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Economic and biopower efficiency of complex presowing treatment of seeds of buckwheat with Khetomic and Diazobacterin

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The purpose. To give economic and power assessment of joint application of microbial specimens Khetomic and Diazobacterin in technique of growing of buckwheat of sowing campaign. **Methods.** Field experiments were spent according to the conventional methodical recommendations. Economic and power efficiency of presowing treatment of seeds of buckwheat microbial specimens Khetomic (bioagent — *Chaetomium cochliodes* 3250) and Diazobacterin (bioagent — *Azospirillum brasilense* 18-2) was determined according to basic methodical approaches based on comparison of result got from certain agricultural method with expenditures for its holding. The prices for resources and agricultural products are taken at average actual level on 2017 according to available statistical data. For assessment of reliability of differences between alternatives of experiments they evaluated the least essential variance. **Results.** By three-year field experiments it is determined that increase of yield in case of preseeding inoculation with Diazobacterin makes 20,6%, presowing treatment with Khetomic — 22 %. The highest result of Presowing treatment of seeds of buckwheat with Khetomic and Diazobacterin decreased cost price of a unit of production on 1026 hrn/t, increased conditional profit on 7463 hrn counting upon 1 hectare of the area of sowing, and also raised rated level of profitableness of production of grain of buckwheat on 79,0% that ensured pay-back of additional expenditures with profit at the level of 36,95 hrn/hrn. The quotient of power efficiency at complex use of microbial specimens made 3,64. Thus energy content of yield of buckwheat increased on 12167 MJ/hectare due to heightening exit of produce. **Conclusions.** On the basis of results of long-term field and farm experiments it is offered to farm-producers to use complex presowing treatment of seeds of buckwheat with microbial specimens Khetomic and Diazobacterin. That is economically and energetically expedient in technique of cultivation of crop.

Key words: *buckwheat, Khetomic, Diazobacterin, productivity, economic efficiency, power efficiency.*

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Fungi are biochemically active microorganisms-edifiers, forming a medium rich in metabolites. They synthesize amino acids, proteins, monosaccharides, organic acids, vitamins and biologically active compounds that can stimulate other microorganisms. Thus, bacteria can develop on fungal hyphae, using products of their metabolism, and interact with mycelium [1, 2]. In the mycorrhiza root zone of the plant, there are other micellar and unicellular fungi, bacteria that are exposed to the exudates of the plant. In this case, rhizobacteria (diazotrophs, phosphate-mobilizing bacteria and others) have a positive effect on plant-fungi associations. They all exhibit different specificities in terms of fungi they interact with [2]. Mutual associations of plants and fungi are formed in a wide range of terrestrial media and play an important role in mineral nutrition and plant resistance to abiotic and biotic stressors [3, 4].

At the Institute of Agricultural Microbiology and Agroindustrial Manufacture of the NAAS, a microbial preparation Khetomik was created based on the natural strain of ascomycetes-antagonist *Chaetomium cochliodes* Palliser 3250 [5]. *C. cochliodes* 3250 synthesizes a variety of fatty acids, including arachidonic acid, that is a biogenic elicitor [6], which, in turn, induces a systemic immune response of plants to the action of pathogens and adverse environmental factors. Also, *C. cochliodes* 3250 actively colonizes the root system and limits the development of phytopathogenic fungi causative agents of crop root rot. Micromycetes contribute to increasing the number of diazotrophs in the root zone of wheat and increase the activity of the process of fixation of atmospheric nitrogen [7].

In addition, at the Institute of Agricultural Microbiology and Agroindustrial Manufacture of the NAAS, strain of *Azospirillum brasilense* 18-2 was isolated from rhizosphere of buckwheat and patented. Diazobakteryn, created on the basis of this strain, is used as a bacterial fertilizer for buckwheat [8]. Positive effect of *A. brasilense* 102 on the associative interaction of *C. cochliodes* 3250 with wheat plants, with the formation of a three-component symbiotic system is known [9].

The use of complex microbial preparations that contribute to increasing the supply of mineral nutrients (nitrogen and phosphorus) to crops is an environmentally safe way to increase plant productivity. This is especially important for cultures, from which children's and dietary nutrition is produced. One of these crops is common buckwheat.

