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# ECONOMIC EFFICIENCY OF BIOLOGIZED TECHNOLOGIES OF GROWING AGRICULTURAL CROPS

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***Abstract***

*The study was conducted in 2017–2019 at the experimental field of the Institute of Irrigated Agriculture of NAAS (now the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine).Based on the results of the economic analysis of winter wheat field trials, it has been established that varieties, sowing dates, and plant protection applications significantly influence the indicators of economic efficiency in winter wheat cultivation. The conditional net profit under natural moisture increased to 11,000 UAH/ha with the variety Maria sown in the first term (September 20) and the application of chemical plant protection. The maximum level of profitability (157%) was achieved with the variety Kohana sown in the third term and adhering to a biological plant protection system. The highest conditional net profit (14,800 UAH/ha) and profitability level (103.3%) were obtained by cultivating winter wheat with irrigation, sown on September 15, and using chemical plant protection. The most profitable results (11,000-11,100 UAH/ha) were obtained with the Ovidiy variety using integrated and chemical plant protection methods. The highest profitability level (75.8%) was achieved with the Ovidiy variety using plant protection involving chemical products. Additionally, high profitability at 71.7% was achieved with this variety using integrated plant protection.*

***Key words*****:** *economic analysis, winter wheat, variety, conditional net profit, profitability, net income, cost*

## INTRODUCTION

In market conditions, ensuring guaranteed profitable harvests requires assessing the economic efficiency of various measures. Economic efficiency is a comprehensive economic category that reflects the high performance in resource utilization. The essence of economic efficiency in agriculture is expressed through its indicators, with the key indicators being the yield of cultivated crops and the quality of the products. The primary indicator characterizing agricultural production volume is the value of gross and marketable products, which serves as the basis for calculating gross and net income, as well as conditional net profit [3].

Research by agricultural economists confirms that a significant direction towards increasing production efficiency in any form of economic activity within a complex economy is the rational and efficient use of land resources and material-technical means using methodical approaches from economic science [11].

Addressing the problem of increasing the production of high-quality agricultural products while reducing costs, while maintaining the ecological state of the environment and enhancing soil fertility, remains a key task for Ukrainian agriculture. An important condition for increasing the efficiency of producing high-quality agricultural products is identifying and implementing effective agronomic practices suitable for different soil-climatic and economic conditions [8].

One of the fundamental measures to prevent and mitigate environmentally hazardous

processes and negative impacts on plant productivity in agroecosystems is scientifically substantiating crop rotations, the structure of sown areas, the variety composition, and crop placement in rotations after the best predecessors, with rational soil management practices [6]. These measures enable more productive use of mineral fertilizers, maximally realizing the biological potential of crop varieties and hybrids, reducing vegetative cover, mitigating the impact of pests and diseases in crops with minimal use of chemical pesticides. All of these positively impact the environment and provide additional opportunities to increase agricultural production while reducing production costs [9].

According to many scientists, the economic efficiency of agriculture is achieving the maximum amount of production per hectare of land with minimal expenses. Therefore, it is necessary to use both natural and purely economically justified parameters in agricultural production. The natural indicators of obtaining agricultural products, considering their quality, serve as the starting point for economic efficiency. The yield indicator of agricultural crops reflects the entire system of economic measures and directly influences the magnitude of other indicators [2, 12].

Among valuable indicators, the most crucial is the cost price, which reflects the outcome of the entire agricultural operation from production to sale of agricultural products. The cost price of production is the monetary representation of expenses incurred in the production and sale of products, enabling conclusions to be drawn regarding the efficiency of crop cultivation and identifying ways to enhance profitability. Cost price serves as the starting point for determining net profit [4, 7].

When analyzing the cost structure of agricultural production, expenses are grouped into economic elements and calculation categories, thereby calculating the cost price per unit of production based on specific expenses. The total expenditure consists of three main groups: 1) material costs (the cost of seeds, feed, fertilizers, fuel, lubricants, and plant protection substances entirely used for production and fully included in the expense amount); 2) depreciation charges (wear and tear of fixed and production assets); 3) labor costs. Grouping expenses by specific categories allows for their classification based on economic content aimed at calculating the total value of net production [1].

