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Economic efficiency of growing winter barley in the Southern Steppe zone of Ukraine under the influence of variety and biological preparations

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Abstract. The relevance of the article lies in the determination of the most optimal varieties and biopreparations that ensure high yield and profitability of growing winter barley. The purpose of the research was to determine the main indicators of the economic efficiency of the elements of the technology of growing winter barley for foliar fertilizing of plants in the main periods of vegetation with biological preparations. When conducting research, generally accepted methods were used: systematic approach and systematic analysis, field and statistical. The article provides data on the economic efficiency of the elements of winter barley cultivation technology based on the results of research conducted with four varieties of the crop in the conditions of the Educational and Scientific Practical Center of the Mykolaiv National Agrarian University in 2016-2019. The impact of variety selection, foliar fertilizing with modern bacterial preparations on the main indicators of the economic efficiency of growing winter barley was analysed. It was established that the cost of the grown grain depended on and changed under the influence of the features of the variety, biological preparation and the number of fertilizing. Obtaining the maximum cost of grain ensured the cultivation of winter barley varieties Valkyrie and Oscar for carrying out foliar feeding in the phase of tillering and emergence of plants in the tube with the biological preparation Organic Balance: 26.5 and 26.3 thousand hryvnias/ha, respectively. The same varieties, in case of two-time fertilization with Azotophyt, formed the value of grain at 25 thousand UAH/ha, and in controls – 20.1 and 21.1 thousand UAH/ha, respectively. Indicators of conditional net profit and level of profitability also changed with a similar dependence. Values of the cost of growing a unit of production of winter barley had the opposite dependence. The obtained scientific research results and definitions will contribute to the cultivation of winter barley on the basis of resource conservation with the use of biological preparations to increase productivity and the main factors of economic efficiency

Keywords: cost of grown grain; conditional net profit; level of profitability; cost of growing a unit of production

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INTRODUCTION

Technological measures in the cultivation of any culture should ensure economy, ease of use, obtaining stable productivity while simultaneously forming optimal indicators of economic efficiency. The specified factors, the selection of varieties and the possibility of optimizing nutrition on a resource-saving basis determine the relevance of this article. Winter barley in Ukraine, and in particular in the Southern Steppe zone, is an important crop of the grain wedge, it significantly increases productivity by optimizing nutrition, which in turn affects the overall costs and profitability of cultivation.

It is possible to significantly improve plant nutrition, to obtain a high yield with at the same time high-quality indicators of grain at low costs. It is appropriate to effectively manage the processes of forming the productivity of winter barley on a resource-saving basis through the use of optimization of nutrition with modern biological preparations in the main periods of plant growth and development. In addition to having a beneficial effect on growth processes and increasing the yield level, each element of cultivation technology must be economically feasible and ensure profitability and profitability, that is, not significantly increase costs and unit cost of production.

O. Vinyukov *et al.* (2021) have established with their own studies that inoculation of seeds with a microbiological preparation in the technologies of growing winter wheat helps to increase the supply of nutrients to plants that stimulate the development of plants during the growing season, and, as a result, increased the parameters of the crop structure. Based on the results of research by I. Mosiychuk *et al.* (2022), who conducted research with biological preparations Oracle multicomplex, Vimpel 2 and a mixture of preparations Vimpel 2 + Oracle multicomplex, formed the opinion that biological preparations significantly affect the sowing quality of spring barley seeds of the Sebastian and Helios varieties. The most effective is the use of a mixture of drugs Vimpel 2 + Oracle multicomplex, that is, the use of biological drugs in a complex increased growth processes, and also increased the energy of germination and laboratory germination of seeds.

Yu. Mashchenko *et al.* (2023) believe that the yield of winter wheat in grain-steam-row crop rotation when using the organo-mineral fertilization system with the biopreparation Mikofrend was 6.18 t/ha, and the increase from mineral fertilizers was 0.56 t/ha. A significant increase in yield was obtained due to the biological preparation, which was recorded in the version without fertilizers – 0.45 t/ha. That is, scientists have confirmed that the use of a biological preparation significantly increased the yield. A number of authors, I. Kohut *et al.* (2021) determined the influence of growth regulators on the productivity of winter barley sowing Highlight in the conditions of the Southern Steppe of Ukraine. Thus, the use of the scheme with Chlormequat chloride at a dose of 1.5 l/ha and Terpal at a dose of 1.0 l/ha led to a lengthening of interphase periods, which in turn led to the longest vegetation period of winter barley in this experiment – 169 days. Application of Terpal at a dose of 2.0 l/ha shortened the vegetation period by 2 days compared to the first scheme. Winter barley completed the growing season the fastest in the control variant, where the length of the growing season was 156 days.

