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ВІННИЦЬКИЙ НАЦІОНАЛЬНИЙ
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# Сільське господарство та лісівництво

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**ВІННИЦЬКИЙ НАЦІОНАЛЬНИЙ АГРАРНИЙ УНІВЕРСИТЕТ**

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# INFLUENCE OF PRE-SOWING SEED TREATMENT WITH BIOPREPARATIONS ON THE YIELD OF WINTER WHEAT IN THE CONDITIONS OF THE RIGHT-BANK FOREST STEPPE

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*Pre-sowing seed treatment is one of the elements of crop cultivation technology and is widely used in grain production in the Vinnytsia region.*

*The article presents the three-year results of the influence of preparations of different compositions, which are used for seed treatment, on the yield and structure of the winter wheat crop. To establish a field experiment at the research site of the research farm "Agronomichne" VNAU village. Agronomic Vinnytsia district, seeds of the medium-ripening variety 'Skagen' were treated with the following biological preparations: Avicena, SE in a dose of 0.4 l/t, Azotophyt-r – 0,8 l/t, Organic balance – 1 l/t, Help Rost – 1 l/t, a combination of growth regulator and poisoner Azotophyt – 0,8 l/t + Avicena. SE – 0,4 l/t, Organic balance – 1 l/t + Avicena, SE – 0,4 l/t and Help Rost - 1 l/t + Avicena, SE – 0,4 l/t.*

*In the course of the research, the effect of pre-sowing seed treatment with poison and growth regulators on the index of productive tillering, which in the control variant was 1,8 stems/plant, was noted. When used for pre-sowing seed inoculation of biopreparations Azotophyt and Organic balance, productive tillering was 2,1 stems/plant, which was 0,3 stems/plant more than the data obtained on the control variant without treatment. A similar result was observed in the variant that involved sowing seeds treated with the combination of Organic Balance + Avicena, SE.*

*The pre-sowing treatment of Skagen winter wheat seeds with biological preparations, a poison and their combined use had a positive effect on the elements of the crop structure. The number of grains from a plant in the options that provided for the treatment of seeds with biopreparations Azotophyt-r, Organic Balance and Help Rost was on average 34,5-35,3 pcs., which is 1,4-2,3 pcs. exceeded this indicator in the control.*

*The highest yield of the crop – 6,18 t/ha was recorded with the combined pre-sowing treatment of winter wheat seeds with a mixture of Organic Balance (1 l/t) + Avicena, SE (0,4 l/t). Compared to the control option, the increase in grain yield was 1.12 t/ha, and the conditional net profit was UAH 8,866, with a profitability level of 40,2%.*

***Keywords****: biological preparations, yield, seed treatment, winter wheat, cost price, profit.*
***Table 7. Fig. 1. Lit. 13.***

**Formulation of the problem.** Agriculture faces serious problems in ensuring not only gross harvest but also high-quality products. Winter wheat is one of the most valuable food crops in Ukraine, and obtaining stable harvests with high grain quality is the most important task of agricultural producers. Modern equipment, a fertilization system, and plant protection products allow us to count on obtaining high yields of this crop with the favourable agro-climatic potential of the region. However, ignoring the treatment of seed material with protective and stimulating drugs leads to direct crop losses [1].

Pre-sowing treatment of seeds with multifunctional drugs is one of the most popular methods of growing grain crops. Since this agro measure does not require high production costs, it is of great interest to study the effect of drugs on winter wheat plants to increase productivity [2].

Currently, the effective method of protection is chemical, but it has some significant drawbacks, a negative impact on ecosystems and agrocenoses, under its influence, new races and strains of pathogens, more virulent and resistant to fungicides, are formed. In recent years, the production of ecologically safe agricultural products has become a priority in many developed countries of the world. Thus, the search for methods and means that effectively restrain the development of phytopathogens and at the same time are safe for humans and the environment, significantly increase the physiological resistance of agricultural crops to stress factors, is relevant [3]

One of these methods is the use of microbial preparations that limit the development of pathogens and improve the functional state of plants.

Today, scientists have developed a wide range of biological preparations based on beneficial microorganisms with different mechanisms of action, which are aimed at increasing soil fertility, reducing mineral fertilizer rates, increasing plant productivity, and improving the quality of grown products. In recent years, the use of bacterial preparations by the domestic company "BTU centre", which is allowed for use in organic farming, is gaining popularity, which is confirmed by the relevant "Organic Standard" certificate [4].

However, the effect of bacterial preparations on plant objects, especially at the initial stages of their interaction, remains insufficiently studied. Mechanisms of interaction between microorganisms and higher plants also require research to further improve the effectiveness of the use of similar biological preparations in the practice of agricultural production. Relevant information can be provided by the study of the peculiarities of the use of biological preparations and their role in the processes of growth and resistance to the effects of pathogens and pests of bacterized plants [5].

Thus, the study of the peculiarities of the use of biological preparations based on microorganisms with useful properties that contribute to increasing the yield of plants creates prerequisites for the scientific justification of this agrotechnical measure, as one of the main elements of ecologically balanced technology. All this emphasizes the relevance of our research and its production orientation.

**The purpose of the study** is to increase the biological yield of winter wheat, for which the influence of pre-sowing treatment of seeds with bacterial preparations was established, depending on the norm and variant of treatment in farms of the Vinnytsia region.

**Analysis of recent research and publications.** The potential of winter wheat in the zone of the right-bank forest steppe of Ukraine has not yet been realized. This is due to the insufficient level of study of certain physiological features of crop cultivation in the region, and certain agricultural methods that contribute to the

optimization of technology. One of the ways to solve this problem can be the use of bacterial preparations.