Therefore, the economic literature presents numerous indicators of economic efficiency and methodologies for their determination, which continue to increase in number with the development of market relations. However, they are unified toward the common goal of enhancing agricultural efficiency. We will focus only on those directly related to solving the issue of increasing agricultural production based on rational land use, addressing previously unresolved parts of the overall problem. To calculate the economic efficiency of winter wheat cultivation under different soil cultivation systems in crop rotations, it is necessary to correctly determine a system of interconnected indicators that most objectively characterize its level.

Calculations were conducted using electronic technological sheets, which allowed obtaining the following economic indicators: gross production value (based on the cost of 1 ton of production at market prices [5, 10], which were compiled in the last year of research), production costs, cost price of 1 ton of grain, net profit, and profitability level.

## MATERIALS AND METHODS

The study was conducted in 2017–2019 at the experimental field of the Institute of Irrigated Agriculture of NAAS (now the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine).

The soil of the experimental field is dark chestnut medium loam with a humus content in the plow layer of 2.2%. The field capacity of the soil layer to a depth of one meter is 22.4%, and the wilting point moisture content is 9.5%. The groundwater is located deeper than 10 meters.

The area size of the primary seed plot is 500 $m^2$, the accounting plot is 100 $m^2$, and the secondary plot is 50 $m^2$. The plots are systematically arranged. The experiment is

replicated three times.

ORAKUL® Multicomplex is a comprehensive liquid microfertilizer for foliar feeding, containing macro- and microelements in chelated and other readily accessible forms that plants perceive as part of their own structure.

Vimpel is a natural growth regulator that stimulates seed germination, promotes active root system development, and increases crop yield by 20–30%, depending on the crop. It contains polyatomic alcohols, humic acids, and naturally occurring carbonic acids.

Agat-25K contains biological active substances from the life activities of Pseudomonas aureofaciens strain N16 bacteria, with a total amino acid content of 38%. This product supports soil fertility and plant health through its biological activity.

Huapsin is a bacterial preparation containing two strains of Pseudomonas aureofaciens (B-111 and B-306) along with initial doses of macronutrients. It is used to combat plant diseases and pests effectively, even after symptoms appear.

Trichodermin is a biological fungicide used to protect plants from a wide range of fungal and bacterial diseases. It contains specially selected strains of Trichoderma fungi with enhanced synthesis of natural fungicidal and biologically active substances.

## RESULTS AND DISCUSSIONS

The results of the economic analysis of the field study with winter wheat have shown that the varieties, sowing dates, and plant protection applications significantly impact the economic efficiency indicators of winter wheat cultivation (Table 1).

The gross production value per hectare across all varieties and sowing dates in the plant protection treatment options exceeded the control, attributed to a significant increase in grain yield with protection, especially chemical protection.

Production costs varied mainly due to the experimental scheme, influenced by the plant protection factor. In the control variant, this indicator amounted to 6.5 thousand UAH/ha, while in the variants with chemical and biological protection, it increased by 6.2–13.8%, corresponding to 6.9 and 7.4 thousand UAH/ha, respectively.

The cost of seed was also characterized by a certain stability. The lowest cost, at 0.98 thousand UAH/ton, was observed with the variety Maria sown on September 20 and treated with biological plant protection. The highest seed cost, at 1.07 thousand UAH/ton, was recorded for the same variety sown on October 10 with chemical plant protection.

The conditional net profit increased to 11 thousand UAH/ha with the variety Maria sown on September 20 and using chemical plant protection. The investigated economic indicator decreased by 18.3% (to 9.3 thousand UAH/ha) for the Ovidiy variety sown on September 20 without plant protection (control with water treatment only).

The maximum level of profitability (157%) was achieved with the Kohana variety sown on October 10 and using biological plant protection. The reduction of this indicator to 131% was observed with the Maria variety sown on October 10 with chemical plant protection. Therefore, considering that profitability is the most important aspect of each studied element of the technology, it can be concluded that the optimal approach is to cultivate the Maria variety of winter wheat sown on September 20 and applying chemical plant protection. This combination of agricultural practices ensures an increase in conditional net profit to 11 thousand UAH/ha and a profitability level of 148%.

