UDC: 633.11:631.811 (477.7)
DOI: 10.56407/bs.agrarian/4.2025.09

Ukrainian Black Sea Region Agrarian Science
Vol. 29, No. 4

The influence of an optimised system of mineral nutrition and biological products on the formation of winter wheat productivity in the conditions of southern Ukraine

Antonina Drobitko*
Doctor of Agricultural Sciences, Professor
Mykolaiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
https://orcid.org/0000-0002-6492-4558

Iryna Smirnova
PhD in Agriculture, Associate Professor
Mykolaiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
https://orcid.org/0000-0002-8976-3818

Tetiana Kachanova
PhD in Agricultural Sciences, Associate Professor
Mykolaiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine
https://orcid.org/0000-0003-0032-3996

Ion Bacean
Associate Professor
Technical University of Moldova
MD-2004, 168 Stefan cel Mare Boulevard, Chisinau, Moldova
https://orcid.org/0000-0001-8236-4489

Abstract. In Ukraine, one of the key tasks of agriculture is to ensure stable production of high-quality grain, which is of great importance for food security and the national economy, particularly through wheat exports. Intensification of grain production is closely associated with the introduction of modern biopreparations that significantly affect the growth and development of agricultural crops. The aim of the study was to determine the effect of mineral fertilisers and pre-sowing seed treatment with biopreparations on the productivity of winter wheat. The article presented data from research conducted at the educational, scientific and practical centre of Mykolaiv National Agrarian University during 2020-2022 on winter wheat of the variety duma odeska. The study employed generally accepted methods, including analysis and synthesis, laboratory and field experiments. It was found that yield levels were strongly influenced by the biopreparations used for pre-sowing seed treatment, the level of mineral nutrition, and the impact of climatic conditions during the growing season. Similarly, changes in grain yield under the influence of cultivation factors were reflected in the elements of yield structure. The use of biopreparations affected the yield level of winter wheat. The greatest yield increase was obtained with the biopreparation Azotofit-r, while the lowest was recorded with Phytocid-r. Grain yield significantly increased with the application of mineral fertilisers at a rate of $N_{30}P_{3}0K_{30} + N_{30}$ as early spring topdressing. The highest yield was obtained with

Article's History:
Received: 07.08.2025
Revised: 02.12.2025
Accepted: 23.12.2025

Suggested Citation:
Drobitko, A., Smirnova, I., Kachanova, T., & Bacean, I. (2025). The influence of an optimised system of mineral nutrition and biological products on the formation of winter wheat productivity in the conditions of southern Ukraine. *Ukrainian Black Sea Region Agrarian Science*, 29(4), 9-17. doi: 10.56407/bs.agrarian/4.2025.09.

*Corresponding author

seed treatment using the biopreparation Azotofit-r – 4.15 t/ha, while the lowest yield was formed in the control variant – 3.34 t/ha. The research confirmed the feasibility of pre-sowing seed treatment with biopreparations that optimise the nutrition of winter wheat for the formation of high grain yields. The obtained scientific results will contribute to wider application of biopreparations for seed treatment, ensuring rapid and full plant growth and development of winter wheat, as well as further increases in productivity and gross grain yield

Keywords: number of productive stems; 1,000-kernel weight; mineral fertilisers; grain weight per spike; yield increase

INTRODUCTION

The yield and quality of winter wheat depend on environmental conditions, farming practices, and the type and cultivar of the plants. Modern agricultural systems are aimed at minimising the costs of soil cultivation and using specialised crop rotation, which includes 2-3 types of plants that have similar cultivation technologies. However, sometimes such decisions prove to be unsuccessful, leading to a decrease in crop productivity. Research by V. Pichura *et al.* (2024) has shown that growing global demand for food is forcing agricultural producers to switch to more intensive land use, increasing the chemical load on the environment, which, in the context of climate change, can lead to depletion and deterioration of food quality, requiring a rethinking of fertiliser use and methods of justifying crop fertilisation systems. Studies by M. Korkhova *et al.* (2023) have established that wheat is the main agricultural crop in many countries around the world and the main food crop in steppe regions, so agrotechnical systems should be aimed at creating optimal conditions for high yields of this crop. Due to the growth of the world's population and the reduction of cultivated land due to military actions, there is an urgent need to find innovative approaches to increase crop productivity, which, in turn, will contribute to an increase in global food supplies. Annual fluctuations in wheat yields depend on factors such as moisture levels during the growing season, crop rotation structure, agrotechnical measures, and the type and dose of nutrients applied, which determine the effectiveness of plant growth and development.