The author O. Makuha (2021) reports in her research that when spring barley seeds are treated with the phosphate-mobilizing biopreparation albobacterin, the increase in net profit compared to the control variant varied from UAH 851/ha in the Sovira variety to UAH 1,011/ha in the variety Helot. At the same time, the increase in profitability ranged from 4.9% to 5.6%, depending on the variety. Under the influence of the biological preparation polymyxobacterin, an even higher increase in net profit was observed for the specified varieties, namely UAH 1,303/ha and UAH 1,704/ha, respectively. The level of profitability also increased, being 7.6% and 9.5%, respectively, for these varieties.

Among the most cost-effective components of the cultivation technology of any crop should be the selection of the variety. It should be adapted to a certain zone, provide a high yield potential, and for winter barley also be frost-resistant, have signs of resistance to adverse environmental conditions and changes in soil and climatic conditions. After all, under absolutely identical growing conditions, the realization of the genetic potential of productivity within varieties can manifest itself and differ significantly. The listed studies contributed to the development of the topic, but the most productive varieties and biological preparations for foliar feeding of plants during important phases of their vegetation have not yet been determined. That is why the purpose of the research was to substantiate the economic aspects of the introduction of the use of biological preparations on winter barley varieties during the main periods of plant growth and development.

MATERIALS AND METHODS

The research was conducted with winter barley during 2016-2019 at the Educational and Scientific Practical Center of the Mykolaiv National Agrarian University. The scheme of the experiment included the following options: Factor A – varieties of winter barley: Worthy, Valkyria, MIP Oscar and MIP Yason; Factor B – biological preparations: control (water treatment), Azotophyt, Mycofriend, Melanoriz, Organic balance (Table 1).

Table 1. *Scheme of the experiment*

Factor A – varieties:	**Factor B – biologics:**
Worthy (st)	Control (water treatment)
Valkyrie	Azotophyt
MIP Oscar	Mycofriend
MIP Yason	Melanoriz
	Organic balance

Source: *developed by the authors*

The research material was four varieties of winter barley presented by leading institutions of Ukraine: Dostoiny and Valkyrie from the Breeding and Genetic Institute – National Center for Seed Science and Varietal Research in Odesa, which are recommended for all zones of Ukraine since 2014. Additionally, MIP Oscar and MIP Yason are represented by the Myroniv Wheat Institute named after V.M. Crafts of the National Academy of Agrarian Sciences of Ukraine and included in the register of plant varieties of Ukraine in 2016-2017 (State register of plant varieties, 2023). In the experiment, the effect of four biopreparations, namely Azotophyt, Mycofriend, Melanoriz, and Organic Balance, was studied on the specified varieties of winter barley.

Azotophyt is a systemically acting biological preparation that contains natural *Azotobacter bacteria chroococcum* and biological products of their vital activity. It stimulates the development of the root system of plants, strengthens their immune system, improves the quality of the soil, helps to increase the yield and increases the nitrogen content in the soil. Mycofriend is a mycorrhizal biopreparation containing *Glomus fungi sp.*, rhizosphere microorganisms that contribute to the formation of mycorrhizae. Also included are phosphate-mobilizing bacteria and bacteria with fungicidal properties. Melanoriz is a complex mycorrhizal preparation created to nourish plants and protect them from diseases. It contains mycorrhizal fungi *Glomus, Aspergillus terreus, Trichoderma lignorum, Trichoderma viride,* which help plants absorb nutrients and protect them from diseases. Organic balance is a biological preparation that stimulates the growth and development of agricultural crops, provides stress resistance and balanced nutrition. It contains a concentrated mixture of live producer bacteria that provide plants with nitrogen, phosphorus and potassium, and also have fungicidal properties to protect plants from bacterial and fungal diseases. The research was conducted during 2017-2018 and 2018-2019, and the drugs were used at a dose of 200 g/ha, while the working solution was 200 l/ha.