That is why the **objective of the study** was to check the economic and energy efficiency of the complex treatment of buckwheat with microbial preparations Diazobakteryn and Khetomik.

Materials and methods. Field experiments were conducted according to the methodological recommendations [10]. Soil (experimental field of the Institute of Agricultural Microbiology and Agroindustrial Manufacture of the NAAS) – leached weakly glued light loamy on loess. Agrotechnical cultivation is generally accepted for the Polissia area. Phosphorus and potassium fertilizers were introduced in a dose of $P_{30}K_{45}$, nitrogen fertilizers were not introduced.

Schedule of experiment:

1. control (seed treatment with tap water);
2. inoculation with Diazobakteryn (2 10^5 bacterial cells per seed);
3. pre-sowing treatment of seeds with Khetomik 3250 (4 10^4 CFU per 1 seed);
4. complex treatment with Khetomik 3250 (4 10^4 CFU per 1 seed) and Diazobakteryn 18-2 (2 10^5 bacterial cells per 1 seed).

The economic and energy efficiency of pre-sowing treatment of Antariia buckwheat seed with microbial preparations Khetomik (bioagent – *C. cochliodes* 3250) and Diazobakteryn (bioagent – *A. brasilense*-18-2) were carried out according to generally accepted methodological approaches based on comparison of results from carrying out of certain agro-activity from expenses for its application [11, 12]. For this purpose, the main parameters characterizing the economic efficiency of production are identified and analyzed: the cost per ton of grain of buckwheat, the profit per 1 hectare of sown area, the level of profitability of production, the recoupment of additional costs by additional profits. In this case, the cost of production is calculated by calculating its full cost based on the methodology [13] with the determination of both direct and overhead (distributable) costs (organization and management of production, etc.). With the use of such a methodological approach, the estimated level of cost of production increased, however, the completeness and objectivity of the results of the analysis increased.

Due to the fact that the crop data was obtained in the conditions of field experiments, that is, in small-sized areas, to determine the economic efficiency of different experimental variants, simulation of technologies in production conditions under the use of typical technologies was applied. Therefore, the resulting economic parameters are of estimated nature.

Technological operations, standard cost of resources and the algorithm of cost estimation of products was adopted on the basis of the methodology [14] with the inclusion of additional operations and related costs associated with the use of microbial preparations Khetomik and Diazobakteryn. Prices for resources and agricultural products were established at the average actual level for 2017, according to available statistical data.

To assess the bioenergetic efficiency of various variants of application of microbial preparations in the technologies of buckwheat growing, the costs of all types of material resources and labour in natural form and the yield of grains were converted into energy equivalents under the use of techniques and standards [16-19] with the following determination of the main parameters of bioenergetic efficiency of production: energetic efficiency factor (by main production) and energetic efficiency factor of the additional costs of anthropogenic energy associated with the use of Khetomik and Diazobakteryn.

The least significant difference (HIP_{05}) was calculated for assessing the validity of the differences between the experimental variants.

Results. Under the conditions of 3-year field experiments (Table 1), it was shown (Table 1) that the increment of the crop during pre-sowing inoculation with *A. brasilense* 18-2 is 20.6 %, while under the pre-sowing treatment with *C. cochliodes* 3250 – 22.0 %. The highest is the result of the complex action of the diazotroph *A. brasilense* 18-2 and the soil fungi *C. cochliodes* 3250 – 34.9 %.

1. Yield of Antariia variety buckwheat under the pre-sowing treatment with Khetomik and Diazobakteryn

Variant	Yield, t/ha			Average yield for three years	
	2014	2016	2017	t/ha	% to control
Control (seed treatment with tap water)	1.92	1.91	2.46	2.09	-
Inoculation of seeds with Diazobakteryn	2.36	2.56	2.65	2.52	120.6
Treatment of seeds with Khetomik	2.23	2.52	2.89	2.55	122.0
Complex treatment with Khetomik and Diazobakteryn	2.62	2.63	3.20	2.82	134.9
HIP_{05}	0.12	0.10	0.24	-	-

The results of field experiments are confirmed in the production experiment (Table 2), conducted on a deep low-humus chernozem on loess with common buckwheat of variety Deviatka (Alliance, LLC of Lipovodolynskyi District of the Region of Sumy). Complex pre-sowing treatment with diazotroph and endophytic fungus contributed to the increase in crop yield by 0.61 t/ha (30.5 %).

