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The Formation of the Productivity of Winter Wheat Depends on the Predecessor, Doses of Mineral Fertilizers and Bio Preparations

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Abstract. Wheat is the main agricultural crop in many countries of the world, as well as the main food in the steppe zone, so the system of agrotechnical measures should be aimed at creating favourable conditions for obtaining a high yield. The issue of intensification of grain production is inseparable from the production and use of new biogenic effective drugs that have a positive effect on the growth and development of cultivated plants. The purpose of this study was to establish the effect of foliar fertilisation with bacterial preparations, precursors, and doses of mineral fertilisers on grain yield and productivity elements of winter wheat. The paper provides data on the results of the research of winter wheat of the Duma Odeska variety in the conditions of the Educational and Practical Centre of the Mykolaiv NAU in 2019-2021. During the study, generally accepted methods were used: monographic, systematic approach and systematic analysis, analysis and synthesis, field and statistical. The influence of the precursor, foliar feeding with modern bacterial biopreparations and the use of different doses of mineral fertilisers on the elements of the crop structure and grain yield of winter wheat was analysed. It was established that the yield level depended and changed on the precursor taken for foliar feeding of the bacterial preparation, the level of mineral nutrition and to a large extent on the influence of the weather conditions of the growing year. Over the years of research, precursors, mineral fertilisers, and treatment of plant sowing with biological preparations affected the number of productive stems, the number of grains from an ear, the mass of grain from one ear and the mass of 1,000 grains of winter wheat. The conducted studies confirmed the expediency of foliar fertilising in the main periods of vegetation with biological preparations to optimise the nutrition of winter wheat plants with the aim of forming a stable grain yield. The obtained scientific results of the research will contribute to the wide application of biological preparations, which will ensure the rapid and full growth and development of winter wheat plants, which will further contribute to increasing the yield and gross harvest of grain

Keywords: grain yield, top dressing, productive stalks, number of grains from 1 ear, weight of 1000 grains



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INTRODUCTION

Of all the environmental factors in the conditions of the south of Ukraine, the formation of growth processes and the productivity of plant organisms after moisture is most affected by the nutrition regime, which is created by the correct rotation of crops in crop rotation and the use of an optimal fertilisation system (Miroshnychenko *et al.*, 2018).

In modern agriculture, the role of mineral fertilisers has considerably increased due to the insufficient use of organic fertilisers, the increase in the share of row crops in crop rotation, in particular the oversaturation of sunflowers, as well as the spread of erosion processes. To form stable harvests and obtain a full-fledged, according to the main quality indicators, grain of winter wheat, it is necessary to create optimal plant nutrition, and foremost, in terms of macroelements (Havryliuk, 2019). One of the important conditions for the effective use of fertilisers is to determine the plants' need for them, for the desired yield level, considering the content of mobile NPK compounds in the soil (Yan *et al.*, 2021).

Increasing the grain yield of winter wheat is directly related to various elements of the crop structure, which mainly consist of three parts: the productive amount of straw per unit area, the number of grains in an ear and the weight of a thousand grains. To study the role of various productivity factors in the formation of wheat grain yield, the determination of this indicator depends on 50% of productive straw, 25% on the number of grains in an ear, and 25% on the weight of 1,000 grains (Olkhovskiy *et al.*, 2019).

In the conditions of the Southern Steppe of Ukraine, farmers should firstly pay attention to the accumulation and preservation of moisture in the soil, ensuring the maximum use of water by plants, which is the most principal factor affecting the level of yield of agricultural crops, including winter cereals. All life processes are determined by the movement of water in plant organs. In addition, soil moisture not only determines the level of vital activity of plants, but also determines the level of vital activity of microbes, ensuring the intensity of many physico-chemical processes. Due to climate change and global warming, moisture has become a major key factor influencing crop yields. Research by O. Tsyliuryk established that most of the moisture in the soil accumulates in black steam, but recently this precursor of winter wheat is used less and less due to the excessive cost of caring for it (Tsiliuryk, 2019).

Many researchers have established that the grain yield of winter wheat depends on the nutritional background of the previous crop, but to a greater extent on the weather conditions in the year of sowing – the supply of water to plants during wintering and growing season (Korkhova & Mykolaichuk, 2022; Panfilova *et al.*, 2020; Andriichenko & Kachanova, 2018).

Increasing the yield of winter wheat grain with reducing resource inputs and reducing the chemical

load on the soil is a priority area of agricultural development, success in which can be achieved by greening crop production (Raneesha Madushanki *et al.*, 2019; Soto-Gómez & Pérez-Rodríguez, 2022). Due to the introduction of excessive amounts of fertilisers, environmental pollution increases, quality decreases, and the energy intensity of the produced products increases (Kulkarni & Goswami, 2019).

Recently, there has been an increase in the interest of domestic agricultural producers in biological preparations, which is associated with the increase in the price of mineral fertilisers, the contamination of agricultural land with chemicals, and the expansion of acreage for organic farming (Kulkarni & Goswami, 2019). Biopreparations stimulate the growth and development of agricultural crops, increase resistance to stress, diseases, and balance nutrition. This effect is achieved since living bacteria convert insoluble compounds into available forms, provide nitrogen nutrition and protect plants from bacterial and fungal diseases (Krutyakova, 2020; Panfilova & Mohylnytska, 2019).