The calculations of the economic efficiency of the second study on winter wheat showed that the Maria variety, grown on irrigated lands with different sowing dates and plant protection systems, exhibited more significant fluctuations in the studied indicators compared to the first study (Table 2). For instance, the gross production value was lowest at 23.0 thousand UAH/ha for wheat sown on October 15 without plant protection (control with water treatment). This value increased by 26.1–26.5% (to 29.0–29.1 thousand UAH/ha) for earlier sowings (September 15 and 25) with chemical plant protection.

Table 1. Economic efficiency of winter wheat varieties depending on sowing dates and plant protection

| Variety (factor A) | Sowing Date (Factor B) | Plant Protection (Factor C) | Economic indicators | | | | |
|---|---|---|---|---|---|---|---|
| | | | Gross Production Value, thousand UAH/ha | Production Costs, thousand UAH/ha | Cost of 1 ton of Grain, thousand UAH | Conditional Net Profit, thousand UAH/ha | Profitability, % |
| Ovidiy | First (20.09) | Control | 15.8 | 6.5 | 1.02 | 9.3 | 144 |
| | | Bio-protection | 17.0 | 6.9 | 1.02 | 10.1 | 145 |
| | | Chemical protection | 17.7 | 7.4 | 1.05 | 10.4 | 140 |
| | Second (01.10) | Control | 16.3 | 6.5 | 0.99 | 9.9 | 152 |
| | | Bio-protection | 17.3 | 6.9 | 0.99 | 10.4 | 149 |
| | | Chemical protection | 17.7 | 7.4 | 1.03 | 10.3 | 139 |
| | Third (10.10) | Control | 15.9 | 6.5 | 1.00 | 9.4 | 146 |
| | | Bio-protection | 17.2 | 6.9 | 1.00 | 10.3 | 148 |
| | | Chemical protection | 17.4 | 7.4 | 1.06 | 10.0 | 135 |
| Maria | First (20.09) | Control | 16.1 | 6.5 | 0.99 | 9.6 | 148 |
| | | Bio-protection | 17.4 | 6.9 | 0.98 | 10.5 | 151 |
| | | Chemical protection | 18.4 | 7.4 | 0.99 | 11.0 | 148 |
| | Second (01.10) | Control | 16.0 | 6.5 | 1.00 | 9.5 | 147 |
| | | Bio-protection | 17.1 | 6.9 | 1.00 | 10.1 | 146 |
| | | Chemical protection | 17.8 | 7.4 | 1.03 | 10.4 | 140 |
| | Third (10.10) | Control | 16.0 | 6.5 | 1.00 | 9.5 | 147 |
| | | Bio-protection | 16.8 | 6.9 | 1.03 | 9.9 | 142 |
| | | Chemical protection | 17.1 | 7.4 | 1.07 | 9.7 | 131 |
| Kohana | First (20.09) | Control | 16.4 | 65 | 0.99 | 10.0 | 154 |
| | | Bio-protection | 17.1 | 6.9 | 1.02 | 10.2 | 146 |
| | | Chemical protection | 17.7 | 7.4 | 1.04 | 10.3 | 139 |
| | Second (01.10) | Control | 16.9 | 6.5 | 0.99 | 10.4 | 156 |
| | | Bio-protection | 17.4 | 6.9 | 1.00 | 10.5 | 150 |
| | | Chemical protection | 17.9 | 7.4 | 1.03 | 10.5 | 142 |
| | Third (10.10) | Control | 16.7 | 6.5 | 0.99 | 10.2 | 149 |
| | | Bio-protection | 17.3 | 6.9 | 1.00 | 10.4 | 157 |
| | | Chemical protection | 17.5 | 7.4 | 1.05 | 10.1 | 137 |

Source: Own calculation based on experimental data.

Production costs ranged from 13.2 to 14.3 thousand UAH/ha, resulting in a difference of 8.3% between the variants. This slight variation can be attributed to the particular study design, as there were no differences in costs based on sowing dates. The variations were only observed in variants with biological and chemical plant protection, as well as due to the additional costs associated with harvesting and transporting the additional

wheat grain yield.

