

THE EFFECTIVENESS OF BIOLOGICALS IN SOYBEAN CROPS UNDER THE CONDITIONS OF THE RIGHT-BANK FOREST-STEPPE OF UKRAINE

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Topicality. There is a global trend towards biologisation of agriculture, driven not only by environmental and social issues, but also by economic ones. Therefore, the search for and implementation of effective energy-saving and environmentally friendly elements of crop cultivation technologies, including the use of biologicals with fungicidal and stimulating properties, as well as biodestructors of plant residues, is of high relevance. The effectiveness of biologicals is unstable and depends on many environmental factors, so they need to be studied and adapted to the soil and climatic conditions of a particular ecological and geographical zone. **Purpose.** Evaluation of the impact of seed and crop treatments with biologicals and introduction of a plant residue biodestructor on soybean productivity and disease infection. **Methods.** The field method was used to study the impact of the interaction of the studied factors on soybean productivity and disease infection; the quantitative and weighing method was used to determine soybean yield; and the mathematical and statistical method was used to analyse and establish the reliability of the results. **Results.** The influence of soybean seed treatment with the Vympel-K stimulant (0.5 l/t), MycoHelp biofungicide (3 l/t) and treatment of seeds and crops with Organic-Balance biological product of systemic action (1.5 l/t and 0.5 l/ha) on the background of introduction of Organic-Balance (1.5 l/ha) as a biodestructor into the soil on productivity and disease infection was investigated. It was found that pre-sowing treatment of seeds with environmentally friendly formulations increases soybean yield by 3.9–14.4 %, depending on the use of Organic-Balance for spraying crops and introducing it into the soil as a biodestructor. Spraying the crops with Organic-Balance increased soybean yields by 7.1–15.3 %, the introduction of Organic-Balance biodestructor into the soil increased yields by 5.0–9.6 %. The most effective variant was the seed treatment with MycoHelp biofungicide in combination with Organic-Balance for introduction into the soil and spraying of crops, where the yield increase was 31% or 0.71 t/ha compared to the control without biologicals. Also, seed treatment and introducing biodestructor reduced the spread of root rot to 5.0–8.1 %, compared to 14.0 % in the control. The spraying of the crops with Organic-Balance restrained the spread of Septoria leaf spot to 41–45 %, compared to 70–72 % in the control. **Conclusions.** The use of biologically friendly formulations (Organic-Balance, Vympel-K, and MycoHelp) leads to a significant increase in yield (by 3.9–15.3 %) and a decrease in soybean disease infection. Seed treatment formulations show a higher percentage efficiency in increasing yields in variants without the destructor introduction and without spraying crops (by 7.6–14.4 %) compared to the background with these treatments (by 3.9–8.0 %). These elements of agricultural technology can be used to improve environmentally friendly technologies of soybean cultivation in agricultural formations of the Right-Bank Forest-Steppe of Ukraine.

Key words: biologicals, plant growth stimulators, soybean, yield, destructor of plant residues, soybean diseases

Introduction. The primary objective of modern global agriculture is ensuring environmentally friendly, highly productive and low-cost agricultural production. Thus, agrarians' focus on reproductive and environmentally balanced agriculture is driven by the loss of soil fertility, excessive energy intensity of mineral fertiliser

production and the high cost of chemical plant protection. In addition, there is the problem of meeting the growing needs of the world's population and livestock with protein, in which an important place is given to expanding the area under crops and increasing the productivity of soybeans (*Glycine hispida* (Moench) Max) [1, 2].

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With climate warming, warm-season crops (maize, soybeans, sunflower) have become dominant in the structure of the western region's acreage, but the intensity of plant infection by most diseases has increased and the range of pests and heat-loving weeds has expanded, which has necessitated the improvement of protection systems [3, 4]. In the context of climate change, the introduction of legumes into crop rotations reduces nitrogen fertiliser application, reduces production costs and contributes to the production of environmentally friendly products. In addition, as the climate becomes more arid, biologically-based farming systems also contribute to the sustainability of crop production [5–7].