The purpose of the research was to determine the productivity of winter wheat of the Duma Odeska variety depending on the predecessor, doses of mineral fertilisers and foliar fertilisation with biological preparations.

LITERATURE REVIEW

In agricultural production, crop rotation is always one of the main agrotechnical measures that contribute to increasing the yield of agricultural crops. It follows from scientific literature that farms use a high proportion of cereals in crop rotations, which leads to a decrease in winter wheat grain yield (Kvasnitska & Voitova, 2021; Woźniak, 2019; Alemu *et al.*, 2014).

In the South of Ukraine, many scientists were engaged in the research of predecessors for winter wheat. For example, A.O. Lytovchenko *et al.* (2017), A.I. Kryvenko and S.I. Burykina (2018) determined that black steam forms higher grain yield and better indicators of its quality in winter wheat plants.

R. Oripov and A. Buriev (2021) claim that for sustainable wheat production in the Republic of Uzbekistan, peas, as a precursor to winter wheat, are better compared to repeated crops.

Long-term research carried out in the Northern Steppe of Ukraine determined that the highest productivity of winter wheat is formed when it is grown after black steam and corn for silage, in years with the termination of autumn vegetation in the 3rd decade of November, and the lowest – in the 1st decade of November (Mostipan *et al.*, 2019).

The studies of V. Hanhur and Y.O. Kotliar (2021) prove that it is necessary to place winter wheat on a black pair only in dry years, while in years favourable for moistening, there is a decrease in productivity due to the lodging of crops.

In a long-term (1996-2009) field experiment conducted by S.I. Kudria at the experimental field of the Kharkiv National Agrarian University named after V.V. Dokuchaev, it was determined that in crop rotation with leguminous precursors (peas and soybeans) of winter wheat, the content of available forms of nitrogen nutrients was higher (116-120 mg/kg of soil) than with pure steam (111-114 mg/kg of soil) and corn for silage (110-113 mg/kg of soil) (Kudria, 2020).

As can be seen from the conducted research, the soil and climatic zone of cultivation, varieties, feeding conditions and weather conditions during the years of research have a significant impact on determining the best and good predecessors for winter wheat.

The analysis of the results of 14-year research (2007-2020) conducted by S. Burykina *et al.* (2021) on the topic: "Effectiveness of winter wheat fertilisation systems in the Southern Steppe of Ukraine" showed that the application of fertilisers in a dose of $N_{180}P_{60}K_{60}$ increased grain yield by 2.24 t/ha, or by 40.3% compared to the control variant (without fertilisers) (Burykina *et al.*, 2021).

Research conducted by O.V. Sidiyakina and V.F. Dvoretzky (2020) determined that as a result of foliar feeding with complex fertilisers, 0.62-0.96 t/ha of grain was additionally formed.

Pekarskas J. *et al.* (2017) prove that the use of biological preparation Fertenat increased the yield of spring wheat by 0.05-0.30 t/ha or by 2.29-13.76%.

Research by D. Jodaugiene *et al.* (2022) determined that the use of biological preparations did not have a significant effect on seed germination, but contributed to tillering, an increase in the number of productive stems and the leaf surface area of winter wheat plants, the weight of 1,000 grains, the number of grains in an ear, the weight of grain in an ear, and increased grain yield compared to control.

Therefore, both Ukrainian and foreign scientists paid considerable attention to the research of predecessors and optimisation of nutrition for soft winter wheat, but in connection with climate change, the introduction of significant areas into crop rotation for sunflower, mustard, with the appearance of new varieties, changes in fertility soil, there is a need to investigate this issue in more detail.

MATERIALS AND METHODS

Experimental research was conducted during 2019-2021 at the research field of the Educational-Scientific-Practical Centre of the Mykolaiv National University, which belongs to the Southern Steppe zone of Ukraine.

The research material was the winter wheat variety Duma Odeska, the owner of which is the Breeding and Genetic Institute – National Centre for Seed Science and Varietal Research (BGI – NCSSVR), which was registered in the State Register of Plant Varieties Suitable for Distribution in Ukraine in 2017 (State register of plant varieties..., 2022).

The agricultural technique of conducting the experiments was generally accepted for the current zonal recommendations for the conditions of the Southern Steppe zone of Ukraine, except for the factors that were taken for study. Sowing of winter wheat was carried out on October 1 with a sowing rate of 5 million units/ha.

The soil type is southern chernozem with a humus content of 3.3% in the arable layer, a neutral reaction of the soil solution (pH – 6.8-7.2) and an average availability of mobile forms of nitrogen, phosphorus, and potassium. The area of the sowing area was 50 m², and the accounting area was 26 m², it was repeated 4 times. Experimental plots were placed by the method of incomplete randomisation.

The scheme of the experiment included the following options: Factor A – precursors: black steam, legumes (peas), cruciferous vegetables (mustard of the spring); Factor B – doses of mineral fertilisers: without fertilisers (control), application of $N_{32}P_{32}K_{32}$, application of $N_{64}P_{64}K_{64}$; Factor C – bacterial preparations: control (water treatment), Biocomplex-BTU-r, Organic Balance.

