UDC 631.5:631.527.53.02:633.15 (477.4)

IMPROVEMENT OF THE ELEMENTS OF AGRICULTURAL TECHNOLOGY FOR THE GROWING OF NEW MAIZE HYBRIDS IN THE CONDITIONS OF THE CENTRAL FOREST STEPPE OF UKRAINE

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Goal. To establish the features of yield formation of innovative corn hybrids depending on the genotype, the density of the cenosis and to determine the correlation-regression dependence of these characteristics. **Methods.** Field, measuring-weighing, calculation-comparative, mathematical-statistical. **Results.** Research conducted in 2019–2021 showed that the weight of 1,000 grains depends on the hybrid genotype and plant density. In the experiment, all corn hybrids showed the maximum mass of 1000 grains at a density of 70 thousand plants / ha - 255 g. An increase in the sowing density to 80 thousand plants / ha led to a drop in the mass of 1000 grains to 253 g, for an increase in the density to 90 thousand plants / ha this feature was at the level of 249 g, at a density of 100,000 plants / ha, the maximum decrease in the weight of 1,000 grains was up to 247 g, or 3.2%.

Among the hybrids, the highest mass of 1000 grains on average was observed in the mid-ripening hybrid Zedan 32 (FAO 320) - 275 g. The mid-early maize hybrid Zedan 26 (FAO 240) showed the maximum grain yield at a density of 90 thousand plants / ha - 12.9 t/ha . The mid-early hybrid Zedan 28 (FAO 260) showed the maximum grain yield at the same density – 13.5 t/ha. The mid-ripe hybrid Zedan 32 (FAO 320) gave the maximum grain yield at a density of 80,000 plants/ha – 15.2 t/ha. **Conclusions.** Plant density of corn hybrids of different maturity groups is closely related to productivity. Each ripeness group has an optimal density of plants to obtain the maximum grain yield due to compliance with the optimal feeding area of one plant. The most productive mid-late hybrid reacted negatively to the density of crops. Also, the yield of grain depends on the genotypic response of the corn hybrid to the density of the coenosis in a specific agro-ecological zone.

Key words: *FAO group, weight of 1000 grains, plant density, productivity, correlation-regression dependences.*

Corn is one of the most common crops in world agriculture. The potential of its productivity is determined by the characteristics of the hybrid or variety and the provision of living conditions during the growing season: heat, light, water, mineral elements. In connection with climate changes and the spread in the production of new innovative hybrids, the relevance of improving the varietal technology of corn cultivation is always high [1].

To fully realize the high productivity potential of an individual hybrid, it is necessary to artificially create a certain growing regime thanks to agrotechnological measures, in particular, taking into account the demanding nature of plants to environmental factors [2]. In the complex of agrotechnological measures for the cultivation of corn, on which the harvest and its quality depend, the density of the coenosis occupies an important place. The maximum yield can be obtained due to the high individual productivity of plants and the maximum permissible stem density in a specific agro-ecological zone of cultivation [3, 4].

In the conditions of the forest-steppe zone of Ukraine, corn has a leading role as a widely used crop. In order to obtain high-quality corn grain, it is necessary to observe optimal agricultural techniques, one of the elements of which is sowing density. It is especially important when growing corn hybrids to choose the density corresponding to the genotype, which will allow to achieve the maximum grain yield, while not deteriorating its quality indicators. Although a number of research institutions and agricultural companies justify the densities of hybrids depending on the maturity group, they are indicative with a rather wide range [5], therefore, for a certain hybrid, it is necessary to individually select the optimal plant density depending on the biological characteristics of each genotype [6, 7].

The density of plants, greater or less than the recommended one, has a negative effect, because with a greater density, low-productive plants appear, while with insufficient thickening, the area of nutrition and insolation is used irrationally, which also leads to a decrease in yield [8]. Hybrids with a longer vegetation period, as a rule, need more thinning of sowing compared to hybrids with a short vegetation period. Early-ripening hybrids have a smaller leaf mass and require less moisture and nutrients for growth, plant development and grain formation [9, 10].

When placing corn after the best predecessors (fertilized winter and spring grain ears, legumes, sugar and fodder beets, buckwheat), one should focus on the upper limit of density, and after other crops - on the lower [11]. Field germination and natural death of plants during the growing season reduces the harvesting density of plants. To compensate for the decrease in these factors, it is recommended to increase the optimal density of plants by 15–25%, depending on the area where the crop is grown [12].

Corn is characterized by slow growth, a poorly developed root system and a small coefficient of water consumption at the beginning of the growing season. It is during this period that it almost does not react to thickening or thinning. In the following stages of ontogenesis, stem density significantly affects the growth,

development, and productivity of both individual corn plants and the crop as a whole [13].