Today, the soil quality is deteriorating in all soil and climatic zones, i.e. the humus content is decreasing (over the past decade, the humus fund of Ukraine has decreased by 10–14 %), nitrogen is lacking in the soil, the content of mobile forms of phosphorus and potassium in the topsoil is decreasing, and the area of acidified and saline soils is increasing. As a result of chemicalisation, the biological activity of soils is significantly depressed, as the diversity and quantity of microflora has decreased, which has, in particular, worsened the decomposition of plant residues [4, 8, 9].

So, to solve these problems, biodestructors and microbial preparations with multifunctional action should be used, as they have a number of advantages. For example, the destructor application improves mineral nutrition of plants, accumulates biological nitrogen in the soil, improves soil structure and composition, reduces moisture evaporation, suppresses many diseases and reduces the number of some pests that are localised on plant residues [4, 10, 11]. The beneficial soil microorganisms introduced into agrocenoses, having colonised the root areas, block plant infection by pathogenic bacteria and micromycetes for a long time. Scientists have found that in epiphytic years for certain diseases, pre-sowing seed inoculation with certain biologicals helped to delay the development of diseases by 2–3 weeks (which significantly affected crop yields), and seeds produced by bacterised plants are less infected by pathogens, thus significantly increasing grain storage [12, 13].

Analysis of modern scientific developments also indicates that the introduction of bio-

logicals into agricultural production provides a 15–30 % increase in yield with a significant improvement in product quality. Biologicals help to reduce the application of pesticides and thereby improve the environmental conditions in agrophytocenoses. Improving plant resistance to diseases is associated with the antibiotic properties of bacteria, improved nitrogen nutrition, competition between pathogens and symbionts for nutrients, and changes in the immunity of host plants [14–15].

In addition, microorganisms contribute to the formation of physiologically active compounds in the rhizosphere, including phytohormones, which are natural regulators of plant growth and development. Such microorganisms are often used to produce microbial preparations used in crop production to stimulate seed germination, accelerate root formation, and the growth and development of crops [16–18].

Biologicals can increase crop yields, reduce the chemical load on the environment and reduce crop cultivation costs, but according to statistics, the probability of a positive effect of microbial preparations was only 65–70 % [19, 20]. Therefore, biologicals of comprehensive action were developed, which contain physiologically active compounds of biological origin in addition to the bacterial component. Under favourable conditions, the components of such biologicals have a synergistic effect on the plant, while under unfavourable conditions (when the effect of the bacterial component is levelled), the production process of the crop is affected by the physiologically active component [12, 21, 22].

The study of biologically based crop production is very relevant for modern crop production. However, the instability of the effects of the application of biologicals requires further study of their impact on crop productivity and infection, in particular in the Right-Bank Forest-Steppe of Ukraine.

The research was aimed at studying the effect of seeds and crops treatment with biologicals with the introduction of plant residues biodestructor into the soil on soybean productivity and disease infection.

Materials and Methods. The research was conducted on the fields of the Khmelnytskyi State Agricultural Research Station of the Institute of Feed Research and Agriculture of Podillia of the National Academy of Agrarian Sciences of

Ukraine using soybean (*Glycine hispida* (Moench) Max) of Siverka variety during 2021–2023.

The main research method was field trial (studying the interaction of the studied factors on productivity and disease infection of soybeans). Also we used the quantitative weight method (determining the yield) and the mathematical and statistical method (analysing and establishing the reliability of the results).

The soil of the experimental plot is a slightly podzolised medium loamy, medium-heavy low-humus chernozem on loess loam of brownish-pale colour. Variants are systematically placed. The registration area of the plot is 32 m², the total area is 40 m². The experiment was repeated three times. The cultivation technology is generally accepted in the Khmelnytskyi region, however chemical protection consisted of only one herbicide treatment in the spring.

Agrochemical characteristics of the soil were as follows: humus content (according to Tyurin) – 2.8–2.9 %; pH – 5.8–6.2; hydrolytic acidity – 1.9–2.3 mg/eq. per 100 g; total nitrogen reserves 0.153–0.163 %; phosphorus content 0.136–0.149 %; easily hydrolysed nitrogen – 17–19.3 mg; mobile forms of phosphorus and potassium (according to Chirikov) – 20.8–22.6 and 8–12 mg per 100 g of soil, respectively.

