УДК 631.5:633.15 https://doi.org/10.31867/2523-4544/0261

FORMATION OF MAIZE GRAIN YIELD DEPENDS ON THE METHODS OF SOWING AND PLANT DENSITY IN THE NORTHERN STEPPE OF UKRAINE

M. I. Dudka, O. P. Yakunin
State Enterprise Institute of Grain Crops NAAS, 14 Volodymyr Vernadskyi St., Dnipro, 49009, Ukraine

Topicality. *In the context of global warming and climate changes, it is important to substantiate, develop and implement agrotechnical practices to mitigate the negative effects of drought, heat and soil moisture deficit. The solution to these problems is to find ways to optimise the growing conditions of maize (Zea mays L.), using the adaptive properties and agrocenotic resistance of new hybrids to adverse environmental stressors with rational management of the growing season and agroclimatic resources of soil and ecological zones. Sowing methods and plant density, as well as other technological factors, play an important role in the complex of zonal agrotechnical practices. Maize plants demonstrate considerable biological plasticity in interaction with environmental conditions. The life support processes of maize plants depend on ecological changes caused by the quantitative and spatial placement of maize plants in the crop. The variability of the size and configuration of the individual plant nutrition area is limited primarily by the plant's requirements for environmental factors that ensure their normal growth, development and high productivity.* ***Purpose.*** *The research was aimed to identify the peculiarities of plant growth and development, as well as the formation of maize grain yield depending on the method of sowing and plant density in the Northern Steppe of Ukraine.* ***Materials and Methods.*** *The research was carried out at the Experimental Farm "Dnipro" of the State Enterprise Institute of Grain Crops of NAAS. The soil was ordinary low-humus full-profile chernozem. The mid-early maize hybrid DN Stiah was sown with row spacing of 30, 45 and 70 cm at plant density of 40, 50, 60 and 70 thousand plants/ha, fertiliser background – $N_{60}P_{45}K_{45}$.* ***Results.*** *Sowing methods and plant density influenced the structural elements of the yield and maize grain yield. In 2019–2021, the highest average maize yield (11.13 t/ha) for factor A (sowing method) was obtained by sowing with row spacing of 30 cm. Increasing the row spacing to 45 and 70 cm led to a decrease in the grain productivity of the maize hybrid DN Stiah by 0.21 and 0.75 t/ha (i.e. by 1.9 and 6.7 %), respectively. For factor B (planting density), the highest average grain yield (11.03 and 10.95 t/ha) was obtained at a planting density of 60 and 50 thousand plants/ha, respectively.* ***Conclusions.*** *In the face of resource constraints, narrowed row spacing in maize cultivation may have the potential to increase the realisation of hybrid productivity potential.*

Key words: *maize, method of sowing, plant density, biometric indicators of plants, individual productivity of plants, structural elements of yield, grain yield*

Introduction. Accelerated and sustainable grain production is the most important task for the Ukrainian agricultural sector. Maize, one of the most productive crops for multiple uses, plays an essential role in the successful achievement of this goal. Demand for this crop is growing annually both on the global and domestic markets. The main directions of development of the Ukrainian grain sector include the growth of grain production of all grain crops, including maize [1].

As the evidence from practice shows, in the context of global climate change, maize productivity is becoming more unstable over the years, and there is a need to develop more efficient technological models for its cultivation.

Over the past century, as a result of the impact of global climate change, Ukraine has experienced a general trend of increasing precipitation and a certain temperature rise. According to A. O. Babych and A. A. Babych-Poberezhna, the annual air temperature in the soil and ecological zones of the country has increased by 1.0–1.7 °C over the past 114 years, and the total annual precipitation has increased by 65–106 mm or 19.9 %. As a result of global and local climate changes, there is a decrease in precipitation in dry years in all maize cultivation zones and a certain increase in favourable years, with the greatest deficit and variation in the Steppe zone and the least ones in the Forest-Steppe zone, the highest precipitation and its sig-

Author information:
Mykola I. Dudka, *Doctor of Agricultural Sciences, Head of the Laboratory of Agrobiological Resources of Maize and Sorghum*,e-mail: maize-technology@ukr.net, https://orcid.org/0000-0002-4214-1288
Oleksii P. Yakunin, *Doctor of Agricultural Sciences, Professor, Chief Researcher of the Laboratory of Agrobiological Resources of Maize and Sorghum,* e-mail: maize-technology@ukr.net, https://orcid.org/0000-0001-6368-7338

nificant variation in Polissia and the western region [2].

