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BIOLOGIZATION OF AGRICULTURE AS AN ELEMENT OF INCREASING ECONOMIC EFFICIENCY OF CROP PRODUCTION IN THE TERRITORY OF SOUTHERN UKRAINE

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ABSTRACT
Extensive system of agriculture applying mineral fertilizers and pesticides has caused ecological imbalance in agro-ecosystems, soil degradation, negative consequences in the biosphere and problems of food safety. The research establishes that application of biological preparations and plant growth regulators in crop production is a promising trend in agriculture ensuring high potential of agricultural production with a minimal impact on agro-ecosystems. The purpose of the study is to determine effectiveness of application of bio-preparations and plant growth regulators for growing agricultural crops in the Southern Steppe zone of Ukraine. The research was conducted using field, analytical, economic-statistical, comparative and abstract-logical methods. The study on productivity of agricultural crops under arid conditions of the Southern Steppe of Ukraine was based on application of the plant growth regulators Hreinaktyv C and Nano-Hro. The highest increase in winter wheat grain yield was identified in the crops treated three times with Hreinaktyv C at the stage of tillering, flag leaf emergence and grain filling (3.2 c/ha, 18 %). In this case the greatest effect was observed in the crops treated at the stage of tillering, where an increase in the yield was 2.9 c/ha, +16 % to the control variant. Treatment of the crops at the stage of a flag leaf contributed to an increase in the yield by 0.7 c/ha (4 %), and at the stage of grain filling – by 0.8 c/ha (4.5 %). Pre-sowing treatment of sunflower hybrid seeds with Nano-Hro and treatment of the crops at the growing stage (before a flowering stage) resulted in an equal increase – by 0.9 c/ha of seeds (+12 % to the control variant). An increase in the yield was only 0.32 c/ha (4 %) when sunflower crops were treated after flowering. The highest increase in the sunflower yield was observed when the crops were treated three times at the mentioned development stages being 1.6 c/ha (+22 % to the control variant). A positive effect of the preparation was identified at the initial stages of the industrial crop development due to the growth of the root system and an increase in absorption of nutrients from the soil. The research establishes that the preparation Hreinaktyv C is environmentally friendly, it decomposes quickly in soil, does not cause an effect of adaptation and reduces a risk of plant diseases, has a positive impact on agricultural crop productivity. Pre-sowing treatment with the plant growth stimulator Nano-Hro contributes to immune effect of plants, increases their resistance to unfavorable weather conditions, decreases pesticide loads on soils and protects against pests.Application of bio-preparations contributes to a rise in economic efficiency and improvement of agricultural production, allows reducing norms of the pesticides used, increasing productivity and quality of grain and industrial crops. It was established that total costs for seed treatment or herbage treatment with Hreinaktyv-C and Nano-Hro equaled 30–65 UAH/ha, the level of profitability amounted to 10 thous. UAH/ha. Implementation of biological technology elements increases profits of agricultural production to 80% that is a precondition for sustainable development of agro-industrial complex and a further rise in productivity of Ukraine's economy.
Keywords*: economic efficiency, profitability, biological technologies, agricultural production, soil quality.*

INTRODUCTION

Intensive development of the global civilization has caused irreversible degradation processes in natural ecosystems. A reduction in the quality of soils, water resources and atmospheric air has affected productivity of plant cover which plays a key role in fixation and transmission of energy to living beings, products of organic matter and oxygen. The existing technologies in agricultural production based on extensive system of soil tillage, application of mineral fertilizers and pesticides disrupt balance in all components of the environment. A further tendency for intensive use of land resources with application of chemical preparations will cause negative global consequences in the biosphere, problems of food safety for humans and emergencies threatening the existence of life on Earth. A promising trend in agriculture ensuring high poten-

tial of agricultural production with a minimal impact on agro-ecosystems is application of biological preparations and growth regulators in crop production.

ANALYSIS OF THE RECENT RESEARCH AND PUBLICATIONS

A wide application of biological methods for plant protection in agricultural production occurred in the 60's of the 20th century. Advancement of scientific research was based on the development of new technological decisions concerning an increase in efficiency of bio-preparations, plant growth regulators and complex application of them in agriculture [1]. The issue of introduction of alternative biological agriculture, specificity of application of biological and growth-regulating preparations aimed at achieving environmental safety was considered in the scientific studies by O. L. Dubytskyi [2], S. A. Yashchenko. [3], M. Kozhushko [4], H. M. Sedilo [5], O. A. Kovalenko [6], I. V. Honcharuk [7], Ye. O. Domaratskyi [8], T. P. Shepilova [9], H. A. Chuhrii [10], T. O. Hrabovska [11], M. H. Vasylenko [12], A. T. Farniev [13] and others.

