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RESEARCH ARTICLE

Productivity of Sugar Maize of Hybrid Moreland F1 Depending on Technological Factors of Growing

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The article presents the results of research on studying the influence of plant standing density and level of mineral fertilization on the productivity of sugar maize of hybrid Moreland F1 on sod-podzolic soils under conditions of Ivano-Frankivsk region. It was found that the highest field germination of seeds was observed in the variant with application of mineral fertilizers in the dose $N_{135}P_{90}K_{125}+N_{60}+N_{30}$, and the lowest - in the control without fertilizers. Application of mineral fertilizers was favorable for better plant survival, which was 82.5-84.9%. The best indices of harvest structure were provided by the crops of sugar maize under agro-technical complex with nutrition background $N_{135}P_{90}K_{125}+ N_{60}+ N_{30}$ and plant density 60 thousand/ha, namely: quantitative yield of grain from the commodity cob - 445.2 pieces; dimensions of commodity cob without covers - 17.1 cm in length and 4.3 cm in diameter; weight of commodity cob - in covers 181.6, without covers - 138.7 g; mass yield of grain from the commodity cob - 65.5 g. The highest level of crop yield was achieved with fertilization background $N_{135}P_{90}K_{125}+N_{60}+N_{30}$ and plant density of 70 thousand/ha, namely 5.56 t/ha.

Keywords: Sugar maize; Plant standing density; Mineral fertilizers; Yield

Introduction

Maize is one of the most highly productive, multi-purpose cereal crops, which are grown for food, fodder and technical usage. The countries of the world use about 20% of maize grain for food needs, and 15% - for technical ones, the rest goes for forage (Vihrachov, 2010). As it is known, the grain growing is the main task of agricultural production. And significant place in its decision belongs to maize, which has always occupied leading position in the grain and feeding balances of Ukraine. Domestic scientific experience shows that this crop is practically unmatched by the potential of grain and green mass productivity, feeding and energy value, and it is irreplaceable in feeding rations for agricultural animals, especially pigs and poultry. Therefore, it is difficult to overestimate the importance of maize in grain production increasing and establishing of strong feeding base for livestock (Pysarenko, 1999; Hlushko, 2010; Butenko et al., 2019).

Demand for sugar maize is increasing in Ukraine for the last time. Milk state grain is used in food in freshly cooked, frozen and canned form. In terms of caloric content, the grain of these subspecies of maize significantly predominates over wheat and rye grain. It contains 18.6-23.4% of sugar, 47-51% of starch and dextrin. The composition of grain includes proteins with high feeding qualities, fats, vitamins (Tsykov, 1998; Zhuzhukyn, 1992; Karpenko et al., 2019).

Most scientists have developed zonal technologies for growing of fodder maize, an important element of which is plant density (Skubitskyi, 1994; Marenichenko, 2005; Kolisnyk et al., 2019). However, sugar maize differs from fodder one by morphological and biological properties, so for production of high-yielding, early-matured cereals with milk ripeness of grain it is necessary to develop cultivation technologies adapted to certain soil and climatic zone.

At present stage, the task of significant improvement of maize grain productivity for the needs of national economy is staying in front of agricultural producers in Ukraine. It is possible to solve this problem with application of high-yielding hybrids, advanced energy-saving technologies, seeds of high quality, etc. The global development of agriculture shows that this problem can be solved both by expanding sowing area and by increasing yields of hybrids. New economic relations require finding rational ways of reducing energy and material costs of production and preservation of soil fertility.

Materials and Methods

Field studies were conducted on the base of dendrological park "Druzhba" named after Zinovy Pavlikat SPEI of Prycarpathian national university named after Vasyl Stefanyk in Ivano-Frankivsk region on sod-podzolic surface-clay-covered soil during 2018-2019. According to the results of soil survey, the soil of experimental plot contains average humus up to 2.63%. The amount of absorbed bases is in the range of 11-12 mg-eq. per 100 g. of soil, the level of base saturation - 86%, the reaction of soil solution - acid (pH of saline solution 4.2-4.5, hydrolytic acidity is negligible).

Field and laboratory studies were conducted according to generally accepted methods of research in agronomy (Lytvynov, 2011; Bondarenko, 2001, Radchenko et al., 2018). The sowing was performed according to the scheme of experiment. A hybrid Moreland F1 was used for sowing. Research topics included the study of such factors: Factor A -fertilizing background: 1. Without fertilizers; 2. N90P90K90; 3. N135P90K125+ N60+ N30. FactorB - plant density, thousand/ha: 1. 60; 2. 70; 3. 80.