The influence of biopreparations Biocomplex-BTU-r and Organic Balance was studied on the studied winter wheat variety. Biocomplex-BTU-r – has a complex effect, as it contains a mixture of different microbial strains. Organic Balance – a concentrated mixture of living and inactivated microorganisms and their active metabolites, living bacteria: nitrogen fixation – provides plants with nitrogen; phosphorus and potassium mobilisation – transforms insoluble compounds into forms available to plants; has microorganisms with bactericidal properties – protect plants from bacterial and fungal diseases, components of the nutrient medium (macro-, micro-, and organic food sources). The preparations are used for foliar feeding of plants during the spring-summer vegetation period at the rate of 1.0 and 0.3 l/ha, respectively.

Planting density calculations were determined on test plots with an area of 1 m² twice per growing season, located diagonally across the plot area. The first time is calculated at the stage of full seedlings, and the second time – before harvesting.

The mass of 1,000 grains was determined according to GOST 10842-89. The average number of grains in an ear is calculated according to the ratio, where the numerator is the total number of grains after threshing 25 ears, and the denominator is the sum of the average weight of the studied sample (25 ears), and the weight of grain from 1 ear is the weight of grain from the sheaf divided by the number of productive stalks, obtained in the bundle sample.

Harvesting of winter wheat was carried out with a SAMPO-500 harvester from each repetition. After threshing each plot, the threshing machine of the combine was turned off, the harvested grain was weighed separately and transferred to standard humidity (14%) and purity (100%).

The obtained research results in the form of analytical digital material were subjected to statistical and

mathematical processing, performed by the method of dispersion and correlation analyses thanks to computer programs Microsoft Excel and "Agrostat" by the method of variation, correlation, and dispersion analyses.

RESULTS AND DISCUSSION

A mandatory technique for obtaining high-yielding winter wheat grain is to provide plants with nutrients during

the growing season. Therefore, fertilisation systems should be based on the specific features of the soil and climatic conditions of the region, predecessors, and varieties of winter wheat (Panfilova *et al.*, 2019).

The conducted study shows that the highest yield of winter wheat grain can be obtained by placing it in a black pair, both in individual years of sowing, and on average during the three years of the study (Fig. 1).

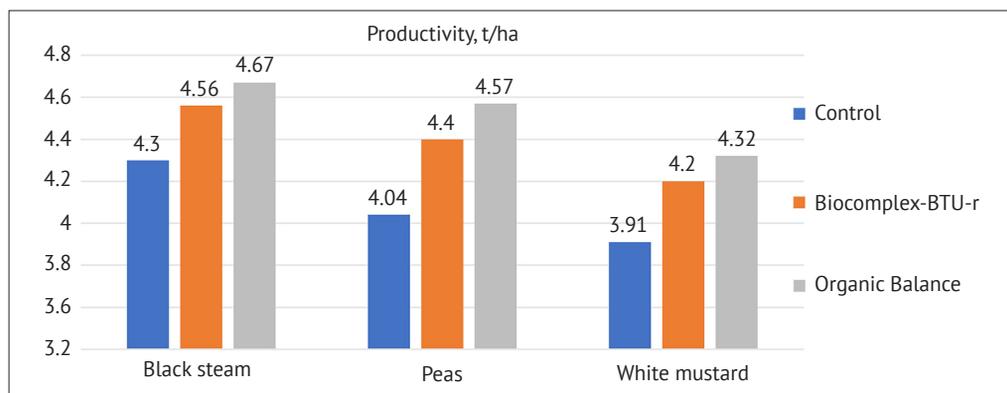


Figure 1. Yield of winter wheat grain depending on the predecessor for cultivation in unfertilised control with feeding with bacterial preparations (average for 2019-2021), t/ha

Source: developed by the authors of this study

After peas or white mustard, when grown without the use of mineral fertilisers, it was 3.9-8.6% lower, and with their application in a dose of $N_{64}P_{64}K_{64}$ – by

16.0-17.6% lower compared to the predecessor of black steam, on average by a factor treatment with biological preparations (Table 1).

Table 1. Yield of winter wheat depending on the predecessor, doses of mineral fertilisers and foliar fertilisation with bacterial preparations, (average for 2019-2021), t/ha