Under these conditions, it is important to substantiate, develop and implement agrotechnical practices to mitigate the negative effects of drought, heat and soil moisture deficit. The solution to these problems is to find ways to optimise maize growing conditions, use the adaptive properties and agrocenotic resistance of modern hybrids to adverse environmental stressors through the rational use of the growing season and agroclimatic resources of soil and environmental zones. In the complex of zonal agrotechnical measures, an important place is occupied by sowing methods and plant density and other technological factors.

Maize plants have significant biological plasticity in interaction with environmental conditions. This indicates the possibility of certain variability in the size and configuration of the individual plant nutrition area, depending on the placement of corn on the field, i.e. on the row spacing and the number of plants per hectare under the appropriate agricultural technology.

Changes caused by the quantitative and spatial placement of maize plants in the crop also have a certain impact on their life processes. The variability of the size and configuration of the individual nutrition area of maize plants is limited, first of all, by the requirements of the plants to environmental factors, the demand for the most favourable growing conditions that ensure their normal growth, development and high productivity. Therefore, the patterns of growth, development and productivity of maize plants depending on the methods of sowing with optimised plant density are of theoretical and practical interest.

A significant number of scientific papers have been devoted to the study of the influence of row spacing and plant density of maize plants under the single-seed sowing method on the productivity of hybrids with different morphological and biological characteristics, also under the conditions of the Northern Steppe of Ukraine.

Thus, the results of studies conducted at the Erastivska Experimental Station and the Experimental Farm of the All-Union Research Institute of Maize (1963–1966) show that the single-seed sowing method with 90–100 cm row spacing was appropriate in the Northern Steppe. The mid-early maize hybrid VIR 42 formed a higher grain yield due to the single-seed sowing method with 100 cm row spacing at a plant density of 30–35 thousand plants/ha at the Experimental Farm of the All-Union Research Institute of Maize, and at a plan density of 25–30 thousand plants/ha at the Erastivska Research Station. Row spacing of 70 cm led to an increase in the area of uncultivated protective zones of plants in maize crops, resulting in a deterioration of the phytosanitary condition and a negative impact on the growth, development and productivity of the crop, especially in the lack of manual weeding [3].

In 1968–1972, the Experimental Farm of the All-Union Research Institute of Maize and the Erastivska Research Station studied the grain productivity of the mid-early Dniprovskyi 438 and mid-ripening VIR 42 maize hybrids using the single-seed sowing method with row spacing of 100 and 50 cm, at plant density of 30, 40 and 50 thousand plants/ha. It was found that in the conditions of the Experimental Farm, when reducing the row spacing from 100 to 50 cm, there was a tendency to increase the grain yield of both maize hybrids, while in the studies at the Erastivska Research Station, with both sowing methods, the yield of these hybrids was almost the same [4].

According to the S. S. Kravets' research conducted at the SE Institute of Grain Crops of NAAS in 2009–2011, the grain yield of the early ripening hybrid Pochaivskyi 190 MV under the traditional single-seed sowing method (row spacing of 70 cm) and natural weed infestation of the crop was 2.69 t/ha, while reducing the row spacing to 35 cm resulted in an increase in grain yield by 0.54 t/ha or 20.1 % [5].