Registrations and observations were carried out in accordance with generally accepted methods of research in agriculture [23–25]. Recording of soybean diseases was carried out in accordance with the guidelines edited by V. P. Omeliuta [26].

Biologicals were applied to soybeans according to the experimental design: *Factor A* (introduction of a plant residue destructor into the soil): 1) no destructor; 2) Organic-Balance biodestructor (1.5 l/ha). *Factor B* (seed treatment): 1) water treatment; 2) Vympel-K (0.5 l/t); 3) Organic-Balance (1.5 l/t); 4) MycoHelp (3.0 l/t). *Factor C* (spraying of crops): 1) no spraying; 2) Organic-Balance (0.5 l/ha).

The biodestructor was applied to the soil and plant residues in the autumn after harvesting the predecessor crop immediately before soil disking. Seed treatment with biologicals was carried out at the date of sowing, considering the methodology edited by V. V. Volkohon [12]. Soybean crops were sprayed twice – at the 1–2 pairs of true leaves stage and flower bud formation stage.

Results and Discussion. According to the results of the research, it was found that pre-sowing seed treatments with the growth stimulator of natural origin Vympel-K and microbiologicals Organic-Balance and MycoHelp, as well as foliar treatment with Organic-Balance have a positive effect on the growth and development of soybean plants.

It was confirmed that the seed yield level of soybean was significantly dependent on the studied factors (Table 1).

Over the three years of research, the average yield of soybean seeds of the Siverka variety was 2.29–3.00 t/ha, depending on the introduction of a destructor and pre-sowing treatment of seeds and crops with biologically safe preparations. We found that the application of these formulations led to an increase in the seed yield of soybean by an average of 3.9–15.3 %.

According to the results of the data analysis, seed treatment with biologicals contributes to growth of soybean grain yield by 3.9–14.4 %, introduction of biodestructor into the soil – by 5.0–9.6 %, while spraying with Organic-Balance biologicals – by 7.1–15.3 %. The most productive variant among these is seed treatment with MycoHelp biofungicide in combination with the introduction of a biodestructor into the soil and spraying of the crop with Organic-Balance, which resulted in a yield increase of 31 % or 0.71 t/ha compared to the control (without the application of biologicals).

We found that the highest efficiency of biologicals for seed treatment of soybean was observed on the background without the introduction of a destructor and, especially, without spraying the crops with a biologicals.

Thus, in the variant with a single seed treatment, the yield increase was 7.9–14.4 %, while in the variant with the introduction of a biodestructor into the soil and spraying of the crop – 3.9–6.4 %.

However, the highest increase in crop productivity was achieved with the combined action of all three factors. Thus, treatment of soybean seeds with MycoHelp biofungicide increased the yield by 0.33 t/ha on average, while in combination with biodestructor and spraying with Organic-Balance – by 0.71 t/ha (Table 1).

Our research has also shown that the application of a plant residue biodestructor and seed treatment with biologicals limit the spread of soybean root rot (Table 2).

Table 1. Soybean yields depending on the introduction of a biodestructor into the soil and treatment of seeds and crops with biologicals, t/ha, 2021–2023

