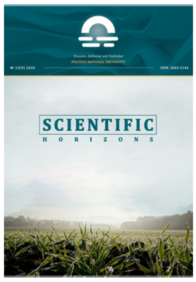
# SCIENTIFIC HORIZONS

**Journal homepage: https://sciencehorizon.com.ua**
***Scientific Horizons*, 28(3), 54-67**


UDC 633.11:631.51:658.5
DOI: 10.48077/scihor3.2025.54

## Assessment of the economic efficiency of growing winter wheat using the resource-saving Mzuri-ProTil technology

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***Article's History*:**
Received: 12.08.2024
Revised: 27.01.2025
Accepted: 26.02.2025

**Abstract**. The aim of the study was to investigate the economic efficiency of winter wheat cultivation of the Perlyna Odeska variety using the resource-saving Mzuri-ProTil technology. The results of the analysis showed that this technology has a significant impact on the yield and economic performance of production. In 2022-2024, research conducted at the Training and Research Centre of Mykolaiv National Agrarian University showed that the use of Mzuri-ProTil technology results in higher yields compared to conventional technology. In 2023, the yield of the classical technology was 6.30 t/ha, while the Mzuri-ProTil technology yielded 7.10 t/ha, which is 0.80 t/ha more. In 2024, the yield of the classical technology decreased to 4.17 t/ha, while the yield of the Mzuri-ProTil technology was 4.78 t/ha (+0.61 t/ha). This advantage demonstrates the more efficient use of resources and the ability of Mzuri-ProTil technology to deliver

***Suggested Citation*:**
Shebanin, V., Drobitko, A., Panfilova, A., & Ruzhniak, M. (2025). Assessment of the economic efficiency of growing winter wheat using the resource-saving Mzuri-ProTil technology. *Scientific Horizons*, 28(3), 54-67. doi: 10.48077/scihor3.2025.54.



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better results even in adverse weather conditions. The costs of Mzuri-ProTil technology in 2022-2023 amounted to 22373.70 UAH/ha, and in 2023-2024 – 1,5811.18 UAH/ha, which was lower compared to the costs of conventional technology (23,637.22 and 16,541.09 UAH/ha, respectively), due to optimised use of resources and reduced number of operations on the field. However, the increase in yields compensated for the additional costs, which helped to improve the overall economic efficiency of production. To assess profitability, we calculated the cost of production per unit of output. The cost of growing one tonne of wheat using the Mzuri-ProTil technology, taking into account costs and yields, was lower than using the classical technology due to higher yields, which reduced unit costs. Thus, the economic analysis shows the benefits of using Mzuri-ProTil technology, as it provides higher productivity and more products per hectare, which results in higher production revenues, even with higher input and machinery costs. Mzuri-ProTil technology is economically viable for farmers seeking to improve wheat production efficiency in the face of climate change and limited resources

**Keywords:** agriculture; profitability; resource-saving technologies; sustainable development; yield

## INTRODUCTION

Agriculture is one of the main sectors of Ukraine's economy, which meets not only the country's domestic needs but also its export potential. Winter wheat, which remains one of the main grain crops due to its high productivity and stable demand on both domestic and international markets, plays a particularly important role in the agricultural sector. The issues related to optimisation of the export potential of cereals in the context of climate change were covered by K. Vasylkovska *et al.* (2021). In their study, they emphasise the need to introduce innovative technologies that can increase the efficiency of grain production and ensure Ukraine's competitiveness in the global market. The relevance of the study is due to the need to assess the economic efficiency of the latest wheat growing technologies that can help increase the productivity and sustainability of agricultural production in Ukraine. Climate change has a significant impact on agriculture, in particular on wheat growing, which requires adaptation of agricultural technologies to new conditions (Dolia & Shevchenko, 2024). In the context of global climate change, an important strategy is to introduce renewable energy sources that reduce dependence on fossil fuels and reduce greenhouse gas emissions. The use of technologies such as solar panels, wind turbines or biogas plants can not only ensure environmental sustainability but also reduce energy costs. According to a study by M.M. Rahman *et al.* (2022), the use of renewable energy sources in the agricultural sector can reduce the cost of machinery and soil cultivation, which in turn increases the economic efficiency of agricultural production. This is especially important in a context where efficient use of resources is key to ensuring sustainable agricultural development in the face of climate change.

The principle of operation of the Mzuri Pro-Til seed drill is based on precise strip tillage. A cutter bar on the front of the machine cuts through plant residues, after which a special tine loosens the seedbed, cleans it of residues and simultaneously applies fertiliser to the set depth. The press wheel compacts the soil to ensure optimum contact between the seed and the moist soil layer. Each furrow is processed separately, allowing for precise adjustment of the sowing depth and uniform seed distribution. According to a study by I. Koženiauskas (2021), such strip-till has a positive effect on soil structure, reducing energy costs for cultivation and reducing the negative impact on the environment, which confirms the effectiveness of this technology in increasing the productivity and sustainability of agricultural production. However, despite the widespread availability of various methods and technologies aimed at improving agricultural production efficiency, there is still a lack of sufficient research comprehensively comparing the cost-effectiveness of the latest technologies in wheat production. In particular, this applies to Mzuri-ProTil technology, which demonstrates significant potential for both increasing yields and reducing soil impact.

Current research tends to focus on agronomic aspects, including the impact of technologies on crop productivity, soil physicochemical properties and environmental sustainability. For example, I. Jaskulska *et al.* (2022) investigated the effectiveness of strip-till technology in pea and barley cultivation as a component of intercropping. Although their study confirmed the benefits of this technology for soil conservation and increased production sustainability, the issue of economic feasibility of its application was not addressed. It is known that traditional tillage and sowing technologies significantly reduce soil fertility and have a negative impact on the environment (Shakoor *et al.*, 2020). Frequent passes of machinery across the field lead to soil compaction, reduced aeration and water permeability, which ultimately negatively affects yields. At the same time, the latest technologies, such as Mzuri-ProTil, help to reduce machinery costs and improve crop performance. However, the question of the economic feasibility of their application remains open and requires more detailed research. The study by A. Panfilova *et al.* (2021) shows that optimisation of crop nutrition systems contributes to a significant increase in grain yield and quality, providing a 26-28% increase in productivity. This confirms the importance of precise fertilisation, which is a key aspect of the resource-saving Mzuri-ProTil technology.