Treatment with biological preparations (factor C)	Precursor (factor A)			Mean	± To control	
	Black steam	Peas	White mustard		t/ha	%
Without the use of mineral fertilisers (factor B)						
Control (water treatment)	4.30	4.04	3.91	4.08	–	–
Biocomplex-BTU-r	4.56	4.40	4.20	4.39	0.30	7.43
Organic Balance	4.67	4.57	4.32	4.52	0.44	10.69
Mean for factor A	4.51	4.34	4.14	4.33	0.25	6.04
Mineral fertiliser $N_{32}P_{32}K_{32}$ (factor B)						
Control (water treatment)	4.66	4.54	4.44	4.55	–	–
Biocomplex-BTU-r	4.94	4.80	4.64	4.79	0.25	5.43
Organic Balance	5.01	4.85	4.74	4.87	0.32	7.04
Mean for factor A	4.87	4.73	4.61	4.74	0.19	4.15
Mineral fertiliser $N_{64}P_{64}K_{64}$ (factor B)						
Control (water treatment)	5.48	4.70	4.67	4.95	–	–
Biocomplex-BTU-r	5.73	4.94	4.84	5.17	0.22	4.44
Organic Balance	5.79	5.03	4.94	5.25	0.30	6.13
Mean for factor A	5.67	4.89	4.82	5.12	0.17	3.52
LSD ₀₅ by factor A	0.17	0.11	0.10			
LSD ₀₅ by factor B	0.22	0.14	0.11			
LSD ₀₅ by factor C	0.23	0.15	0.13			

Source: developed by the authors of this study

The conducted research also determined that under the influence of weather conditions of the growing year, and especially the supply of moisture during the growing season, the grain yield of winter wheat changes (Table 2). Notably, from the years of conducting research, the lowest yield was formed in 2020 due to unfavourable overwintering conditions, which led to a significant decrease in the number of winter wheat plants during the period of their full maturity, i.e., before harvesting

the grain crop. In this growing year, the advantage of the black pair over other predecessors was most evident. In addition, the lowest grain productivity in the specified year was formed when the crop was grown after black steam against the background of applying a high dose of mineral fertiliser $N_{64}P_{64}K_{64}$ with treatment with the biological preparation Organic Balance and amounted to 3.46 t/ha, which is 0.61 t/ha or 21.4% exceeded the predecessor white mustard in a similar version of fertiliser.

Table 2. The yield of winter wheat grain (t/ha) under the influence of the studied factors (average for 2019-2021)

Treatment with biological preparations (factor C)	Precursor (factor A)									Mean
	Black steam			Peas			White mustard			
	2019	2020	2021	2019	2020	2021	2019	2020	2021	
Without the use of mineral fertilisers (factor B)										
Control (water treatment)	5.36	3.74	5.52	5.11	3.25	5.31	4.94	3.12	5.14	4.61
Biocomplex-BTU-r	5.57	4.18	5.76	5.34	4.03	5.60	5.26	3.47	5.48	
Organic Balance	5.66	4.33	5.86	5.48	4.27	5.77	5.41	3.59	5.61	
Average by years	5.53	4.08	5.71	5.31	3.85	5.56	5.20	3.39	5.41	
Mineral fertiliser $N_{32}P_{32}K_{32}$ (factor B)										
Control (water treatment)	5.85	4.21	5.93	5.63	4.15	5.78	5.48	4.01	5.69	
Biocomplex-BTU-r	6.18	4.48	6.21	5.96	4.46	5.99	5.66	4.38	5.81	
Organic Balance	6.22	4.55	6.31	5.98	4.53	6.07	5.75	4.42	5.96	
Average by years	6.08	4.41	6.15	5.86	4.38	5.95	5.63	4.27	5.82	
Mineral fertiliser $N_{64}P_{64}K_{64}$ (factor B)										
Control (water treatment)	6.72	4.18	6.90	5.89	4.22	6.02	5.84	4.22	5.98	
Biocomplex-BTU-r	6.88	4.63	7.11	6.15	4.51	6.27	5.99	4.46	6.11	
Organic Balance	6.93	4.89	7.19	6.28	4.58	6.35	6.07	4.59	6.26	
Average by years	6.84	4.57	7.07	6.11	4.44	6.21	5.97	4.42	6.12	

Source: developed by the authors of this study

Despite the investigated factors, favourable weather conditions during the growing seasons of 2019 and 2021 ensured a significantly higher yield of winter wheat. Thus, judging by the average indicators of predecessors, foliar feeding, and mineral fertilisers, 5.84 t/ha was formed in 2019, and 6.0 t/ha in 2021, which exceeds the level of 2020, which was less favourable, on 2.96 and 3.12 t/ha or by 102.8 and 108.3% relative to years.

In all years of research, the positive effect of applying mineral fertilisers is clearly visible. More substantial increases in grain yield, optimisation of nutrition of winter wheat plants, is ensured by growing the crop according to non-paired (more impoverished in nutrients) predecessors. At the same time, it is important to pay attention to the fact that with the improvement of the nutritional regime of winter wheat plants, even in the unfavourable year 2020, the yield for cultivation after peas and white mustard was not so significantly reduced compared to black steam. With the optimisation of plant nutrition, the value of the precursor is reduced,

and the yield from applied mineral fertilisers increases on soils more depleted of nutrients.

The productivity of winter wheat is significantly determined and varies under the influence of the weather conditions of the growing season, the availability of plant nutrients and foliar fertilisation with bacterial preparations. Of the studied bacterial preparations, the largest yield increases are provided through the bacterial preparation Organic Balance, and the lowest – Biocomplex-BTU-r. Of the predecessors, regardless of the weather conditions of the year of growing winter wheat, black steam provides the highest grain yield. The level of grain yield increases significantly when mineral fertilisers are applied to the crop. To a greater extent, this can be traced to the cultivation of impoverished predecessors – peas and white mustard.