Table 2. Economic efficiency of cultivating different winter wheat varieties with biological properties of the Maria variety depending on the sowing period under irrigation.

| Sowing Date (Factor A) | Plant Protection (Factor B) | Economic indicators | | | | |
|---|---|---|---|---|---|---|
| | | Gross Production Value, thousand UAH/ha | Production Costs, thousand UAH/ha | Cost of 1 ton of Grain, thousand UAH | Conditional Net Profit, thousand UAH/ha | Profitability, % |
| 5 September | Without protection | 24.3 | 13.3 | 2.45 | 11.1 | 83.4 |
| | Bio-protection | 25.7 | 14.1 | 2.46 | 11.6 | 82.7 |
| | Chemical protection | 26.7 | 14.3 | 2.41 | 12.4 | 87.0 |
| 15 September | Without protection | 26.0 | 13.3 | 2.30 | 12.7 | 95.8 |
| | Bio-protection | 27.5 | 14.1 | 2.31 | 13.4 | 94.8 |
| | Chemical protection | 29.1 | 14.3 | 2.21 | 14.8 | 103.3 |
| 25 September | Without protection | 25.4 | 13.3 | 2.35 | 12.2 | 91.6 |
| | Bio-protection | 27.5 | 14.1 | 2.31 | 13.4 | 94.8 |
| | Chemical protection | 29.0 | 14.3 | 2.22 | 14.7 | 104.4 |
| 5 October | Without protection | 25.0 | 13.3 | 2.39 | 11.7 | 88.3 |
| | Bio-protection | 26.7 | 14.1 | 2.37 | 12.7 | 89.8 |
| | Chemical protection | 27.1 | 14.3 | 2.37 | 12.9 | 90.0 |
| 15 October | Without protection | 23.0 | 13.2 | 2.59 | 9.8 | 73.9 |
| | Bio-protection | 25.2 | 14.1 | 2.51 | 11.1 | 79.0 |
| | Chemical protection | 25.5 | 14.3 | 2.52 | 11.2 | 78.7 |

Source: Own calculation based on experimental data.

The lowest cost of 1 ton of grain for the studied crop was 2.21 thousand UAH with wheat sown on September 15 and using chemical plant protection throughout the vegetation period. This cost increased by 17.2% (to 2.59 thousand UAH/ton) for winter wheat sown in the late period (October 15) without plant protection.

The maximum conditional net profit (14.8 thousand UAH/ha) and level of profitability (103.3%) were achieved by cultivating winter wheat with irrigation, sown on September 15th, and using chemical plant protection. These economic indicators decreased significantly by 50.0% and 38.6%, respectively (to 9.8 thousand UAH/ha and 73.9% profitability), when sowing the Maria variety in later periods without plant protection (control variant of factor B). Additionally, it is worth noting that for later sowing dates (October 5th and 15th), the effectiveness of biological plant protection increased significantly and was comparable to chemical plant protection, with a difference in conditional net profit of only 0.9–1.6% and profitability of 0.2–0.4%.

In the third winter wheat trial for the Zira and Ovidiy varieties, the effectiveness of both chemical and integrated plant protection containing a biological component on irrigated land was demonstrated. An analysis of the gross production value of cultivating winter wheat varieties by factors and variants allowed establishing their impact on agrotechnological process indicators. It was shown that this economic indicator reached its maximum value of 26.5 thousand UAH/ha in the variant with the Ovidiy variety under a chemical plant protection system (Table 3). The minimum level of gross production value (20.4 thousand UAH/ha) was obtained in the control variant of the Zira variety. Therefore, the difference between these variants was 29.9%.