Research by W. Jarecki (2023) has established that winter wheat is one of the most productive crops in terms of biological characteristics. It is the highest-yielding crop in the cereal group, making the most use of photosynthetically active radiation. However, its yield potential can only be achieved under certain conditions, such as normal overwintering of crops, good field preparation, moisture accumulation, and the use of agricultural practices that ensure sufficient fertilisation and the use of plant protection products against pests. S. Shahini *et al.* (2023) found that increasing yield is the main goal, but excessive fertiliser application causes environmental problems, with about 70% of the total amount of mineral fertilisers being nitrogen-containing. This pattern is observed for most soil types in the steppe regions of southern Ukraine. The first minimum is nitrogen nutrition of plants. It is recommended to partially satisfy the need for nitrogen by including legumes in the structure of cultivated areas, which tend to accumulate biological nitrogen, because it does not pollute the soil and is not lost, but is 100% utilised by plants. According to the results of research by S. Kulkarni & A. Goswami (2019), it has been established that high crop yields can only be achieved under optimal mineral nutrition conditions. The use of excessive doses of fertilisers not only fails to increase productivity, but also hinders plant growth and development. In addition, exceeding these norms has negative environmental consequences, including the accumulation of heavy metals in the soil, eutrophication of water bodies, and increased nitrate content in products. At the same time, the increase in the cost of mineral fertilisers in recent years has contributed to increased interest in the use of biological products and the expansion of areas used for organic farming. A study by Y. Domaratskyi *et al.* (2020) showed that stable crop yields can be achieved by deliberately creating optimal conditions for their growth and development throughout the growing season. It has been established that the level of soil nutrients plays an important role in the formation of wheat plants, which can be effectively adjusted by applying different doses and fertilisation schemes.

Research by G. Olkhovskyi *et al.* (2019) has shown that grain yield is determined by two main parameters: the density of productive stems and the weight of grain per ear, the structure of which depends on many components. Research by D. Jodaugiene *et al.* (2022) conducted at the experimental station of the Academy of Agriculture in 2019-2020 (Lithuania) determined that the use of biological products did not have a significant effect on seed germination, but led to an increase in the number of productive stems and tillering. The use of biological products had a positive effect on the formation of the leaf surface of winter wheat, contributed to an increase in the weight of 1,000 grains, an increase in the number of grains in the ear, and the weight of grain

from one ear. As a result, a significant increase in crop yield was recorded compared to the control variant. Research by V. Shebanin *et al.* (2025) has established that the use of biological products in the fertilisation system of grain crops enhances the effectiveness of mineral nutrition, stimulates the development of the root system, and has a positive effect on the formation of productivity elements, which is especially important for the conditions of the southern steppe of Ukraine. Research by V. Bazalii *et al.* (2020) showed that the formation of productivity and yield traits in winter wheat varieties largely depends on growing conditions. The authors note that various agronomic and environmental factors, such as nutrition, moisture, and climatic conditions, affect the morphophysiological characteristics of plants and potential yield. Scientists M. Mostipan *et al.* (2019) concluded that the productivity of winter wheat significantly depends on the weather conditions of the growing season, namely on overwintering and moisture supply to plants during the growing season.

According to the findings of A. Panfilova & A. Mohylnytska (2019) conducted in the soil and climatic conditions of the Southern Steppe of Ukraine, it was established that the application of mineral fertilisers at a rate of $N_{30}P_{30}$ before pre-sowing soil cultivation, combined with foliar feeding of winter wheat crops at the beginning of spring vegetation renewal with Escort -bio and Organic D_2 at the beginning of spring vegetation renewal contributes to the formation of the best crop structure indicators and an increase in their productive potential. Biological products stimulate the development of roots and above-ground vegetative biomass of agricultural crops, increase plant stress resistance, yield, and quality. Biological products increase the availability and speed of plant nutrient uptake by converting insoluble compounds into available forms with the help of live bacteria, providing nitrogen nutrition and protecting plants from diseases. The aim of the study was to evaluate the productivity of the Duma Odessa winter wheat variety depending on the application of different rates of mineral fertilisers and the use of biological products for pre-sowing seed treatment.

MATERIALS AND METHODS

The research was conducted during 2020-2022 at the experimental field of the Educational, Scientific, and Practical Centre of Mykolaiv National Agrarian University, located in the southern soil and climatic zone of Ukraine. The studies used the soft winter wheat variety Duma Odeska, which was included in the State Register of Plant Varieties… (2024). The integration of an optimised mineral nutrition system with biological products is in line with international approaches to preserving agrobiodiversity and greening agriculture, as defined by The Convention on Biological Diversity (1992). The recommendations for agriculture in the southern steppe zone of Ukraine were used to conduct the research, with the exception of the factors mentioned in the study. Winter wheat was sown on October 10 with a sowing rate of 4.0 million seeds per hectare.