Repeatedness of the experiment - four times. Experimental plot with a total area of 50 m2, accounting - 10 m2. Placement of

repetitions was carried out by continuous method, disposition of variants - by the method of randomized split blocks.

The control was the variant without fertilizers. The following mineral fertilizers were used for the research: complex fertilizers in the form of nitrogen-phosphorus-potassium (16% of a.s.); ammonium nitrate (34.4% of a.s.). Fertilizers were introduced on the plots in spring under cultivation. Additional fertilizing of sugar maize crops was carried out by nitrogen fertilizers according to corresponding variants of the experimental scheme in the phase of 3-4 and 6-7 leaves.

During the experiments, were conducted meteorological observations of the following indicators: average air temperature, precipitation amount (Lytvynov, 2011). When studying meteorological indicators were used data from weather station in Ivano-Frankivsk. The weather conditions of vegetation period during sugar maize growing were characterized by considerable divergence during the studies and were marked by significant deviations of basic meteorological indicators from the average long-term data. In the studied year, amount of precipitations during vegetation period of sugar maize exceeded the long-term norm by 79.5 mm. However, it is necessary to note their clear uneven distribution over the time. It was found that only during two decades of May, in vegetation period of the studied crop dropped 59% of the total precipitations: 33% - in the first decade of May, and 26% - in the third decade of the same month. While the rest of vegetation period was dry. Concerning air temperature, in general, the temperature regime during the years of research was characterized by general trend for increasing of average monthly and sum of active temperatures (> 10ºC) during vegetation period of the crop compared to the average long-term ones. Increasing of average monthly temperatures and the sum of active temperatures affirms about condition improvement for providing vegetation period of the crop with thermal resources, which promotes faster growth and development of plants under conditions of sufficient humidification.

The aim of the research is to establish optimal parameters of pre-harvesting density of the plants and to define yield formation peculiarities for sugar maize grain depending on nitrogen fertilization under conditions of Ivano-Frankivsk region.

Results and Discussion

In our research was studied the influence of optimal parameters of pre-harvesting density of plants and mineral fertilizers on productivity of sugar maize, hybrid Moreland F1.

One of the most important factors that determines future productivity is plant density. The analysis of conducted studies shows that the density and survival of sugar maize plants, field germination rate of seeds varied depending on the studied factors, in particular the doses of mineral fertilizers.

Obtaining of high field germination rate is one of the most important tasks of agricultural technology, as the level of future harvest depends on it. The field germination of seeds and crop yields are directly related. Calculations of scientists show that 1% decrease in field germination results in a 1.5-2.0% decrease in the yield of spring cereals (Abramenko, 1966; Litvinov et al., 2019). In turn, its amount influences the choice of various agro-measures to form necessary density of productive stem-standing. Thus, field germination rate determines the future of technology in the field.

As a result of conducted studies it was determined (Table 1) that increasing of plant standing density from 60 to 80 thousand/ha within each fertilization level resulted in slight (1.5-2.6%) decrease in field germination rate of sugar maize seeds.

Table 1. Field germination rate of maize seeds depending on the level of mineral fertilizing and plant standing density.

Variants	Standing density, thousand pcs./ha	Number of plants per1 ha, thousand		
		germination	harvesting	Survival, %
Control (without fertilizers)	60	56.1	43.7	72.9
	70	63.3	50.5	72.1
	80	74.5	57.4	71.7
N90P90K90	60	56.7	50.6	84.4
	70	63.9	58.2	83.2
	80	75.0	66.0	82.5
$N_{135}P_{90}K_{125}+ N_{60}+ N_{30}$	60	56.8	50.9	84.9
	70	64.6	58.5	83.5
	80	75.5	66.2	82.7

Thus, with the usage of mineral fertilizers with a dose of N90P90K90 in main fertilizing, the field germination rate of sugar maize seeds during germination period was 56.7-75.0 thousand pieces per 1 ha, and during harvesting period - 50.6-66.0 thousand pieces, depending on the density of standing plants, which is 0.6-8.4 thousand pieces more than in the control. With increasing of fertilizer dose to N135P90K125+ N60+ N30the field germination rate of seeds increased to 56.8 thousand pieces per hectare, and the plant survival was 84.9%, which is 12.0% more than in the control. We observed in our studies the influence of plant standing density on the field germination rates of maize seeds and their survival. It was found that the highest field germination rate of seeds was in all variants of fertilizing at plant standing density of 80 thousand pieces per 1 ha, which was within limits of 56.1-75.5 thousand pieces per 1 ha. Whereas, the highest plant survival was noted at the plant standing density of 60.000 pieces per hectare, which ranged from 72.9 to 84.9%.