In turn, K. Alekseieva *et al.* (2023) highlight the importance of state support for the introduction of innovative technologies in the agricultural sector, especially under martial law. The application of Mzuri-ProTil technology is consistent with the areas of support identified in the study, as this technology contributes to increased yields, efficient use of resources, and economic stability even under adverse conditions. In scientific works on the use of resource-saving technologies, authors such as Z. Ding *et al.* (2020), M. Habib-Ur-Rahman *et al.* (2022) have studied the impact of the latest technologies on increasing wheat yields, using specialised machinery, and reducing agronomic costs. They point to the possibility of reducing tillage and preserving soil structure, which contributes to increased fertility in the long term. However, most of these studies are limited to agronomic aspects only, and the issue of economic efficiency of Mzuri-ProTil technology remains insufficiently studied.

Thus, this study was aimed at determining the economic efficiency of growing winter wheat of the variety "Perlyna Odeska" using the Mzuri-ProTil technology in comparison with the classical technology.

## MATERIALS AND METHODS

The research methodology included a comprehensive approach to assessing the economic efficiency of growing winter wheat of the variety "Perlyna Odeska" using the Mzuri-ProTil technology in comparison with the classical technology. The study was conducted during two agricultural seasons, 2022-2023 and 2023-2024, at the Educational and Research Centre of Mykolaiv National Agrarian University. The plots met the agronomic requirements for wheat cultivation. The soils of the experimental field are southern chernozems, residual slightly saline heavy loamy on loess. The humus content in the 0-30 cm layer is 3.1-3.3%. The reaction of the soil solution is neutral (pH 6.8-7.2). The topsoil contains 15-25 mg/kg of nitrates (according to Grandval Liege), 41-46 mg/kg of mobile phosphorus (according to Machigin), 389-425 mg/kg of exchangeable potassium mg/kg of soil (using a half-beam photometer). In 2022-2023, the weather conditions were favourable, which contributed to high yields, while 2023-2024 were characterised by periods of drought, which potentially affected the results. The Mzuri-ProTil technology used a specialised seed drill that provides simultaneous soil loosening, fertilisation and precision sowing. The classic technology included a full cycle of tillage using traditional approaches to seedbed preparation and crop care.

The variety selected for the study, Perlyna Odeska, is one of the most widespread in the region due to its adaptability to local climatic conditions. The results obtained may be relevant for other varieties with similar characteristics. The absence of significant fluctuations in the prices of fertilisers, fuel, and crop protection products during the study period minimised their impact on economic performance. To ensure the reliability of the results, statistical analysis was carried out, including estimation of average values and testing the significance of differences between methods. The choice of materials and the sample for the study covered 1-hectare plots divided into two equal parts of 0.5 hectares each. On one part, the Mzuri-ProTil technology was used, which involved the use of a specialised Mzuri Pro-Til 3T Select seeder, which ensured precise sowing, minimal soil tillage and fertilisation in the strip. John Deere 6R tractors with GPS navigation were used to ensure the accuracy of field operations. On another plot, we used the classic cultivation technology with traditional SZ-3.6 seeders and tractors without automated control systems, such as MTZ-82. This approach made it possible to compare the economic efficiency and agronomic performance of both methods on the same area with similar conditions.

The methodology for calculating economic efficiency is based on the identification and comparison of key economic indicators in 2022-2024, such as cost, gross margin, net profit, profitability, and payback period. For this purpose, data on production costs, crop yields, sales prices and costs of introducing new technology are used, in particular, based on statistical data on the grain market in Ukraine. According to the information available on the Statista platform (2024), grain prices and other important economic indicators in Ukraine in 2022-2024 showed certain fluctuations that could significantly affect the costs of agricultural enterprises and the effectiveness of new technologies in agriculture. This data served as the basis for assessing the financial feasibility of introducing technologies such as Mzuri-ProTil, which can reduce costs and increase production efficiency.

The production costs of winter wheat using Mzuri-ProTil technology were lower than those of conventional technology. For example, the costs in 2022-2023 and 2023-2024 were 22,373.70 and 15,811.18 UAH/ha for Mzuri-ProTil technology, respectively, while for the classical technology they were 23,637.22 and 16,541.09 UAH/ha. It should be noted that the cost of growing the crop in 2022-2023 was significantly higher than in 2023-2024, primarily due to the much higher price of mineral fertilisers. The results of the study took into account the specifics of winter crops, which require different approaches depending on agro-climatic conditions and economic situation in the analysed periods. This approach ensures that the economic performance of both technologies is correctly compared, as it eliminates the impact of cost changes on the assessment of their profitability and efficiency. This allows us to focus on analysing the impact of other factors, such as yield, net profit and payback period, and draw reasonable conclusions about the feasibility of using a particular technology in modern agricultural production conditions. The first step was to calculate the cost of winter wheat production. The cost of 1 tonne of grain (COG) is determined by dividing the production costs in UAH for growing the crop per 1 ha by the yield (1):

$$COG = \frac{PC}{y}, \tag{1}$$

where PC – production costs, UAH/ha; Y – yield, t/ha.

The second step was to calculate the value of gross production, which is defined as the product of yield and market price of grain. Comparing the value of gross production by different technologies allows us to assess the impact of Mzuri-ProTil technology on crop productivity and income (2):

$$V = Y \times Pm, \tag{2}$$

where V is the value of gross output, UAH/ha; Y is the yield, t/ha; Pm is the market price, UAH/t.

Based on the data on the value of gross output, net profit is calculated as the difference between the value of gross output and total production costs. Net profit is a key indicator for assessing the financial benefits of introducing a new technology (3):

$$P = V - PC, \tag{3}$$

where P – net profit, UAH/ha ; V – value of gross output, UAH/ha ; PC – production costs, UAH/ha.

Next, the production profitability was calculated, which shows the level of cost efficiency. To do this, the net profit is divided by the production costs and the result is multiplied by 100% to express the figure as a percentage. Comparison of profitability levels allows us to conclude that the Mzuri-ProTil technology is economically viable (4):

$$R = \frac{P}{PC} \times 100, \tag{4}$$

where R – production profitability, %; P – net profit, UAH/ha; PC – production costs, UAH/ha.

The final step was to estimate the payback period of the investment in the new technology. To do this, the total cost of implementation (including the cost of purchasing Mzuri-ProTil equipment and related costs) was divided by the net profit generated by using this technology. The result showed how long it would take for the initial investment to be fully recouped (5):

$$T = \frac{PC}{P}, \tag{5}$$

where T is the payback term, period; PC is production costs, UAH/ha; P is net profit, UAH/ha.

The collected data was processed to analyse the results, which allowed us to obtain accurate and substantiated conclusions regarding the cost-effectiveness of comparing different methods. The authors adhered to the standards of the Convention on Biological Diversity (1992).