The experimental plots were located on southern-type chernozem soils with a neutral soil solution reaction. The arable layer is characterised by a humus content of 3.3%, which provides sufficient fertility for the growth and development of winter wheat. The area of each sowing plot was 70 m^2, and the accounting area was 48 m^2; the experiment was set up with three repetitions of the variants and sequential arrangement, which minimised the influence of soil and microclimatic variability on the results of the experiment. The experimental design included the following variants: Factor A – mineral fertiliser doses: no fertiliser (control), application of $N_{30}P_{30}K_{30}$, application of $N_{30}P_{30}K_{30} + N_{30}$ in early spring fertilisation; Factor B – pre-sowing seed treatment: control (treatment with water), Phytocide-r, Azotofit-r. The influence of the biological products Azotofit-r and Phytocide-r was studied on the variety under investigation. Azotofit-r is a natural biostimulant that promotes the fixation of molecular nitrogen in the atmosphere, creates substances that promote growth, improve seed germination, enhance root system development, increase crop yield, and promote the fixation of other nutrients. Phytocide -r is a biological fungicide for the elimination of fungal and bacterial diseases, increasing resistance to adverse environmental conditions, and improving the quality of plant products. Biological preparations for pre-sowing seed treatment are used at a dose of 0.8 and 1.0 l/t, respectively.

The average number of grains in an ear was determined as the ratio of the total number of grains after threshing 25 ears to the number of ears in the analytical sample (25 pcs.). The average weight of grain per ear was calculated by dividing the weight of grain in the sheaf sample by the number of productive stems in this sample. The weight of 1,000 grains was determined in accordance with DSTU ISO 520:2015 (2016). The winter wheat harvest was recorded using a SAMPO-500 combine harvester (Finland). The experimental data obtained were processed using statistical and mathematical methods with the help of the Agrostat computer program. To assess the impact of the factors under study, analysis of variance (ANOVA) was used, and the statistical significance of the differences between the mean values of the variants was determined at a significance level of $p \leq 0.05$. The reliability of the differences between the variants was assessed by the least significant difference (LSD05).

RESULTS AND DISCUSSION

The yield of winter wheat is mainly determined by the interaction of such productivity components as the number of stems, the number of grains per ear, the weight of grain per ear, and the weight of 1,000 grains, which vary significantly depending on the fertilisation schemes used. Thus, the most productive stems were formed by plants on fertilised plots, which exceeded this indicator by 1.2 times on plots without fertilisers (Fig. 1).

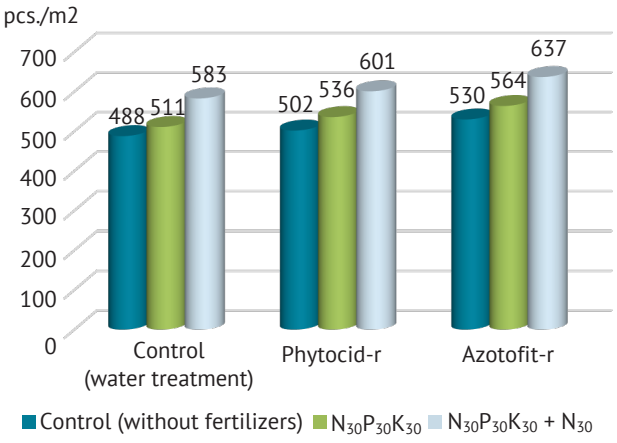

Figure 1. *Effect of mineral fertilisers and biological products on the number of productive stems in winter wheat plants (average for 2020-2022), pcs/m²*
Source: *developed by the authors*

On average, for 2020-2022, the maximum density of productive winter wheat stems was observed with pre-sowing treatment of seeds with the Azotofit-r biological product against the background of fertiliser application at the rate of $N_{30}P_{30}K_{30} + N_{30}$, reaching 637 pcs/m². When only N30P30K30 was applied, the number of productive stems was slightly lower – 601 stems/m². Pre-sowing treatment of seeds with the biological product Phytocide-r also had a positive effect on the formation of productive stems, but its effect was slightly weaker compared to Azotofit-r. These results indicate that the combination of optimal mineral nutrition with the use of biological products contributes to the intensification of growth processes and an increase in the potential yield of winter wheat. The lowest indicator when using this biological product was obtained in the control variant without fertilisers – 502 pcs/m², which is 19.7% less compared to the fertilised variant at a dose of $N_{30}P_{30}K_{30} + N_{30}$ in early spring feeding. The studies have shown that the nutrient background also affected the grain weight per ear (Fig. 2). Winter wheat plants placed on fertilised plots had the highest grain weight per year.