An important part of the research is the analysis of the crop structure. Its studying and characteristics make it possible to find out the relationship between the elements of cultivation technology and peculiarities of growth and development of crops, peculiarities of their using natural and anthropogenic factors, the course of the production process and the formation of quantitative indicators of the crop, the level of potential disclosure of a variety or hybrid of plants under different conditions of growing. During the study of structural parameters of crop yield, the primary importance receives the genotype factor of crops. Technological measures of cultivation are not able to have a decisive influence on the indicators stipulated by species and variety characteristics of the plant organism. The change in the structure of the crop yield under the influence of agricultural technology is based on different disclosure level of the potential, laid by selection is its, for the species or hybrid of the crop through realization of technological factors. One of the important indicators of yield structure of sugar maize is the output of grain from a cob. It should be emphasized that this indicator is a relative characteristic of agricultural technology intensity, as the higher grain content in a cob indicates that

cultivation technology contributes to the disclosure of biological potential of a plant and is able to satisfy its requirements for the conditions of growth and development. The studied factors, namely different plant standing density and doses of mineral fertilizers significantly influenced the grain output from the commodity cob of sugar maize (Table 2).

The maximum output of grain from the commodity cob of sugar maize, amounting to 390.6 pcs. was obtained when growing crops with plant standing density 60 thousand/ha with double fertilization background $N_{135}P_{90}K_{125}$+ N_{60}+N_{30}.

Table 2. Number of rows, grains in a row and their output from commodity cob of sugar maize depending on plant standing density and level of mineral fertilizers, pcs.

Variant	Standing density, thousand pcs./ha	Number rows	Number grains in a row	grains on a cob
Control (without fertilizers)	60	13.0	22.8	311.8
	70	12.8	22.3	305.9
	80	12.5	22.0	302.5
N90P90K90	60	13.8	24.7	363.1
	70	13.7	24.3	357.4
	80	13.4	24.0	351.6
$N_{135}P_{90}K_{125}$+ N_{60}+ N_{30}	60	14.1	26.1	390.6
	70	13.9	25.7	373.8
	80	13.7	25.4	366.3

The further densification of crops up to 80 thousand/ha, reduction of mineral fertilizer dose lead to a gradual decrease of grain output from commodity crop cod, on average, by 3.0, 2.8 and 6.3%, respectively. The minimum output of grains was in commodity cobs, collected at plots with plant standing density of 80 thousand/ha and unfertilized agro-background, and amounted to 302.5 pcs.

Another important characteristic besides quantitative output of grain is physical parameters of commodity cob. Exactly these indicators are of great importance both for industrial use of sugar maize and for the market of fresh vegetables. As a rule, medium-sized cobs with proportional length and diameter are in much better demand in the fresh vegetable market. The study of size parameters of commodity cobs showed their significant dependence on the studied agro-technical factors. It was found that the largest commodity cobs of sugar maize without covers were harvested from experimental plots with variant of fertilizing background of $N_{135}P_{90}K_{125}$+ N_{60}+ N_{30}, and plant standing density 60 thousand pcs./ha, where in the average, their length was 17.1 cm, and diameter - 4.3 cm respectively. It was determined that the smallest cobs were at the control without fertilizers with plant standing density of 80 thousand pieces/ha, where their length was 14.0 cm and diameter - 3.4 cm (Table 3).

An important element of yield structure of sugar maize which is of great importance both for processing enterprises and for the market of fresh products is the mass of commodity cob (with and without covers) and grain from it. Higher mass output of grain from a cob is an indicator of high technology and suitability of products for manufacturing of canned food.

Table 3. Dimensions and weight of commodity cobs of sugar maize without covers depending on plant standing density and fertilization level, cm.

Variant	Standing density, thousand pcs./ha	Dimension parameters of commodity cobs, cm		Mass, g		
		diameter	length	in covers	without covers	grains
Control (without fertilizers)	60	3.5	14.8	149.2	106.5	41.7
	70	3.5	14.6	148.5	105.8	40.6
	80	3.4	14.0	147.3	105.0	39.5
N90P90K90	60	3.9	16.5	160.7	125.3	53.0
	70	3.9	16.3	158.7	124.1	52.2
	80	3.8	15.8	157.2	122.8	51.5
$N_{135}P_{90}K_{125}$+ N_{60}+ N_{30}	60	4.3	17.1	181.6	138.7	65.5
	70	4.2	16.8	180.1	137.2	63.9
	80	4.0	16.4	178.7	135.9	63.0
LSD05		0.14			1.27	

The maximum mass have commodity cobs, obtained from experimental plots with plant standing density 60 thousand/ha with double fertilization background - on average of 181.6 and 138.7 g in the covers and without them, respectively. The lowest was the mass of commodity cobs at the maximum plant standing density on unfertilized background - an average of 149.2 and 106.6 g in the covers and without them, respectively. There is a clear decrease in the mass of commodity cobs with increasing of plant standing density and worsening of fertilization background.