The scientific and theoretical basis of our research became the scientific works of domestic scientists who studied the mechanisms of interaction of plants and biological preparations, as well as the behaviour of preparations of different concentrations on the environment and the reaction of plants to their use in different soil and climatic zones. In particular, we are talking about such researchers as Bazalii V.V. [5], Herman M.M., Dumych V.V., Klyuchenko V.V., Kovalishyn A.B. [9], Pinchuk N.V. [4] Chabanyuk Y.V., Shevchenko L.A., Yaroshenko S.S. etc.

Despite the fundamental nature of the work carried out, some questions regarding the effectiveness of the mixture of biological preparations when used in modern agricultural technologies and their role in the process of forming the yield and quality of crops, in particular winter wheat, remain insufficiently elucidated.

Research conditions and methodology. Research aimed at the development of modern adaptive technology for growing winter wheat with the use of biological preparations based on microorganisms and their effect on productivity and efficiency was carried out in the conditions of the Scientific Research Farm "Agronomichne" VNAU village. Agronomy of the Vinnytsia district, in accordance with the assigned tasks. The research was conducted on winter wheat crops of the Skagen variety at the VNAU experimental field during 2020-2023 p.

The arable layer is characterized by the following agrochemical parameters: humus content - 1.9%, saline pH - 5.2, hydrolytic acidity – 36.7 mg-eq. per 1 kg of soil, the number of absorbed bases – 176 mg.-eq. per 1 kg of soil, the degree of alkali saturation – 93.7%, easily hydrolyzed nitrogen according to Kornfield – 62.0 mg, mobile phosphorus and available potassium according to Chirikov – 105 and 119 mg per 1 kg of soil, respectively. Weather conditions during the years of research were generally favourable for the growth and development of winter wheat.

The sowing scheme is a small plot, the area of the accounting plot is 25 $m^2$, the experimental area is 800 $m^2$, the repetition is fourfold, and the placement of the plots is consecutive.

The effect of biological preparations was evaluated in comparison with the control option, where the treatment was not carried out and the natural background of soil microorganisms was.

Sunflower was the predecessor of winter wheat. Tillage consisted of ploughing, disking, pre-sowing cultivation and sowing of seeds. Pre-sowing seed treatment was carried out on the day of sowing. Sowing was carried out on September 16. The seed sowing rate was 400 similar grains per 1 $m^2$, which should provide 550 productive stems per 1 $m^2$ during the harvesting period. The depth of seed wrapping is 4 cm with mandatory rolling of the field after sowing. Sowing method: ordinary serial sowing with rows 15 cm wide.

The scheme of the experiment included: a control variant (without processing) and a study of the effect of biopreparations Azotofit, Organic balance and the

fungicidal protoxin Avicena, which were used in variants with pre-sowing inoculation (Table 1).

*Table 1*

**Scheme of an experiment to determine the effectiveness of biological preparations on winter wheat crops**

| № z/p | Research options |
|---|---|
| 1 | Control (no treatment) |
| 2 | Avicena, SE – 0.4 l/t |
| 3 | Azotofit-r – 0.8 l/t |
| 4 | Organic balance – 1 l/t |
| 5 | Help Rost – 1 l/t |
| 6 | Azotophyte – 0.8 l/t + Avicena, SE – 0.4 l/t |
| 7 | Organic balance – 1 l/t + Avicena, SE – 0.4 l/t |
| 8 | Help Rost – 1 l/t + Avicena, SE – 0.4 l/t |

*the source is formed on the basis of own research results*

Seedlings appeared on the 10–15th day, and the plants entered the 2–3 leaf phase in winter. After the resumption of spring vegetation under favourable conditions, the crops were harrowed twice with a Strigel spring harrow at 14-day intervals to break up the soil crust in the crops and control weeds.

The establishment of field experiments and the study of the effectiveness of drugs were carried out according to the method of B.A. Dospehova Statistical processing of experimental data was carried out by the method of variational statistics [6].

Harvesting was carried out in the phase of full grain ripeness (at a moisture content of 14%) by direct harvesting with minimal losses. Indicators of the structure of the crop and grain quality of winter wheat were determined according to generally accepted methods.

**Presentation of the main research material.** Among bread cereals, wheat is the most important because it's nutritional value and high ecological plasticity (which makes it suitable for growing in the most diverse climatic conditions) are unsurpassed.

The disclosure of the genetic potential of winter wheat productivity is inextricably linked to the application of highly balanced doses of NPK and trace elements. The main direction of the development of plant nutrition systems and the creation of highly effective fertilizers is the development of complex forms of preparations. The greatest attention is paid to the creation of complex fertilizers for the pre-sowing treatment of seeds and foliar feeding, which allows for an increase in the absorption coefficients of plant nutrients and reduces their entry into the environment [7].

Today, in connection with the increase in the prices of fertilizers and energy resources, the main problem in the introduction of feeding systems of high-yielding varieties of cereals is the increase of the assimilation coefficients of macro- and microelements. The main direction of solving this problem is seed treatment with

appropriate drugs, dividing the element dose into several applications; local application of fertilizers (effective above all for wheat varieties of the intensive type, which respond well to increased doses of fertilizers); foliar feeding; integration of nutrition and crop protection systems. An important component of the development of plant nutrition systems and the creation of highly effective fertilizers is the use of complex, physiologically balanced forms of chemical and biological preparations [4].