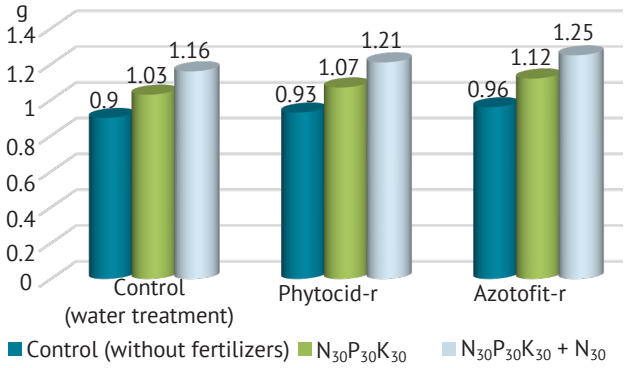

Figure 2. *The effect of nutrition and seed treatment on the weight of grain from 1 ear of winter wheat (average for 2020-2022), g*
Source: *developed by the authors*

On average, in 2020-2022, when sowing winter wheat on fertilised plots, the weight of grain per ear, depending on the use of the Azotofit-r biological product, ranged from 1.12 to 1.25 g. The effect of Azotofit-r on the grain weight per ear was also quite significant. On average, over the years of research, the most productive ears were those of plants treated with the Azotofit-r; without this agricultural measure, their weight decreased by 6.7-8.7% depending on the nutrient background. The indicator characterising grain size, i.e., the weight of 1,000 grains, also varied depending on the agricultural measures studied (Fig. 3).

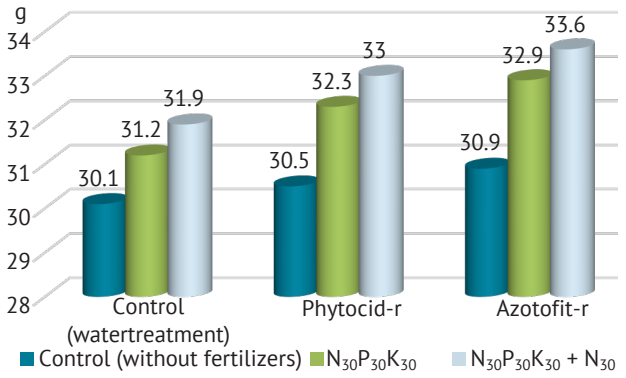

Figure 3. *The importance of nutrition and seed treatment for the weight of 1,000 grains of winter wheat (average for 2020-2022), g*
Source: *developed by the authors*

On average, for 2020-2022, when sowing winter wheat, the weight of 1,000 grains on fertilised plots exceeded this indicator compared to the plot without fertilisers, respectively, without seed inoculation by 0.4 and 0.8 g; with the use of Phytocide-r – by 1.8 and 2.5 g, and with the use of the Azotofit-r – by 2.0 and 2.7 g. The

grain density of the ear, which depends on weather conditions and agrotechnical cultivation methods, plays an important role in the formation of the yield. The results of the studies show that the number of grains in the ear of winter wheat varied depending on fertilisation – from 26.2 to 27.1 grains without seed inoculation and from 27.8 to 29.4 grains with seed inoculation, depending on the biological product studied (Fig. 4).

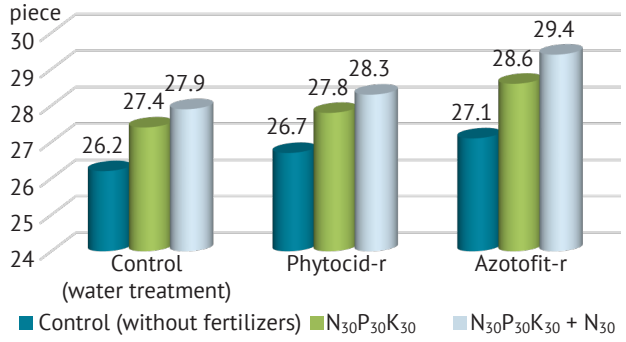

Figure 4. *Number of grains in a winter wheat ear depending on the factors studied*
Source: *developed by the authors*