It is known that increasing of gross yield for commodity products of sugar maize mainly influenced by, primarily, plant varieties - about 50%. Agro-technical measures of cultivation occupy the second place (30%), and only then - climate (20%) (Lykhochvor, 2002; Pashchenko, 2010). The results of our research on studying effect of different doses of nitrogen fertilizers when growing sugar maize under conditions of Ivano-Frankivsk region showed that the studied elements of cultivation technology had significant impact on the yield of commodity cobs of the crop (Figure 1).

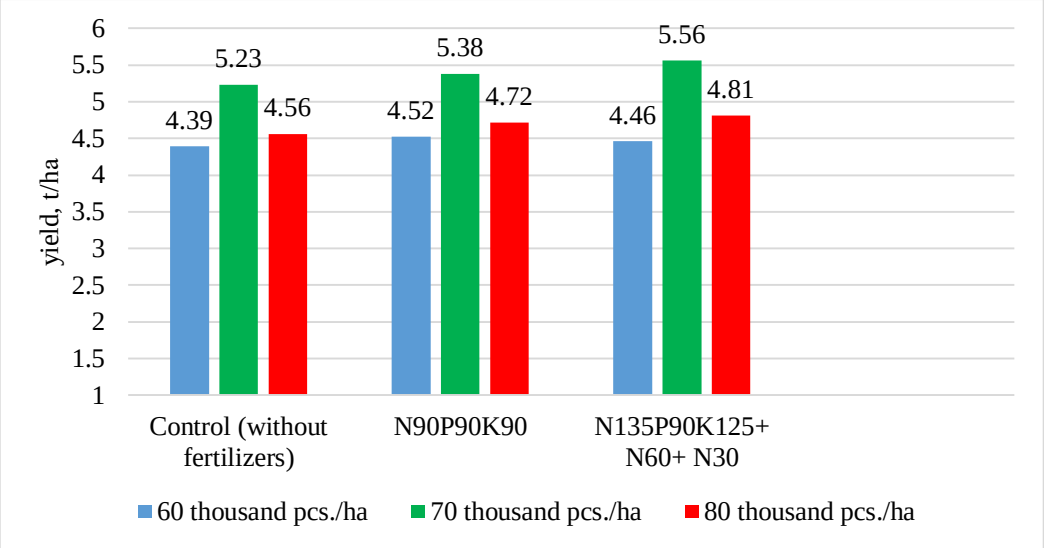

Figure 1. Maize grain yield at humidity of 14% depending on plant standing density and fertilizer doses during 2019, t/ha.

The results of field experiments showed that natural fertility of sod-podzolic soil is not sufficient for obtaining stable high yields of commodity crop products. Application of mineral fertilizers with the dose of N90P90K90 contributed to an increase of maize grain yield by 19.2-24.5%, and the dose of N135P90K125+ N60+ N30 – by 4.0-8.1% compared with unfertilized background. Plant standing density of 70 thousand /ha is the most optimal for growing sugar maize under conditions of Ivano-Frankivsk region of Ukraine. Higher and lower plant standing density in crop sowing are significantly inferior in yield. Thus, increase of plant standing density for maize crops from 60 to 70 thousand/ha contributed to yield increase by 0.84-1.1 t/ha, and the further density increase to 80 thousand /ha leads to yield decrease by 12.4% on average.

Conclusion

It was established that the best indicators of yield structure were provided by the crops of sugar maize in agro-technical complex with fertilizer background N135P90K125+N60+N30 and plant standing density 60 thousand/ha, namely: quantitative output of grain from the cob - 445.2 pieces; size parameters of commodity cob without covers - 17.1 cm in length and 4.3 cm in diameter; the mass of commodity cob - in covers 181.6 g., without covers - 138,7 g; mass output of grain from commodity cob - 65,5 g.
The highest level of crop yield was achieved on fertilizer background of $N_{135}P_{90}K_{125}+N_{60}+N_{30}$ and plant standing density70 thousand/ha, namely: 5.56 t/ha.

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