Foliar fertilizing of winter barley was carried out at specific moments of the growing season. The first additional feeding took place during the spring tillering of the plants, and the second and third feeding took place after tillering, at the beginning of the emergence of the plants in the tube. The soil on the experimental sites was southern chernozem, with an average concentration of mobile nutrients. The content of organic matter in the 0-30 cm soil layer was 2.9-3.2%, and the pH ranged from 6.8 to 7.2. The area of the sowing plot was 72 m^2, while the area of the accounting plot was 30 m^2, and the experiment was conducted using four times repetition. The predecessor for sowing winter barley was peas. All varieties of barley were sown in accordance with the optimal terms for this climatic zone. Taking into account information about the predecessor and the level of soil nutrition, no mineral fertilizers were used, and the method of growing winter barley corresponded to the generally accepted for the Southern Steppe of Ukraine, except for the factors that were the object of study.

The cost of gross production was determined by multiplying the yield of the crop by the price of 1 ton of grain. The cost of cultivation was determined by dividing production costs by yield. Conventionally, the net profit was determined by the difference between the cost of gross products and production costs. The level of profitability is by dividing net profit by production costs. In order to assess the economic efficiency of growing winter barley varieties under the influence of foliar fertilizing with biological preparations and justifying the expediency of the researched factors, technological maps were drawn up and calculations were made of the cost of products, production costs for cultivation, cost price, conditional net profit and the level of profitability (at the prices of 1.12. 2022).

Experimental plant studies, including the collection of plant material, conformed to the principles established by the relevant institutional, national or international standards. The authors followed the requirements and provisions of the Convention on the Conservation of Biological Diversity (1992), as well as the Convention on Trade in Endangered Species of Wild Fauna and Flora (1979).

RESULTS AND DISCUSSION

The economic efficiency of the use of biological preparations for the researched varieties of winter barley was determined: the cost of gross production, the cost of growing a unit of production, the level of profitability of production. It has been established that the use of complex biological preparations twice in the main periods of winter barley plant development (in the phase of spring tillering and at the beginning of the emergence

of plants into the tube) increases the efficiency of crop cultivation and ensures an increase in the level of profitability. During the research, there was also determined that the cost of gross production for the cultivation of winter barley varied to a certain extent depending on the varietal composition and biological preparations, which is associated with fluctuations in the levels of grain yield according to the variants. With fertilizing, and especially in both phases, this indicator increased regardless of the variety (Table 2).

Table 2. *The cost of gross production when growing winter barley grain depending on the variety and biological preparations (average for 2017-2019), thousand UAH/ha*

Feeding option (factor B)	Variety (factor A)				
	Worthy	Valkyrie	Oscar	Jason	the average factor B
CONTROL (water treatment)	18.7	20.1	21.1	18.4	19.6
Azotophyt I	21.4	24.0	24.2	20.6	22.5
Azotophyt I+II	22.6	25.0	25.0	22.3	23.7
Mikofrend I	21.2	22.8	23.1	20.1	21.8
Mycofriend I+II	21.6	23.7	24.5	20.8	22.7
Melanoriz I	19.8	21.3	22.3	19.2	20.6
Melanoriz I+II	20.3	22.5	22.8	20.3	21.5
Organic balance I	20.4	25.2	25.8	22.6	23.5
Organic balance I+II	21.4	26.5	26.3	23.5	24.4
Average factor A	20.8	23.4	23.9	20.9	22.3

Notes: *Period of foliar fertilization: I – in the phase of spring tillering; I+II – in the phase of tillering and at the beginning of the emergence of plants into the tube*
Source: *developed by the authors*

In the control, and especially with the cultivation of the Yason variety, this indicator was the lowest – 18.4 thousand UAH/ha, and when using the biological preparation Organic-Balance on sowing the Valkyria variety in both phases, it increased to 26.5 thousand UAH/ha or by 44 .0% and was the maximum. Cultivation of the Oscar variety provided these indicators at the levels of 26.3 thousand UAH/ha and 42.9%. The highest value of gross production on average for all variants over the years of research – 23.9 thousand hryvnias/ha was provided by the cultivation of the Oscar winter barley variety. In the Valkyrie variety, it was 23.4 thousand hryvnias/ha, and in the Dostoiny variety, it decreased to 20.8 thousand hryvnias/ha, or by 14.9%. It was determined almost the same for the cultivation of Yason winter barley – 20.9 thousand hryvnias/ha.