## RESULTS

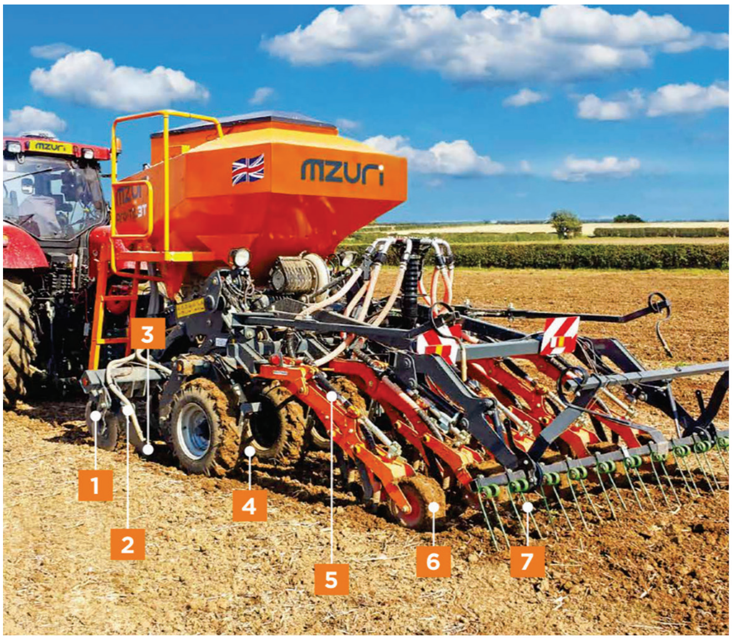
Classical wheat farming technology covers several key stages: soil preparation, sowing, crop care and harvesting. Soil preparation includes ploughing, cultivation and disking to create an optimal seedbed (Mayorov & Tsekhmeystruk, 2021). Sowing is carried out taking into account the timing, seeding rates and even distribution of seeds. Crop care includes fertilisation, weed, pest and disease control. The final stage is harvesting, aimed at minimising grain losses and maintaining its quality. The classical technology uses ploughing, disking, cultivation and levelling of the surface (Hakhula & Kiruta, 2023). These methods improve soil aeration, kill weeds, promote better moisture distribution and mix organic matter. However, intensive cultivation can reduce soil fertility, increase erosion processes and compact the lower layers of the soil, which affects the ecological state of the field.

The classical technology requires significant resources: tractors and tillage equipment for cultivating the field, sowing complexes for sowing, and combines for harvesting. Additionally, a significant amount of fuel is consumed for many field operations. The application of fertilisers and plant protection products also requires specialised equipment, which together increases production costs (Lysenko & Domushchi, 2021). The advantages of the classical technology include high efficiency in weed control, uniformity of crops and relative ease of implementation. However, it is resource-intensive, requiring high costs for machinery, fuel, and fertilisers. Compared to innovative technologies, the classical one has lower profitability and a greater negative impact on the soil due to intensive cultivation.

Crop care in the classical technology includes the application of mineral fertilisers to the soil to maintain fertility, as well as the use of herbicides to control weeds (Dubey *et al.*, 2020). Pesticides are used to protect against pests and diseases. All operations are carried out mechanically, with the use of modern machinery, which ensures efficiency but is costly. Classical technology has a positive effect on aeration and soil structure in the early stages due to loosening, but intensive cultivation reduces fertility due to the destruction of the humus layer and loss of organic matter. The water-holding capacity of the soil decreases due to partial degradation of the structure, which increases the risk of erosion and nutrient flushing, negatively affecting the ecological state of the agroecosystem (Pequeno *et al.*, 2021).

The application of Mzuri-ProTil technology has a significant impact on the yield of winter wheat compared to the classical cultivation technology. This technology provides a significant increase in yields due to a number of important factors, such as improved tillage management, precise fertiliser dosage and optimal seed contact with the moist soil layer. Thanks to these aspects, the technology contributes to the efficiency of winter wheat cultivation, making it an attractive alternative to traditional tillage methods. In 2023, using the classical winter wheat cultivation technology, the yield was 6.30 t/ha, while using Mzuri technology, this figure reached 7.10 t/ha. This means that the use of Mzuri led to a 13% increase in yield. In 2024, there is also a tendency to increase grain yields with the use of resource-saving technology: with the classical technology, it was 4.17 t/ha, while with Mzuri technology, this figure reached 4.78 t/ha, which is 14.6% more. This advantage confirms the effectiveness of Mzuri-ProTil technology in ensuring higher productivity even under adverse weather conditions.

One of the key reasons for this difference is the soil-preserving nature of Mzuri technology. It preserves soil structure, reduces soil compaction and erosion, which has a positive impact on soil fertility. The technology helps to retain moisture in the soil and create favourable conditions for plant growth. This makes it possible to obtain consistently high yields, even in the face of variable weather factors. In the growing season of 2022-2023, weather conditions were generally favourable for wheat production. The spring period was characterised by sufficient precipitation and moderate temperatures, which favoured active plant growth. In the summer, temperatures remained within normal limits, and short-term droughts did not have a significant impact on crop development. Thanks to these conditions, winter wheat was able to produce high yields, especially with Mzuri technology, which allows for the most efficient use of available soil moisture. In 2023-2024, the weather conditions were not favourable enough for winter wheat growing, especially compared to the previous periods. The spring was cool and prolonged, which delayed the start of active crop growth. During the growing season, precipitation was insufficient, resulting in a moisture deficit. The summer period was characterised by long periods of heat, which exacerbated the impact of drought. However, the Mzuri-ProTil technology allowed us to effectively retain moisture in the soil, which resulted in a higher yield compared to conventional cultivation. Mzuri technology involves the integration of several operations in one machine, which significantly optimises the tillage process. The main element is the specialised Mzuri-ProTil seeder, which performs several tasks at once. Figure 1 shows the Mzuri Pro-Til seed drill used for minimal tillage and simultaneous seeding.




1. Optional front disc to cut through surface residue
2. To auto reset leading tine ensures good root development and cleans the sowing strip of surface trash to produce a clean till of moist friable soil
3. Band placement of fertiliser below the seed reduces fertiliser requirement and ensures early nutrient accessibility
4. The staggered wheels remove air pockets and reconsolidate the tilled strips
5. Excellent soil to seed contact is achieved by hydraulic pressure exerted to each individual seed depth wheel
6. Individual depth adjustment to each of the semi-pneumatic coulter depth wheels accurately controls seed placement
7. Hydraulically operated adjustable pressure harrow ensures a level uniformed seed bed

***Figure 1**. Analysis of the design and functioning of the Mzuri-ProTil seeder*
***Source:** created by the authors based on Mzuri UK (2024)*

This image shows the design of the Mzuri-ProTil seed drill, which is the main element of the innovative strip tillage technology. The key feature of this technique is the combination of several operations in one pass, which ensures efficiency and precision of processing. The sowing machine is equipped with a number of working elements, each of which performs a specific function to achieve maximum yield. The design includes a front disc that cuts through plant residues and the surface layer of soil, preparing it for further processing. The deep loosening tine prepares the seedbed, helping to improve aeration and preserve soil structure. The innovative belt fertiliser application system ensures that fertiliser is placed directly under the seed, reducing costs and increasing efficiency. The adjustable pressure wheels ensure optimum contact between the seed and the soil, which contributes to uniform germination. The final step is precise sowing of the seeds to the desired depth with full control of the parameters. An important technical aspect is to minimise the impact on the soil by reducing the number of passes of the machinery. This preserves the natural structure of the soil, reduces compaction and promotes effective moisture management. The hydraulic and mechanical elements of the seed drill work in harmony to ensure uniformity and high quality of the field. The image clearly demonstrates how the Mzuri-ProTil works, highlighting technical innovations that not only reduce costs but also preserve the ecological stability of the soil. This diagram leads to a detailed analysis of the technology itself, its key advantages and potential for implementation in modern agriculture.