| Seed treatment (factor B) | Yield, t/ha | | | | Deviation of yields by: | | | | | |
|---|-------------------|-------|-------|-------------|-------------------------|------|----------------------------------|-----|----------------------|------|
| | | | | | seed treatment | | introduction of biodestructor | | spraying of crops | |
| | 2021 | 2022 | 2023 | average | t/ha | % | t/ha | % | t/ha | % |
| The first background - No treatment of crops with biologicals (factor C) | | | | | | | | | | |
| Without biodestructor (factor A) | | | | | | | | | | |
| Control | 2.57 | 2.12 | 2.17 | 2.29 | C | - | C | - | C | - |
| Vympel-K (0.5 l/t) | 2.89 | 2.27 | 2.26 | 2.47 | 0.18 | 7.9 | C | - | C | - |
| Organic-Balance (1.5 l/t) | 2.89 | 2.30 | 2.34 | 2.51 | 0.22 | 9.6 | C | - | C | - |
| MycoHelp (3.0 l/t) | 3.06 | 2.38 | 2.42 | 2.62 | 0.33 | 14.4 | C | - | C | - |
| Organic-Balance biodestructor (1.5 l/ha) (factor A) | | | | | | | | | | |
| Control | 2.78 | 2.42 | 2.33 | 2.51 | C | - | 0.22 | 9.6 | C | - |
| Vympel-K (0.5 l/t) | 3.14 | 2.56 | 2.41 | 2.70 | 0.19 | 7.6 | 0.23 | 9.3 | C | - |
| Organic-Balance (1.5 l/t) | 3.11 | 2.60 | 2.48 | 2.73 | 0.22 | 8.8 | 0.22 | 8.8 | C | - |
| MycoHelp (3.0 l/t) | 3.18 | 2.68 | 2.54 | 2.80 | 0.29 | 11.6 | 0.18 | 6.9 | C | - |
| The second background - Spraying of crops with Organic-Balance biologicals (0.5 l/ha) (factor C) | | | | | | | | | | |
| Without biodestructor (factor A) | | | | | | | | | | |
| Control | 3.04 | 2.50 | 2.39 | 2.64 | C | - | C | - | 0.35 | 15.3 |
| Vympel-K (0.5 l/t) | 3.16 | 2.62 | 2.48 | 2.75 | 0.11 | 4.2 | C | - | 0.28 | 11.3 |
| Organic-Balance (1.5 l/t) | 3.22 | 2.67 | 2.55 | 2.81 | 0.17 | 6.4 | C | - | 0.30 | 11.9 |
| MycoHelp (3.0 l/t) | 3.22 | 2.71 | 2.62 | 2.85 | 0.21 | 8.0 | C | - | 0.23 | 8.8 |
| Organic-Balance biodestructor (1.5 l/ha) (factor A) | | | | | | | | | | |
| Control | 3.20 | 2.72 | 2.55 | 2.82 | C | - | 0.18 | 6.8 | 0.31 | 12.3 |
| Vympel-K (0.5 l/t) | 3.33 | 2.84 | 2.63 | 2.93 | 0.11 | 3.9 | 0.18 | 6.5 | 0.23 | 8.5 |
| Organic-Balance (1.5 l/t) | 3.33 | 2.85 | 2.68 | 2.95 | 0.13 | 4.6 | 0.14 | 5.0 | 0.22 | 8.1 |
| MycoHelp (3.0 l/t) | 3.37 | 2.90 | 2.73 | 3.00 | 0.18 | 6.4 | 0.15 | 5.3 | 0.20 | 7.1 |
| LSD ₀₅ , t/ha | factor A 0.258 | 0.207 | 0.119 | | | | | | | |
| | factor B 0.185 | 0.140 | 0.056 | | | | | | | |
| | factor C 0.129 | 0.017 | 0.042 | | | | | | | |

Note. C – control by deviations

Table 2. Effect of introduction of biodestructor and seed treatment with biologicals on the root rot infection of soybean, %, 2021–2023

| Seed treatment (factor B) | Root rot infection of soybeans, % | | | |
|--|-----------------------------------|------|------|---------|
| | 2021 | 2022 | 2023 | average |
| Without biodestructor (factor A) | | | | |
| Control | 22.7 | 12.0 | 7.2 | 14.0 |
| Vympel-K (0.5 l/t) | 11.0 | 8.3 | 4.5 | 7.9 |
| Organic-Balance (1.5 l/t) | 11.8 | 8.0 | 3.6 | 7.8 |
| MycoHelp (3.0 l/t) | 9.4 | 5.8 | 2.8 | 6.0 |
| Organic-Balance biodestructor (1.5 l/ha) (factor A) | | | | |
| Control | 17.1 | 9.2 | 6.7 | 11.0 |
| Vympel-K (0.5 l/t) | 9.7 | 6.2 | 4.1 | 6.6 |
| Organic-Balance (1.5 l/t) | 7.6 | 5.5 | 3.0 | 5.4 |
| MycoHelp (3.0 l/t) | 8.9 | 4.4 | 1.6 | 5.0 |
| LSD ₀₅ , % | factor A 0.72 | 0.48 | 0.31 | |
| | factor B 0.42 | 0.30 | 0.19 | |