The global scientific community faces the problem of searching for innovative methods for increasing the global food supply because of a rise in the number of people living on Earth. The studies of the foreign scientists [14-18] confirmed the effect of bio-preparations and plant growth regulators on productivity and improvement of agricultural product quality. In their studies, Jubi Jacob [19]; Shagufta Afreena [20]; Archana Singh [21]., presented nanotechnologies for increasing productivity of agricultural crops on the basis of plant growth regulators containing carbon and cuprum, protecting plants against pathogenic organisms and negative factors of the environment. Reda Ben Mrid suggested applying bio-stimulators and bio-protectors on the basis of extracts of sea weeds, humin substances, protein hydrolysates, aminoacids, plant extracts for improving plant growth and productivity, reducing a negative impact of abiotic and biotic factors of the environment [22].

Main purpose of the chapter is to substantiate appropriateness of applying bio-preparations and growth regulators for increasing economic efficiency of crop production in the Steppe zone of Ukraine.

METHODS OF RESEARCH

The research was carried out by means of field, analytical, economic-statistical, comparative and abstract-logical methods.

The territory of the research is located in the Steppe zone of Ukraine characterized by unfavorable natural climatic conditions for agricultural production which manifest themselves as intensive ineffective rainfalls and periods without rainfalls under conditions of high summer temperatures. The soils are mainly chestnut, alkali and soloth. The thickness of humus horizon is 45–55 cm. The density of composition is 1.25–1.35, the density of a solid phase of soil is 2.65–2.69 g/cm^3. The total porosity is 45–50 %. The humidity of withering is 6–8 %, LMC – 21-30 %. pH of the environment is 7.2–7.4. Waterproof aggregates of more than 0.25 mm make 40–42 % [8].

The effect of the stimulator Hreinaktyv-C on productivity of the winter wheat Driada-1was determined using the following experiment scheme:

1. Without plant treatment (control).
2. Plant treatment at the stage of tillering.
3. Plant treatment at the stage of the flag leaf.
4. Plant treatment at the stage of grain filling.
5. Three-time plant treatment.

The experiment was replicated four times. The area of the registered plot was 100 m^2.

The effect of the stimulator Nano–Hro on productivity of the sunflower hybrid Siuzhet was determined using the following experiment scheme:

1. Control (without treatment).
2. Seed treatment before sowing.
3. Treatment at the stage of growth.

4. Treatment after flowering.
5. Three-time plant treatment.

The experiment was replicated four times. The area of the registered plot was 100 m^2.

RESULTS AND DISCUSSIONS

The territory of Kherson region is dangerous in terms of erosion with strong winds – more than 6 m/s, dry, with a high average annual air temperature and an insufficient amount of precipitation. Groundwater is located 3–4 m deep. Disruption of the hydrodynamic regime of groundwater caused a decline in the water table, an increase in the number of dry days and a reduction in air humidity, that led to a drop in productive moisture in the soil and a fall in the crop productivity of 20–70 % [23].

The agro-meteorological conditions of the research territory are unfavorable for obtaining high yields of agricultural crops, therefore, it is necessary to apply biological preparations in order to increase productivity of agricultural products under dry conditions and ensure ecologically balanced agricultural production.

The mechanism of the effect of bio-preparations consists in fermentative fixation of atmospheric nitrogen and fermentative assimilation of poorly soluble phosphates ensuring intensive development of a plant root system that has a positive impact on the ability of winter crops to survive winter. It should be mentioned that treated agricultural crops are more resistant to diseases due to improvement of their general immunity, there is a significant increase in energy of seed germination, there are favorable conditions for the formation of plant stand and generative organs, intensity of ontogenesis and photosynthesis improves.

Seed treatment with biological preparations facilitates activation of nitrogen-assimilation ferments in plants that causes additional protein synthesis in grains. Examination of the effect of the preparation Hreinaktyv-C on winter wheat crops showed its positive impacts on the crop productivity. Hreinaktyv-C is an innovative preparation with a systemic positive impact on agricultural crops. The active ingredient is a soluble biologically active organic compound containing nitrogen atoms boosting exchange processes in plants, facilitating processes of nitrification and ammonification in soil and plant growth under conditions of moisture deficit. Formation of plant-bacteria association contributes to substantial accumulation of nitrogen in soil, that improves indexes of its fertility and increases winter wheat productivity. It was established that the effects of the preparation Hreinaktyv-C depended on the stages of plant development in which the crops were treated with the growth stimulator (Table 1). According to the data in Table 1, the most considerable increase in winter wheat grain productivity was observed under 3-time treatment of the crops at the stages of tillering, the flag leaf and grain filling (3.2 c/ha, or 18 %).