The production of its grain is considered one of the strategic areas for strengthening the state's economy. However, one of the factors that significantly reduce its yield and grain quality is diseases. It is known that losses of the gross grain harvest due to diseases annually amount to 20–30%, and in epiphytotic years – up to 50% [8]. Therefore, knowledge of the features of the development of diseases in winter wheat, monitoring of the species composition of pathogens, the level of infection of its grain with fungi, and the degree of contamination with mycotoxins require constant control of the relevant factors to carry out appropriate protective measures for the crop.

In the main areas where winter wheat is grown, fungi from the genus Fusarium (*Fusarium avenaceum, Fusarium qraminearum* and others) are the most common root rot pathogens. Research has established that in conditions of a sufficient supply of moisture (60–80% of the total moisture content of the soil), plants are less susceptible to disease. With a shortage or with sharp fluctuations in the moisture content of the soil, as well as with the formation of a crust on the surface of the soil and other unfavourable factors that weaken the plants, a significant development of root rot is observed, the number of dead plants increases, and from those that survived at the time of harvesting, the percentage of those affected doubles. If 5–10% of wheat plants are affected, winter crop loss can reach 3.5–7% [9].

The research was conducted in two directions: determination of the effect of biological preparations on the physiological and biometric parameters of plants and damage by diseases.

Increasing field fertility and productivity in modern crop production technology is one of the important tasks of crop production. Today, various agrotechnical methods are used to increase these indicators, and new high-yielding varieties with high adaptive potential to adverse environmental factors are being introduced. Since the quality of the seed material largely determines the amount of the harvested crop, pre-sowing seed treatment is an integral part of agricultural cultivation technology. cultures

2). The use of biological preparations contributed to the acceleration of the duration of the "sowing-seedling" period. Sowing was carried out in the third decade of May. In the areas where the biological preparation Organic Balance was used for the pre-sowing inoculation of winter wheat seeds of the Skagen variety, the duration of the "sowing - seedling" period was shorter by 1 day compared to the results obtained in the control, and in the areas where the biological preparation Azotophyt was used, the duration of the "sowing - seedling" period was shorter was less by 2 days compared to the control variant without treatment.

When sowing seeds poisoned with the fungicide Avicena, SE, the period of the emergence of seedlings was also reduced by 1 day compared to the control variant.

*Table* 2

**The effect of pre-sowing treatment on seed germination indicators of winter wheat, 2021-2023**

| № | Research options | The duration of the «sowing – seedling» period, days | Field germination of seeds, % | Formation of knotted roots, pcs. |
|---|---|---|---|---|
| 1 | Control (no treatment) | 23 | 89 | 1,8 |
| 2 | Avicena, SE – 0.4 l/t | 22 | 91 | 2,3 |
| 3 | Azotofit-r – 0.8 l/t | 21 | 91 | 2,6 |
| 4 | Organic balance – 1 l/t | 22 | 92 | 2,7 |
| 5 | Help Rost – 1 l/t | 21 | 91 | 2,6 |
| 6 | Azotophyte – 0.8 l/t + Avicena, SE – 0.4 l/t | 21 | 93 | 2,8 |
| 7 | Organic balance – 1 l/t + Avicena, SE – 0.4 l/t | 21 | 93 | 2,7 |
| 8 | Help Rost – 1 l/t + Avicena, SE – 0.4 l/t | 21 | 93 | 2,7 |
| $LSD_{05}$ | | | | 0,21 |

*the source is formed on the basis of own research results*

Combined treatment of seeds with a combination of growth regulator and poisoner Azotophyt + Avicena, Organic Balance + Avicena and Help Rost+ Avicena also accelerated the emergence of winter wheat seedlings by 2 days compared to the control option. Also, pre-sowing treatment increased the field germination of seeds and contributed to the better formation of nodal roots.

In particular, in the variants where the pre-sowing inoculation of winter wheat seeds with biopreparations Azotofit-r, Organic balance and Help Rost was carried out, the field germination of seeds was higher by 2-3% compared to the data obtained on the control variant without treatment. The number of nodal roots also increased by 44% and 50%, which was 2.6-2.7 pcs., while in the control this indicator was 1.8. With the combined use of Azotophyt + Avicen, Organic Balance + Avicena and Help Rost + Avicena, field germination was 93%, which was 4% higher than the control variant. The number of nodal roots was also greater - 2.8-2.7 pcs., which is 0.5-0.4 pcs. exceeded the option, which provided only for poisoning with the drug Avicen, SE.

Despite a certain commonality of physiological effects of biological preparations on seeds, it can be assumed that different types and doses of biological preparations to varying degrees affect not only the sowing qualities of seeds but also, what is important, the development of plants obtained from such seeds.

In our studies, the pre-sowing treatment of Skagen winter wheat seeds with protoxin and growth regulators had a positive effect on the biometric indicators of plants during the period of germination - seedling growth (Table 3).

*Table* 3

**The influence of pre-sowing seed treatment on biometric indicators of winter wheat seedlings (2021-2023)**

| № | Research options | Density plants, pcs./m$^2$ | Productive tugging, stem/plant | Density stalked, pcs./m$^2$ |
|---|---|---|---|---|
| 1 | Control (no treatment) | 256 | 1,8 | 461 |
| 2 | Avicena, SE – 0.4 l/t | 272 | 2,0 | 544 |
| 3 | Azotofit-r – 0.8 l/t | 276 | 2,1 | 580 |
| 4 | Organic balance – 1 l/t | 280 | 2,1 | 588 |
| 5 | Help Rost – 1 l/t | 277 | 2,1 | 586 |
| 6 | Azotophyte – 0.8 l/t + Avicena, SE – 0.4 l/t | 284 | 2,2 | 625 |
| 7 | Organic balance – 1 l/t + Avicen, SE – 0.4 l/t | 282 | 2,1 | 592 |
| 8 | Help Rost – 1 l/t + Avicena, SE – 0.4 l/t | 281 | 2,1 | 608 |
| | $LSD_{05}$ | 0,14 | 0,13 | 0,32 |

*the source is formed on the basis of own research results*

In particular, in the variants where the pre-sowing inoculation of winter wheat seeds with biological preparations was carried out, the density of plants was higher compared to the data obtained on the control variant. When used for pre-sowing seed inoculation of biological preparation Azotophyt, plant density was 20 units/m$^2$ higher compared to the data obtained on the control variant without treatment, when inoculated with biological preparation Organic Balance this indicator was greater by 24 units/m$^2$ compared to the control, and in the case of inoculation with biological preparation Help Rost, this indicator was higher by 21 pcs./m$^2$ compared to the control.