Today, one of the main methods of sowing maize in all cultivation zones in Ukraine is a wide-row single-seed method with 70 cm row spacing, which is supported by effective chemical weed control in maize cultivation technologies. Despite the introduction of new maize hybrids, which are characterised by precocity, lower plant architecture, and higher adaptability to adverse environmental stressors, the sowing method and plant density have remained unchanged for a long time [6, 7].

It was found that the optimal plant density of maize in different soil and ecological zones

depends on the moisture supply and morphological and biological characteristics of hybrids. For example, in the arid steppe areas of maize cultivation (average annual precipitation of 350–400 mm), early ripening and mid-early maize hybrids usually provide the highest yield at a plant density of 45–60 thousand plants/ha, under conditions of unstable moisture supply in the Forest-Steppe (400–500 mm) at a plant density of 65–85 thousand plants/ha, and in the Polissya with high moisture content (500–500 mm) – at a plant density of 75–90 thousand plants/ha in the favourable moisture conditions (500–800 mm and more) [8–10].

The aim of our research was to determine the peculiarities of plant growth and development, as well as the formation of grain yield of maize (Zea mays L.) depending on the method of sowing and plant density in the Northern Steppe of Ukraine.

Materials and Methods. The research was carried out in the Experimental Farm "Dnipro" of SE Institute of Grain Crops of NAAS. Soil cover was represented by ordinary low-humus full-profile chernozem. Humus content in the arable layer of soil was 3.14 % (according to Tiurin), general nitrogen – 10.7 mg/kg (CINAO methods, GOST 26488–85), mobile phosphorus – 199 mg per kg of soil and exchangeable potassium – 106 mg per kg of soil (according to Chirikov, DSTU 4115–2002). The reaction of the soil solution of the humus horizon is close to neutral (pH of the aqueous suspension is 6.75).

The experiment was laid out by the Laboratory of Agrobiological Resources of Maize and Sorghum in 2019–2021. Early-ripening maize hybrid DN Stiah (originator SE Institute of Grain Crops of NAAS) was sown with row spacing of 30, 45 and 70 cm and plant density of 40, 50, 60 and 70 thousand plants per hectare. The maize sowing date was early against background of $N_{60}P_{45}K_{45}$.

The experiment is a small-plot, manual sowing method, with 4 replications. Plots were arranged sequentially in the field experiment. The area of the sowing plot with 70 cm row spacing was 15.1 m2, with 45 cm row spacing was 13.0 m^2, with 30 cm row spacing was 11.9 m^2, and the accounting plot was 10.08 m^2, 9.72 m2, 9.72 m^2, respectively.

During the field trials, we used "Methodical recommendations for field experiments with maize" (Dnepropetrovsk, 1980), "Methods of field experiments with maize" (Dnipropetrovsk, 2008) [11, 12].

Results and Discussion. The maize growth season in 2019 was moderately dry, with a hydrothermal coefficient (according to G. T. Selyaninov) of 0.77 in May–September, while the norm was 0.83. At the same time, May, July and August were not wet enough, and June and September were very dry, which significantly affected the growth and development of maize plants.

The growing season of 2020 was characterised by moderately dry hydrothermal conditions, which were notable for a fairly early effective temperature, their rapid increase and moisture deficit, and there was absolutely no precipitation from the third ten-day period of June and the first ten-day period of July, with only 30 % of the long-term average in August, and precipitation was observed only in the last days of September, with a hydrothermal coefficient of 0.65 in May–September.

In 2021, the maize growing season was well supplied with moisture, with the hydrothermal coefficient of 1.28 in May-September compared to the normal 0.83. At the same time, May was dry, and June was ultra-humid, July was moderately humid, and August was dry.

The maize hybrid DN Stiah was sown on 25 April, 14 April and 13 May in 2019, 2020 and 2021, respectively, with seedlings emerging on 9, 20 and 8 days after sowing. The productive moisture reserves in 2019 during sowing in the soil layer of 0–10, 0–50 and 0–100 cm were 10.2, 65.7 and 140.9 mm, in 2020 – 8.1, 49.0 and 108.2 mm, and in 2021 – 13.2, 69.5 and 141.2 mm, respectively.