The highest grain yield was observed in areas that received mineral fertilisers, with the maximum number of grains formed by plants when $N_{30}P_{30}K_{30} + N_{30}$ was applied in combination with pre-sowing treatment of seeds with the Azotofit-r. This indicator exceeded the control group without fertilisers and seed treatment with biological products by 12.2%, which emphasises the effectiveness of the combined use of mineral nutrition and biological products to increase the productivity of winter wheat. The yield of winter wheat is the final stage of plant development and fully reflects the effectiveness of the agricultural techniques used to grow it during the growing season. The interaction of plant productivity factors was shaped by a complex combination of biotic and abiotic factors affecting wheat in close interaction with the studied agricultural techniques, which led to the formation of yields of varying productivity during the study period. The analysis of the impact of the studied factors on winter wheat plants reveals patterns in crop yield formation depending on the level of nutrition and pre-sowing treatment of seeds with biological products. This approach makes it possible to evaluate the effectiveness of various fertilisation schemes and biological stimulants in ensuring high productivity and grain quality (Table 1). The data show that the average yield of winter wheat in all variants with the use of fertilisers during the years of research was 0.11-0.38 t/ha higher than in the variant without fertilisers. The greatest increase from the use of Azotofit-r was 0.43-0.50 t/ha. An increase was also observed from the use of the biological product Phytocide-r – 0.29-0.33 t/ha, which is 3.4-4.7% less than with the Azotofit-r.

Table 1. *The effect of fertiliser application and seed treatment with biological products on the yield of winter wheat variety Duma Odeska (average for 2020-2022), t/ha*

Seed treatment (factor B)	Nutritional background (factor A)	Yield, т/га	Increase from the use of biological products	
			т/га	%
Control (water treatment)	Control (no fertilisers)	3.34	-	-
	$N_{30}P_{30}K_{30}$	3.45	-	-
	$N_{30}P_{30}K_{30} + N_{30}$	3.72	-	-
Phytocide-r	Control (no fertilisers)	3.65	0.31	9.3
	$N_{30}P_{30}K_{30}$	3.78	0.33	9.6
	$N_{30}P_{30}K_{30} + N_{30}$	4.01	0.29	7.8
Azotofit-r	Control (no fertilisers)	3.83	0.49	14.7
	$N_{30}P_{30}K_{30}$	3.95	0.50	14.5
	$N_{30}P_{30}K_{30} + N_{30}$	4.15	0.43	11.6
LSD_{05}, t/ha: A – 0.24; B – 0.29; AB – 0.42				

Source: *developed by the authors*

Analysis of experimental data shows that the use of mineral fertilisers and biological products significantly affected the yield of winter wheat. The highest yield indicators (3.72-4.15 t/ha) were obtained in variants with the application of $N_{30}P_{30}K_{30}$ in combination with early spring feeding with N_{30}, which significantly ($p \leqslant 0.05$) exceeded both the control without fertilisers and the variants with basic fertilisation without feeding, since the difference between the variants exceeded the LSD_{05} value for factors A, B, and their interaction. A separate analysis of the factors showed that the use of only mineral fertilisers without pre-sowing seed treatment provided an increase in yield compared to the control, but the maximum effect was achieved with the combined use of fertilisers and biological products. Pre-sowing seed treatment with the biological products Phytocide-r and Azotofit-r contributed to an additional yield increase of 7.8-14.7%, with the greatest

effect observed in the variants with the use of Azotofit-r. The advantage of the Azotofit-r biological product is explained by its ability to activate associative nitrogen fixation, improve the supply of available forms of nitrogen to plants in the early stages of organogenesis, and stimulate the development of the root system. This, in turn, increases the efficiency of mineral nutrition, as confirmed by the maximum yield of 4.15 t/ha in the $N_{30}P_{30}K_{30} + N_{30}$ variant in combination with pre-sowing treatment of seeds with Azotofit-r.

The complex effect of fertilisers and biological products was probably achieved not only through an increase in overall productivity, but also through an improvement in the structural elements of the crop, in particular the formation of a greater number of productive stems and an increase in grain weight per ear. Research by L. Marcińska-Mazur & M. Mierzwa-Hersztek (2023) showed that both a deficiency and an excess of nutrients have a negative impact on soil condition. The rational use of fertilisers aimed at increasing crop yields replenishes nutrients in the soil, which stimulates plant growth and development and increases the quantity and quality of the harvest. At the same time, excessive fertilisation can lead to contamination of groundwater and surface water and loss of nutrients through leaching into deeper soil layers. Therefore, to ensure sustainable agricultural production and environmental protection, fertilisers should be applied in optimal doses. The effectiveness of Azotofit-r on southern black soil depends on its average fertility level. The highest effectiveness was recorded on plots without mineral fertilisers, where yield increases were minimal and ranged from 0.18 to 0.30 t/ha. When using an ineffective predecessor, even with minimal fertilisation rates, a slightly higher but still limited increase was observed – about 0.35 t/ha. At the same time, with the background application of $N_{64}P_{64}K_{64}$ fertilisers during the cultivation of the Knopa variety on black fallow, stable yield increases of 0.19-0.26 t/ha were noted, indicating a moderate but positive response of the crop to nutrition and a more favorable agricultural background. These results indicate a significant influence of the predecessor and the level of mineral nutrition on the productivity of the variety, as well as the need to optimise the fertilisation system depending on the growing conditions.