At the first stage, the sowing disc cuts through plant residues and the surface soil layer. The next working element, the deep-ripper, creates the seedbed, reducing soil compaction and improving soil aeration. At the same time, fertiliser is applied to the desired depth, ensuring precise and even plant nutrition. After processing the seedbed, the seed drill presses the soil in the strip using independently adjustable pressure wheels to ensure optimum contact between the seed and the soil. This ensures that the seeds germinate evenly and develop a strong root system. The final stage is sowing the seeds to the set depth with full control of the depth and density. The key technical innovation is the integration of GPS navigation in tractors, which ensures accuracy in all operations. Reducing the number of passes across the field minimises soil compaction, which is one of the main advantages of Mzuri-ProTil technology. Reducing the number of treatments not only reduces fuel and labour costs, but also preserves the natural structure of the soil, preventing soil degradation. This technology also contributes to the effective management of soil moisture retention properties, which is especially important in the context of climate change and uneven rainfall distribution. The costs per hectare of Mzuri-ProTil technology have changed compared to conventional winter wheat cultivation, and this is due to several factors that affect the cost structure.

The cost of growing winter wheat is an important indicator that reflects all the direct costs of producing 1 tonne of product (Kotlánová *et al.*, 2024). Formula 1 was used to calculate the cost of applying the classical technology and the Mzuri-ProTil technology. The analysis of the cost of the classical technology and the Mzuri-ProTil technology allows assessing their economic feasibility and impact on the final financial results. In 2022-2023, the cost of growing winter wheat using Mzuri-ProTil technology was 22,373.70 UAH/ha, which is lower than the classical technology, where these costs amounted to 23,637.22 UAH/ha. Due to higher yields, which amounted to 7.10 t/ha, the cost of one tonne of wheat decreased to 3,151.23 UAH/t, which is lower than the classical technology by 600.71 UAH/t. In 2023-2024, the cost of growing winter wheat using conventional technology was 16,541.09 UAH/ha. Given the yield of 4.17 t/ha, the cost per tonne of production was calculated as the ratio of total costs to the yield. Thus, the cost of winter wheat produced using conventional technology was approximately UAH 3,966.69 per tonne. The cost of growing winter wheat using Mzuri-ProTil technology in 2023-2024 was 15,811.18 UAH/ha, which is lower than the classical technology. The reduction in costs using Mzuri-ProTil technology is due to optimised use of technical resources, efficient application of materials and a reduction in the number of field operations. The yield of this technology was 4.78 tonnes per hectare. The cost of one tonne of production using Mzuri-ProTil technology decreased to 3,307.78 UAH/t, which is lower than the classical technology. This indicates that the increase in yields allowed reducing the cost per unit of production, compensating for the cost of implementing the technology. The results of the analysis show that Mzuri-ProTil technology provides economic benefits due to lower unit costs due to higher yields. This confirms its feasibility for agricultural producers seeking to optimise their costs and increase the competitiveness of their products on the market.

Firstly, Mzuri technology involves the use of specialised machinery that allows several operations to be performed simultaneously in the field: tillage, sowing, fertilisation and plant protection. Although the initial cost of purchasing and maintaining such equipment can be high, it can significantly reduce labour and fuel costs, as well as the number of tillage operations, which in turn reduces other operating costs. Secondly, thanks to the precise application of fertilisers and crop protection products, Mzuri technology ensures more efficient use of these resources. This reduces the total amount of chemicals used, thus reducing the cost of purchasing them. This approach also contributes to a more sustainable use of natural resources and reduces fertiliser costs, which is an important factor in improving economic efficiency. Gross margin is a key indicator of economic efficiency, as it is determined by the volume of products grown and their realizable value (Challoumis & Eriotis, 2024). Formula 2 was used to analyse the gross margin, and the results of two winter wheat cultivation technologies were considered: classical and Mzuri-ProTil. The calculations used statistical data on prices for winter wheat sales by agricultural producers in Ukraine for 2023 and 2024, which were adapted to real market conditions (State Statistics Service of Ukraine, 2024). In particular, the prices provided by official statistical sources were adjusted in accordance with the actual figures received from agricultural producers engaged in the cultivation and sale of winter wheat on the domestic market of Ukraine in order to accurately reflect the current market situation.

During the years of research, wheat yields using classical technology were 4.17-6.30 t/ha at a market price of 5,600-6,000 UAH/t. This resulted in a gross production value of 25,020-35,280 UAH/ha. This level of income demonstrates the potential of conventional technology to deliver stable financial results under favourable weather conditions, but costs and production costs remain critical factors in comparison with alternative approaches such as Mzuri-ProTil. Over the same period, Mzuri-ProTil technology delivered higher yields of 4.78-7.10 tonnes per hectare. At the market price of 5,600-6,000 UAH/t, the cost of gross production using this technology was 28,680-39,760 UAH/ha, which exceeds the classical technology by 3,660-4,480 UAH/ha. These results confirm the economic feasibility of Mzuri-ProTil technology due to its ability to use resources more efficiently even in adverse weather conditions.

