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INFLUENCE OF AGROTECHNOLOGICAL GROWING PRACTICES ON THE FORMATION OF BIOMETRIC INDICATORS OF KHORASAN WHEAT (TRITICUM TURANICUM) IN THE CONDITIONS OF THE EASTERN PART OF THE NORTHERN STEPPE OF UKRAINE

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Topicality. *The popularity of Khorasan wheat among consumers is due to the fact that their grain has more useful properties than traditional wheat types. The distribution of this wheat is restricted by the lack of accurate agrotechnological practices that would allow plants to maximise their genetically programmed productivity.* ***Purpose.*** *To determine the influence of the proposed elements of cultivation technology on the formation of biometric parameters by Khorasan wheat plants in the eastern part of the Northern Steppe of Ukraine.* ***Methods.*** *In 2021–2022, research was conducted in the field crop rotation of the Donetsk State Agricultural Research Station of NAAS, according to the method of B. O. Dospehov. The predecessor was a sunflower. The Khorasan wheat of Sarmat variety was used for sowing. Research methods were used: field, laboratory, mathematical and statistical.* ***Results.*** *Application of mineral fertilisers in the cultivation of Khorasan wheat contributes to the formation of better biometric parameters during the growing season compared to the control variant. At full maturity stage, the habitus of plants exceeds the control variant by 22 cm. The number of nodal roots per plant increases by 0.7 pcs and the productive tillering coefficient – by 0.1. When lower seeding rates are applied (2.0 and 3.0 million seeds/ha), plants form better biometric parameters regardless of nutritional background. The largest number of productive shoots of the Khorasan wheat forms in the nutrition background $N_{30}P_{30}$. Depending on the seeding rate, the coefficient of productive tillering varied from 1.4 to 1.2.* ***Conclusions.*** *Increasing or decreasing the seeding rate does not significantly affect the physiological ability of the crop to form a high plant density. Economically efficient plant density per unit area can be formed by increasing the seeding rate, which will reduce the number of productive stems per plant, but the total number of productive stems per 1 m^2 will increase, as a result, grain yield will increase.*

Key words: *Khorasan wheat, seeding rate, nutritional background, tillering coefficient, number of nodal roots, plant height, productive tillering coefficient, number of stems*

Introduction. In recent years, wild and ancient types of wheat have become increasingly popular among consumers worldwide.

Analysis of information sources of foreign and domestic research results shows that *Triticum turanicum* Jakubz. (*T. turgidum subsp. turanicum* (Jakubz.) Á. Löve & D. Löve, 2n = 4x = 28, AABB) is a species genetically close to durum wheat, known as Khorasan wheat. It is cultivated in 40 countries and is known worldwide as Kamut. [1].

Pure sowings of *T. turanicum* are cultivated in Iran, Turkey, Syria, Afghanistan, Uzbekistan, Turkmenistan and Kazakhstan. Since this wheat is a distinct ecotype of irrigated agriculture in hot and arid regions, the species *T. turanicum* is characterised by high tolerance to heat and atmospheric drought, but is completely non-resistant to soil drought [2, 3].

Many scientists have established that the yield of this wheat under conditions of heat and atmospheric drought was only 30 % lower than under optimal growing conditions. When high temperatures were combined with atmospheric and soil drought, the yield depression was almost 8 times higher due to a sharp decrease in productive tillering and head grain content [4–6].

Plant height of Khorasan wheat is 106–110 cm, reaching 115–125 cm under irrigation. The plants have low resistance to lodging due to the weak development of mechanical tissues in the three lower nodes.

The straw has a thickness of 3.5–4.0 mm, without anthocyanin; the nodes are thickened, covered with short hairs. The drooping spike is elongated, 11–14 cm long. The spike contains 16–20 spikelets and 34–37 grains. The awns are 14–17 cm long, very jagged, coarse, and easily

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fall off, so the spike appears to be awnless before harvest. The kernels are very long (11–12 mm), glassy [7–8]. The kernels of this ancient wheat are amber in colour and twice larger the kernels of ordinary wheat. Cooked kernels acquire a rich creamy and nutty flavour. Khorasan wheat is rich in fibre, magnesium and selenium, as well as antioxidants. It is nutritious and can be used in the same way as other wheat species.