The growth and development of plants during the growing season and the yield they produce when sowing grain crops are determined by the structural elements of productivity. These are mainly: the density of

the plant stand (the number of productive stems per 1 m²), the number of grains in the ear and the weight of 1,000 seeds. The three components listed above directly determine the level of productivity. The formation of structural elements of the crop is influenced by many factors the weather conditions of the year, biological features of the variety, crop care, including agrotechnical measures, namely mineral nutrition of plants (Panfilova *et al.*, 2020).

The interaction of productivity factors contributed to the formation of winter wheat grain yield, mainly the number of productive straws formed, the weight of 1,000 grains, the size, and weight of the grain in the ear (Tsvey *et al.*, 2021). Studies of the main indicators for determining the structure of winter wheat crops show that under the influence of mineral fertilisers, the number of productive stems increases (Table 3).

Table 3. The influence of the investigated factors on the number of plants before harvesting and the number of productive stems (average for 2019-2021), pcs/m²

Treatment with biological preparations (factor C)	Doses of mineral fertilisers (factor B)		
	Without fertiliser (control)	N ₃₂ P ₃₂ K ₃₂	N ₆₄ P ₆₄ K ₆₄
Black steam (factor A)			
Control (water treatment)	344	352	354
	442	455	488
Biocomplex-BTU-r	353	366	370
	448	467	496
Organic Balance	361	368	371
	453	471	500
Peas (factor A)			
Control (water treatment)	327	330	332
	425	443	450
Biocomplex-BTU-r	339	351	356
	438	460	462
Organic Balance	346	359	362
	443	460	470
White mustard (factor A)			
Control (water treatment)	321	322	330
	421	436	450
Biocomplex-BTU-r	334	340	343
	433	455	463
Organic Balance	342	346	347
	442	457	470

Note: in the numerator – the number of plants before harvesting; in the denominator – the number of productive stems

Source: developed by the authors of this study

Of the predecessors studied, the highest density of productive stems was formed by winter wheat plants according to the steam precursor – 469 pcs/m², and after peas and white mustard, they were formed somewhat less – 450 and 447 pcs/m². The most productive stalks of winter wheat are formed against the background of applying a dose of mineral fertilisers N₆₄P₆₄K₆₄ and foliar fertilisation of the crop with the bacterial preparation Biocomplex-BTU-r and Organic Balance at the main stages of plant growth. Thus, in these variants of the winter wheat plant placed after the steam predecessor, 496 and 500 pcs/m² of productive stems were formed, respectively, and after white mustard – 463 and 470 pcs/m². Against the background of the introduction of mineral fertilisers in the dose

of N₃₂P₃₂K₃₂, a slightly lower density of the productive stem was formed. During the years of research, 461 pcs/m² of productive stems were formed on 1 m² for fertilising with Biocomplex-BTU-r and 463 pcs/m² – Organic Balance in the section of predecessors.

The choice of feeding option also influenced to some extent the amount of grain formed in the ears of winter wheat (Table 4). Thus, if in the control without fertilising, on average over the years of the study, there are 26.9 grains in the ear of winter wheat after placement on the background of the steam precursor, 26.4 pcs – after peas, 25.9 pcs – white mustard, the application of mineral fertilisers in doses of N₃₂P₃₂K₃₂ and N₆₄P₆₄K₆₄ increased these indicators by 0.6-2.9; 1.3-1.5 and 1.8-1.9 grains, respectively.

Table 4. The number of grains from 1 ear and their weight depending on the precursor, fertiliser and biological preparations (average for 2019-2021)

Treatment with biological preparations (factor C)	Doses of mineral fertilisers (factor B)		
	Without fertiliser (control)	N ₃₂ P ₃₂ K ₃₂	N ₆₄ P ₆₄ K ₆₄
Black steam (factor A)			
Control (water treatment)	26.9 0.97	27.5 1.02	29.8 1.12
Biocomplex-BTU-r	27.7 1.02	27.8 1.06	30.0 1.16
Organic Balance	27.8 1.03	27.9 1.06	29.9 1.16
Peas (factor A)			
Control (water treatment)	26.4 0.95	27.7 1.02	27.9 1.04
Biocomplex-BTU-r	25.5 1.00	27.7 1.04	28.3 1.07
Organic Balance	28.0 1.03	27.8 1.05	28.2 1.07
White mustard (factor A)			
Control (water treatment)	25.9 0.93	27.7 1.02	27.8 1.04
Biocomplex-BTU-r	26.8 0.97	27.6 1.02	27.8 1.05
Organic Balance	26.7 0.98	28.0 1.04	27.9 1.05

Note: in the numerator – the number of grains from 1 ear, pc.; in the denominator – the mass of grains from 1 ear, g