The analysis shows that the Mzuri-ProTil technology demonstrates a stable advantage in gross income due to higher yields. Even in the unfavourable conditions of the 2023-2024 growing season, it remained more efficient, which underlines its potential to provide higher profitability compared to the classical technology. This makes Mzuri-ProTil technology an attractive option for farmers seeking to maximise their income by optimising yields. The increase in yields with Mzuri-ProTil technology has played a key role in compensating for the additional costs of machinery and inputs, and here are some of the main factors that explain how this happened. The increase in yields with Mzuri-ProTil technology has significantly increased the gross revenue per hectare. In the 2023-2024 season, Mzuri-ProTil technology yielded 4.78 t/ha, which is 14.6% more than the classic technology (4.17 t/ha). This led to an increase in gross income per hectare, as the products sold at UAH 6,000/t brought in more money. The increase in gross income helped cover the additional costs associated with the use of more expensive inputs, such as fuel, machinery maintenance and fertiliser. Secondly, the precise application of fertilisers and crop protection products using Mzuri technology significantly reduces excessive chemical costs. This means that part of the savings on fertiliser and pesticide application can be used to cover the cost of machinery and its maintenance. Net profit is a key financial indicator that demonstrates the difference between gross revenue and production costs (Devkota & Yigezu, 2020). The analysis of net profit calculated according to Formula 3 allows us to assess the economic efficiency of the classical winter wheat cultivation technology and the Mzuri-ProTil technology.

The cost of gross production in 2022-2023, depending on the technology of winter wheat cultivation, was 35,280-39,760 UAH/ha, which allowed obtaining 11,642.78-17,386.30 UAH of net income per 1 ha. In 2023-2024, according to the classical technology, the cost of gross production was 25,020 UAH/ha at a cost of 16,541.09 UAH/ha. This resulted in a net profit of 8,478.91 UAH/ha. Lower yields due to unfavourable weather conditions resulted in a decrease in net profit compared to favourable years, which highlights the vulnerability of the classical technology to climate change. In 2023-2024, Mzuri-ProTil technology provided a gross production value of 28,680 UAH/ha at a cost of 15,811.18 UAH/ha. This resulted in a net profit of 12,868.82 UAH/ha, which is 4,389.91 UAH/ha more than with the classical technology. The advantage of the Mzuri-ProTil technology is related to its ability to use moisture and other resources more efficiently, which ensured better results even in adverse weather conditions.

The analysis shows that the Mzuri-ProTil technology provides a consistently higher net profit than the classical technology, even under unfavourable conditions. This demonstrates its cost-effectiveness and potential to increase the profitability of agricultural enterprises. In addition, specialised tillage equipment based on Mzuri technology reduces the number of treatments and the cost of fuel and labour. The technology also reduces the risk of soil compaction, which ensures consistently high yields even in less favourable weather conditions. This not only increases yields, but also reduces the cost of additional agronomic measures, which also helps to maintain profitability. Thus, the increase in yields provided by Mzuri-ProTil technology compensates for the additional costs of machinery and resources, providing a higher gross income. This allows agricultural producers not only to cover the costs of implementing the new technology, but also to generate additional profits, making this method economically viable in the long term.

The higher yields provided by Mzuri-ProTil technology help to reduce unit costs due to several important factors. First, higher yields reduce unit costs through economies of scale. When yields per hectare increase, the total amount of product produced from the same field increases. This means that fixed costs, such as machinery, maintenance and other inputs, are spread over more units of output. Thus, the cost per unit of output (e.g., per tonne of grain) is reduced. Secondly, Mzuri technology reduces the overall cost of tillage and fertilisation through more efficient use of resources. The precise application of fertilisers and crop protection products and the reduction in the number of treatments reduce the cost of chemicals and fuel. This is important because higher yields mean more output with fewer inputs, which helps to reduce the cost per unit. Third, by reducing the number of treatments and using high-performance machinery, Mzuri technology reduces labour and fuel costs. The Mzuri-ProTil technology optimises the number of operations performed on the field by simultaneously performing several important agronomic activities, such as tillage, sowing, and fertilisation. This reduces the cost of machine maintenance and ensures more efficient use of resources. Overall, the higher yields achieved with Mzuri-ProTil technology help to reduce unit costs by increasing overall production and optimising resource use. This allows for greater profit from each unit of production and makes the technology more cost-effective for agricultural producers. The introduction of the Mzuri-ProTil technology has led to significant changes in the profitability of winter wheat production, in particular, to its growth compared to the classical cultivation technology. This is manifested in several aspects that indicate the increased economic efficiency of using this technology.

Yield growth is a key factor that contributes to increased profitability. The Mzuri-ProTil technology resulted in wheat yields of 4.78-7.10 t/ha in 2023 and 2024, which is 11.3-14.6% higher than the conventional technology (4.17-6.30 t/ha). Higher yields increase the gross income per hectare, which has a positive impact on the profitability and economic efficiency of the technology. Mzuri technology reduces unit costs by optimising growing processes, such as precise fertilisation and plant protection products, and reducing the number of operations on the field. Although the initial cost of machinery and its maintenance is higher, these additional costs are offset by the increase in yields, which reduces the overall cost per unit of production. Profitability is an important indicator that characterises the economic efficiency of a wheat production technology, as it reflects the ratio of net income to costs (De Andrade Ferrazza *et al.*, 2024). A high level of profitability indicates the ability of the technology to generate profit for every hryvnia spent. An analysis of the profitability of the classical technology and the Mzuri-ProTil technology allows us to assess which of these methods is more profitable for agricultural producers. Formula 4 was used to determine the level of profitability.

In 2022-2023, due to the high net income, the profitability of winter wheat cultivation was 49.3-77.7%. At the same time, using Mzuri-ProTil technology, the level of profitability of winter wheat cultivation was 28.4% higher compared to the classical technology of crop cultivation. In 2023-2024, the classic technology resulted in costs of 16,541.09 UAH/ha, while the net profit was 8478.91 UAH/ha. The decline in yields was a key factor that affected the economic performance of this technology. Profitability fell to 51.3%, which demonstrates the significant dependence of the classical technology's efficiency on weather conditions and yields. This demonstrates the need for adaptive and resource-saving technologies to ensure stable profits in the face of climate change. For the Mzuri-ProTil technology, in 2023-2024, the costs were 15,811.18 UAH/ha, and the net profit was 12,868.82 UAH/ha. The profitability level of winter wheat cultivation using this technology was 81.5%, which is higher than the same indicator of the classical technology. The efficiency of Mzuri-ProTil is ensured by greater resistance to adverse weather conditions and optimised use of resources, which allows for higher profit per unit of investment.