Based on the results of 14 years of research (2007-2020), S. Burykina *et al.* (2021) established the effectiveness of applying a fertilisation system for winter wheat in the southern regions of Ukraine. The application of fertilisers at a rate of $N_{180}P_{60}K_{60}$ led to an increase in grain yield by 2.24 t/ha compared to the variant without fertilisers, which emphasises the significant positive effect of optimal mineral nutrition on crop productivity. The formation of winter wheat grain yield is determined by the interaction of various productivity factors, in particular the number of productive straws, the weight of 1,000 grains, their size and quality (Olkhovskyi *et al.*, 2019; Tsvey *et al.*, 2021). According to research by M. Lozinskiy *et al.* (2021), the weight of grain on a single ear, which reflects its productivity, directly depends on the effectiveness of that ear. Undoubtedly, the main ear is of key importance in determining the productivity and yield of wheat grain, as it is the result of the interaction of many genetic factors that determine its quality and quantity. The results of studies by N. Pinchuk *et al.* (2022) showed that treating Skagen winter wheat seeds with biological products before sowing led to an increase in stem density compared to the control variant. The use of the Azotofit-r biological product for pre-sowing treatment against the background of adding $N_{30}P_{30}K_{30} + N_{30}$ in spring fertilisation showed a stem density of 637 pcs/m^2, which is 20.2% higher than in experiments without fertiliser application.

The use of biological products significantly affects the weight of 1,000 grains and the yield of winter wheat. The highest weight of 1,000 grains (38.7 g) was recorded when treating seeds with the Organic Balance biological product for the Duma Odeska variety, which is 13.2% higher than the results of treatment with the Azotofit -r against the background of $N_{30}P_{30}K_{30} + N_{30}$ application in early spring fertilisation. The use of biological products also has a positive effect on the overall productivity of the crop: the maximum yield was obtained after black fallow treated with Organic Balance, and for the Duma Odessa variety it was 7.19 t/ha, which is 30.3% higher than the variant without fertilisers. These results highlight the effectiveness of the combined use of biological products and agrotechnical measures to increase the productivity of winter wheat. D. Jodaugiene *et al.* (2022) found that the use of biological products does not significantly affect seed germination, but contributes to an increase in tillering, leaf area, number of productive stems, weight of 1,000 grains, weight of grain from the ear, and grain yield compared to the control variant. Thus, the studied biological products for pre-sowing seed treatment significantly affect key indicators of winter wheat productivity, in particular the number of productive stems, grain weight per ear, yield, and weight of 1,000 grains, contributing to an increase in the overall efficiency of crop cultivation.

CONCLUSIONS

Studies conducted in the southern regions of Ukraine during 2020-2022 showed that winter wheat productivity directly depends on the availability of nutrients and the use of pre-sowing seed treatment with biological

products. The use of biological products had a significant impact on crop yields: among the products studied, Azotofit-r provided the highest yield increase, while Phytocide-r showed the least effect. In addition, a significant increase in grain yield was observed when mineral fertilisers were applied at a rate of $N_{30}P_{30}K_{30}+N_{30}$ in early spring fertilisation, which contributed to active growth and the formation of productive stems.

The yield of winter wheat was largely determined by the interaction of productivity components, such as the number of productive stems, the number of grains per ear, the weight of grain per ear, and the weight of 1,000 grains, which varied significantly depending on the type of fertiliser applied. Plants that received mineral fertilisers at a rate of $N_{30}P_{30}K_{30}+N_{30}$ in combination with pre-sowing treatment of seeds with the biological product Azotofit-r formed the maximum number of productive stems – 637 pcs/m^2. Pre-sowing treatment of seeds with the biological product Phytocide-r also had a positive effect on this indicator, providing 601 pcs/m^2, which is 23.2% higher than the control. The weight of grain from one ear varied from 1.07 to 1.25 g depending on the use of biological products and mineral nutrition. The highest grain yield was observed in areas with a combination of fertilisation and pre-sowing treatment of seeds with biological products, where the number of grains per ear ranged from 27.8 to 29.4.

