90	14*33	14*29	12*40	13.3*34.0
Mean	14.6*36	14*32	14*42	14.2*36.5
Leleka (FAO 260) 70				
80	18*41	16*36	16*45	16.6*40.6
90	16*40	16*33	18*30	16.6*34.3
Mean	16*31	16*31	16*35	16.0*32.3
Donor MV (FAO 310)	16.6*37.3	16*33.3	16.6*36.6	16.4*35.7
60	16*45	16*34	14*38	15.3*39
70	16*40	16*37	16*40	16.0*39
80	16*38	16*34	16*40	16.0*37.3
Mean	16*41	16*35	15.3*39.3	15.7*38,4

The researcher's states that number of grain rows differs by hybrids more than by rate of sowing and level of fertilization. (Xue et.al 2005) indicate that effect of hybrid is more significant factor than density of plants influencing structure of yield components (in the study, density was 52500-67500 seeds per hectare). (Saeidinezhad & Saffari 2015), at one time, said that denser crops prevent development of weeds.

Main index of researched parameters in the technology of growing agricultural crops is its yield. According to the results of research based on different variants of seeding rate and year conditions, it can be stated that hybrid Zorianyi FAO 190 had the highest yield in 2018 with sowing rate of 90.000 pcs at 8.87 t per ha and in 2020 at 8.84 t per ha (Tab. 3). The lowest yield was recorded in 2019 at 7.32 t ha^{-1} with seeding rate of 70.000 pcs. When choosing early-ripening hybrid Zorianyi with seeding rates of 70 thousand seeds per hectare and 80 thousand seeds per hectare, yield values were within limits of LSD05, and the same yield data were received. The highest yield was obtained at 90 000 pcs.

Table 3. Grain yield of maize depending on seeding rate.

Factor A. Seeding rates pcs ha^{-1}	Factor B – hybrids. Grain yield, t ha^{-1} 2018			
		2019	2020	Average 2018-2020
Zorianyi (FAO 190)				
70	8.6	7.32	8.16	8.03
80	8.53	7.63	8.43	8.2
90	8.87	7.84	8.84	8.51
Mean	8.6	7.56	8.47	
Leleka (FAO 260)				
70	9	8.41	8.86	8.75
80	9.35	8.61	9.09	9
90	9.56	8.53	9.21	9.1
Mean	8.79	8.13	8.46	
Donor MV (FAO 310)				
60	9.84	8.29	9.21	9.11
70	9.72	8.94	9.81	9.49
80	9.59	8.75	9.45	9.26
Mean	8.94	8.35	8.93	

$LSD_{0.05}$ for hybrids 0.2, for plant density 0.22, interaction factors A and B 0.41

We can note that conditions of 2019 also were not good for potential of hybrid Leleka, and yield was the lowest in various variants of seeding rate. The highest yield in 2018 was obtained with the norm of 80 thousand pcsand 90 thousand pcs, and in 2020 at the norm of 90 thousand pcs, but without significant difference with yield of 80 thousand pcs

Hybrid Donor produced the highest yield in 2020 with seeding rate of 70.000 pcs and provided 9.81 t per ha. Annual average yield was 9.11 t per ha-9.27 t per ha.

Works of (Rudavska & Hlyva 2018) and (Kalenska et al. 2018, 2022) confirm the data obtained by us regarding influence of weather conditions and plant density on structural crop components of maize hybrids. (Didur et al. 2022), conducting research with hybrids of different FAO in the forest-steppe of the Vinnytsia region in the wet 2021 year, obtained data on the better yield of the mid-early ripening hybrid compared to the mid-ripening and mid-late hybrids. The optimal seeding rate for hybrids was 75,000 units per hectare. Reducing the seeding rate by 5 thousand-10 thousand seeds resulted in a decrease in grain yield by 5%-9%. (Zubko et al. 2018) emphasize that at lower sowing rates, 1.5 cobs-2 cobs with low quality and yield can be formed on a plant, and at increased rates (80 thousand pcs), one cob with a good weight is formed on plants, the yield increases to 10%. Increasing the seeding rate from 60,000 pcs to 90,000 pcs leads to a prolongation of the growing season of the plant (Kadyrov S. & Kharitonov M., 2019).

Conclusions

It was found that plant height depended on weather conditions and seeding rate of seeds. During research years, the highest index was noted in the phase of shooting panicles (VVSN 51) with rate of sowing seeds 90 thousand pcs for early and mid-early ripening hybrids and 80.000 pcs for medium ripening ones.

Height of cob attachment depends on FAO value. The highest index has been noted in late ripening groups of maize, which are hybrids Leleka and Donor.

We can state that field density of plants affects the number of grains in the row. The highest yield was obtained with sowing rate of 70.000 pcs.

Yield of maize grain during vegetation period depended not only on climatic conditions, but also on the potential of hybrid itself. The highest yield indices were recorded for hybrid Donor (mean 2018-2020) on experimental plot with seeding rate of 70.000 pcs; for hybrid Zoryanyi with seeding rate of 80,000 pcs-90,000 pcs, for Leleka 90.000 pcs.

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