Topicality of the research. Consumers prefer Khorasan wheat because their grain has more nutritional properties than traditional species. For this reason, scientists at the Donetsk State Agricultural Research Station have started breeding work with Khorasan wheat (*Triticum turanicum* Jakubz.), and in 2022, two lines of this crop were submitted to the State Variety Testing.

Khorasan wheat is a niche crop, the dissemination of which is constrained by the lack of precise agrotechnological cultivation techniques. There are still unresolved issues related to the selection of technological elements that would allow plants to maximise their genetically programmed productivity.

Purpose of the research. To determine the effect of the proposed elements of cultivation technology on the formation of biometric parameters by Khorasan wheat in the eastern part of the Northern Steppe of Ukraine.

Materials and Methods. In 2021–2022, the research was carried out in the field crop rotation of the Donetsk State Agricultural Research Station of NAAS. The soil is ordinary low-humus, heavy loamy chernozem. The humus content is 4.9 %, the pH is slightly alkaline, close to neutral, and the content of total nitrogen is 0.22, phosphorus – 0.14 %.

The sown area of the plot is 84 m^2, the recorded area is 76.9 m^2. The multifactorial field experiments were conducted using the method of sequential plots, in a systematic method. Experiments were repeated three times. The predecessor is sunflower. Mineral fertilisers were applied during sowing according to the scheme of the experiment.

Sowing was carried out in the early part of April using a SN-16 seeder in an assembly with a T-25 tractor. The sowing method was solid row sowing with 15 cm row spacing and with the depth of seed placement of 4–5 cm. In order to improve the conditions for its germination, the soil was compacted with 3KKSh-6A star-wheeled rollers.

Khorasan wheat of Sarmat variety was sown.

Hydrothermal conditions over the years of research were not significantly different from the long-term average, but allowed us to determine the response of Khorasan wheat plants to all manifestations of weather conditions typical for the eastern part of the Northern Steppe.

The research was carried out in accordance with the methodology of B. O. Dospiekhov [9]. Research methods were as follows: field, laboratory, mathematical and statistical.

Results. Khorasan wheat is characterised by relatively high general tillering, but productive tillering is lower. Therefore, the first step is to establish the optimal seeding rate for this crop to form the most efficient stem stand capable of providing the highest possible level of plant productivity.

Two nutrition backgrounds were also studied in the experiment, and the control was the background without fertilisation.

One of the most critical stages of organogenesis for cereals is the tillering stage. At the beginning of this stage, the future head is initiated, which determines the future productivity. Therefore, determining the effect of the proposed technological measures on the condition of plants during this period is interesting from a scientific point of view. For the analysis of biometric parameters, plants were selected at the end of the tillering stage (Table 1).

During the first stages of organogenesis, the nutritional background significantly influenced the habit of Khorasan wheat plants. Under the natural nutrition background, the plant height was the lowest, which ranged from 15.4 cm to 15.8 cm, depending on the seeding rate. Under moderate nutrition background ($N_{15}P_{15}$), the habitus of plants increased by an average of 0.9 cm compared to the natural background. Depending on the seeding rate, the plant height varied from 16.0 cm to 16.9 cm. The highest plants were grown under the mineral nutrition background of $N_{30}P_{30}$. At increased rates of mineral fertilisers, the height of Khorasan wheat plants was from 17.8 cm to 18.4 cm.

Analysis of the effect of seeding rates on plant habit determined that the increased seeding rates resulted in an insignificant increase in plant height. So, on moderate nutrition background

Table 1. Biometric parameters of Khorasan wheat of Sarmat variety at the end of the tillering stage, 2021–2022

Fertiliser rate	Seeding rate, mln seeds/ha	Height, cm	Depth of tillering node, cm	Tillering coefficient	Number of nodal roots, pcs/plant
N_0P_0	2.0	15.4	3.4	2.6	5.4
	3.0	15.4	3.4	2.5	5.2
	4.0	15.7	3.5	2.2	5.0
	5.0	15.8	3.4	2.2	5.1
$N_{15}P_{15}$	2.0	16.0	3.5	2.6	5.5
	3.0	16.2	3.6	2.7	5.6
	4.0	16.9	3.6	2.6	5.4
	5.0	16.9	3.6	2.5	5.5
$N_{30}P_{30}$	2.0	17.8	3.6	2.9	6.0
	3.0	17.8	3.7	2.9	5.9
	4.0	18.3	3.6	2.6	6.1
	5.0	18.4	3.7	2.6	5.9

($N_{15}P_{15}$), the difference between 2.0 million seeds/ha and 5.0 million seeds/ha was 0.9 cm. It is explained by the fact that plants need to increase their habitus to receive the required amount of physiologically active radiation when plant density is thickened.