In 2021, the spread of soybean root rot (caused by fungi of the genus *Fusarium spp.*) was significant due to a sharp transition from moisture deficit to heavy showers in May, however, even during this period, the development of the disease did not exceed 1 point of infection for all years of research. It was found that the spread of the disease in areas without the application of biologicals was 14.0 % on average over three years, with the application of only a biodestructor – 11.0 %, while in plots with seed treatment with biologicals – 6.0–7.9 % and 5.0–6.6 %, respec-

tively. Seed treatment with MycoHelp biofungicide was slightly more effective, which reduced the spread of root rot to an average of 5.0–6.0 %. Seed treatment with Vympel-K stimulant inhibited the spread of root rot, indicating the ability of the formulation to enhance plant resistance to the disease.

It was also found that spraying the crops with Organic-Balance in the 2–3 pairs of true leaves and flowering stages helped to limit the spread of Septoria leaf spot in soybeans (Table 3).

Thus, soybean infection with *Septoria glyci-*

Table 3. Effect of seed treatment and spraying crops with biologicals on Septoria leaf spot infection in soybean, %, 2021–2023

| Seed treatment (factor B) | | Septoria leaf spot infection of soybeans, % | | | |
|---|----------|---|------|------|-------------|
| | | 2021 | 2022 | 2023 | average |
| The first background – No treatment of crops with biologicals (factor C) | | | | | |
| Without biodestructor (factor A) | | | | | |
| Control | | 81 | 93 | 44 | 72.7 |
| Vympel-K (0.5 l/t) | | 80 | 92 | 42 | 71.3 |
| Organic-Balance (1.5 l/t) | | 77 | 90 | 44 | 70.3 |
| MycoHelp (3.0 l/t) | | 76 | 92 | 41 | 69.7 |
| Organic-Balance biodestructor (1.5 l/ha) (factor A) | | | | | |
| Control | | 78 | 90 | 43 | 70.3 |
| Vympel-K (0.5 l/t) | | 79 | 91 | 43 | 71.0 |
| Organic-Balance (1.5 l/t) | | 80 | 93 | 44 | 72.3 |
| MycoHelp (3.0 l/t) | | 78 | 90 | 42 | 70.0 |
| The second background – Spraying of crops with Organic-Balance biologicals (0.5 l/ha) (factor C) | | | | | |
| Without biodestructor (factor A) | | | | | |
| Control | | 56 | 47 | 31 | 44.7 |
| Vympel-K (0.5 l/t) | | 51 | 47 | 30 | 42.7 |
| Organic-Balance (1.5 l/t) | | 50 | 46 | 32 | 42.7 |
| MycoHelp (3.0 l/t) | | 52 | 44 | 29 | 41.7 |
| Organic-Balance biodestructor (1.5 l/ha) (factor A) | | | | | |
| Control | | 40 | 47 | 30 | 39.0 |
| Vympel-K (0.5 l/t) | | 49 | 47 | 30 | 41.7 |
| Organic-Balance (1.5 l/t) | | 46 | 45 | 29 | 40.0 |
| MycoHelp (3.0 l/t) | | 43 | 42 | 28 | 37.7 |
| LSD ₀₅ , % | factor A | 2.61 | 2.20 | 1.21 | |
| | factor B | 1.22 | 1.15 | 1.06 | |
| | factor C | 1.12 | 1.03 | 1.04 | |

nes T. Hemmi was reduced by spraying the crop with Organic-Balance to 38–45 %, compared to 70–73 % in variants without this measure, on average over three years of research. The introduction of biodestructor and seed treatment with biologicals had no effect on the spread of spot diseases.

Thus, biologicals for seed treatment such as Vympel-K, Organic-Balance and MycoHelp,

as well as the biodestructor Organic-Balance have a positive effect on limiting the spread of root rot in soybeans, and spraying crops with the biological product Organic-Balance – of Septoria leaf spot.