In 2019, the duration of the period from seedling emergence to tasseling was the shortest and amounted to 58 days. In 2020, due to the cool May and dry June, the duration of this period was 66 days, regardless of the plant placement method. In 2021, favourable moisture conditions and elevated air temperature led to accelerated onset of organogenesis phases, the period from seedling emergence to tasseling was 60 days, with an average of 61 days over three years. The effect of plant density on the onset of phenological phases and the duration of interphase periods during the years of research

was not found.

Due to dry weather in the second half of the 2020 growing season, differences in the duration of intermediate interphase periods were levelled out, and full grain maturity in the mid-early hybrid DN Stiah occurred on 109 days in the plots, regardless of the sowing method and plant density. In 2021, a favourable year in terms of moisture, the duration of the period of seedling emergence – full grain maturity was the longest and was 123 days, on average for three years – 116 days.

According to the results of biometric studies, the shortest plants (217–234 cm) were formed by the maize hybrid in 2020, and the highest (269–297 cm) – in 2021, while biometric parameters depended on both plant density and sowing method.

Changing the shape of the nutrition area (at the same plant density) practically did not affect the plant height of maize. On average, for factor A (sowing method), when maize plants were placed in a single-seed method with row spacing of 45 and 30 cm on average over three years (2019–2021), the value of this indicator was only 1 and 2 cm lower, respectively, than with row spacing of 70 cm (Table 1).

As a result of the increase in plant density from 40 to 70 thousand plants/ha (on average for factor B), the height of maize plants decreased by 14 cm on average over the years of research. The highest plants (259 cm) were grown with the traditional wide-row sowing method (70 cm) at the lowest plant density (40 thousand units/ha). Under the influence of the studied factors, the ear insertion height indicators changed similarly.

Table 1. Biometric indicators of maize hybrid DN Stiah depending on the sowing method and the plant density, 2019–2021

Plant density, ths. plants/ha (B)	Plant height, cm				Ear insertion height, cm			
	1*	2**	3***	Average (B)	1	2	3	Average (B)
70	245	243	242	245	92	92	99	92
60	249	248	248	249	95	94	102	95
50	255	255	253	255	96	96	106	96
40	259	257	256	259	99	98	109	99
Average (A)	252	251	250	–	96	95	104	–

*Note: Sowing method: *wide-row, with 70 cm row spacing; ** wide-row, 45 cm; *** wide-row, 30 cm.*

The pre-harvest grain moisture content of the DN Stiah hybrid significantly depended on the weather conditions during the years of research. Its indicators in the experimental variants were the lowest (9.5–11.0 %) in the dry year of 2019, and the highest (18.1–21.4 %) in a year favourable for moisture supply in 2021. In the dry years (2019 and 2020), when maize plants density increased from 40 to 70 thousand units/ha, the grain moisture content decreased by 1.2–1.3 percentage points at row spacing of 70 cm, and by 0.8–1.1 and 0.7–1.2 percentage points at row spacing of 45 and 30 cm, respectively, due to the lack of soil moisture for a larger number of plants per unit area. In the favourable in terms of moisture 2021, with similar increasing the plant density (from 40 to 70 thousand plants/ha), on the contrary, the harvesting moisture content in grain increased by 2.7–2.8 percentage points when maize was sown with row spacing of 70, 45 and 30 cm, which was due to the poorer ventilation of the stem stand (Table 2).

On average, over the three years, we did not observe any influence of the sowing method and plant density on grain moisture content, and its moisture content was in the range of 14.6–14.9 and 14.5–15.0 %, respectively.