It was found that seeding rates do not affect the depth of the tillering node. Comparison of the effect of nutrition backgrounds revealed that an increased fertiliser rate led to a partial deepening of the tillering node. So, at application of $N_{15}P_{15}$ the tillering node deepened by 0.2 cm compared to the natural background, and at $N_{30}P_{30}$ – by 0.3 cm, respectively. This phenomenon is explained by the physiological ability of plants to adapt to more favourable nutritional conditions, i.e., when forming a more favourable agrochemical background, plants form a root system in more favourable conditions for their further development.

The nutrition background and sowing rates had a more significant effect on the formation of the number of shoots by plants and, as a result, the tillering coefficient.

The highest tillering coefficient (2.6) was observed in the variant without fertiliser at a seeding rate of 2.0 million seeds/ha. With an increase in the seeding rate, the tillering coefficient decreased from 0.1 at 3.0 million seeds/ha to 0.4 at 4.0 and 5.0 million seeds/ha.

The tillering coefficient increased by 0.2 in comparison with the control, when mineral fertilisers $N_{15}P_{15}$ were applied during sowing. Comparison of seeding rates revealed that at the rate of 3.0 million seeds/ha, the Khorasan wheat plants formed the highest tillering coefficient, which exceeded the variants with the seeding rate of 2.0 and 4.0 million seeds/ha by 0.1, and with the seeding rate of 5.0 million seeds/ha – by 0.2.

The pre-sowing application of mineral fertilisers at the rate of $N_{30}P_{30}$ contributed to the formation of the highest tillering coefficient (2.9) in the experiment. When comparing the effect of seeding rates on this indicator, it was found that 2.0 and 3.0 million seeds/ha allowed plants to form a tillering coefficient higher by 0.3 than in the variants with seeding rates of 4.0 and 0.5 million seeds/ha.

The number of nodal roots formed by the plants of Khorasan wheat differed significantly at various nutrition backgrounds. This indicator varied from 5.2 pieces in the variant without fertilisation to 6.0 pieces in the $N_{30}P_{30}$ background.

Seeding rates also had a different effect on the number of nodal roots depending on the nutrition background. The highest number of nodal roots was at a seeding rate of 3.0 million seeds/ha in the control. With a moderate mineral nutrition background, this indicator was also the highest at 3.0 million units/ha. For pre-sowing application of $N_{30}P_{30}$, the largest number of nodal roots was formed by plants at a seeding rate of 4.0 million seeds/ha.

The analysis of biometric parameters of plants at the end of the growing season of Khorasan wheat of Sarmat variety allowed determining the effect of agrotechnological practices on plants during the stages of organogenesis (Table 2).

Studies have shown that seeding rates did not significantly affect the plant height. Only the application of mineral fertilisers of $N_{30}P_{30}$ contributed to an increase in the habitus of the Khorasan wheat plants. So, this indicator increased by 22.0 cm compared to the control, and to the nutrition background $N_{15}P_{15}$ – by 18 cm.

Table 2. Biometric parameters of Khorasan wheat plants of Sarmat variety in the full ripeness stage, 2021–2022

Fertiliser rate	Seeding rate, mln seeds/ha	Height, cm	Number of stems, pcs/m^2		Tillering coefficient	
			total	productive	total	productive
N_0P_0	2.0	86	520	260	2.6	1.3
	3.0	86	750	360	2.5	1.2
	4.0	85	880	480	2.2	1.2
	5.0	85	1100	500	2.2	1.0
$N_{15}P_{15}$	2.0	88	520	260	2.6	1.3
	3.0	90	810	390	2.7	1.3
	4.0	91	1040	480	2.6	1.2
	5.0	91	1250	550	2.5	1.1
$N_{30}P_{30}$	2.0	108	580	280	2.9	1.4
	3.0	108	870	420	2.9	1.4
	4.0	108	1040	520	2.6	1.3
	5.0	106	1300	600	2.6	1.2

Regardless of the nutritional background, it is observed the trend towards the formation of a higher coefficient of total tillering at lower seeding rates. Thus, in the variant without fertilisation at a seeding rates of 2.0 million seeds/ha, the total tillering coefficient was 2.6, and at seeding rates of 4.0 and 5.0 million seeds/ha, this coefficient decreased by 0.4. The application of mineral fertilisers increased the coefficient of total tillering compared to the control.