Fertilization with Organic-Balance biological preparation twice during the growing season ensured an increase in the value of gross production for all varieties to UAH 24.4 thousand/ha, which is 24.5% more compared to the control option (treatment of crops with water). The effectiveness of the use and advantages of biological preparations, which are taken for research, is illustrated in Fig. 1, which shows the average values of the cost of grown products for carrying out one and two treatments of weeding plants.

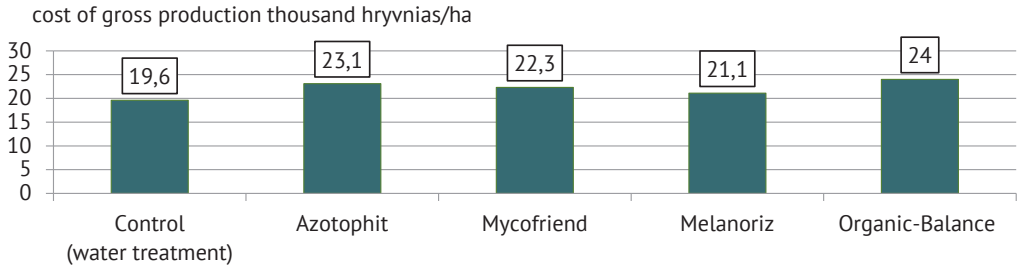

Figure 1. *Cost of gross production under the influence of biological preparations (average by varieties for 2017-2019), thousand UAH/ha*
Note: **Organic balance for 2018-2019*
Source: *developed by the authors*

The cost of growing 1 ton of winter barley grain is a minimum of UAH 1.7 thousand. determined by the Valkyrie variety after a one-time sowing treatment with the drug Azotophyt (Table 3).

This indicator increased to 2.29 thousand hryvnias/t or by 32.9% when growing the Yason variety treated with the same biological preparation in the spring budding phase.

Table 3. *Cost of growing 1 ton of winter barley grain depending on the influence of the studied factors (average for 2017-2019), thousand UAH*

Feeding option (factor B)	Variety (factor A)				
	Worthy	Valkyrie	Oscar	Jason	The average factor B
CONTROL (water treatment)	1.99	1.87	1.80	2.02	1.92
Azotophyt I	2.20	1.70	1.98	2.29	2.04
Azotophyt I+II	2.21	1.74	1.72	2.23	1.98
Mikofrend I	2.06	1.92	1.90	2.16	2.01
Mycofriend I+II	2.14	1.97	1.91	2.22	2.06
Melanoriz I	2.19	2.05	1.96	2.25	2.11
Melanoriz I+II	2.27	2.07	2.04	2.27	2.16
Organic balance I	2.13	1.76	1.72	1.94	1.89
Organic balance I+II	2.16	1.78	1.79	1.99	1.93
Average factor A	2.15	1.87	1.87	2.15	2.01

Notes: *Period of foliar fertilization: I – in the phase of spring tillering; I+II – in the phase of tillering and at the beginning of the emergence of plants into the tube*
Source: *developed by the authors*

According to the varietal composition, the Valkyria and Oscar varieties provided the advantage in forming the minimum values of the cost of production of 1 ton of grain at the level of UAH 1.87 thousand. For the cultivation of other researched varieties, this indicator increased to UAH 2.15 thousand/t or by 14.9%. On average, based on the nutritional background (factor B), the lowest cost of growing 1 ton of grain of the studied crop at the level of UAH 1.89 thousand was determined by the option of using the drug Organic-Balance once in the tillering phase. This indicator increased by 14.2% (up to 2.16 thousand hryvnias/t) during two-time feeding with the drug Melanoriz. In the conditions of a market economy, one of the main criteria for the economic efficiency of technological processes is the obtaining of conditional net profit and the level of profitability. A comparison of indicators of conditional net profit shows that it was the lowest (10,000 hryvnias/ha) when growing the Yason variety with a one-time feeding with the biopreparation Melanoriz during the tillering phase (Table 4). A significant increase of this indicator to 16.4 thousand hryvnias/ha or by 64.0% was provided by the Valkyrie variety after two-time treatment of crops with the biological preparation Organic-Balance.