The density of plants on the variant where sowing was carried out with seeds impregnated with Avicena, SE seedling density was 272 pcs./m$^2$, which is 4-8 pcs./m$^2$ less than when inoculated with regulators Azotophyt-r, Organic balance and Help Rost. The highest seedling density of 284-282 pcs./m$^2$ was recorded with the simultaneous treatment of winter wheat seeds with growth regulators and a poisoner – Azotofit + Avicena, Organic Balance + Avicena and Help Rost+ Avicena.

In the course of the research, the effect of pre-sowing seed treatment with poison and growth regulators on the index of productive tillering was noted, which was 1.8 stems/plant in the control variant. When used for pre-sowing seed inoculation of biopreparations Azotophyt and Organic balance, productive tillering was 2.1 stems/plant, which was 0.3 stems/plant more than the data obtained on the control variant without treatment. A similar result was observed in the variant that involved sowing seeds treated with the combination of Organic Balance + Avicena. The highest index of productive tillering is 2.2 stems/plant. was recorded in the Azotophyte + Avicena variant, which exceeded this indicator by 0.2 stems/plant in the area where seeds treated only with the poison were sown.

The density of plants and the coefficient of productive bushing had an effect on the stem density of winter wheat crops of the Skagen variety, which was 544 in the variant that provided for the treatment of seeds only with a poison, which was 18% higher than the corresponding indicator in the control. When used for pre-sowing seed inoculation of biopreparations Azotophyt and Organic balance, stem density was 580-588 pcs./$m^2$, which is 26-28% more compared to the data obtained on the control variant without treatment. The combination of the pre-sowing treatment of the poisoner seeds and the growth regulator showed the highest stem density. Thus, in the variants Azotophyt + Avicena and Organic Balance + Avicena, the stem density was 625-592 pcs./$m^2$, respectively, which exceeded the control variant by 36+28%.

The primary task of the pre-sowing treatment of seeds of agricultural crops is the maximum mobilization and stimulation of growth processes in them, increasing on this basis the resistance of seedlings, and then of vegetative plants to damage by infectious diseases and adverse environmental conditions (treatment of seeds with growth regulators or influence on them by physical means), as well as direct protection of seeds from pathogens by chemical and biological destruction (seed treatment with fungicides) [11].

Analyzing the damage of winter wheat seedlings by root rot, a positive effect of pre-sowing treatment in controlling damage by pathogens was noted, the damage of which was 10.5% of the control (Fig. 1).

The use of regulators stimulated the resistance of plants to damage by pathogens. When seeds were inoculated with Azotophyt-r and Organic balance, root rot damage of seedlings was 6.6-4.5%, respectively, which is 1.6-2.3 times lower than the damage of seedlings on the control variant. The use of the Avicena poison, SE at the rate of 0.4 l/t allowed to reduce the damage to seedlings to 1.6%, which is 6.5 times lower than in the control.

The lowest damage of winter wheat seedlings by root rot was observed as a result of a combination of pre-sowing treatment of seeds with poison and biological preparations.

Thus, when treating seeds with a mixture of Azotophyt-r + Avicena, Organic balance + Avicena and Help Grow + Avicena, the damage of seedlings by root rot was 1.2-0.9%, respectively, which is 10 times lower than the level of spread of pathogens in the control.

It should be noted that modern technologies for growing winter wheat involve the use of various biological and re-regulating drugs that increase the drought resistance and winter resistance of plants, increase their productivity, and improve grain quality [12].

The research established that winter wheat plants came out of overwintering in different ways, it was established that pre-sowing treatment with a poison and biological preparations had a positive effect on the winter hardiness of winter wheat plants, which in the control was 90.5%, which ensured the density of shoots in the spring of 417.2 pcs./ $m^2$ (Table 4).