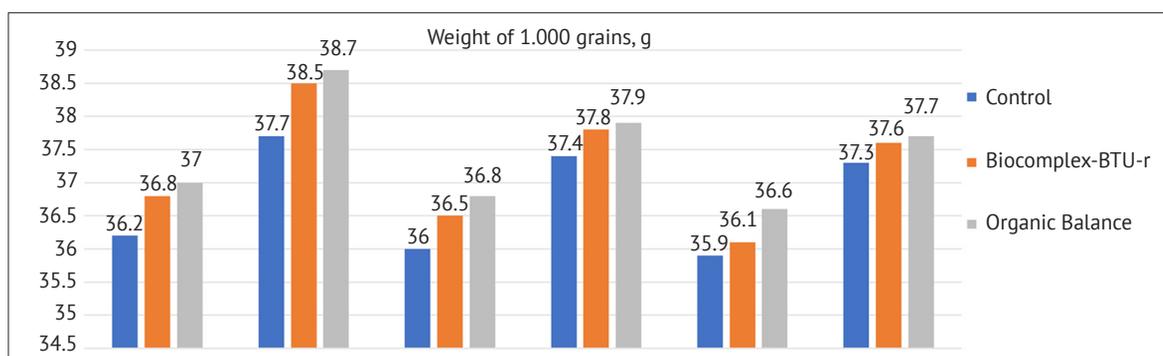
Source: developed by the authors of this study

In all years of research, the number of grains in the ear was the largest in winter wheat plants placed after the steam precursor with the use of mineral fertilisers in the dose of N₆₄ P₆₄ K₆₄ and foliar fertilisation with the bacterial preparation Biocomplex-BTU-r, which is 3.1 pcs or by 10.3% more compared to the control option.

During the years of research, it was determined that precursors, mineral fertilisers, and treatment of plant sowing with biological preparations had an effect on the mass of grain from one ear (Table 3). Thus, when a low dose of mineral fertiliser N₃₂ P₃₂ K₃₂ was applied to winter wheat after the steam precursor, the mass of grain from the ear, compared to the unfertilised control, increased by 4.9%, after peas – by 6.9%, and after

white mustard – by 8.8%. Foliar fertilising with bacterial preparations Biocomplex-BTU-r and Organic Balance increased the specified indicator of crop structure, respectively: by 8.5% – after black steam, by 9.1% – after peas and by 9.7% – after white mustard.

The conducted studies showed that there are certain differences in the influence of precursors and feeding conditions during the growth of winter wheat on the formation of grains of varied sizes by plants. The weight of 1,000 grains, depending on the precursor, treatment with biological preparations and the use of mineral fertilisers, varied widely and amounted to 36.2-38.7 g for the steam precursor, for peas – 36.0-37.9 g, and after white mustard – 35.9-37.7 g (Fig. 2).

**Figure 1.** The influence of the precursor, mineral fertilisers and biological preparations on the weight of 1,000 grains of winter wheat (average for 2019-2021), g

Source: developed by the authors of this study

Foliar feeding of a winter wheat plant with organic balance organic preparation over the years of research in the section of predecessors against the background of a high dose of mineral fertilisers ($N_{64}P_{64}K_{64}$) increased the mass of 1,000 grains to 38.1 g, which exceeds this indicator compared to the control variant by 2.1 g or 5.8%.

Thus, on average, over the previous years and during the years of research, the use of mineral fertilisers increased the mass by 1,000 grains. In particular, the application of mineral fertilisers in a dose of $N_{32}P_{32}K_{32}$ showed an increase in the yield structure indicator compared to the control by 1.0 g or by 2.8%, and with biological preparations (provided this dose of mineral fertilisers is applied) increased by 1.5-01.7 g or 4.2-4.7%. At the same time, it should be noted that among the options for growing winter wheat plants with fertilisation of the crop with the bacterial preparation Organic Balance, the weight of 1,000 grains was the highest – 37.7-38.7 g, depending on the predecessor, with the use of mineral fertilisers in the dose of $N_{64}P_{64}K_{64}$.

CONCLUSIONS

Research conducted in the South of Ukraine in 2019-2021 shows that the yield of winter wheat grain largely depends on and varies under the influence of weather conditions during the growing season, the supply of plant nutrients and foliar fertilisation with bacterial preparations.

Of the studied bacterial preparations, the largest increase in yield was provided using the bacterial preparation Organic Balance, the smallest – Biocomplex-BTU-r. Among the predecessors, black steam significantly increased the yield of winter wheat, regardless of weather conditions during the growing years. When mineral fertilisers are applied to crops, the level of grain yield increases significantly, and this applies even more to cultivation after depleted predecessors – peas and white mustard.

The use of biological preparations has a significant effect on winter wheat productivity. Comparing the values between the years of the study, it can be noted that the highest yields were obtained in a more favourable year for growing (2021) on the option for growing the crop on black steam against the background of applying a high dose of mineral fertiliser $N_{64}P_{64}K_{64}$ with treatment with the biological preparation Organic Balance and amounted to 7.19 t/ha, which is more compared to the control variant by 1.67 t/ha or by 30.3%.

Of the studied bacterial preparations, the greatest increase in yield is provided by feeding with the bacterial preparation Organic Balance, and the lowest by Biocomplex-BTU-r. Regardless of the weather conditions of the growing year, a significantly higher yield of winter wheat grain is formed by black steam. The level of grain yield increases significantly with the introduction of mineral fertilisers to the culture, and to a greater extent due to the impoverished predecessors – peas and white mustard.