The largest number of ears (127–166 ears per 100 plants) was formed by maize plants of the DN Stiah hybrid in the favourable moisture year 2021, and the lowest (88–116 ears per 100 plants) in the driest 2019. The number of economically viable ears averaged 115 pcs. per 100 plants in 2019–2021 according to factor A (sowing method) in the traditional sowing method with 70 cm row spacing, and with 45 and 30 cm

Table 2. Grain moisture content and individual productivity of maize plants depending on the sowing method and the plant density, 2019–2021

Plant density, ths. plants/ha (B)	Moisture content of grain, %				Number of ears, pcs per 100 plants			
	1*	2**	3***	average (B)	1	2	3	average (B)
70	14.3	14.8	15.1	14.7	104	109	111	108
60	14.2	14.6	14.9	14.6	109	115	117	114
50	14.2	14.8	15.1	14.7	117	123	125	122
40	14.3	14.5	14.8	14.5	131	134	136	134
average (A)	14.2	14.7	15.0	–	115	120	122	–

*Note: Sowing method: * wide-row, with 70 cm row spacing; ** wide-row, 45 cm; *** wide-row, 30 cm.*

row spacing it increased to 120 and 122 pcs., respectively. This indicator (according to factor B) at a plant density of 70 thousand plants/ha was 108 pcs, and when the plant density was reduced to 60, 50 and 40 thousand plants/ha – 114, 122 and 134 pcs, respectively. On average over three years, the largest number of ears (131–136 pcs/100 plants) was formed by maize plants with the lowest plant density (40 thousand plants/ha) regardless of the sowing method.

It was found that the hybrid DN Stiah had a high grain yield per ear (82.2–85.0 %) during the years of research, while the weather conditions of the growing season influenced the value of this indicator. In dry years (2019 and 2020), with the plant density of maize plants from 40 to 70 thousand plants/ha for all sowing methods, there was a tendency to decrease the grain yield per ear, and in favourable moisture (2021) with similar plant density, there was a tendency to increase the values of this indicator, which was due to the formation of a larger number of second ears with less grain content in plants (Table 3).

The grain yield per ear in the DN Stiah

Table 3. Structural elements of maize yield depending on the sowing method and the plant density, 2019–2021

Plant density, thousand plants/ha (B)	Grain yield per ear, %				Grain content per ear, kernels			
	1*	2**	3***	average (B)	1	2	3	average (B)
70	83.1	83.5	83.6	83.4	482	481	479	481
60	83.3	83.6	83.8	83.6	541	531	532	535
50	83.4	83.6	83.8	83.6	598	576	570	581
40	83.4	83.6	83.8	83.6	609	620	619	616
average (A)	83.3	83.6	83.8	–	558	552	550	–

*Note: Sowing method: * wide-row, with 70 cm row spacing; ** wide-row, 45 cm; *** wide-row, 30 cm.*

hybrid at harvesting both by factor A (83.3–83.8 %) when changing the row spacing and by factor B (83.4–83.6 %) at different plant density changed insignificantly.

In dry years (2019 and 2020), the grain content of the ear in maize crops with row spacing of 70 cm at different plant densities was 455–620 and 490–657 kernels, respectively, with row spacing of 45 cm – 484–657 and 457–645 kernels, and with row spacing of 30 cm – 485–663 and 448–634 kernels. In 2021, which was more favourable for moisture, the average grain content of the ear was 502–551 kernels under the traditional sowing method with row spacing of 70 cm, and 502–559 and 503–589 kernels, respectively, when the row spacing was narrowed to 45 and 30 cm. To our mind, the decrease in the average grain content of the ear in a favourable year in terms of hydrothermal parameters was due to the formation of the second

ear on maize plants.

On average, in 2019–2021, the highest grain content of the ear according to factor A (sowing method) was 558 kernels, which was observed in maize plants with the traditional sowing method (70 cm), while the average number of formed kernels on the ear decreased by 6 and 8 kernels, respectively, with row spacing of 45 and 30 cm.

On average, over the years of research, maize plants with the lowest plant density (40 thousand pieces/ha) had the best ear grain content (616 kernels) according to factor B (planting density) in all sowing methods.