Table 1. The effect of the growth stimulator Hreinaktyv-C on winter wheat productivity

№	Variants	Productivity, c/ha					+ -	Ranking
		Replication				Average		
		I	II	III	IV			
1	Without treatment (control)	18.2	16.8	19.4	17.6	18.0	0	5
2	Treatment at the stage of tillering	20.1	21.2	21.6	20.9	20.9	+2.9	2
3	Treatment at the stage of the flag leaf	19.1	18.6	19.2	17.9	18.7	+0.7	4
4	Treatment at the stage of grain filling	18.0	19.6	18.5	19.0	18.8	+0.8	3
5	3-time treatment	21.3	20.6	22.1	20.5	21.2	3.2	1

$LSD_{0.05}$ – 0.92 c/ha

The most significant effect was observed under the crop treatment at the stage of tillering, when an increase in the yield equaled 2.9 c/ha, or +16 % in comparison with the control variant. The crop treatment at the stage of the flag leaf contributed to an increase in the yield – 0.7 c/ha (4 %), and at the stage of grain filling – 0.8 c/ha (4.5 %), which were within the limits of the experiment error being 0.92 c/ha.

The preparation Hreinaktyv-C is environmentally friendly, because it decomposes in soil, does not cause the effect of habituation and reduces the risk of damage by plant diseases and has a positive effect on crop productivity.

A positive impact of the preparation Nano-Hro on sunflower hybrid productivity was also established (Table 2).

Table 2. The effect of the growth stimulator Nano-Hro on sunflower hybrid productivity

№	Variants	Productivity, c/ha					+ -	Ranking
		Replication				Average		
		I	II	III	IV			
1	Control (without treatment)	7.0	6.8	7.9	7.7	7.3	0	5
2	Seed treatment	8.3	7.8	8.9	7.5	8.2	0.9	3
3	Treatment at the stage of growth	8.1	8.6	7.8	8.0	8.2	0.9	2
4	Treatment after flowering	7.6	8.0	7.2	7.4	7.6	0.3	4
5	3-time treatment	8.7	9.2	8.5	6.4	8.9	1.6	1

$LSD_{0.05}$ – 0.54 c/ha

According to the data in Table 2, the effectiveness of the preparation also depends on the time of application.

The identical increase – 0.9 c/ha of seeds (+12 % in comparison with the control variant) – was observed under pre-sowing seed treatment at the stage of growth (before flowering), and an increase in the yield under sunflower treatment after flowering was only 0.32 c/ha (4 %). The most considerable increase in the yield was observed under 3-time treatment at the above stages of sunflower development – 1.6 c/ha (+22 % in comparison with the control variant). A positive effect of the bio-preparation was observed at the initial development stages of the industrial crop due to the growth of a root system and more intensive absorption of nutrients from the soil.

Pre-sowing treatment with the growth stimulator Nano-Hro contributes to a rise in immune activity of plants, increases their resistance to unfavorable weather conditions, protects against pests and results in a reduction in pesticide loads in soils.

Application of bio-preparations of a complex effect in agricultural production is especially important for the zone of Southern Ukraine which is characterized by unfavorable climatic conditions. Since productivity of agricultural crops depends on abiotic and biotic conditions of the environment, plant treatment with growth regulators facilitates improvement of immune and productive potential of plants and increases resistance of agricultural crops to unfavorable ecological factors of the environment. Apart from a positive effect on physiological processes of plants, growth stimulators have a positive impact on micro-biological processes in soil, in particular, on assimilation of carbon dioxide by heterotrophic microorganisms. Accumulation of organic matter occurs and soil formation process in agrocenoses improves.

Due to their growth-regulating, anti-stress and protective functions, the preparations Hreinaktyv-C and Nano-Hro allow obtaining environmentally friendly agricultural products and contribute to ensuring food security of Southern Ukraine. Application of poly-functional growth-regulating preparations is an effective technology for treatment of grain and industrial crops.

Application of biological methods for plant protection contributes to an increase in economic efficiency of agricultural production and a rise in productivity under extreme weather factors. The values of economic indexes for each agricultural crop of field crop rotation depends on agro-technical production and duration of a direct effect of the applied bio-active substances.

An increase in the volume of agricultural products under treatment of agricultural crops with bio-preparations ensures an increase in profitability up to 800 conventional units per hectare. Therefore, it is recommended that agricultural enterprises improve technologies for agricultural production on the basis of application of biological and integrated plant protection products, reduce use of chemical methods with a dangerous prolonged effect on the environment and human health in order to increase the level of profitability.