REFERENCES

- [1] Alemu, T., Emanu, B., Haji, J., & Legesse, B. (2014). Farmers choices of precursor crop for wheat production in arsi zone of Ethiopia. *Journal of Economics and Sustainable Development*, 5(3), 93-99.
- [2] Andriichenko, L.V., & Kachanova, T.V. (2018). Formation of winter wheat grain yield in the Steppe zone of Ukraine depending on the variety, fertiliser and precursor. *Taurian Scientific Bulletin*, 100(1), 3-8.
- [3] Burykina, S., Kryvenko, A., Solomonov, R., Kapustina, G., & Drobitko, A. (2021). Efficiency of winter wheat fertilisation systems in the Steppe one of Southern Ukraine. *International Journal of Ecosystems and Ecology Science*, 11(4), 819-830. doi: 10.31407/ijees11.4.
- [4] Hanhur, V.V., & Kotliar, Y.O. (2021). Influence of predecessors on water consumption and productivity of winter wheat in the zone of the left-bank Forest-Steppe of Ukraine. *Bulletin of the Poltava State Agrarian Academy*, 1, 122-127. doi: 10.31210/visnyk2021.01.14.
- [5] Havryliuk, M.M. (2019). *Priority is given to short-stemmed varieties of winter wheat*. Retrieved from <http://hipzmag.com/tehnologii/rasteniievodstvo/prioritet-korotkosteblovimsortam-pshenitsi-ozimoyi/>.
- [6] Jodaugiene, D., Čepulienė, R., & Pranckietienė, I. (2022). Effect of biological preparations and different nitrogen fertilisation on winter wheat crop. *Chemistry Proceedings*, 10(38). doi: 10.3390/IOCAG2022-12262.
- [7] Korkhova, M., & Mykolaichuk, V. (2022). Influence of weather conditions on the duration of interphysical periods and yield of durum winter wheat. *Scientific Horizons*, 25(2), 36-46. doi: 10.48077/scihor.
- [8] Krutyakova, V. (2020). Biological method as the basis of sustainable development of domestic agriculture. *Herald of Agrarian Science*, 9(810), 5-14. doi: 10.31073/agrovisnyk202009-01.
- [9] Kudria, S. (2020). The influence of grain-beet crop rotation with different leguminous predecessors of winter wheat on the nutritive regime of typical chernozem. *Herald of Agrarian Science*, 4(805), 15-20. doi: 10.31073/agrovisnyk202004-02.