Conclusions. The application of biologically safe formulations (Organic-Balance biodestructor, Vympel-K, Organic-Balance, and

MycoHelp) contributes to a significant increase in yield (by 3.9–15.3 %) and a decrease in the infection of soybean diseases (root rots and Septoria leaf spot). Seed treatment formulations are more effective in increasing soybean yields on plots without the use of destructors and without

spraying the crop (by 7.6–14.4 %), compared to the variants where these methods are used (by 3.9–8.0 %). These agrotechnical methods are recommended for improvement of environmentally friendly soybean cultivation technologies in the Right-Bank Forest-Steppe of Ukraine.

References

- Kaminskyi, V. F. & Saiko, V. F. (2015). Agriculture of the 21st century. Problems and solutions. *Zemlerobstvo: mizhvidomchyi naukovyi zbirnyk* [Interdepartmental scientific collection “Agriculture”], 1. 3–15. [in Ukrainian].
- Godfray, H. C. J., Beddington, J. R., Crute, I. R. & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science*, 327. 812–818. <https://doi.org/10.1126/science.1185383>
- Polovyi, V., Lukashchuk, L., & Lukianyk, M. (2019). Influence of climate fluctuations on development of plant growing in conditions of Western region. *Visnyk ahrarnoi nauky* [Bulletin of Agricultural Science], 9. 29–34. <https://doi.org/10.31073/agrovisnyk201909-04> [in Ukrainian].
- Lykhochvor, V. V. (2004). *Biologichne roslinnytstvo*. [Biological crop production]. Lviv: NVF Ukrainski tekhnologii. [In Ukrainian].
- Ivanina, V. V. & Korotenko, I. M. (2022). Influence of nitrogen fertilizers and predecessors on the productivity of winter wheat. *Zernovi kultury* [Grain Crops], 6 (2). 100–105. <https://doi.org/10.31867/2523-4544/0238> [in Ukrainian]
- Palmer, J., Thorburn, P., Biggs, J., Dominati, E., Probert, M., Meier, E., Huth, N., Dodd, M., Snow, V., Larsen, J. & Parton, W. (2017). Nitrogen Cycling from Increased Soil Organic Carbon Contributes Both Positively and Negatively to Ecosystem Services in Wheat AgroEcosystems. *Front Plant Sci*. 8. 731. <https://doi.org/10.3389/fpls.2017.00731>
- Isbell, F., Craven, D., Connolly, J., Loreau, M., Schmid, B. & Beierkuhnlein, C. (2015). Biodiversity increases the resistance of ecosystem productivity to climate extremes. *Nature*. 526, 574–577. <https://doi.org/10.1038/nature15374>
- Volkohon, V., Dimova, S., Volkohon, K., & Sydorenko, V. (2020). The efficiency of microbial preparations indifferent systems of fertilizing crops. *Visnyk ahrarnoi nauky* [Bulletin of Agricultural Science], 6. 5–14. <https://doi.org/10.31073/agrovisnyk202006-01> [in Ukrainian]
- Dubyt'ska, A. O., Kachmar, O. Yo., Dubyt'skyi, O. L. & Vavrynovych, O. V. (2019). The impact of ecologically safe fertilizer systems of the winter wheat on the biological activity of the soil under conditions of climate change. *Zernovi kultury* [Grain Crops], 3 (2). 331–336. <https://doi.org/10.31867/2523-4544/0093> [in Ukrainian].
- Tokmakova, L. & Shevchenko, L. (2023). Antagonistic activity of cellulolytic bacteria – destroyers of organic matter against phytopathogenic micromycetes. *Visnyk ahrarnoi nauky* [Bulletin of Agricultural Science], 6. 18–24. <https://doi.org/10.31073/agrovisnyk202306-02>
- Kovalenko, A. M., Novokhyzhnii, M. V., Tymoshenko H. Z. & Serhieieva, Yu. O. (2020). Features of application of destructors of stubble in the Steppe zone. *Visnyk ahrarnoi nauky* [Bulletin of Agricultural Science], 2. 44–51. <https://doi.org/10.31073/agrovisnyk202002-07> [in Ukrainian].
- Volkohon, V. V., Zaryshniak, A. S., Hrynyk, I. V., Berdnikov, O. N., Tsentylo, L. V., Nadkernychna O. V. ... Murach O. M. (2011). *Metodolohiia i praktyka vykorystannia mikrobynykh preparativ u tekhnolohiiakh vyroshchuvannia silskohospodarskykh kultur*. [Methodology and practice of using microbial preparations in technologies of growing crops]. Volkohon V. V. (Ed.). Kyiv: Ahrarna nauka. [in Ukrainian].
- O'Callaghan, M. (2016). Microbial inoculation of seed for improved crop performance: issues and opportunities. *Appl. Microbiol. Biotechnol.*, 100. 5729–5746. <https://doi.org/10.1007/s00253-016-7590-9>
- Iutinskaya, G. A., & Ponomarenko, S. P. (Eds.) (2010). *Bioregulyatsiya mikrobo-rastitelnykh sistem* [Bioregulation of microbial-plant systems: monograph]. Kiev: NICH LAVA [In Russian].
- Van Lenteren, J.C., Bolckmans, K., Kohl, J. Ravensberg, W. J. & Urbaneja, A. (2018). Biological control using invertebrates and microorganisms: plenty of new opportunities. *BioControl*, 63. 39–59. <https://doi.org/10.1007/s10526-017-9801-4>
- Hrytsayenko, Z. M., Ponomarenko S. P., Karpenko V. P. & Leontyuk I. B. (Hrytsayenko Z. M. (Ed.)). (2008). *Biologichno aktyvni rechovyny v roslinnytviv* [Biologically active substances in crop production]. Kyiv: ZAT «NICH LAVA». [In Ukrainian].
- Chen, P., He, W., Shen, Y., Zhu, L., Yao, X., Sun, R., Dai, C., Sun, B. & Chen, Y. (2022). Interspecific Neighbor Stimulates Peanut Growth Through Modulating Root Endophytic Microbial Community Construction. *Front. Plant Sci*. 13. <https://doi.org/10.3389/fpls.2022.830666>
- Vasylenko, M. H. (2017). Organo-mineral fertilizers and plant growth regulators in organic farming. *Visnyk ahrarnoi nauky* [Bulletin of Agricultural Science], 2. 11–18. <https://doi.org/10.31073/agrovisnyk201702-02> [in Ukrainian].
- Okon, Y. (1982). Field inoculation of grasses with Azospirillum. *Biological nitrogen fixation in tropical agriculture*. 459–467.
- Hryhorieva, O. M., Cheriachukin, M. I. & Almaieva, T. M. (2020). Biologized technology of soybean growing under conditions of risky agriculture of the Right-bank Steppe of Ukraine. *Zernovi kultury* [Grain Crops], 4 (1). <https://doi.org/10.31867/2523-4544/0110>
- Volkohon, V. V., Nadkernychna, O. V., Kovalevska, T. M., Tokmakova, L. M., Kopylov, E. P., Kozar, S. F. et al. (2006). *Mikrobnii preparaty u zemlerobstvi. Teoriia i praktyka: Monohrafiia*. [Microbial preparations in agriculture. Theory and practice: a monograph]. Kyiv : Ahrarna nauka. [in Ukrainian].
- Bashan, Y., de Bashan, L.E., Prabhu S.R. & Hernan-