Since there are no unequivocal recommendations regarding the stand density of new innovative corn hybrids, the direction of research is relevant and of great practical importance.

The purpose of the research is to establish the peculiarities of the formation of the yield of innovative corn hybrids depending on the genotype, the density of the cenosis, and to determine the correlation-regression dependence of these characteristics.

Research materials and methods. Field experiments were conducted during 2019–2021 in the agricultural production cooperative "Peremoga" (Klepachi village, Khorolsky district, Poltava region) in the agro-ecological zone of the Central Forest Steppe. The climate of the Central Forest-Steppe is moderately continental, the soil of the research area is typical chernozem. Agricultural technology for growing corn hybrids in experiments was generally accepted for the forest-steppe zone of Ukraine. The predecessor is soy. The research was conducted according to the field experiment method, the statistical processing of the research results was carried out by the method of dispersion analysis [14, 15].

The following hybrids served as the object of research: hybrid Zedan 26 (FAO 240), Zedan 28 (FAO 260), Zedan 32 (FAO 320).

Research results and their discussion. Observations conducted in 2019–2021 showed that the weight of 1,000 grains depends on the hybrid genotype and plant density. Thus, among the hybrids, the highest weight of 1000 grains was observed in the mid-ripe hybrid Zedan 32 (FAO 320) - 275 g on average, and the lowest weight on average was shown by the hybrid Zedan 26 (FAO 240) - 237 g (Table 1).

1. Weight of 1000 grains of corn hybrids, g (average for 2019–2021)

Hybrid (factor A)	Plant density, thousand/ha (factor B)				On average, by factor A
	70	80	90	100	

Zedan 26 (FAO 240)	239	238	236	235	237
Zedan 28 (FAO 260)	245	241	239	237	241
Zedan 32 (FAO 320)	281	279	271	268	275
Average by factor B	**255**	**253**	**249**	**247**	
Assessment of the significance of partial differences					
LSD_{05}, г	A=4; B=5				

The genotype of the hybrid (factor A) had the greatest significant effect on the weight of 1,000 grains of corn, in particular, the mid-ripening hybrid Zedan 32 (FAO 320) at a density of 70,000 plants / ha showed the largest weight on average over the years - an average of 275 g. For an increase in density to 80 thousand plants / ha, this trait of this line had a tendency to decrease by 0.8% and averaged 279 g. An increase in the density to 100 thousand plants / ha led to a sharp drop in the mass of 1000 grains to 268 g on average, or by 4 .7%. In general, the hybrid Zedan 28 (FAO 320) reacts negatively to the density of crops.

According to factor B, all corn hybrids showed the maximum mass of 1000 grains at a density of 70 thousand plants / ha - 255 g. Increasing the sowing density to 80 thousand plants / ha led to a drop in the mass of 1000 grains to 253 g, at a density of 90 thousand plants / ha - up to 249 g, at a density of 100,000 plants / ha, the decrease in the indicators of the investigated characteristic was maximum - up to 247 g, or by 3.2%. Thus, for the maximum manifestation of the "weight of 1,000 grains" characteristic, the density of 70,000 plants/ha was optimal. At a density of 100,000 plants/ha, all hybrids of different FAO groups showed minimal manifestation of the trait.

In order to find out whether the weight of 1000 grains of corn hybrids is related to grain yield, the closeness of the correlation relationship was calculated. A positive correlation (r = 0.301...0.626) was established between the grain yield of corn hybrids and the weight of 1000 grains in all studied hybrids, however, the positive influence of grain size was determined by certain parameters of this characteristic (Fig.).