The Mzuri technology also reduces the negative impact of weather conditions through improved soil moisture retention and reduced soil compaction. This makes the technology more resilient to climate change and ensures consistently high yields, which also has a positive impact on profitability. Thus, after the introduction of the Mzuri-ProTil technology, the profitability of wheat growing has increased significantly due to higher yields, lower unit costs and improved resistance to adverse weather conditions. In general, this increases the economic efficiency of wheat cultivation and makes this method more profitable for farmers compared to conventional technologies. The payback period is an important indicator of the economic efficiency of a technology, which allows us to estimate how long it will take for the investment in the introduction of a new technology to be fully covered by the profit generated (Saquee *et al.*, 2024). Formula 5 was used to calculate the payback period. The payback period for the use of Mzuri-ProTil technology in 2022-2023 was 1.3 years, and for the use of conventional technology – 2 years. The cost per hectare of wheat cultivation in 2023-2024 was UAH 16,541.09 using the classical technology. The net profit was UAH 8,478.91. The payback period for this technology was calculated as the ratio of costs to net profit. According to the results of the calculations, the payback period was 1.95 seasons, which is equivalent to about two years. This indicates that in adverse weather conditions, investments are recovered more slowly, which reduces the economic attractiveness of the classical technology in such conditions. For the Mzuri-ProTil technology, the cost per hectare in 2023-2024 was 15,811.18 UAH, and the net profit was 12,868.82 UAH. The payback period was calculated using the same formula as for the classical technology. The results showed that the payback period for Mzuri-ProTil was 1.23 seasons, or approximately 1 year and 3 months. This indicates that the technology, despite its higher costs, provides a faster return on investment due to higher yields and optimised resources. Thus, in 2022-2024, Mzuri-ProTil technology proved to be more efficient than the classical technology, demonstrating a shorter payback period and a more stable financial result even in unfavourable climate conditions.

The Mzuri-ProTil technology is economically viable for farmers, especially in the face of climate change and limited resources. It offers several significant advantages that make it a profitable and efficient alternative to conventional wheat growing technology. Mzuri technology provides a significant increase in yields. Thanks to specialised machinery and precise application of fertilisers and crop protection products, farmers can achieve consistently high yields, even in adverse weather conditions. This is especially important in a changing climate, where extreme weather events such as droughts or excessive rain can significantly reduce yields. Mzuri technology mitigates the risks associated with such changes and ensures a stable income. The technology can significantly reduce unit costs. By optimising the costs of inputs such as fuel, fertiliser, pesticides and labour, farmers can achieve more efficient use of limited resources. Precise application of fertilisers and crop protection products can reduce their consumption, which not only reduces overall costs but also has a positive environmental impact. In this way, agricultural producers can not only maintain their profits but also make their production more sustainable and environmentally friendly.

The use of Mzuri technology helps to retain moisture in the soil, which is especially important in a changing climate where droughts are becoming more common. The technology helps to reduce soil erosion, improves soil structure and increases moisture retention, which allows plants to better withstand periods of drought. In addition, Mzuri technology helps to reduce tillage costs and reduces the number of treatments, which also has a positive impact on economic results. The use of multifunctional equipment allows for the simultaneous performance of several operations on the field, which reduces the need for additional equipment and labour. The results of a comparative analysis of the economic efficiency of two winter wheat cultivation technologies show significant differences between the classical technology and the soil-saving Mzuri-ProTil technology (Table 1). The main indicators such as yield, gross income, costs, net profit, profitability, and payback period were the key criteria for assessing the economic feasibility of both technologies. The soil-saving Mzuri-ProTil technology provided higher yields during the years of research, which directly influenced the increase in gross income compared to the classical technology. Despite the higher costs of implementing the Mzuri-ProTil technology, the increased productivity resulted in higher net profit and higher profitability. The payback period analysis showed that, although the classical technology is characterised by lower costs, it has limited prospects for long-term economic efficiency. The Mzuri-ProTil technology demonstrates economic viability in the medium term, providing better resistance to changes in weather conditions.

***Table 1****. Comparative analysis of the economic efficiency of using Mzuri-ProTil technology and classical technology for growing winter wheat*

| Indicator | Technology | | | |
|---|---|---|---|---|
| | Classic | | Mzuri-ProTil | |
| | Years | | | |
| | 2022-2023 | 2023-2024 | 2022-2023 | 2023-2024 |
| Yield (t/ha) | 6.30 | 4.17 | 7.10 | 4.78 |
| Production costs (UAH/ha) | 23,637.22 | 16,541.09 | 22,373.70 | 15,811.18 |
| Cost price (UAH/t) | 3,751.94 | 3,966.69 | 3,151.23 | 3,307.78 |
| Gross production value (UAH/ha) | 35,280 | 25,020 | 39,760 | 28,680 |
| Net profit (UAH/ha) | 11,642.78 | 8,478.91 | 17,386.3 | 12,868.82 |
| Profitability level (%) | 49.3 | 51.3% | 77.7 | 81.5% |
| Payback period (period) | 2 years | 1 year 11 months | 1 year 3 months | 1 year 3 months |

***Source:*** *created by the authors*

In 2023-2024, the yield of Mzuri-ProTil technology was 4.78 t/ha, which is 0.61 t/ha higher than the result of the classical technology (4.17 t/ha). This resulted in a gross income of 28,680 UAH/ha compared to 25,020 UAH/ha with the conventional technology. Despite the fact that the costs of growing using Mzuri-ProTil technology were UAH 729.91 lower, the cost of production remained lower – 3,305 UAH/t, compared to 3,412 UAH/t for the classic technology. The net profit of Mzuri-ProTil technology in 2023-2024 was 12,868.82 UAH/ha, which is 4,389.91 UAH more than the classic technology. The profitability of cultivation using the Mzuri-ProTil technology reached 81.5%, which is also higher than the classical technology (51.3%). As for the payback period, Mzuri-ProTil requires 1 year and 3 months to recover costs, while the classical technology requires almost 2 years. In summary, the results of the analysis show that Mzuri-ProTil technology provides higher economic performance compared to the classical technology, even with a decrease in yields in 2023-2024. It remains more cost-effective and profitable, which confirms its feasibility for farmers seeking to improve the efficiency of their farms in the medium and long term. Thus, Mzuri-ProTil technology is economically viable for farmers due to its ability to increase yields, reduce costs, improve climate resilience and conserve natural resources. In the face of a changing climate and limited resources, this technology is a profitable and effective way to ensure sustainable agricultural development.

The Mzuri-ProTil technology demonstrates a significant increase in economic efficiency compared to conventional wheat growing technologies. It delivers higher yields, reduces unit costs by optimising inputs and facilitates adaptation to climate change. Higher yields and improved resource utilisation result in higher profits, despite higher initial costs for machinery and its maintenance. Sowing campaigns in a changing climate are becoming increasingly challenging for farmers

(Zhao *et al.*, 2022). Climate change, such as temperature fluctuations, changes in precipitation patterns and the frequency of extreme weather events, has a significant impact on agricultural production efficiency. This particularly applies to aspects such as sowing timing, variety selection and cultivation technology. In such circumstances, agronomists are forced to adapt their strategies to minimise the negative impact of climate change. In a changing climate, where droughts and extreme weather conditions are becoming more common, Mzuri technology is becoming an important tool for ensuring stable yields and economic sustainability for farmers. It reduces tillage costs, improves moisture retention and reduces the risks associated with unstable weather conditions, making it a profitable and viable option for modern agriculture.