2. Influence of complex treatment with Khetomik and Diazobakteryn on the yield of common buckwheat of variety Deviatka

Variant of experiment	Crop area, ha	Yield, t/ha	Increment of yield, t/ha	Increment of yield, %
Control (seed treatment with tap water)	10	2.00	-	-
Complex treatment with Khetomik and Diazobakteryn	10	2.61	0.61	30.5

The main parameters of the economic efficiency of the use of microbial preparations Khetomik and Diazobakteryn in buckwheat cultivation technologies (Table 3) are calculated on the basis of the study of the results of their influence on the crop yield shown in Table 1.

Thus, under bacterization of buckwheat seed with Diazobakteryn, costs per hectare of sown area increased by 1.3 %, but an increase in crop yield by 20.6 % resulted in a 15.9% reduction in the unit cost of production. Proportionally to increase in the yield of buckwheat, receipts in cash increased. Due to the combined effect of these factors (reducing the cost and increasing the size of the proceeds as a result of increased productivity), profitability increased significantly. Thus, the amount of profit per 1 hectare of sowing increased from UAH 13,078 to UAH 17,475 (33.6 %), while the level of profitability of production increased by 47.0 percentage points. The payback of additional expenses to profit amounted to UAH 37.26, that is, for every UAH spent on the use of Diazobakteryn, additional profit of UAH 37.26 was gained.

During the pre-sowing treatment of buckwheat seeds by Khetomik, the cost per hectare of crop area increased by 2.3 %. At the same time, increase of the yield amounted to 22.0 %, which resulted in a reduction in the cost of one ton of grain of buckwheat by 16.1 %. In proportion to the increased revenue due to crop yields increase, profit margin increased by 35.4 % and the level of profitability of production increased by 47.7 percentage points. The payback of additional expenses to profit amounted to UAH 22.91/UAH.

3. Economic efficiency of the use of microbial preparation in buckwheat cultivation technologies

Parameters	Control	Diazobakteryn			Khetomik			Diazobakteryn + Khetomik		
		value	deviation, +/-		value	deviation, +/-		value	deviation, +/-	
			absolute	relative, %		absolute	relative, %		absolute	relative, %
Yield, t/ha	2.09	2.52	0.43	20.6	2.55	0.46	22.0	2.82	0.73	34.9
Costs per 1 ha, UAH	8867	8985	118	1.3	9069	202	2.3	9069	202	2.3
Cost value of 1 t, UAH	4242	3566	-676	-15.9	3557	-685	16.1	3216	-1026	-24.2
Revenue per 1 ha, UAH	21945	26460	4515	20.6	26775	4830	22.0	29610	7665	34.9
Profit per 1 ha, UAH	13078	17475	4397	33.6	17706	4628	35.4	20541	7463	57.1
Profitability, %	147.5	194.5	47.0	-	195.2	47.7	-	226.5	79.0	-
Payback of additional costs by profit, UAH/UAH	-	37.26	-	-	22.91	-	-	36.95	-	-

Under the pre-sowing treatment of buckwheat seed with Khetomik compared with bacterization with Diazobakteryn, there is a slightly higher increase in efficiency by most economic parameters, but the costs associated with the use of a microbial preparation based on micromycetes are higher.

Under the complex application of Khetomik and Diazobakteryn for pre-sowing treatment of buckwheat seed, costs increase by 202 UAH/ha (2.3 %) for 1 ha of sown area compared with the control. As a result, the cost per unit of production decreased by 1,026 UAH/t (24.2 %). Conditional profit increased by UAH 7,463 (57.1 %) per hectare of sown area, with the estimated level of profitability of grain production of buckwheat reached 226.5 %, which is 79.0 percentage points higher than control. That is, the payback of additional expenses by profit was at the level of 36.95 UAH/UAH.