Table 4. *Conditionally net profit when growing winter barley grain depending on the variety composition and biological preparations (average for 2017-2019), thousand UAH/ha*

Feeding option (factor B)	Variety (factor A)				
	Worthy	Valkyrie	Oscar	Jason	the average factor B
CONTROL (water treatment)	10.8	12.1	13.0	10.5	11.6
Azotophyt I	11.4	15.3	14.0	10.6	12.8
Azotophyt I+II	12.0	15.7	15.8	11.7	13.8
Mikofrend I	11.9	13.5	13.8	10.9	12.5
Mycofriend I+II	11.8	13.8	14.6	11.0	12.8
Melanoriz I	10.6	12.0	13.0	10.0	11.4
Melanoriz I+II	10.5	12.6	12.9	10.5	11.6
Organic balance I	11.1	15.8	16.3	13.2	14.1
Organic balance I+II	11.6	16.4	16.3	13.5	14.4
Average factor A	11.3	14.1	14.4	11.3	12.8

Notes: *Period of foliar fertilization: I – in the phase of spring tillering; I+II – in the phase of tillering and at the beginning of the emergence of plants into the tube*
Source: *developed by the authors*

The average factorial values proved the advantage of growing the Oscar variety, which provided an increase in conditional net profit to UAH 14.4 thousand/ha, which was 27.4% higher than the level of the Dostoiny and Yason varieties, which generated a profit of UAH 11.3 thousand/ha Ha. With regard to factor B (nutritional background), the advantage of two-time feeding of crops with the preparation Organic-balance, which contributed

to the growth of the studied indicator to 14.4 thousand hryvnias/ha, was substantiated. The minimum level of conditional net profit (11.4 thousand hryvnias/ha) was provided by one-time feeding with the biological preparation Melanoriz. A clear confirmation of the advantages of the biological preparation Organic-Balance and, conversely, the lowest efficiency in ensuring the conditional net profit from Melanoriz, are the data in Figure 2.

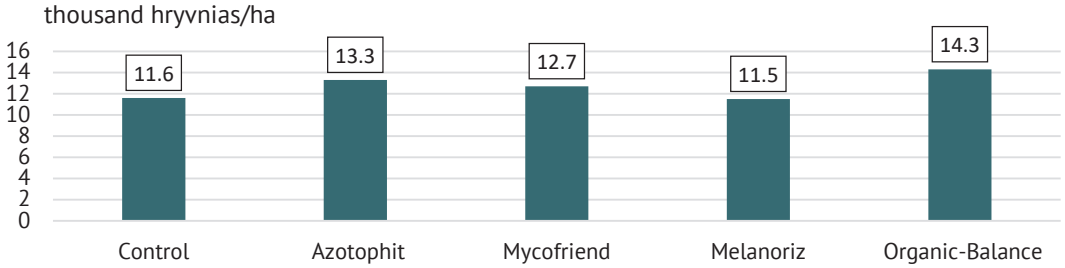

Figure 2. *Conditional net profit depending on the biological preparation (average by varieties for 2017-2019), thousand UAH/ha*

Source: *developed by the authors*

An important indicator of economic efficiency is the profitability of culture production. The level of profitability of the elements of the winter barley grain cultivation technology, depending on the varietal composition and biological preparations, ranged from 105.4% in the version with the Yason variety for a one-time sowing treatment with the biological preparation Azotophyt. In the Valkyrie variety, in the same variant, it increased to 177.1%, or the difference between these identical variants of feeding with Azotophyt in the phase of spring tillering was 68.0 relative percent (Table 5).

Table 5. *The level of profitability of winter barley grain cultivation technology depending on the variety composition and biological preparations (average for 2017-2019), %*

Feeding option (factor B)	Variety (factor A)				
	Worthy	Valkyrie	Oscar	Jason	average by factor B
CONTROL (water treatment)	136.2	150.9	160.5	133.2	145.2
Azotophyt I	113.4	177.1	136.8	105.4	133.2
Azotophyt I+II	113.0	170.7	172.7	110.3	141.7
Mikofrend I	128.2	144.2	147.4	118.0	134.5
Mycofriend I+II	119.4	138.8	146.0	111.9	129.0
Melanoriz I	114.8	129.6	139.2	108.7	123.1
Melanoriz I+II	107.1	127.6	130.6	107.1	118.1
Organic balance I	120.4	167.6	172.5	142.0	150.6
Organic balance I+II	117.6	163.3	162.1	136.2	144.8
Average factor A	118.9	152.2	152.0	119.2	135.6

Notes: *period of foliar fertilization: I – in the phase of spring tillering; I+II – in the phase of tillering and at the beginning of the emergence of plants into the tube*