Efficiency of the technological method is determined by the crop yield. Weather conditions during the maize growing season had a significant impact on the yield. Under dry growing conditions in 2019 and 2020, the yield of maize grain, depending on the sowing method and plant density, was 9.0–11.13 and 7.68-8.95 t/ha, respectively, and under favourable moisture conditions during the growing season in 2021 – 12.56–14.80 t/ha (Table 4).

In dry years (2019 and 2020), under the traditional single-seed method with row spacing of 70 cm, the DN Stiah hybrid formed the highest grain yield (10.35 and 8.46 t/ha, respectively) at a plant density of 50 thousand plants/ha, and under favourable conditions (2021) it formed the highest grain yield (14.64 t/ha) at a plant density of 70 thousand plants/ha. Narrowing the row spacing to 45 and 30 cm in dry conditions contributed to the highest productivity of maize at a plant density of 50–60 thousand plants/ha, and under favourable moisture conditions with a density of 70 thousand plants/ha.

Table 4. Grain yield of maize hybrid DN Stiah depending on the sowing method and the plant density

Plant density, ths. plant/ha (factor B)	Grain yield, t/ha				Average by factors	
	2019	2020	2021	average	A	B
Sowing method – wide-row, with 70 cm row spacing (factor A)						
70	9.00	7.68	14.33	10.34	10.38	10.85
60	9.76	8.31	13.37	10.48	–	11.03
50	10.35	8.46	13.32	10.71	–	10.95
40	9.41	8.00	12.56	9.99	–	10.41
wide-row sowing, 45 cm						
70	10.57	7.80	14.64	11.00	10.92	–
60	10.84	8.57	14.10	11.17	–	–
50	10.56	8.69	13.72	10.99	–	–
40	10.34	8.19	12.98	10.50	–	–
wide-row sowing, 30 cm						
70	10.91	7.94	14.80	11.22	11.13	–
60	11.13	8.95	14.22	11.43	–	–
50	10.83	8.81	13.78	11.14	–	–
40	10.70	8.31	13.22	10.74	–	–
LSD_{05}, t/ha	A 0.07	0.07	0.43	–	–	–
	B 0.08	0.08	0.50	–	–	–
	AB 0.15	0.14	0.86	–	–	–

The highest average yield for three years (11.13 t/ha) for factor A (sowing method) was obtained by sowing maize with row spacing of 30 cm. Increasing the row spacing to 45 and 70 cm led to a decrease in the grain productivity of the DN Stiah hybrid by 0.21 and 0.75 t/ha (i.e. by 1.9 and 6.7%), respectively.

According to factor B (plant density), the highest grain yield (11.03 and 10.95 t/ha) was obtained at a plant density of 60 and 50 thousand plants/ha, respectively.

Conclusions. Therefore, sowing methods and plant density influenced the elements of the

yield structure and grain yield of maize. On average, in 2019–2021, the number of economically viable ears per 100 plants according to factor A (sowing method) in the traditional single-seed method with row spacing of 70 cm was 115 pcs, with row spacing of 45 and 30 cm – increased to 120 and 122 pcs, respectively. The value of this indicator by factor B at a plant density of 70 thousand pcs/ha was 108 pcs, and with a decrease in plant density to 60, 50 and 40 thousand pcs/ha – 114, 122 and 134 pcs, respectively.

Higher grain content of the ear (558 kernels) according to factor A (sowing method) was observed in maize plants with the traditional single-seed method (70 cm), with row spacing of 45 and 30 cm the average number of formed kernels on the ear decreased by 6 and 8 kernels, respectively. The best ear grain content (616 pcs) by factor B under all sowing methods, on average over the years of research, was observed in maize plants with the lowest plant density (40 thousand pcs/ha).