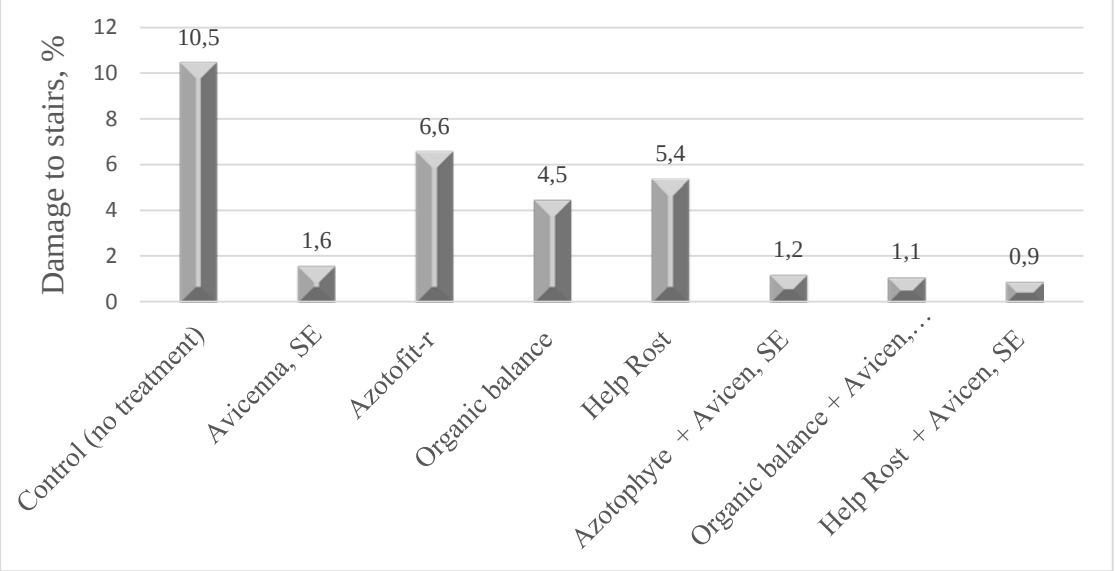


Fig. 1. The effect of pre-sowing seed treatment on damage to winter wheat seedlings by root rot

*the source is formed on the basis of own research results*

The highest rate of winter hardiness was observed in the version using the poisoner Avicena, SE, which was 94.8%, which ensured the density of shoots in the spring of 515.7 pcs./m$^2$.

On the variants that involved pre-sowing treatment with biopreparations Azotofit-r, Organic balance and Help Rost, winter hardiness was noted at the level of 93.2-93.8%, which ensured the density of shoots in the spring of 540.6-551.5 pcs./m$^2$, respectively. The joint treatment of wheat seeds with poison and biopreparations also contributed to increasing the winter hardiness of plants.

*Table 4*

**The influence of pre-sowing treatment of seeds on the winter hardiness of plants of winter wheat, 2021-2023**

| № | Research options | Number of shoots in spring, pcs./m$^2$ | Winter hardiness, % |
|---|---|---|---|
| 1 | Control (no treatment) | 417,2 | 90,5 |
| 2 | Avicena, SE – 0.4 l/t | 515,7 | 94,8 |
| 3 | Azotofit-r – 0.8 l/t | 540,6 | 93,2 |
| 4 | Organic balance – 1 l/t | 551,5 | 93,8 |
| 5 | Help Rost – 1 l/t | 545,2 | 93,5 |
| 6 | Azotophyte – 0.8 l/t + Avicena, SE – 0.4 l/t | 588,1 | 94,1 |
| 7 | Organic balance – 1 l/t + Avicen, SE – 0.4 l/t | 558,3 | 94,3 |
| 8 | Help Rost – 1 l/t + Avicena, SE – 0.4 l/t | 573,2 | 94,0 |
| $LSD_{05}$ | | 2,8 | |

*the source is formed on the basis of own research results*

Thus, in the variants treated with Azotophyt-r + Avicena, Organic Balance + Avicena and Help Rost+ Avicena compositions, the winter resistance of winter wheat plants was observed at the level of 94.0-94.3%, which in turn ensured the density of shoots in the spring of 588.1-558,3 pcs./$m^2$, respectively.

Analyzing the data in Table 4, it can be asserted that the pre-sowing treatment of winter wheat seeds with a poisoner, biological preparations and a mixture of them had a positive effect in stressful winter conditions, which is especially important for the preservation of the obtained seedlings and the formation of crops during the spring growing season.

Pre-sowing treatment of Skagen winter wheat seeds had a positive effect on the formation of the root system of plants and contributed to the reduction of the period of seed germination, which is important in adverse winter environmental conditions and contributes to the overwintering of plants.

It is known that the main factors that form a productive stem stand are the genetic and physiological characteristics of the variety, the supply of plant nutrients and the hydrothermal conditions of the growing season. It is believed that the number of productive stems per 1 $m^2$ or the density of the productive stem plays the determining role in shaping the yield of winter wheat in the forest-steppe conditions out of the two main elements of the structure [12].

The component of the productivity structure - the number of plants per 1$m^2$ during the harvesting period - depends on the number of seedlings in this area, which in turn is determined by the field germination of the seeds. It is known that the field germination of seeds of most agricultural crops remains low, in grain crops it is 65-85% [14].

In the conducted studies, the field germination of winter wheat seeds also varied by year from 89% to 93%, and its average value was 91%.

During the records carried out in the period of the beginning of earing, it was noted that the pre-sowing treatment of Skagen winter wheat seeds had a positive effect on the productive bushiness, which in the control was 88.5, which provided an average of 369.2 pcs./$m^2$ of productive stems (table. 5).

When used for pre-sowing seed inoculation of the bio preparation Azotophyt-r, the total number of stems was 540.6 pcs./$m^2$, which is 123.4 pcs./$m^2$ more compared to the data obtained on the control version without treatment, the part of productive stems was 91.3 %, which on average provided 493.5 pcs./$m^2$ of productive stems on this variant.

During the pre-sowing inoculation of seeds with the biological preparation Organic balance, the total number of stems was 551.5 pcs./$m^2$, which is 134.3 pcs./$m^2$ more compared to the data obtained on the control variant without processing, and the part of productive stems was 89.6%, which, on average, provided 494.2 pieces/$m^2$ of productive stems on this variant.