## DISCUSSION

Due to global climate change and growing demands on agricultural production efficiency, farmers are looking for new ways to increase productivity and reduce costs. Among the innovative methods that are gaining popularity are technologies aimed at preserving soil and minimising agronomic intervention. Mzuri-ProTil technology, compared to traditional No-till technology, provides better efficiency due to more precise control of sowing and fertilisation processes, which contributes to higher yields and economic efficiency. However, No-till also has the advantage of preserving soil structure and reducing erosion. Scientists such as H.S. Jat *et al.* (2020) emphasise that No-till is effective for sustainable agriculture, especially in the face of soil degradation, by maintaining soil health in the long term. However, in conditions where control over agronomic processes is important to achieve high yields, Mzuri-ProTil technology may have an advantage due to the ability to fine-tune fertilisation and seeding processes. On the other hand, while No-till provides significant soil conservation benefits, it does not provide the same level of control that can limit its effectiveness in optimising yields. Therefore, the choice between technologies depends on specific conditions and goals: No-till may be preferred for soil structure preservation and erosion control, while Mzuri-ProTil may be preferred for higher yields and economic efficiency.

Minimum tillage technology involves cultivating the soil to a shallow depth to improve sowing conditions, while keeping most of the organic residues on the surface (Pavlova & Litvinov, 2024). Compared to Mzuri-ProTil, minimum tillage uses less precise seeding and fertilisation management, which can reduce efficiency, especially in a changing climate. Scientists such as S.M. Junge *et al.* (2020) note that minimum tillage can be useful for conserving moisture and organic material, but its potential for increasing yields is less than that of more precise technologies. Mzuri-ProTil, on the other hand, allows for simultaneous precision seeding and fertilisation, which results in higher yields and better economic results. Thus, Mzuri-ProTil provides greater precision and control compared to minimum tillage, making it more effective when it is required to maximise productivity. Strip till technology involves cultivating only the strips of soil on which the seed is sown, leaving the rest of the field untilled. This helps to preserve organic residues on the soil surface, reduce erosion and retain moisture, similar to no-till technology. However, Strip till provides more precise soil management in the sowing area, which can be important for achieving high yields.

Compared to Mzuri-ProTil, Strip till also uses minimal tillage, but Mzuri-ProTil is even more precise as it allows for simultaneous sowing, fertilisation and plant protection products, which ensures even more efficient use of resources. Research, in particular the work of I. Jaskulska and D. Jaskulski (2020) show that strip tillage provides certain advantages over conventional tillage, but Mzuri-ProTil technology provides better yields due to additional opportunities for precise management of agronomic processes. Thus, Mzuri-ProTil delivers higher results in terms of yield and economic efficiency compared to Strip till. Conventional tillage technology involves complete loosening of the soil with a plough and other cultivation tools to prepare the field for sowing (Bulgakov *et al.*, 2019). This provides deep loosening, which facilitates the penetration of water and air into the soil, and kills weeds and organic residues. However, conventional tillage reduces soil organic matter, can cause erosion and moisture loss, and is costly in terms of fuel and technical resources (Zymaroieva *et al.*, 2021).

Compared to Mzuri-ProTil, Conventional tillage is less effective in terms of maintaining soil fertility in the long term. Mzuri-ProTil takes a more innovative approach by preserving organic residues on the soil surface, minimising erosion and retaining moisture. In addition, Mzuri-ProTil technology allows for precision sowing and simultaneous application of fertilisers and crop protection products, which increases resource efficiency and contributes to higher yields. Analysing the research of scientists such as M. Allam *et al.* (2022), it can be distinguished that Mzuri-ProTil technology has certain advantages over conventional tillage, in particular in a changing climate, due to better preservation of soil structure and more efficient use of water and nutrients. Ridge till technology involves tillage that creates ridges or raised strips on which to sow. This improves drainage, provides better air access to plant roots and reduces water erosion. At the same time, this technology allows preserving organic residues between the ridges and minimising erosion in the row spacing.

Compared to Mzuri-ProTil, Ridge till technology also retains a significant amount of organic residue on the soil surface, but it does not provide such high precision in seeding and fertilisation. Mzuri-ProTil allows for more precise control of sowing and plant nutrition, as it simultaneously applies fertiliser and plant protection products to the optimum locations for growth. Scientists such as O. Alagbo *et al.* (2022) note that Ridge till has advantages in conditions where it is important to improve drainage and soil structure, but Mzuri-ProTil gives better results in terms of yield and economic efficiency due to precise management of agronomic processes. Therefore, Mzuri-ProTil can be a more efficient option compared to Ridge till, especially in conditions that require high yields and conservation of resources. Aeration tillage technology involves tilling the soil to improve its aeration (Boiko & Kovalenko, 2024). Instead of deep loosening, this technology uses special tools that create small holes or cracks in the soil, improving oxygen access to the root system of plants and reducing soil compaction. This allows for increased water and air permeability of the soil, while retaining organic residues on the surface and minimising erosion.

Compared to Mzuri-ProTil, Aeration tillage technology is a less precise method for seeding and fertilisation control. Mzuri-ProTil not only aerates the soil, but also simultaneously performs precision sowing, fertilisation and plant protection products, which helps to increase yields and economic efficiency. Studies, such as those by G.O. Awe *et al.* (2023), show that while Aeration tillage improves soil structure, Mzuri-ProTil provides benefits through a more integrated approach to tillage and resource use, which leads to better production results. Drill till technology involves the use of special seed drills that combine tillage and sowing, ensuring precise seed placement in the treated strip. This method allows for minimal tillage, preserving organic residues on the surface, while preparing a separate strip for sowing, which increases the accuracy and uniformity of seed placement.

Compared to Mzuri-ProTil, Drill till technology has certain advantages in terms of sowing accuracy, but does not provide such high efficiency in the application of fertilisers and plant protection products. Mzuri-ProTil allows simultaneous precision sowing, fertilisation and crop protection in one operation, which reduces the cost of technical resources and improves the economic efficiency of production. Research, in particular the work of Y. Mykhaylichenko *et al.* (2023), show that Drill-Till technology is an effective method for reducing tillage costs and preserving soil structure, as well as ensuring precision in sowing, which contributes to stable yields and sustainable use of agricultural resources. However, this technology does not allow combining several operations into one, as implemented in Mzuri-ProTil.