The highest average yield for three years (11.13 t/ha) for factor A (sowing method) was obtained by sowing with row spacing of 30 cm. Row spacing of 45 and 70 cm resulted in a decrease in grain productivity of DN Stiah hybrid by 0.21 and 0.75 t/ha (i.e. by 1.9 and 6.7 %), respectively. The highest average grain yield (11.03 and 10.95 t/ha) by factor B (plant density) was obtained at a plant density of 60 and 50 thousand plants/ha, respectively.

In conditions of resource deficit, narrowed row spacing in maize cultivation may have prospects for implementation, provided that other opportunities to increase the level of realisation of the productivity potential of hybrids that do not involve costly technical re-equipment are exhausted.

References

1. Cherchel, V. Yu., Dziubetskyi, B. V., Kondratenko, P. V., Kyrpa, M. Ya., Hyrka, A. D., Dudka, M. I. et al. (2021). *Prohrama vyroshchuvannia kukurudzy v Ukraini v umovakh zminy klimatu* [Maize program in Ukraine under climate change]. Dnipro: SE IGC NAAS. [in Ukrainian].
2. Babych, A. O., Babych-Poberezhna, A. A. (2014). *Zasukha, sukhovii i pylova buria v period hlobalnykh zmin klimatu* [Drought, dry and dust storms in the period of global climate change]. Vinnytsia: DILO. [in Ukrainian].
3. Filyov, D. S. (1968). *Osobennosti biologii i tekhnologiya mekhanizirovannogo vozdelivaniya kukuruzi v stepnoi zone Ukraini* [Features of biology and technology for mechanized cultivation of maize in the Steppe zone of Ukraine]. (Report abstract of Dr. Agric. Sci. Diss.). Kharkov. Ukraine. [in Russian].
4. Filyov, D. S., Markov, N. P., Sidorenko Ya. P (1976). Productivity of maize of sowing it with conventional and narrowed rows. *Byulleten VNII kukuruzi* [Bulletin of the VNII of maize], *3 (43),* 3–6 [in in Russian].
5. Kravets, S. S. (2013). *Formuvannia produktyvnosti kukurudzy zalezhno vid shyryny mizhriad i herbitsydiv v pivnichnomu Stepu Ukrainy* [Formation of maize productivity depending on the width of interrows and herbicides in northern Steppe] (Extended Abstract of PhD. Agric. Sci. Diss.). Dnipropetrovsk, Ukraine. [in Ukrainian].
6. Tsykov, V. S. (2003) *Kukuruza: tekhnologiya, gibridi, semena* [Maize: tecnology, hybrids, seeds] Dnepropetrovsk: Zorya [in Russian].
7. Pashchenko, Yu. M., Borysov, V. M., Shyshkyna O. Yu. (2009). *Adaptyvni i resursozberezhni tekhnolohii vyroshchuvannia hibrydiv kukurudzy* [Adaptive and resource-saving technologies of growth of hybrids of maize]. Dnipropetrovsk: ART-PRES. [in Ukrainian].
8. Zubets, M. V., Sytnyk, V. P. (Eds). (2010) *Naukovi osnovy ahropromyslovoho vyrobnytstva v zoni Stepu Ukrainy* [Scientific bases of agricultural production in the region of Stepa of Ukraine]. Kyiv: Ahrarna nauka. [in Ukrainian].
9. Zubets, M. V., Sytnyk, V. P. (Eds). (2010) *Naukovi osnovy ahropromyslovoho vyrobnytstva v zoni Lisostepu Ukrainy* [Scientific bases of agricultural production in the zone of Forest-Steppe of Ukraine]. Kyiv: Ahrarna nauka. [in Ukrainian].
10. Zubets, M. V., Sytnyk V. P. (Eds). (2004) *Naukovi osnovy ahropromyslovoho vyrobnytstva v zoni Polissia i zakhidnoho rehionu Ukrainy* [Scientific bases of agricultural production in Polissya and western region of Ukraine]. Kyiv: Urozhai. [in Ukrainian].
11. Filyov, D. S., Logachyov, N. I. (1980) *Metodicheskiye rekomendatsyyi po provedeniyu polevykh opytov s kukuruzoy* [Metodical recommendations on carrying out the field tests with a maize]. Dnepropetrovsk: N. p. [in Russian].
12. Lebid, Ye. M., Tsykov, V. S., Pashchenko Yu.M. et al. (2008). *Metodika provedennia polovykh doslidiv z kukurudzoiu*. [Method of field researches with maize] Dnipropetrovsk. [in Ukrainian].