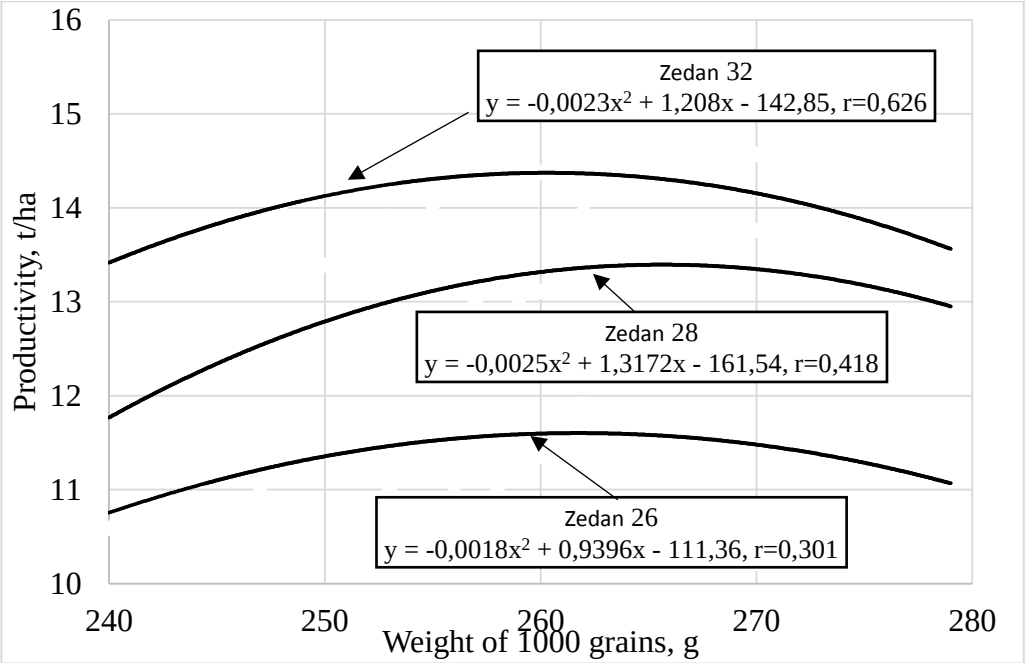

Fig. Correlation-regression dependences of the weight of 1000 grains and grain yield

Therefore, the increase in the mass of 1000 grains, due to both the genotype of the hybrid and the density of the cenosis, has a positive effect on the grain yield of hybrids. An increase in the density of plants in the sowing has a negative effect on the "weight of 1000 grains", therefore, for each hybrid, it is necessary to experimentally establish the optimum density of plants in order to obtain the maximum yield of grain with high quality. At the same time, the highest grain yield was formed in the mid-ripening hybrid Zedan 32, on average according to the experiment – 14.34 t/ha (Table 2).

2. Grain yield of corn hybrids, t/ha (average for 2019–2021)

Hybrid (factor A)	Density, thousand / ha (factor B)				On average, by factor A
	70	80	90	100	
Zedan 26 (FAO 240)	10,75	11,94	12,92	12,52	12,03
Zedan 28 (FAO 260)	11,83	12,32	13,54	12,94	12,66
Zedan 32 (FAO 320)	14,14	15,24	14,63	13,33	14,34
Average by factor B	12,24	13,17	13,70	12,93	
Assessment of the significance of partial differences					
LSD_{05}, т/га	A=0,62; B=0,80				

On average, according to the experiment, the maximum yield of corn grain was shown by the mid-ripening hybrid Zedan 32 - 13.33–15.24 t/ha. The increase in grain yield was significantly influenced by plant density. Thus, the increase in

grain yield of the Zedan 32 hybrid at the optimal density of 80,000 plants/ha in comparison with other density options will be at the level of 0.61–1.91 t/ha, or 4.1–12.5%.

It was determined that hybrids of different FAO groups have their own optimal cenosis density for obtaining the maximum yield.

The mid-early hybrid Zedan 26 (FAO 240) showed the maximum grain yield at a density of 90,000 plants/ha – 12.92 t/ha. A decrease in density to 80,000 plants/ha led to a drop in yield by 0.98 t/ha, or 7.8%, thinning of sowing to 70,000 plants/ha caused a decrease in grain yield by 2.17 t/ha, or 17.1%, planting density up to 100,000 plants/ha caused a drop in yield by 0.40 t/ha, or 3.2%.

The mid-early hybrid Zedan 28 (FAO 260) showed the maximum grain yield at a density of 90,000 plants/ha – 13.54 t/ha. A decrease in density to 80,000 plants/ha led to a drop in yield by 1.22 t/ha, or 8.9%, thinning to 70,000 plants/ha - to a decrease in grain yield by 1.71 t/ha, or 12.6%, at the same time, the intensification of sowing to 100,000 plants/ha led to a drop in yield by 0.60 t/ha, or 4.5%.

The medium-ripe hybrid Zedan 32 (FAO 320) showed the maximum grain yield at a density of 80,000 plants/ha – 15.24 t/ha (the highest rate in the experiment among other genotypes). A decrease in density to 70,000 plants/ha caused a drop in yield by 1.10 t/ha, or 7.3%, an increase in sowing density to 90,000 plants/ha led to a decrease in grain yield by 0.61 t/ha, or 3.9%, and the thickening of sowing to 100,000 plants/ha caused a decrease in yield by 1.91 t/ha, or 12.5%.

Analyzing the yield data of Zedan 26 (FAO 240), Zedan 28 (FAO 260) and Zedan 32 (FAO 320) hybrids, we can summarize: each hybrid has its own optimal plant density for obtaining the maximum yield. The mid-ripe hybrid Zedan 32 (FAO 320) shows maximum productivity at a density of 80,000 plants/ha and sharply reduces productivity at a density of up to 100,000 plants/ha. Mid-early hybrids show maximum yield at a density of 90,000 plants/ha, while an increase or decrease in plant density from the optimum leads to a decrease in grain yield.