Source: *developed by the authors*

On average, in relation to the varietal composition, the studied indicator reached the highest level of 152.0 and 152.2% for the cultivation of Oscar and Valkyria varieties, respectively. The Dostoiny and Yason varieties have a significantly lower profitability level of 118.9; 119.2% or 27.5-28.0 relative percent less compared to the Valkyrie and Oscar varieties. According to feeding options, the lowest level of profitability was determined on an average of 118.1% for two-time use for feeding the drug Melanoriz. This indicator exceeded 150% for a one-time feeding with the biological preparation Organic-Balance. This testifies to the high economic efficiency of foliar fertilizing of plants of winter barley varieties with the biological preparation Organic-Balance, and the use in both phases is 144.8%.

It should also be noted that the use of Organic Balance for top dressing, especially in the spring tillering phase, increased the profitability levels of the production of all studied varieties of winter barley, except for the Dostoiny variety, the cultivation of which achieved the highest profitability in the control option for the treatment of sowing plants with water without the use of biological preparations. The reaction of winter barley varieties to foliar fertilizing is presented in Figure 3.

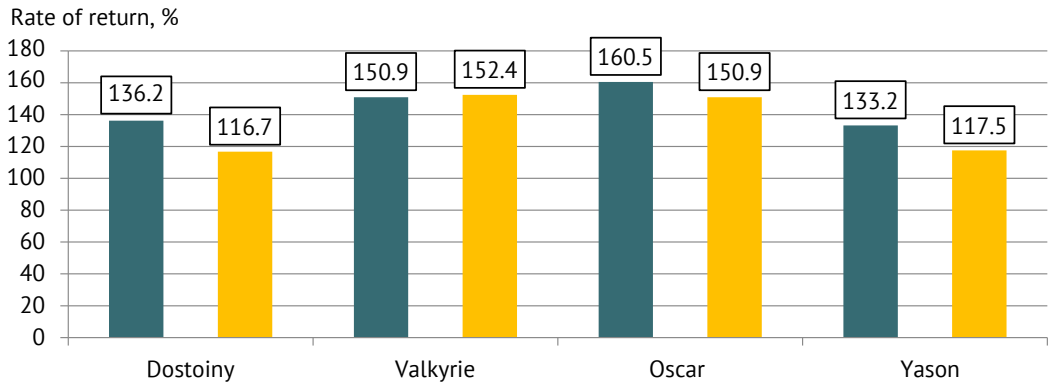

Figure 3. *The level of profitability of growing winter barley varieties depending on foliar fertilizing with biological preparations (average for 2017-2019), %*

Notes: *control (water treatment); Average values for variants of feeding with biological preparations*

Source: *developed by the authors*

At the same time, despite a certain decrease in the profitability of growing winter barley varieties in the case of seed fertilization, and vice versa, a certain increase in the cost price compared to the control, the conditional net profit at the same time increases in most variants of the experiment, which indicates the expediency and payback of the incurred costs and generally confirms the economic efficiency of this technological measure. Studies and calculations have confirmed that a certain agricultural measure, which is included in the technology of growing an agricultural plant, should be distinguished by positive results in relation to the main economic indicators. It should not be highly expensive in terms of the total cost of cultivation, provide conditional net profit and level of profitability, and not significantly increase the cost price.

The most important factors of the agro-economic efficiency of growing winter barley, which were determined under the influence of the use of such an element in technology as foliar feeding with modern biological preparations to optimize plant nutrition on the basis of resource conservation, are consistent with the previously obtained results of many scientists conducted with winter crops (Vozhegova & Krivenko 2019; Pozniak, 2019; Gamayunova & Kuvshinova 2021).

A number of studies by H. Huang *et al.* (2019) testify to a significant increase in yield levels with the use of mineral fertilizers to feed grain crops. However, growing costs due to the high cost of both the fertilizers themselves and their direct application are increasing. The introduction of resource-saving measures in cultivation technology, in particular biological preparations and re-regulating substances, has a favourable effect both on the growth processes and yield of plants, and on indicators of economic efficiency. According to the results of research by A. Krivenko (2019) and comparing the use of mineral fertilizers and biological preparations on winter wheat after black steam at the Odesa Agricultural Research Station, the advantage of the latter was noticeable: the level of profitability in the option of using N_{60} was 115.1%, and Azotophyta – 154.2%. The grain yield was at the levels of 4.06 and 3.97 t/ha, respectively, production costs were 9.9 and 8.2 thousand UAH/ha, conditional net profit was 11.4 and 12.6 thousand UAH/ha, and the cost of production 2.44 and 2.06 thousand UAH/t, respectively. In the studies of the same author, grain yield from the use of complete mineral fertilizer $N_{64}P_{64}K_{64} + N_0$ was formed at the level of 5.41 t/ha, or significantly higher, but the level of profitability decreased to 95.7% and the cost of cultivation increased to 2.68 thousand hryvnias/t.