- [10] Kulkarni, S., & Goswami, A. (2019). Effect of excess fertilisers and nutrients: A review on impact on plants and human population. In *Proceedings of international conference on sustainable computing in science, technology and management (SUSCOM)* (pp. 2094-2099). Jaipur: Amity University Rajasthan.
- [11] Kryvenko, A.I., & Burykina, S.I. (2018). Productivity and quality of winter wheat under long-term use of fertilisers. *Taurian Scientific Bulletin*, 101, 68-80.
- [12] Kvasnitska, L.S., & Voitova, H.P. (2021). Effectiveness of grain crop rotations in the zone of sufficient moisture of the Right Bank Forest Steppe. *Foothill and Mountain Agriculture and Stockbreeding*, 70(1), 102-115. doi: 10.32636/01308521.2021-(70)-1-8.
- [13] Lytovchenko, A.O., Hlushko, T.V., & Sydiakina, O.V. (2017). Grain quality of winter wheat varieties depending on the factors and conditions of the year of cultivation in the southern Steppe of Ukraine. *Agrarian Bulletin of the Black Sea Littoral*, 3, 101-110.
- [14] Miroshnychenko, M., Hladkykh, Ye., & Smichenko, V. (2019). *Management of plant nutrition under conditions of stress*. Retrieved from <https://propozitsiya.com/ua/upravlenie-pitanie-rasteniy-v-usloviyah-stressa>.
- [15] Mostipan, M., Umrykhin, N., & Mytsenko, V. (2019). The interrelation between the productivity of winter wheat and weather conditions in autumn and early spring periods in the northern Steppe of Ukraine. *Știința agricolă*, 1, 10-16.
- [16] Olkhovskiy, G., Bobro, M., & Chechui, O. (2019). The detailed method for determining the structure of winter wheat crops. *Herald of Agrarian Science*, 97(12), 22-29. doi: 10.31073/agrovisnyk201912-03.
- [17] Oripov, R., & Buriev, A.A. (2021). *Soil productivity of household crops and effect on autumn wheat yield*. Termiz: Novateur Publication.
- [18] Panfilova, A., Gamajunova, V., & Smirnova, I. (2020). Influence of fertilising with modern complex organic-mineral fertilisers to grain yield and quality of winter wheat in the Southern Steppe of Ukraine. *Journal of Agricultural Science*, 2, 196-201.
- [19] Panfilova, A., & Mohylnytska, A. (2019). The impact of nutrition optimisation on crop yield of winter wheat varieties (*Triticum aestivum* L.) and modeling of regularities of its dependence on structure indicators. *Agriculture and Forestry*, 65(3), 157-171.
- [20] Panfilova, A., Korkhova, M., Gamayunova, V., Drobitko, A., Nikonchuk, N., & Markova, N. (2019). Formation of photosynthetic and grain yield of soft winter wheat (*Triticum aestivum* L.) depending on varietal characteristics and optimisation of nutrition. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 10(2), 78-85.
- [21] Pekarskas, J., Gavenauskas, A., & Dautartė, A. (2017). Biologinio preparato Fertinat įtaka vasarinių kviečių derlingumui ir kokybei. *Zemės ūkio Mokslai*, 24, 10-19. doi: 10.6001/zemesukiomokslai.v24i1.3441.
- [22] Raneesha Madushanki, A.A., Halgamuge, M.N., Surangi Wirasagoda, W.A.H., & Syed, A. (2019). Adoption of the internet of things (iot) in agriculture and smart farming towards urban greening: A review. *International Journal of Advanced Computer Science and Applications*, 10(4), 11-28.
- [23] Soto-Gómez, D., & Pérez-Rodríguez, P. (2022). Sustainable agriculture through perennial grains: Wheat, rice, maize, and other species. A review. *Agriculture, Ecosystems & Environment*, 325, 10747. doi: 10.1016/j.agee.2021.107747.
- [24] Sydiakina, O.V., & Dvoretzkyi, V.F. (2020). Productivity of winter wheat depending on the nutritional background in the conditions of the Western Polissia. *Scientific Horizons*, 7(92), 45-52.
- [25] State register of plant varieties suitable for distribution in Ukraine. (2022). Retrieved from <https://minagro.gov.ua/file-storage/reyestr-sortiv-roslin>.
- [26] Tsyliuryk, O. (2019). *Efficiency of black steam*. Retrieved from <http://agro-business.com.ua/agro/ahronomiia-sohodni/item/12606-efektyvnist-chorno-ho-paru.html>.
- [27] Tsvey, Ya., Ivanina, R., Ivanina, V., & Senchuk, S. (2021). Yield and quality of winter wheat (*Triticum aestivum* L.) grain in relation to nitrogen fertilisation. *Revista Facultad Nacional de Agronomía Medellín*, 74(1), 9413-9422.
- [28] Woźniak, A. (2019). Effect of crop rotation and cereal monoculture on the yield and quality of winter wheat grain and on crop infestation with weeds and soil properties. *International Journal of Plant Production*, 13, 177-182. doi: 10.1007/s42106-019-00044-w.
- [29] Yan, F., Zhang, F., Fan, X., Fan, J., Wang, Y., Zou, H., Wang, H., & Li, G. (2021). Determining irrigation amount and fertilisation rate to simultaneously optimize grain yield, grain nitrogen accumulation and economic benefit of drip-fertigated spring maize in northwest China. *Agricultural Water Management*, 243, article number 106440. doi: 10.1016/j.agwat.2020.106440.

Формування продуктивності пшениці озимої залежно від попередника, доз мінеральних добрив та біопрепаратів

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Анотація. Пшениця є основною сільськогосподарською культурою в багатьох країнах світу, а також основною продовольчою – у степовій зоні, тому система агротехнічних заходів повинна бути спрямована на створення сприятливих умов для отримання високої врожайності. Питання інтенсифікації виробництва зерна невіддільні від виробництва та використання нових біогенних ефективних препаратів, які позитивно впливають на ріст і розвиток культурних рослин. Метою роботи було встановити вплив позакореневого підживлення бактеріальними препаратами, попередників та доз мінеральних добрив на урожайність зерна та елементи продуктивності пшениці озимої. У статті наведено дані про результати дослідження пшениці озимої сорту Дума одеська в умовах Навчально-практичного центру Миколаївського НАУ у 2019–2021 рр. У ході проведення дослідження використовувалися загальноприйняті методи: монографічний, системний підхід і системний аналіз, аналіз і синтез, польовий та статистичний. Було проаналізовано вплив попередника, позакореневого підживлення бактеріальними сучасними біопрепаратами та застосування різних доз мінеральних добрив на елементи структури врожаю та врожайність зерна пшениці озимої. Встановлено, що рівень урожаю залежав і змінювався від попередника, взятого для позакореневого підживлення бактеріального препарату, рівня мінерального живлення і значною мірою за впливу погодних умов року вирощування. За роки досліджень, попередники, мінеральні добрива та обробка посіву рослин біопрепаратами вплинули на кількість продуктивних стебел, кількість зерен з колосу, масу зерна з одного колосу та масу 1000 зерен пшениці озимої. Проведеними дослідженнями підтверджено доцільність позакореневих підживлень в основні періоди вегетації біопрепаратами для оптимізації живлення рослин пшениці озимої з метою формування сталої врожайності зерна. Отримані наукові результати досліджень сприятимуть широкому застосуванню біопрепаратів, які забезпечать швидкий та повноцінний ріст і розвиток рослин пшениці озимої, що в подальшому сприятиме підвищенню врожайності та валових зборів зерна

Ключові слова: урожайність зерна, підживлення, продуктивні стебла, кількість зерен з 1 колосу, маса 1000 зерен