Conclusions. Plant density of corn hybrids of different maturity groups is closely related to productivity. Each ripeness group has an optimal density of plants to obtain the maximum grain yield due to compliance with the optimal feeding area of one plant. The most productive mid-late hybrid reacted negatively to the density of crops. Also, the yield of grain depends on the genotypic response of the corn hybrid to the density of the coenosis in a specific agro-ecological zone.

Bibliography

1. *Gadzalo Y. M., Vozhehova R. A., Kokovikhin S. V., Biliaieva I. M., Drobytko A. V.* Scientific substantiation of corn growing technologies on irrigated lands taking into account hydrothermal factors and climate changes. *Irrigated agriculture.* 2020. No. 73. P. 21–26. https://doi.org/10.32848/0135-2369.2020.73.3.

2. *Kaminskyi V.F., Asanishvili N.M.* Peculiarities of growth and development of corn plants in crops and their photosynthetic activity depending on the cultivation technology in the conditions of the forest-steppe. *Foothill and mountain agriculture and animal husbandry.* 2020. Issue 67 (II). P. 92–112. https://doi.org/10.32636/01308521.2020-(67)-2-6.

3. *Zhemela G. P., Barabolya O. V., Lyashenko V. V., Lyashenko E. S., Podolyak V. A.* Formation of grain productivity by corn hybrids depending on the sowing rate. *Bulletin of the Poltava State Agrarian Academy*. 2021. No. 1. P. 97–105. https://doi.org/10.31210/visnyk2021.01.11.

4. *Mostipan M. I., Vasylkovska K. V., Andriyenko O. O. Reznichenko V. P.* Modern aspects of tilled crops productivity forecasting. *INMATEH – Agricultural Engineering*. 2017. № 53 (3). P. 35–40.

5. *Andrienko O. O., Vasylkovska K. V., Andrienko A. L.* The reaction of corn hybrids to changes in plant stand density in the northern steppe of Ukraine. *Collection of scientific works of the Uman National University of Horticulture*. 2020. No. 96 (1). P. 635–651.

6. *Moldovan Z. A., Sobchuk S. I.* The influence of sowing dates, plant density and abiotic factors on the formation of grain yield of corn hybrids of different maturity groups in the conditions of the Western Forest Steppe. *Bulletin of the Institute of Agriculture of the Steppe Zone of the National Academy of Sciences of Ukraine*. 2016. No. 11. P. 39–45.

7. *Vozhehova R., Lavrynenko Yu., Marchenko T., Zabara P.* Productivity of lines - parental components of corn hybrids depending on irrigation methods and plant density in the Southern Steppe. *Herald of Agrarian Science.* 2020. No. 98 (2). P. 58–63. https://doi.org/10.31073/agrovisnyk202002-09.

8. *Kalenska S. M., Taran V. G., Danilov P. O.* Peculiarities of yield formation of corn hybrids depending on fertilization, plant stand density and weather conditions. *Taurian Scientific Herald*. 2018. No. 101. P. 42–49.

9. *Masliyov S. V.* The effect of plant density on the yield of flint corn in the conditions of the eastern part of the Steppe of Ukraine. *Bulletin of the Poltava State Agrarian Academy*. 2016. No. 3. P.11–14.

10. *Jańczak-Pieniążek M., Buczek J., Bobrecka-Jamro D., Szpunar-Krok E., Tobiasz-Salach R., Jarecki W.* Morphophysiology, productivity and quality of soybean (*Glycine max* (L.) Merr.) cv. Merlin in response to row spacing and seeding systems. *Agronomy*. 2021. № 11(2), P. 403. doi: 10.3390/agronomy11020403.

11. *Bagan A. V.* Formation of productivity and grain quality of corn hybrids depending on the predecessor. Bulletin of the Poltava State Agrarian Academy. 2015. No. 4. P. 32–35.

12. *Krasnenkov S.V., Dudka M.I., Berezovskyi S.V., Nosov S.S.* Influence of sowing dates on the yield and grain moisture of corn hybrids of different maturity groups. *Bulletin of the Institute of Agriculture of the Steppe Zone of the National Academy of Sciences of Ukraine*. 2014. No. 7. P.62–66.

13. *Knyazyuk O.V., Lypoviy V.G.* Physiological and biological features of the formation of the productivity of corn hybrids depending on the technological methods of cultivation. *Agrobiology.* 2016. No. 1. P. 47–53.

14. *Ushkarenko V.O., Nikishenko V.L., Holoborodko S.P., Kokovikhin S.V.* Dispersion and correlation analysis of the results of field experiments: monograph. Kherson: Ailant, 2009. 372 p.

15. *Ushkarenko V. O., Vozhehova R. A., Holoborodko S. P., Kokovikhin S. V.* Field experiment methodology (Irrigated agriculture). Kherson: Grin D.S., 2014. 448 p.