- dez, J.-P. (2014). Advances in plant growth-promoting bacterial inoculants technology: formulations and practical perspectives (1998–2013). *Plant Soil*, 378. 1–33. <https://doi.org/10.1007/s11104-013-1956-x>
23. Moyseychenko, V. F. & Yeshchenko, V.O. (1994). *Osnovy naukovykh doslidzhen v ahronomii: Pidruchnyk*. [Basics of scientific research in agronomy: Textbook]. Kyiv: Vyshshcha shkola. [in Ukrainian]
24. Trybel, S. O., Siharova, D. D., Sekun, M. P. & Ivashchenko, O. O. (Trybel S. O. (Ed.)). (2001). *Metodyky vyprovuvannia i zastosuvannia pestytsydiv* [Methods of testing and application of pesticides]. Kyiv: Svit. [in Ukrainian]
25. Tsykova, V. S. & Pykush, H. R. (Ed.). (1983). *Metodicheskie rekomendacii po provedeniiu polevyh opytov s zernovymi, zernobobovymi i kormovymi kulturami (issledovaniia, uchety i nabliudeniia)*. [Methodological recommendations for conducting field experiments with grain, leguminous and fodder crops (research, records and observations)]. Dnepropetrovsk: VNIK. 49 p. [In Russian].
- 26 Omeliuta, V. P., Hryhorovych, I. V., Chaban, V. S., Pidoplichko, V. N., Kalenych, F. S., Petruha, O. Yo. & Chernenko, O. O. (Omeliuta V. P. (Ed.)). (1986). *Oblik shkidnykiv i khvorob silskohospodarskykh kultur*. [Accounting for pests and diseases of crops]. Kyiv: Urozhai. [In Ukrainian].