The results of the studies showed that the use of the Azotofit-r biological product during the cultivation of the Duma Odeska winter wheat variety ensures maximum yield – 4.15 t/ha, while in the control variant it was 3.34 t/ha. This emphasises the significant role of pre-sowing seed treatment with biological products in optimising plant nutrition and increasing grain yield. In the future, it is planned to study the combined effect of mineral fertilisers and biological products on pre-sowing seed treatment in order to assess their impact on grain quality characteristics, which will allow for a more detailed description of the productive and technological properties of winter wheat varieties.

ACKNOWLEDGEMENTS

None.

FUNDING

None.

CONFLICT OF INTEREST

None.

REFERENCES

[1] Bazalii, V., Boichuk, I.V., Lavrynenko, Y.O., Bazalii, H.H., Domaratskyi, Y.O., & Larchenko, O.V. (2020). Features of the formation of productivity signs of the yielding capacity in winter wheat varieties under different growing conditions. *Factors of Experimental Evolution of Organisms*, 27, 29-34. doi: 10.7124/FEEO.v27.1298.

[2] Burykina, S., Kryvenko, A., Solomonov, R., Kapustina, G., & Drobitko, A. (2021). Efficiency of winter wheat fertilisation systems in the steppe zone of southern Ukraine. *International Journal of Ecosystems and Ecology Science (IJEES)*, 11(4), 819-830. doi: 10.31407/ijees11.4.

[3] Convention on Biological Diversity. (1992, June). Retrieved from https://www.cbd.int/convention/.

[4] Domaratskyi, Y., Mialkovskyi, R., Koberniuk, O., Muliarchuk, O., & Bezvikonnyi, P. (2020). Analysis of the dependence of winter wheat yielding capacity formation on mineral nutrition in irrigation conditions of southern steppe of Ukraine. *Independent Journal of Management & Production*, 11(8), 751-761. doi: 10.14807/ijmp.v11i8.1036.

[5] DSTU ISO 520:2015. (2016). *Cereals and legumes. Determination of the mass of 1000 grains.* Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=86231.

[6] Jarecki, W. (2023). Effects of sowing date variation on winter wheat (*Tritium aestivum* L.) quality and grain yield. *Journal of Elementology*, 28(4), 1089-1100. doi: 10.5601/jelem.2023.28.2.2403.

[7] Jodaugiene, D., Čepulienė, R., & Pranckietiene, I. (2022). Effect of biological preparations and different nitrogen fertilisation on winter wheat crop. *Chemistry Proceedings*, 10(1), article number 38. doi: 10.3390/IOCAG2022-12262.

[8] Korkhova, M., Smirnova, I., Panfilova, A., & Mykolaichuk, V. (2023). Influence of varietal characteristics of winter wheat and weather conditions on lodging resistance and productivity. *Scientific Horizons*, 26(12), 42-53. doi: 10.48077/scihor12.2023.42.

[9] Kulkarni, S., & Goswami, A. (2019). Effect of excess fertilizers and nutrients: A review on impact on plants and human population. In *Proceedings of international conference on sustainable computing in science, technology and management* (pp. 2094-2099). Jaipur: Amity University Rajasthan.

[10] Lozinskiy, M., Burdenyuk-Tarasevych, L., Grabovskyi, M., Lozinska, T., Sabadyn, V., Sidorova, I., Panchenko, T., Fedoruk, Y., & Kumanska, Y. (2021). Evaluation of selected soft winter wheat lines for main ear grain weight. *Agronomy Research*, 19(2), 540-551. doi: 10.15159/AR.21.07.

[11] Marcińska-Mazur, L., & Mierzwa-Hersztek, M. (2023). Enhancing productivity and technological quality of wheat and oilseed rape through diverse fertilisation practices – an overview. *Journal of Elementology*, 28(3), 717-771. doi: 10.5601/jelem.2023.28.3.3042.

[12] 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. *Ştiinţa Agricolă*, 1, 10-16.

[13] Olkhovskyi, G., Bobro, M., & Chechui, O. (2019). The detailed method for determining the structure of winter wheat crops. *Bulletin of Agricultural Science*, 97(12), 22-29. doi: 10.31073/agrovisnyk201912-03.

[14] 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. doi: 10.17707/AgricultForest.65.3.13.

[15] Pichura, V., Potravka, L.A., Domaratskiy, Y., Nikonchuk, N., & Samoilenko, M. (2024). The impact of pre-crops on the formation of water balance in winter wheat agrocenosis and soil moisture in the steppe zone. *Journal of Ecological Engineering*, 25(3), 253-271. doi: 10.12911/22998993/181553.