In comparison with Drill-Till, Mzuri-ProTil demonstrates advantages through an integrated approach to sowing, fertilising and plant protection. This technology reduces the number of passes of equipment across the field, which not only saves resources but also minimises soil compaction. Thanks to the precision and synchronisation of operations, Mzuri-ProTil allows for better fertiliser use and reduces crop losses due to uneven nutrient distribution, which is especially important in a changing climate. Thus, Mzuri-ProTil is a technology that allows achieving higher economic results on fields with high productivity potential. Precision tillage technology involves the use of modern technologies such as GPS and sensors to precisely control soil cultivation, which reduces fuel and lubricant costs, preserves soil fertility and increases resource efficiency (Golub *et al.*, 2020). It allows for precise control of the depth and width of tillage, including soil conditions and plant needs.

Compared to Mzuri-ProTil, Precision tillage uses high-precision tillage methods, but Mzuri-ProTil is a more integrated technology as it simultaneously performs precision seeding, fertilisation and crop protection, which provides even greater cost-effectiveness. In studies such as those by Y. Sabouri *et al.* (2021), it is noted that Precision tillage provides significant benefits in terms of tillage accuracy, but Mzuri-ProTil provides an integrated approach that allows for higher yields and better economic results due to the simultaneous control of several processes of the agronomic cycle. Broadcast sowing technology provides for the uniform distribution of seeds over the soil surface without preliminary tillage or soil preparation. This method allows sowing large areas quickly and efficiently, but requires additional measures to improve seed contact with the soil, such as rolling or reverse tillage.

Compared to Mzuri-ProTil, Broadcast sowing technology does not have such high precision in sowing and fertilisation. Mzuri-ProTil provides more precise sowing due to the simultaneous application of fertiliser and plant protection products, which improves resource efficiency and increases yields. Studies such as those by K. LoPiccalo (2022) show that while Broadcast sowing can be a fast and economical method, Mzuri-ProTil offers advantages due to the high precision of seeding and plant nutrition management, which ultimately provides better economic and agronomic results.

In turn, V. Havrysh *et al.* (2020) emphasise the importance of introducing energy-saving technologies in the agricultural sector. These conclusions are consistent with the characteristics of the Mzuri-ProTil technology, which, by reducing the number of passes of machinery, contributes to the rational use of energy resources. This is a significant advantage compared to Precision tillage, which, although it provides high precision tillage, does not offer an integrated approach like Mzuri-ProTil. The complexity of the latter allows reducing cultivation costs and increasing yields at the same time, which confirms its economic feasibility.

## CONCLUSIONS

The study revealed a significant economic efficiency of Mzuri-ProTil technology in the cultivation of winter wheat of the Perlyna Odeska variety compared to the classical technology. The Mzuri-ProTil technology has demonstrated advantages in the face of climate change, providing consistently higher yields and economic profitability even under adverse weather conditions. In 2022-2024, the profitability of Mzuri-ProTil technology was 77.7-81.5%, which exceeded the results of conventional winter wheat cultivation by 28.4-30.2%. The net profit of Mzuri-ProTil technology amounted to 12868.82-17386.3 UAH/ha, which is 33-34.1% higher than the classical technology of growing the crop, which provided a net profit of 8478.91-11642.78 UAH/ha, depending on the years of research. The payback period for the Mzuri-ProTil technology in the years of research was 1 year and 3 months, while for the classical technology it was 1 year 11 months – 2 years. This confirms the economic feasibility of introducing the latest technology, even in the face of adverse weather factors typical for this season.

The practical significance of the study was to identify the Mzuri-ProTil technology as an effective means of increasing yields and optimising costs. The latest technology has reduced the number of passes of machinery across the field, which has helped to reduce soil compaction, improve its structure and aeration. The rational use of fertilisers and crop protection products has saved resources and contributed to the environmental sustainability of production. An additional benefit was the reduction in fuel and equipment maintenance costs. Prospects for further research include adapting the Mzuri-ProTil technology to specific soil types, such as heavy clay soils, and analysing the long-term impact on soil fertility. It is also advisable to study the technology's effectiveness under conditions of limited irrigation and rising temperatures, which are characteristic of climate change. Particular attention should be paid to improving technical equipment and introducing automated control systems that can improve the accuracy of operations and reduce costs. The use of integrated digital platforms for monitoring agro-technological processes can significantly improve the efficiency and environmental friendliness of production, contributing to the sustainable development of agriculture.

## ACKNOWLEDGEMENTS

None.

## CONFLICT OF INTEREST

None.

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## Оцінка економічної ефективності вирощування пшениці озимої за ресурсозберігаючої технології Mzuri-ProTil

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**Анотація**. Метою роботи було дослідити економічну ефективність вирощування пшениці озимої сорту «Перлина одеська» за ресурсозберігаючою технологією Mzuri-ProTil. Результати аналізу показали, що ця технологія має значний вплив на врожайність і економічні показники виробництва. За підсумками досліджень в умовах Навчально-науково-практичного центру Миколаївського національного аграрного університету у 2022-2024 роках було встановлено, що застосування технології Технологія Mzuri-ProTil забезпечує вищу врожайність порівняно з класичною технологією. У 2023 році врожайність за класичною технологією становила 6,30 т/га, тоді як за технологією Mzuri-ProTil – 7,10 т/га, що на 0,80 т/га більше. У 2024 році врожайність за класичною технологією знизилася до 4.17 т/га, а за технологією Mzuri-ProTil – склала 4,78 т/га (+0,61 т/га). Ця перевага свідчить про ефективніше використання ресурсів та здатність технології Mzuri-ProTil забезпечувати кращі результати навіть за несприятливих погодних умов. Витрати за технологією Mzuri-ProTil у 2022-2023 рр. склали 22373,70 грн/га, а у 2023-2024 рр. – 15811,18 грн/га, що було нижчим порівняно з витратами за класичною технологією (23637,22 і 16541,09 грн/га відповідно), завдяки оптимізації використання ресурсів і зменшенню кількості операцій на полі. Проте збільшення врожайності компенсувало додаткові витрати, що дозволило підвищити загальну економічну ефективність виробництва. Для оцінки рентабельності було проведено розрахунки вартості виробництва одиниці продукції. Вартість вирощування однієї тони пшениці за технологією Mzuri-ProTil, враховуючи витрати та врожайність, була нижчою, ніж за класичною технологією, завдяки більш високій врожайності, що дозволяє зменшити витрати на одиницю продукції. Таким чином, економічний аналіз свідчить про переваги застосування технології Mzuri-ProTil, оскільки вона забезпечує вищу продуктивність і більшу кількість продукції на один гектар, що в результаті дозволяє забезпечити більш високі доходи від виробництва, навіть за умови збільшення витрат на ресурси та техніку. Технологія Mzuri-ProTil є економічно доцільною для фермерів, які прагнуть підвищити ефективність виробництва пшениці в умовах зміни клімату та обмежених ресурсів

**Ключові слова:** сільське господарство; рентабельність; ресурсозберігаючі технології; сталий розвиток; урожайність