Table 3. Economic indicators of cultivating winter wheat varieties depending on the impact of plant protection under irrigation

| Variety (factor A) | Plant Protection (Factor B) | Economic indicators | | | | |
|---|---|---|---|---|---|---|
| | | Gross Production Value, thousand UAH/ha | Production Costs, thousand UAH/ha | Cost of 1 ton of Grain, thousand UAH | Conditional Net Profit, thousand UAH/ha | Profitability, % |
| Zira | Without protection | 20.4 | 12.9 | 2.71 | 7.6 | 58.9 |
| | Bio-protection | 21.7 | 13.8 | 2.73 | 7.9 | 57.6 |
| | Chemical protection | 23.7 | 14.7 | 2.65 | 9.1 | 62.0 |
| | Integral | 25.1 | 15.6 | 2.66 | 9.6 | 61.4 |
| Ovidyi | Without protection | 22.5 | 13.4 | 2.55 | 9.1 | 68.4 |
| | Bio-protection | 23.4 | 14.0 | 2.56 | 9.5 | 67.9 |
| | Chemical protection | 25.6 | 14.6 | 2.45 | 11.0 | 75.8 |
| | Integral | 26.5 | 15.5 | 2.50 | 11.1 | 71.7 |

Source: Own calculation based on experimental data.

The calculations from the technological map revealed that production costs for cultivating the researched crop tended to increase in variants with plant protection, attributed to higher expenses for purchasing pesticides and increased costs for harvesting, grain transportation, drying, etc. The highest (15.5 thousand UAH/ha) and lowest (12.9 thousand UAH/ha) conditional production costs were observed in the Zira variety under control conditions (no plant protection, water treatment only) and in the variant where integrated plant protection practices were followed, respectively. Therefore, the difference between these values amounted to 21.9%.

The cost at the minimum level of 2.45 thousand UAH/ton was observed with the Ovidiy variety when implementing a chemical plant protection system. The increase in this cost to 2.73 thousand UAH/ton was evident in the Zira variety with biological plant protection.

The maximum profitability of 11.0–11.1 thousand UAH/ha was achieved with the Ovidiy variety using integrated and chemical plant protection. The worst result of 7.6 thousand UAH/ha was obtained for cultivating the Zira variety without any plant protection. Thus, the difference between these variants amounted to 46%.

The highest profitability level of 75.8% was achieved with the Ovidiy variety when applying plant protection with chemical products. Additionally, a high profitability level of 71.7% was achieved with integrated plant protection for this variety. The lowest profitability, at 57.6%, was observed with the Zira variety under biological plant protection.

## CONCLUSIONS

The economic analysis has demonstrated that the gross production value per hectare in the first winter wheat field trial across all varieties and sowing dates with plant protection exceeded the control, primarily due to a significant increase in grain yield with protection, especially chemical plant protection. Production costs in the control variant amounted to 6.5 thousand UAH/ha, while in variants with chemical and biological plant protection, they increased by 6.2–13.8%. The lowest cost price of 0.98 thousand UAH/ton was achieved with the Maria variety sown on September 20th with bio-protection. The highest conditional net profit reached 11 thousand UAH/ha with the Maria variety sown on September 20th and using chemical plant protection. Notably, the highest level of profitability, 157.1%, was achieved with the Kohana variety sown in the third period and applying biological plant protection.

In the second winter wheat trial, it was

determined that the gross production value was highest, ranging from 29.0 to 29.1 thousand UAH/ha for sowings on September 15th and 25th with chemical plant protection. This was 26.1-26.5% higher than the variant with sowing on October 15th without plant protection. Production costs ranged from 13.2 to 14.3 thousand UAH/ha. The minimum cost price was 2.21 thousand UAH for sowing on September 15th with chemical plant protection. Net profit also increased to 14.8 thousand UAH/ha, and profitability reached 103.3% with the same combination of factors. The efficiency of biological plant protection significantly increased for late sowings (October 5th and 15th).

The highest gross production value of 26.5 thousand UAH/ha was achieved with the Ovidiy variety under chemical plant protection. Production costs for cultivating the crop tended to increase with plant protection, with a maximum difference of 21.9%. The lowest cost price (2.45 thousand UAH/ton) was obtained for cultivating the Ovidiy variety with chemical plant protection, while some increase in this indicator was observed for the Zira variety with biological protection. Net profit reached 11.0–11.1 thousand UAH/ha with integrated and chemical protection on the Ovidiy variety. This same variety exhibited maximum profitability of 75.8% with chemical plant protection.

The gross production value for cultivating sunflower reached its highest level at 24.7 thousand UAH.

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