Research by D. Lovarelli *et al.* (2019) also confirmed that, compared to other technological factors, mineral fertilizers or optimization of plant nutrition, including on the basis of resource conservation, affect the level of harvests to a much greater extent. For nutrition, it is important to create other favourable conditions for each culture. In the conditions of climate change, particularly the increase in its aridity, it is expedient to pay considerable attention to soil cultivation measures. This element in plant growing technology is quite expensive and affects the water-physical properties of the soil.

The issue of growing winter barley in crop rotation on irrigated dark-chestnut soil in the conditions of Southern Ukraine was investigated by the authors of M. Malyarchuk *et al.* (2022) established that the maximum efficiency of grain – 6.96 t/ha was formed by the crop with a combination of long-term disk tillage (12-14 cm) and fertilization with $N_{120}P_{40}$ per 1 ha of the crop rotation area against the background of making sideral fertilizer (spring mustard) and use of crop rotation by-products. In the specified variant, in addition to the highest grain yield, the authors also obtained the maximum level of profitability – 242.8% at the same time the lowest cost price – UAH 2,042/t. They also report that the level of grain yield was significantly influenced by the fertilization system in crop rotation, compared to the methods of cultivation.

Research by L. Kolomiets *et al.* (2022), carried out on the basis of organic technology for growing winter

wheat and spring barley in the conditions of the Right Bank Forest Steppe of Ukraine, established the effectiveness of the combination of no-till soil cultivation with the use of biological preparations. This ensured an increase in the grain yield of winter wheat by 28% and spring barley by 15% and was economically efficient. In particular, the costs of growing spring barley with the use of tillage and biological preparations were reduced by 10% for a profitability level of 159%. In addition to favourable economic factors, agricultural production under this approach is based on ecological principles of natural resource protection.

Research by I. Vogeler *et al.* (2023) confirmed that growing catch crops effectively reduces nitrogen leaching costs in farming systems. This becomes possible due to the fact that these crops absorb post-harvest mineral nitrogen from the soil before the onset of the main winter percolation season. Modelling shows that catch crops can reduce nitrogen leaching costs by 38-64% if grown annually and by 21-39% if grown biennially. The replacement value of nitrogen fertilizers varies on average from 28 to 44 kilograms of nitrogen per hectare, but they show high annual variability. It is important to note that indicators of nitrogen replacement by fertilizers do not always correlate with the nitrogen content consumed by the catch crop before its harvest. This may be due to the long-term effect of the process of nitrogen mineralization from the catch crop residues, as well as the competition for nitrogen resources from the catch crop.

Thus, on the basis of a review of literary sources and the results of own research, the importance of plant nutrition as one of the defining elements of technology is highlighted. At the same time, it is also substantiated that this measure can be carried out with minor additional investments. The use of biological preparations can increase the yield and quality of agricultural crops, ensure rational use of nature and economic expediency, because the output of products increases to a greater extent, compared to the incurred costs of resources. This is extremely important for the effective functioning of the agricultural sector, which provides more than 50% of the income of the Ukrainian economy and is a priority (Vakulenko, 2022). A certain record in relation to the gross collection of grain and leguminous crops, which in 2021 was collected by 33.5% more compared to the previous year 2020, was provided by the agrarians of Ukraine (Miroshnyk & Baglai 2022).

Authors V. Gamayunova *et al.* (2019) testify that the issue of increasing the level of grain production efficiency should be resolved both at the state and regional levels. At the same time, the area of winter grain crops in the Mykolayiv region varies from 65.1 to 71.7% in most years, and according to methodological recommendations, their specific weight should not exceed 60% of the arable area. However, there is currently a war going on in Ukraine, the acreage of crops is decreasing, and there are difficulties with the material and technical support of farms. In this regard, the effectiveness of the production of agricultural crops in the war and post-war periods, to increase the output of products, it is necessary to contribute to this on the basis of resource conservation, and the research and proposals of the current research.