Application of the bio-preparations Hreinaktyv-C and Nano-Hro allows reducing the norms of pesticides, increasing productivity and quality of grain and industrial crops. It was established that the total costs for seed treatment and herbage treatment equal 30–65 UAH/ha, the level of profitability is about 10 thous. UAH/ha.

Under current conditions of agricultural production, the system of biological agriculture is considered as a scientifically substantiated complex of agro-technical, organizational and economic measures, ensuring efficient use of land resources, contributing to a reduction in anthropogenic loads on agrocenoses, humus regeneration, an increase in productivity of agricultural crops, plant resistance to diseases and pests, competitiveness of agricultural products on the domestic and global markets.

In Ukraine, the most widespread biological methods for plant protection used in the system of agriculture are bio-preparations of bacterial, fungal and entomological origin. Their main functions consist in increasing productivity of agricultural crops, fixating atmospheric nitrogen, mobilizing poorly available phosphorous and stimulating plant growth. In spite of considerable advantages in application of bio-preparations, their introduction into agricultural production occurs at a slow pace and has an unstable tendency for further use. The share of biological methods for plant protection over the past 20 years has reduced by 11% and application of chemicals has increased three times (Fig. 1).

In 2020 the share biological methods for plant protection equaled 8.3 %, that is 8 % more in comparison with 2018. Bio-preparations are mostly applied in Cherkasy, Khmelnytskyi, Chernihiv, Chernivtsi, Poltava, Kyiv, Sumy, Rivne and Volyn regions [1].

According to the data of the Food and Agriculture Organization of the UNO (FAO), there is a reduction in productivity of agricultural crops by 40 % as a consequence of the impact of pests. Application of chemicals to soil causes an excessive increase in the amount of pollutants in agrocenoses, a reduction in pest resistance to plant protection products, delivery of them through food chains and accumulation in food products.

Because of the global tendencies aimed at ensuring stable and secure economy, a reduction in application of chemical for plant protection, the following is forecasted: a rise in the share of alternative methods of biological orientation in the European agrarian sector to 10 %, an increase in the area of agricultural lands for organic agriculture, a reduction in application of pesticides by 50 %. Since there is an intensive anthropogenic pressure on land resources, the priority problems are safe food for humans and ecological safety of the environment, which can be solved due to transition to alternative biological methods of agriculture.

The process of biologization is aimed at reducing anthropogenic loads on agro-ecosystems, obtaining a high level of productivity of agricultural crops and profitability of agricultural production of about 115–135 %. The scientific studies [24, 25] prove a positive effect of biological methods for plant protection on biometric and qualitative indexes of sunflower and grain crops.

The scientific data obtained by P. V. Pysarenko [26] allowed determining that unstable symbiosis between plants and microorganisms at the initial stages of their development leads to an increase in the effectiveness of biological preparations provided that minimum doses of mineral fertilizers are applied to soil. M. Novohatskyi emphasizes integrated application of traditional agricultural technologies and biological

methods for plant protection with further development of adaptive techniques under global climate change [27].

The scientific studies confirm an increase in productivity and quality of winter wheat due to the growth stimulator Melafen. There is a rise in fiber content by 3 %, protein and nitrogen contents – to 11%, and there is a reduction in the content of pollutants in plants by 8 % [28].

In order to create favorable conditions for plant growth in agrocenoses, it is highly important to provide them with micro- and macro-elements. Samriti Mankotia et al., 2022 examined the mechanism of assimilation of nutrients by plants by means of application of bio-technological methods resulting in improvement of mineral nutrition of plants and qualitative characteristics of agricultural crops [29].

Thorough scientific research on application of innovative bio-preparations in crop production contributes to regeneration of ecological conditions of agro-ecosystems, production of high-quality environmentally friendly food products, ensures food safety on the globe and a rise in the level of profitability of agricultural production. Application of biologized elements of technology increases profits of agricultural production to 80%, that is a precondition for sustainable development of the agro-industrial complex and a further increase in the efficiency of Ukraine's economy.

CONCLUSIONS

The research allowed identifying a positive effect of the growth-regulating preparation Hreinaktyv-C on winter wheat productivity. The most significant increase in yields was observed under crop treatment at the stage of tillering, the level of productivity being 2.9 c/ha (+16 % in comparison with the control variant). When sunflower plants were treated with the preparation Nano–Hro, the highest level of productivity was observed under 3-time treatment at all the stages of sunflower development – 1.6 c/ha (+22 % in comparison with the control). A positive effect of the growth-regulating preparation Nano-Hro was observed at the initial development stages of the industrial crop due to growth of a root system and more intensive absorption of nutrients from soil.

Application of micro-biological and growth-regulating preparations of biological origin in crop production is a promising trend for further research on their complex effect on productivity of agricultural crops and ecological conditions of agro-ecosystems.

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