A similar trend is observed in the formation of the productive tillering coefficient by plants. Under the natural nutrition background, the productive tillering coefficient decreased from 1.3 at a sowing rate of 2.0 million seeds/ha to 1.0 at a sowing rate of 5.0 million seeds/ha.

The mineral background $N_{15}P_{15}$ improved the formation of productive shoots by the plants. The difference in tillering coefficient between the minimum and maximum seeding rates was 0.2 units. The largest number of productive shoots of the Khorasan wheat was formed under $N_{30}P_{30}$ nutrition background. Depending on the seeding rate, the productive tillering coefficient varied from 1.4 to 1.2.

Studies have shown that increased or decreased seeding rates do not significantly affect the physiological ability of the crop to form a dense productive stand. Economically effective dense productive stand per unit area can be formed by increasing the seeding rate, at which the number of productive stems per plant will decrease, but the total number of productive stems per 1 m^2 will increase, which will increase the crop yield.

Conclusions. Khorasan wheat is a niche crop, the dissemination of which is constrained by the lack of precise agrotechnological cultivation techniques.

The application of mineral fertilisers in the cultivation of Khorasan wheat improves biometric parameters during the growing season compared to the control. Thus, the habitus of plants in the full ripeness stage exceeds the control variant by 22 cm; the number of nodal roots per plant increases by 0.7 units, and the productive tillering coefficient – by 0.1.

At lower seeding rates (2.0 and 3.0 million seeds/ha), plants form better biometric parameters regardless of nutrition background. However, the plant height increased at the end of the tillering stage in proportion to the increase in the seeding rate due to the higher competition of the Khorasan wheat plants with each other.

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Вінюков О. О., Бутенко О. М. Вплив агротехнологічних прийомів вирощування на формування біометричних показників пшениці туранської (Triticum turanicum) в умовах східної частини Північного Степу України. *Зернові культури. 2023. 7 (1). 114–118.*

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Актуальність. Популярність серед споживачів пшениці туранської пов'язана з тим, що її зерно має більше корисних властивостей ніж традиційні види. Розповсюдження цих пшениць стримує відсутність чітких агротехнологічних прийомів її вирощування, які б дозволили рослинам максимально сформувати генетично запрограмовану продуктивність. **Мета.** Встановити вплив запропонованих елементів технології вирощування на формування рослинами пшениці туранської біометричних показників в умовах східної частини Північного Степу України. **Матеріали і методи.** Дослідження проводились згідно методики польової справи Б. О. Доспєхова «Методика полевого опыта». Дослідження були проведені у 2021–2022 рр. у польовій сівозміні Донецької державної сільськогосподарської дослідної станції НААН. Попередник – соняшник. Для сівби використовували сорт пшениці туранської Сармат. Методи дослідження: польовий, лабораторний, математично-статистичний. **Результати.** Використання мінеральних добрив при вирощуванні пшениці туранської сприяє формуванню рослинами кращих біометричних показників протягом вегетації порівняно з контрольним варіантом. Так, габітус рослин у фазі повної стиглості перевищує контрольний варіант на 22 см. Кількість вузлових коренів на одній рослині збільшується на 0,7 шт., а коефіцієнт продуктивного кущіння – на 0,1. За використання менших норм висіву (2,0 та 3,0 млн. шт./га) рослини формують кращі біометричні показники незалежно від фонів живлення. Найбільшу кількість продуктивних пагонів рослини пшениці туранської формували за фону живлення $N_{30}P_{30}$. Залежно від норми висіву коефіцієнт продуктивного кущіння варіював від 1,4 до 1,2. **Висновки.** Збільшення або зменшення норми висіву істотно не впливає на фізіологічну здатність культури формувати щільний продуктивний стеблостій. Сформувати господарсько-ефективний щільний продуктивний стеблостій на одиниці площі можна шляхом збільшення норми висіву, за якого кількість продуктивних стебел на рослині буде знижуватись, але загальна кількість продуктивних стебел на 1 м^2 підвищиться, що дозволить підвищити врожайність посіву.

Ключові слова: *пшениця туранська, норма висіву, фон живлення, коефіцієнт кущіння, кількість вузлових коренів, висота рослин, коефіцієнт продуктивного кущіння, кількість стебел*