In the variant that involved poisoning with the drug Avicena, SE (during spring weeding), the total number of stems was 515.7 pcs./$m^2$, which is 98.5 pcs./$m^2$ more compared to the data obtained on the control variant without treatment, and the share

*Table 5*

**The influence of pre-sowing seed treatment on the productive bushiness of winter wheat (beginning of earing), 2021-2023**

| № | Research options | Total number of stalks pcs./m$^2$ | Number of productive ones stalks, pcs./m$^2$ | Productive stalks, % |
|---|---|---|---|---|
| 1 | Control (no treatment) | 417,2 | 369,2 | 88,5 |
| 2 | Avicena, SE – 0.4 l/t | 515,7 | 467,8 | 90,7 |
| 3 | Azotofit-r – 0.8 l/t | 540,6 | 493,5 | 91,3 |
| 4 | Organic balance – 1 l/t | 551,5 | 494,2 | 89,6 |
| 5 | Help Rost – 1 l/t | 545,2 | 493,9 | 90,6 |
| 6 | Azotophyte – 0.8 l/t + Avicena, SE – 0.4 l/t | 588,1 | 549,3 | 93,4 |
| 7 | Organic balance – 1 l/t + Avicen, SE – 0.4 l/t | 558,3 | 519,7 | 93,1 |
| 8 | Help Rost – 1 l/t + Avicena, SE – 0.4 l/t | 572,6 | 534,4 | 93,3 |
| $LSD_{05}$ | | 3,1 | 2,6 | |

*the source is formed on the basis of own research results*

of productive stems was 90.7%, which on average provided 467.8 pieces/m$^2$ of productive stems in this variant.

During the pre-sowing inoculation of seeds with biological preparation Help Rost, the total number of stems was 545.2 pcs./m$^2$, which is 128.0 pcs./m$^2$ more compared to the data obtained on the control variant without treatment, and the part of productive stems was 90.6%, which, on average, provided 493.9 pieces/m$^2$ of productive stems on this variant.

With the combined application for pre-sowing treatment of the options Azotophyt-r + Avicena, SE, Organic balance + Avicena, SE and Help Grow + Avicena, SE, the total number of stems at the beginning of earing was 588.1-558.3 pcs./m$^2$, which by 170,9-141.1 pcs./m$^2$ than on the control, and the part of productive stems was 93.3-93.1%, respectively, which on average provided 549.3-519.7 pcs./m$^2$ of productive stems on these variants.

The winter wheat crop is formed under the influence of a complex set of conditions, each of which affects its quantity and quality. In order to determine the effect of each component on crop formation and their shortcomings, it is necessary to study the elements of the crop structure in each case [1].

The elements of the crop structure mean the productive organs and features of the plant that create and determine the size of the grain harvest. For wheat, the main elements of the harvest are the density of the productive stalk, the graininess of the ear and the fullness of the grain. Each of these elements of the crop can change to a greater or lesser extent under the influence of environmental conditions. Analyzing the previously obtained results, it was noted that the pre-sowing treatment of Skagen winter wheat seeds with biological preparations, a protoxin and their combined use had a positive effect on the elements of the crop structure (Table 6) in particular

the number of grains per plant, the weight of grain per ear and 1000 grains, which in general allowed to obtain a higher yield.

*Table 6*

**Economic efficiency of pre-sowing seed treatment of winter wheat, 2021-2023**

| № | Research options | Number of grains per plant, pcs. | Mass of grain from an ear, g | Mass of 1000 grains, g | Yield, t/ha |
|---|---|---|---|---|---|
| 1 | Control (no treatment) | 33,1 | 1,34 | 37,1 | 5,06 |
| 2 | Avicenna, SE – 0.4 l/t | 34,6 | 1,71 | 40,4 | 5,62 |
| 3 | Azotofit-r – 0.8 l/t | 34,5 | 1,62 | 39,7 | 5,54 |
| 4 | Organic balance – 1 l/t | 35,3 | 1,74 | 40,2 | 5,71 |
| 5 | Help Rost – 1 l/t | 34,8 | 1,67 | 39,9 | 5,62 |
| 6 | Azotophyte – 0.8 l/t + Avicena, SE – 0.4 l/t | 36,0 | 1,83 | 41,0 | 6,03 |
| 7 | Organic balance – 1 l/t + Avicen, SE – 0.4 l/t | 36,5 | 1,86 | 41,2 | 6,18 |
| 8 | Help Rost – 1 l/t + Avicena, SE – 0.4 l/t | 36,1 | 1,84 | 41,0 | 6,07 |
| | $LSD_{05}$ | | 0,21 | 0,91 | 1,22 |

*the source is formed on the basis of own research results*

The number of grains of the plant in the options that provided for the treatment of seeds with biopreparations Azotophyt-r, Organic Balance and Help Rost was on average 34.5-35.3 pcs., which is 1.4-2.3 pcs. exceeded this indicator in the control. In the area where winter wheat seeds poisoned with Avicena were sown, the seaveraged 34.6 grains per plant, which also exceeded the corresponding indicator in the control by 1.5 pcs. The highest number of grains from a plant is 36.0-36.5 pcs. was recorded with the simultaneous pre-sowing treatment of seeds with combinations of Azotophyt-r + Avicen, Organic Balance + Avicena and Help Rost+ Avicen, SE.

The weight of the grain from the ear in the options that provided for the treatment of the seeds with biopreparations Azotophyt-r, Organic Balance and Help Rost averaged 1.62-1.74 g, which was 0.28-0.3 g higher than this indicator in the control. In the area where winter wheat seeds poisoned with the Avicena preparation were sown, the SE average weight of grain from an ear was 1.71 g, which also exceeded the corresponding indicator in the control by 0.37 g. The highest weight of grain from an ear was 1.83-1, 86 g was recorded with the combined pre-sowing treatment of seeds with combinations of Azotophyt-r + Avicena, Organic balance + Avicena and Help Rost + Avicena, SE.