Thus, the use of the studied microbial preparations in buckwheat cultivation technologies is an effective means of increasing the economic efficiency of production. At the same time, based on the results of the comparative evaluation of the studied variants of pre-sowing treatment of buckwheat seeds, the complex application of Khetomik and Diazobakteryn is the most productive way of cultivating the culture by the overwhelming majority of the main parameters of economic efficiency, except for a slight decrease in the level of payback compared with the use of Diazobakteryn due to the higher amount of additional costs.

Along with the analysis of the influence of the complex use of microbial preparations on the economic results of the production of buckwheat grains, it is important to investigate their influence on bioenergetic efficiency. The urgency of this type of analysis is emphasized by its higher objectivity, because, unlike economic (cost) parameters, which are largely influenced by price factors, energetic efficiency parameters do not depend on inflationary processes, market conditions, etc. The main parameters of the energetic efficiency of buckwheat grain production in the control version and under the use of the studied microbial preparations are presented in Table 4.

As is can be seen from the Table 4, application of Diazobakteryn and Khetomik in the cultivation of buckwheat contributes to a significant increase in the energetic efficiency of production. Therefore, the

energetic efficiency ratios in all variants of the use of these biological preparations are considerably higher compared to the control variant. For example, in the pre-sowing bacterization of seeds with Diazobakteryn, the indicated excess was 0.46 or 16.1 %, with the use of Khetomik – 0.50, or 17.5%, with the combined use of these preparations – 0.78 or 23.2 %. In this case, the energetic content of an additional grain crop 15.15-fold the energetic costs of obtaining it when using Diazobakteryn, 16.43-fold – under the use of Khetomik, and 16.62-fold – for the combined use of these biological products. In the analysis of variants, it should be emphasized that the variant with Diazobakteryn is inferior to the variant with Khetomik, and the highest level of energetic efficiency is observed for the combined use of these preparations.

Significant increase in the level of energetic efficiency in the complex use of microbial preparations is achieved due to the fact that the additional costs of anthropogenic energy, associated with their use, are significantly lower than the energetic content of the additional crop.

4. Main parameters of bioenergetic efficiency under the use of Diazobakteryn and Khetomik in buckwheat cultivation technologies

Parameters	Control	Diazobakteryn			Khetomik			Diazobakteryn + Khetomik		
		value	deviation, +/-		value	deviation, +/-		value	deviation, +/-	
			absolute	relative, %		absolute	relative, %		absolute	relative, %
Yield, t/ha	2.09	2.52	0.43	20.6	2.55	0.46	22.0	2.82	0.73	34.9
Costs of antropogenic energy per 1 ha, MJ	12165	12638	473	3.9	12632	467	3.8	12898	733	6.0
Costs of antropogenic energy per 1 t of grain, MJ	5821	5015	-806	-13.8	4954	-867	-14.9	4574	-1247	-21.4
Energetic content of yield, MJ/ha	34834	42001	7167	20.6	42501	7667	22.0	47001	12167	34.9
Energetic efficiency factor	2.86	3.32	0.46	16.1	3.36	0.50	17.5	3.64	0.78	27.3
Energetic efficiency factor of additional energetic costs	x	15.15	-	-	16.43	-	-	16.62	-	-

Conclusion

According to the results of 3-year field studies, the increase in the yield of buckwheat Antariia from seed inoculation with Diazobakteryn is an average of 20.6 %, from the processing of seeds by the Khetomik – 22.0 %, from the complex pre-treatment – 34.9 %. The production check of the efficiency of complex treatment with microbial preparations confirmed the results of field experiments, while the yield increase was 0.61 t/ha (30.5 %).

Pre-sowing treatment of buckwheat seeds by Khetomik and Diazobakteryn contributed to a reduction in the unit cost of production by UAH 1,026/t (24.2 %), an increase in the conditional profit per hectare of sown area of UAH 7,463 (57.1 %), increase of the calculated level of profitability of buckwheat grain production by 79.0 % which provides payback of additional expenses by profit at the level of 36.95 UAH/UAH.

The energetic efficiency factor under the complex treatment with microbial preparations is 3.64 (27.3 %). At the same time, the energetic content of the buckwheat crop increased by 12,167 MJ/ha due to an increase in output.

Based on the results of long-term field and industrial experiments on agricultural production, it is proposed to use a complex pre-sowing treatment of buckwheat seed with microbial agents Khetomik and Diazobakteryn.

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