[16] Pinchuk, N.V., Vergeles, P.M., Kovalenko, T.M., & Amons, S.E. (2022). The effectiveness of the use of biological preparations in winter wheat crops in the conditions of the right bank forest steppe. *Agriculture and Forestry. Plant Protection*, 1(24), 96-113. doi: 10.37128/2707-5826-2022-1.

[17] Shahini, S., Kachanova, T., Manushkina, T., Petrova, O., & Shevchuk, N. (2023). Using organic nitrogen fertilisers to improve soil health and increase yields. *International Journal of Environmental Studies*, 80(2), 433-441. doi: 10.1080/00207233.2023.2174739.

[18] Shebanin, V., Gamayunova, V., Drobitko, A., Smirnova, I., & Khonenko, L. (2025). Use of biologisation elements in the cultivation of grain and industrial crops to obtain high-quality products and preserve the environment. *Scientific Horizons*, 28(5), 32-43. doi: 10.48077/scihor5.2025.32.

[19] State Register of Plant Varieties Suitable for Distribution in Ukraine for 2024. (2024). Retrieved from https://minagro.gov.ua/file-storage/reyestr-sortiv-roslin.

[20] 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. doi: 10.15446/rfnam.v74n1.88835.

Вплив оптимізованої системи мінерального живлення та біопрепаратів на формування продуктивності пшениці озимої в умовах півдня України

Антоніна Дробітько
Доктор сільськогосподарських наук, професор
Миколаївський національний аграрний університет
54008, вул. Георгія Ґонґадзе, 9, м. Миколаїв, Україна
https://orcid.org/0000-0002-6492-4558

Ірина Смірнова
Кандидат сільськогосподарських наук, доцент
Миколаївський національний аграрний університет
54008, вул. Георгія Ґонґадзе, 9, м. Миколаїв, Україна
https://orcid.org/0000-0002-8976-3818

Тетяна Качанова
Кандидат сільськогосподарських наук, доцент
Миколаївський національний аграрний університет
54008, вул. Георгія Ґонґадзе, 9, м. Миколаїв, Україна
https://orcid.org/0000-0003-0032-3996

Іон Байсен
Доцент
Технічний університет Молдови
MD-2004, бульв. Штефан чел Маре, 168, м. Кишинів, Молдова
https://orcid.org/0000-0001-8236-4489

Анотація. В Україні одним із ключових завдань сільського господарства є забезпечення стабільного виробництва якісного зерна, що має важливе значення для продовольчої безпеки та економіки країни, зокрема через експорт пшениці. Інтенсифікація зерновиробництва тісно пов'язана із впровадженням сучасних біопрепаратів, які істотно впливають на ріст і розвиток сільськогосподарських культур. Метою роботи було встановити дію мінеральних добрив та обробки насіння перед сівбою біопрепаратами на продуктивність пшениці озимої. В статті наведено дані результатів досліджень, проведених в умовах Навчально-науково-практичного центру Миколаївського національного аграрного університету впродовж 2020-2022 рр. з пшеницею озимою сорту Дума одеська. При проведенні дослідження використані загальноприйняті методи: аналіз і синтез, лабораторний та польовий. Було виявлено, що на рівень врожайності сильно впливали біопрепарати, які використовувалися для обробки насіння перед сівбою, рівень мінерального живлення та вплив кліматичних умов вегетаційного періоду. Аналогічно, зміни врожайності зерна під впливом факторів вирощування також змінювали елементи структури врожаю. Використання біопрепаратів вплинуло на рівень урожайності пшениці озимої. Найбільший приріст урожаю отримано під дією біопрепарату Азотофіт-р, а найнижчу – Фітоцид-р. Рівень урожаю зерна суттєво підвищився за внесення мінеральних добрив у дозі $N_{30}P_{30}K_{30} + N_{30}$ у ранньовесняне підживлення. Найбільшу врожайність отримано за обробки біопрепаратом Азотофіт-р – 4,15 т/га, а найменшу врожайність було сформовано у контрольному варіанті – 3,34 т/га. Дослідження підтвердили доцільність обробки насіння біопрепаратами перед сівбою, які оптимізують живлення пшениці озимої для формування високих врожаїв зерна. Отримані наукові результати сприятимуть більш ширшому застосуванню біопрепаратів для обробки насіння, що забезпечить швидкий і повноцінний ріст та розвиток рослин озимої пшениці, подальше збільшення продуктивності та валового збору зерна

Ключові слова: кількість продуктивних стебел; маса 1 000 зерен; мінеральні добрива; маса зерна з колоса; збільшення врожайності