The weight of 1,000 grains in the variants that involved seed treatment with biopreparations Azotophyt-r, Organic Balance and Help Rost averaged 39.7-40.2 g, which was 2.6-3.1 g higher than this indicator in the control. In the area where winter wheat seeds poisoned with Avicena were sown, the seaverage weight of 1000 grains was 40.4 g, which also exceeded the corresponding indicator in the control by 3.3 g. The highest weight of 1000 grains was 41.0-41.2 g was recorded with simultaneous

pre-sowing treatment of seeds with combinations of Azotophyt-r + Avicena, Organic Balance + Avicena and Help Rost + Avicena, SE.

Thus, the pre-sowing treatment of winter wheat seeds of the Skagen variety had a positive effect on the parameters of the crop structure, and accordingly on the yield of winter wheat, which was 5.06 t/ha in the control. The yield in the area where the seeds treated with biopreparations Azotophyt-r, Organic Balance and Help Rost were sown averaged 5.54-5.71 t/ha, which was 0.48-0.65 t/ha higher than this indicator in the control. In the area where winter wheat seeds poisoned with Avicen, SE were sown, the yield was recorded at the level of 5.62 t/ha, which was also 0.56 t/ha higher than the corresponding indicator in the control. The highest yield of winter wheat - 6.03-6.18 t/ha was recorded with the combined pre-sowing treatment of seeds with combinations of preparations Azotofit-r + Avicena, Organic Balance + Avicena and Help Rost+ Avicena, SE.

Agriculture is a business, and the basis of every business is to obtain maximum profits for minimum costs. So farmers are used to counting every hryvnia of expenses and monitoring prices to sell their crops more profitably. Winter wheat belongs to economically attractive crops. This is confirmed by the fact that in the structure of crops in the Vinnytsia region this year, it is inferior only to corn and can provide decent profits at moderate costs.

General indicators of the economic efficiency of agricultural production include the following indicators: growth rates of gross output, net profit, increase in labour productivity, profitability of production, and reduction of production costs per unit of gross output.

To characterize the economic efficiency of grain cultivation, it is possible to limit oneself to such indicators as laboratory similarity, cost of production, net profit and level of profitability. Therefore, to determine the economic efficiency of any production, it is necessary to know, on the one hand, the value of the obtained result, and on the other hand, the costs that were incurred in the production process [13].

Pre-sowing treatment of winter wheat seeds makes it possible not only to significantly increase product yield, and improve its quality but also to reduce labor costs and costs for the production of these products.

According to the results of our research, an assessment of the economic efficiency of the pre-sowing treatment of winter wheat seeds with a poisoner and biological preparations was carried out. The results of these studies are presented in Table 7.

As can be seen from the data in the table, among the options for inoculation of winter wheat seeds with biological preparations, the highest yield – 5.71 t/ha was obtained in the option where Organic Balance was used at the rate of 1.0 l/t. The yield increase, compared to the control variant, was 0.65 t/ha, and the conditional net profit was uah 6,925, with a profitability level of 32%. In the variant with seed poisoning with Avicen's fungicidal poison, SE at the rate of 0.4 l/ha yielded winter wheat yield of 5.62 t/ha. The yield increase, compared to the control option, was 0.56 t/ha, and the conditional net profit was UAH 6,240, with a profitability level of 28.5%.

*Table 7*

**Economic efficiency of pre-sowing treatment of winter wheat seeds per 1 ha (average for 2022-2023)**

| Indexes | Research options | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Control (no treatment) | Avicenna, SE – 0.4 l/t | Azotofit-r – 0.8 l/t | Organic balance – 1 l/t | Help Rost – 1 l/t | Azotophyte – 0.8 l/t + Avicena SE – 0.4 l/t | Organic balance – 1 l/t + Avicena, SE – 0.4 l/t | Help Rost – 1 l/t + Avicen, SE – 0.4 l/t |
| Productivity, t/ha | 5,06 | 5,62 | 5,54 | 5,71 | 5,62 | 6,03 | 6,18 | 6,07 |
| Yield increase, t/ha | – | 0,56 | 0,48 | 0,65 | 0,56 | 0,97 | 1,12 | 0,45 |
| Price for 1 t * | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 | 5000 |
| Product cost, hryvnias. | 25300 | 28100 | 27700 | 28550 | 28100 | 30150 | 30900 | 30350 |
| Production costs, UAH | 21140 | 21860 | 21627 | 21625 | 22090 | 22003 | 22034 | 22457 |
| including additional | – | 720 | 487 | 485 | 230 | 863 | 894 | 830 |
| of them for protection | – | 520 | 264 | 285 | 110 | 642 | 685 | 630 |
| Cost of 1 ton, hryvnias. | 4177,9 | 3889,7 | 3903,8 | 3787,2 | 3930,6 | 3648,9 | 3565,4 | 3699,7 |
| Conditional net profit, hryvnias. | 4160 | 6240 | 6073 | 6925 | 6010 | 8147 | 8866 | 7893 |
| including additional | – | 2080 | 1913 | 2765 | 1850 | 3987 | 719 | 1653 |
| Rate of return, % | 19,7 | 28,5 | 28,1 | 32,0 | 27,2 | 37,0 | 40,2 | 35,1 |

**- in 2023 prices*

The highest yield of the crop - 6.18 t/ha was recorded with the combined pre-sowing treatment of winter wheat seeds with a mixture of Organic Balance (1 l/t) + Avicen, SE (0.4 l/t). The yield increase, compared to the control variant, was 1.12 t/ha, and the conditional net profit was UAH 8,866, with a profitability level of 40.2%. The combination in the pre-sowing treatment of Azotofit-r (0.8 l/t) + Avicen, SE (0.4 l/t) was also economically beneficial. With a yield of 6.03 t/ha, which exceeded the control variant by 0.97 t/ha, the conditional net profit amounted to UAH 8,147, with a profitability level of 37.0%.