CONCLUSIONS

Determining the economic efficiency of growing winter barley with the inclusion in the technology of the element of optimizing nutrition on the basis of resource conservation and environmental friendliness, namely the use of modern biopreparations, proved their positive impact. The cost of gross production for all varieties during the years of cultivation without the use of biological preparations for feeding amounted to 19.6 thousand hryvnias/ha on average, and in the most optimal variants of the experiment it increased to 23.7-24.4 thousand hryvnias/ha. Conditionally net profit, respectively, is defined as: 11.6 and 13.8-14.4 thousand hryvnias/ha. The cost of a unit of production for fertilizing with biological preparations in most variants of experiments on average varied insignificantly by variety, and the cultivation of Valkyrie and Oscar varieties, which formed the highest yield, even decreased compared to the control.

The level of profitability also changed with a similar dependence. In the control, it was 145.2% on average by variety, with fluctuations from 133.2 (Yason variety) to 160.5% (Oscar variety). Foliar fertilizing with biological preparations of Dostoiny and Yason varieties led to a decrease in the profitability of cultivation, and Valkyrie and Oscar varieties to growth, especially with the use of Organic Balance and Azotophyt. Thus, according to the results of research and calculations, farms in the Southern Steppe zone of Ukraine, engaged in the cultivation of winter barley, are advised to place it after the best predecessors, in particular after peas, to sow high-yielding varieties Oscar and Valkyrie, and to process the crops of plants in the phases of tillering and emergence into the tube biological preparations Organic Balance and Azotophyt. This will ensure the formation of stable levels of grain harvest and profitability and profitability of production.

Prospects for further research in the field of economic efficiency of growing winter barley may include a more in-depth analysis of the impact of different varieties of barley on the yield and quality of products in view of the conditions of different regions, as well as research on optimal doses and methods of using biological preparations to increase productivity and reduce costs for chemical fertilizers and plant protection. In addition, an important direction can be the assessment of the influence of environmental factors on the cultivation of barley and the development of recommendations for sustainable and stable cultivation of the crop in conditions of climate change and preservation of soil fertility.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Економічна ефективність вирощування ячменю озимого у зоні Південного Степу України за впливу сорту і біопрепаратів

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Анотація. Актуальність статті полягає у визначенні найбільш оптимальних сортів і біопрепаратів, які забезпечують отримання високої прибутковості та рентабельності вирощування ячменю озимого. Метою досліджень було визначити основні показники економічної ефективності елементів технології вирощування ячменю озимого за проведення позакореневих підживлень посіву рослин в основні періоди вегетації біопрепаратами. При проведенні досліджень використовували загальноприйняті методи: системний підхід і системний аналіз, польовий та статистичний. У статті наведено дані економічної ефективності елементів технології вирощування ячменю озимого за результатами досліджень, проведених з чотирма сортами культури в умовах Навчально-науково практичного центру Миколаївського національного аграрного університету у 2016-2019 рр. Проаналізовано вплив добору сорту, проведення позакореневих підживлень сучасними бактеріальними препаратами на основні показники економічної ефективності вирощування ячменю озимого. Встановлено, що вартість вирощеного зерна залежала і змінювалась за впливу особливостей сорту, біопрепарату та кількості проведених підживлень. Отримання максимальної вартості зерна забезпечило вирощування сортів ячменю озимого Валькірія та Оскар за проведення позакореневих підживлень у фази кущіння і виходу рослин у трубку біопрепаратом Органік-баланс: 26,5 та 26,3 тис. грн/га відповідно. Ці ж сорти у разі дворазового підживлення Азотофітом сформували вартість зерна по 25 тис. грн/га, а у контролях – 20,1 і 21,1 тис. грн/га відповідно. З аналогічною залежністю змінювались і показники умовно чистого прибутку та рівня рентабельності. Значення величини собівартості вирощування одиниці продукції ячменю озимого мали протилежну залежність. Отримані наукові результати досліджень та визначення сприятимуть вирощуванню ячменю озимого на засадах ресурсозбереження з використанням біопрепаратів для підвищення продуктивності та основних чинників економічної ефективності

Ключові слова: вартість вирощеного зерна; умовно чистий прибуток; рівень рентабельності; собівартість вирощування одиниці продукції