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Актуальність. У світі назріла потреба біологізації землеробства, зумовлена не тільки екологічними та соціальними, а й економічними проблемами. Тому актуальним є пошук і впровадження ефективних енергоощадних та екологічно безпечних елементів технологій вирощування культур, зокрема, застосування біопрепаратів із фунгіцидними і стимулюючими властивостями, а також біодеструкторів рослинних залишків. Ефективність дії біопрепаратів нестабільна і залежить від багатьох факторів навколишнього середовища, тому вони потребують вивчення та адаптації до ґрунтово-кліматичних умов конкретної еколого-географічної зони. **Мета дослідження.** Оцінка впливу обробки насіння та посівів біопрепаратами при внесенні у ґрунт біодеструктора на продуктивність та ураження хворобами сої. **Методи.** Польовий метод – для вивчення взаємодії досліджуваних чинників на продуктивність та ураження сої хворобами; кількісно-ваговий метод – визначення врожайності; математично-статистичний – аналіз і встановлення достовірності отриманих результатів. **Результати.** Представлені результати досліджень впливу обробки насіння сої стимулятором природного походження Вимпел-К, (0,5 л/т), біофунгіцидом МікоХелп (3 л/т) та обробки насіння і посівів біопрепаратом комплексної дії Органік-баланс (1,5 л/т і 0,5 л/га) при внесенні у ґрунт біодеструктора Органік-баланс (1,5 л/га) на показники продуктивності й ураження хворобами. Встановлено, що передпосівна обробка насіння екологічно безпечними препаратами сприяє збільшенню урожайності сої на 3,9–14,4 %, залежно від застосування Органік-баланс для обприскування посівів та внесення у ґрунт як біодеструктора. Обприскування посіву препаратом Органік-баланс сприяло підвищенню урожайності сої на 7,1–15,3 %, а внесення у ґрунт Органік-баланс біодеструктора – на 5,0–9,6 %. Найбільш ефективним варіантом була обробка насіння біофунгіцидом МікоХелп у комплексі з внесенням біодеструктора та обприскуванням посіву Органік-баланс, і де приріст урожайності становив 31 % або 0,71 т/га до контролю без біопрепаратів. Також обробка насіння та внесення біодеструктора знижували поширення кореневої гнилі до 5,0–8,1 %, порівняно із 14,0 % у контролі. Обробка посівів препаратом Органік-баланс стримувала поширення септоріозу сої до 41–45 %, від 70–72 % у контролі. **Висновки.** Застосування біологічно-безпечних препаратів (Органік-баланс, Вимпел-К і МікоХелп) призводить до значного збільшення урожайності (на 3,9–15,3 %) та зниження ураження сої хворобами. Препарати для обробки насіння показують вищу відсоткову ефективність у збільшенні урожайності у варіантах без внесення деструктора та без обробки посіву (на 7,6–14,4 %), порівняно до фону, де використовуються ці заходи (на 3,9–8,0 %). Означені елементи агротехніки можуть бути застосовані для вдосконалення екологічно-безпечних технологій вирощування сої в агроформуваннях Правобережного Лісостепу України.

Ключові слова: біопрепарати, стимулятори росту і розвитку рослин, соя, урожайність, деструктор рослинних решток, хвороби сої