**Conclusions.** The conducted research expands knowledge in understanding the mechanisms of formation of grain productivity of winter grain crops. The obtained experimental material opens up prospects for further research in the field of the formation of a positive effect on the elements of the plant crop structure under the

influence of biological preparations. The use of biological preparations has a significant impact on growth and physiological processes, increasing the resistance of winter wheat plants to adverse factors. At the same time, the intensity of the effect of pesticides on clay depends on the type of pesticide, its concentration, the method of their application, and the frequency of application. The studied preparations increase the density of winter wheat plants per 1 $m^2$ by an average of 11%. Treatment of winter wheat seeds before sowing increases germination energy by 15% and germination by 13-16%, depending on the type and dose of biological preparation.

Biomasses exert a significant influence on the formation of elements of food structure. So, the weight of 1000 grains in the variants that involved the treatment of seeds with biological preparations Azotofit-r, Organic Balance and Help Rost was on average 39.7-40.2 g, which was 2.6-3.1 g higher than this indicator in the control. In the area where winter wheat seeds poisoned with Avicena, SE were sown, the average weight of 1000 grains was 40.4 g, which also exceeded the corresponding indicator in the control by 3.3 g. The highest weight of 1000 grains was 41.0-41.2 g was recorded with simultaneous pre-sowing treatment of seeds with combinations of Azotophyt-r + Avicen, SE, Organic Balance + Avicena and Help Rost+ Avicen, SE.

The highest yield of winter wheat – 6.03-6.18 t/ha was recorded with the combined pre-sowing treatment of seeds with combinations of preparations Azotofit-r + Avicen SE, Organic Balance + Avicena and Help Rost+ Avicen, SE.

The combination in the pre-sowing treatment of Azotofit-r (0.8 l/t) + Avicena, SE (0.4 l/t) was also economically beneficial. With a yield of 6.03 t/ha, which exceeded the control variant by 0.97 t/ha, the conditional net profit amounted to UAH 8,147, with a profitability level of 37.0%.

Thus, the introduction of the developed technological method of pre-sowing treatment of seeds with biological preparations in combination with trace elements guarantees an increase in the yield of winter wheat by 9-22%, as well as an improvement of the technological and nutritional qualities of the seeds.

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# *АНОТАЦІЯ*
# *ВПЛИВ ПЕРЕДПОСІВНОЇ ОБРОБКИ НАСІННЯ НА ВРОЖАЙНІСТЬ І СТРУКТУРУ ВРОЖАЮ ПШЕНИЦІ ОЗИМОЇ В УМОВАХ ПРАВОБЕРЕЖНОГО ЛІСОСТЕПУ*

*Передпосівний обробіток насіння являється одним із елементів технології вирощування сільськогосподарських культур і широко застосовується при виробництві зерна у Вінницькій області. В статті наведено трьохрічні результати впливу препаратів різного складу, які застосовуються для обробки насіння, на урожайність та структуру врожаю озимої пшениці. Для закладки польового досліду на дослідній ділянці науково-дослідного господарства «Агрономічне» ВНАУ с. Агрономічне Вінницького району, насіння середньостиглого сорту Скаген оброблялось наступними біопрепаратами препаратами: «Авіцена, СЕ» в дозі 0,4 л/т, «Азотофіт-р» – 0,8 л/т, «Органік баланс» – 1 л/т, «Хелп Рост» – 1 л/т, комбінацією регулятора росту та протруйника «Азотофіт» - 0,8 л/т + «Авіцена. СЕ» – 0,4 л/т, «Органік баланс» - 1 л/т + «Авіцена, СЕ» – 0,4 л/т та «Хелп Рост» – 1 л/т + «Авіцена, СЕ» – 0,4 л/т. В ході досліджень відмічено вплив передпосівної обробки насіння протруйником та регуляторами росту на показник продуктивного кущення, яке на контрольному варіанті складало 1,8 стебел/росл. При застосуванні для передпосівної інокуляції насіння біопрепаратів Азотофіт та Органік баланс продуктивне кущення складало 2,1 стебел/росл, що було більше на 0,3 стебел/росл у порівнянні з даними отриманими на контрольному варіанті без обробки. Аналогічний результат спостерігали у варіанті, що передбачав висів насіння протруєного комбінацією Органік баланс + Авіцена, СЕ. Передпосівна обробка насіння пшениці озимої сорту Скаген біопрепаратами, протруйником та сумісне їх застосування мало позитивний ефект на елементи структури врожаю. Кількість зерен з рослини у варіантах, що передбачали обробку насіння біопрепаратами Азотофіт-р, Органік баланс та Хелп Рост становила в середньому 34,5-35,3 шт., що на 1,4-2,3 шт. перевищувало даний показник на контролі. Найвищу урожайність культури – 6,18 т/га зафіксовано при сумісній передпосівній обробці насіння пшениці озимої сумішшю Органік баланс (1 л/т) + Авіцена, СЕ (0,4 л/т). Приріст урожаю зерна, в порівнянні з контрольним варіантом, склав 1,12 т/га, а умовно чистий прибуток – 8866 грн., при рівні рентабельності – 40,2%.*

***Ключові слова:*** *біопрепарати, урожайність, обробка насіння, озима пшениця, собівартість, прибуток.*

***Табл. 7. Рис. 1. Літ. 13.***

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