УДК 633.15:633.15

Дудка М. І., Якунін О. П. Формування врожайності зерна кукурудзи залежно від способу сівби та густоти стояння рослин в Північному Степу. *Зернові культури. 2023. 7 (1). 73–80.*

Державна установа Інститут зернових культур НААН, вул. Володимира Вернадського, 14, м. Дніпро, 49009, Україна

Актуальність. В умовах глобального потепління і зміни клімату актуальним є обґрунтування, розробка і впровадження у виробництво агротехнічних заходів послаблення негативних явищ посухи,

жари і дефіциту ґрунтової вологи. У вирішенні цих проблем важливим є пошук шляхів оптимізації умов вирощування кукурудзи (*Zea mays* L.), використання адаптивних властивостей і агроценотичної стійкості рослин нових гібридів до несприятливих стрес-факторів довкілля за раціонального використання вегетаційного періоду та агрокліматичних ресурсів ґрунтово-екологічних зон. У комплексі зональних агротехнічних заходів важливе місце займають способи сівби і густота стояння рослин та інші технологічні фактори. Рослини кукурудзи мають значну біологічну пластичність за їх взаємодії з умовами навколишнього середовища. Екологічні зміни, зумовлені кількісним і просторовим розміщенням рослин кукурудзи в посіві певною мірою впливають на процеси їх життєзабезпечення. Межі можливої мінливості розміру і конфігурації індивідуальної площі живлення обмежені, перш за все, вимогами самих рослин до екологічних факторів довкілля, необхідністю створення для них в посіві найбільш сприятливих екологічних умов, які забезпечують нормальний їх ріст, розвиток та високу продуктивність. **Мета роботи** полягала у виявленні особливостей росту, розвитку рослин, формування врожайності зерна кукурудзи залежно від способу сівби та густоти стояння рослин в північному Степу. **Матеріали і методи.** Дослідження проводили в дослідному господарстві «Дніпро» ДУ ІЗК НААН. Ґрунтовий покрив – чорнозем звичайний малогумусний повнопрофільний. Середньоранній гібрид кукурудзи ДН Стяг висівали з шириною міжрядь 30, 45 та 70 см за густоти стояння рослин 40, 50, 60 і 70 тис. шт./га, фон удобрення – $N_{60}P_{45}K_{45}$. **Результати.** Способи сівби і густота стояння рослин на площі впливали на елементи структури врожаю і врожайність зерна кукурудзи. Найвищу середню за 2019–2021 рр. урожайність (11,13 т/га) за фактором А (спосіб сівби) було одержано за сівби кукурудзи з міжряддям 30 см. Збільшення ширини міжрядь до 45 та 70 см зумовлювало зниження зернової продуктивності гібрида кукурудзи ДН Стяг на 0,21 та 0,75 т/га (тобто на 1,9 та 6,7 %) відповідно. Вищу середню урожайність зерна (11,03 і 10,95 т/га) за фактором В (густота стояння) було одержано за густоти стояння рослин кукурудзи відповідно 60 і 50 тис. шт./га. **Висновки.** Звужені міжряддя при вирощуванні кукурудзи в умовах дефіциту ресурсного забезпечення можуть мати перспективи впровадження за певного вичерпання інших можливостей підвищення рівня реалізації потенціалу продуктивності гібридів, які не передбачають високовартісного технічного переоснащення.

Ключові слова: *кукурудза, спосіб сівби, густота стояння рослин, біометричні показники рослин, індивідуальна продуктивність рослин, елементи структури врожаю, врожайність зерна*