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REPORT

Research on BIO-GEL biological effectiveness when used on buckwheat, millet and haricot crops

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INTRODUCTION

Intensification of crop cultivation technologies which are based on using chemicals, a great number of large-size cultivating machinery causes the transformation of water-physical, agrochemical and biological properties of soil, higher humus mineralization, unproductive moisture losses, greater erosion. Intensive technologies lead to worsening ecology and farmed products quality.

These negatives trends are partly covered in the organic farming system. Implementation of the organic farming system is accompanied by the complex processes of comprehending and restructuring the main parts of the technological process. On the one hand, the exclusion of chemicals (mineral fertilizers, seed treatment, weed, pest and disease control by chemicals) affects nutrition, infestation, spread of pathogens, which will inevitably affect crop productivity.

Alternatively, there may be widely used some by-products, green manure crops as well as promising varieties, improved technology elements, active strains of nitrogen-fixing and phosphorous-mobilizing bacteria, all that mobilizing the natural resources of soil fertility and regional climate.

In general, precursor by-products and green manure crops are considered as an important part of energy conservation and ecologization of cultivation technologies.

A powerful factor in improving the agrocenosis productivity is interaction but in the organic farming it is improperly used. Therefore, of great importance is large-scale introduction of agricultural technologies using activators of soil microbiological resources which would ensure the implementation of natural processes. The use of microbiological products is an element of fertilization and plant protection which allows at low financial cost to stimulate some processes important for plant development and soil fertility. Bacterial preparations containing effective natural strains make it possible to get pure farm products. Over the past decade a significant number of strains and biological preparations based on symbiotic and associative microorganisms have been created in Ukraine. The application of biological preparations to soil and plants meet the requirements of organic farming. These include humates in the first place. They are synthesized form plant remains and microbial products. Therefore, they are considered as accumulators of organic soil material - amino acids, carbohydrates, biologically active substances and lignin. In addition, they contain nitrogen, phosphorus, potassium and calcium, as well as a number of trace elements (iron, zinc, manganese, molybdenum). Humates are water soluble compounds which can be used for spraying plants [12].

In the above context it is expedient to develop a comprehensive research program in order to comprehensively assess the effect of various crop by-products and green manure crops on plants growth and development taking leguminous (haricot) and cereals (millet and buckwheat) as an example.

SECTION 1. CONDITIONS AND METHODS OF RESEARCH

The research was carried out in the field multi-factor long-term experiment on the *Chabany* Experimental Farm, Institute of Agriculture, NAAS, on the gray forest loam soil. The content of humus in the 0-30 cm soil layer is (according to Tyurin) 1.1-1.3%, easy hydrolysable nitrogen - 6.0-6.5 mg / 100 g, labile phosphorus - 11.4-12.6 , exchangeable potassium - 8-10 mg per 100 g soil pH - 5.4-5.6.

The hydrothermal conditions that emerged during the growing season in 2016 significantly differed from the average long-term indicators (Table 1.2).

Table 1, 2. Weather conditions during the cereals and beans vegetation period according to the meteorological data, the Chabany Experimental Farm, 2016.

Month	10-day period	Temperature, °C			Rainfall, mm		Relative humidity, %	
		average daily	maximum	standard	Total	Standard	Average	Minimum
April	I	13.9	18.5	7.2	1.4	15.0	56.9	41.0
	II	12.7	17.5	8.2	49.5	19.0	73.7	52.0
	III	11.2	16.6	10.8	4.6	15.0	61.6	40.5
Per month		***12.6***	***17.5***	***8.7***	***55.5***	***49.0***	***64.1***	***44.5***
May	I	15.3	20.4	13.7	21.2	17.0	60.1	40.1
	II	13.3	18.1	15.7	42.2	13.0	81.9	58.3
	III	17.7	23.4	15.9	23.4	23.0	75.2	52.4
Per month		***15.4***	***20.6***	***15.2***	***86.8***	***53.0***	***72.4***	***50.2***
June	I	17.2	21.9	16.8	3.40	23.0	59.3	40.3
	II	20.2	25.2	17.8	11.6	24.0	73.0	52.3
	III	25.3	30.2	19.5	1.6	26.0	50.0	50.0
Per month		***21.1***	***25.8***	***18.2***	***16.6***	***73.0***	***67.0***	***47.5***
July	I	20.5	25.7	18.7	9.4	39.0	66.3	43.1
	II	23.0	29.0	19.7	7.4	26.0	63.8	44.1
	III	23.9	29.9	19.5	16.6	23.0	64.4	41.2
Per month		***22.5***	***28.2***	***19.3***	***33.4***	***88.0***	***74.4***	***55.0***
August	I	22.7	28.9	20.1	00.0	18.0	61.7	40.6
	II	17.9	23.1	18.9	18.4	27.0	74.7	49.2
	III	21.8	27.1	17.4	4.4	24.0	65.8	47.8
Per month		***20.8***	***26.4***	***18.6***	***22.8***	***69.0***	***62.0***	***39.2***
September	I	20.2	26.3	16.2	00.0	15.0	57.8	38.5
	II	15.9	21.3	13.7	00.0	14.0	62.4	42.4
	III	11.2	15.6	11.2	3.8	18.0	81.0	62.0
Per month		***14.3***	***19.1***	***13.9***	***3.80***	***47.0***	***69.7***	***51.7***

In April, the average daily air temperature exceeded the norm by 3.9 °C, the amount of precipitation was 55 mm, which exceeded the norm by 13.3%. The average daily temperature in May was 15.4 °C, its value being close to the norm of 15.2 °C. The precipitation in May was 86.8 mm, the norm being 53.0 mm, it replenished the soil moisture and caused the simultaneity of shoots coming up and their intensive growth.

The average daily temperature in June was the highest in the second decade and exceeded the norm by 2.4 °C (17.8 °C). By the end of June moderately warm weather with small precipitation had set in, which positively influenced the growth processes of the vegetative mass.

The first and second decades of July were not favorable for the growth and development of beans, millet and buckwheat. During the second decade of July when the period of generative development began, only 28.5% of the precipitation fell, which negatively affected the processes of flowering and fertilization and, as a result, of the fruit elements.

The absence of precipitation in the first decade of August reduced the phase of beans formation and their number. The average daily temperature in this month (20.9°C) exceeded the norm by 2.3°C, the monthly precipitation dropped to only 33% of the norm (69 mm). Such conditions shortened beans formation stage and reduced their weight, thus affecting the beans productivity. In general, for beans 2016 was not favorable and for millet and buckwheat it was satisfactory.

The research program envisages the conducting of an experiment in which the effects of various types of organic fertilizers (inoculation, green manure, buckwheat straw, BIO-GEL) on the soil fertility, biometrics, plants chemical composition and their yields will be studied.

Organic residues (buckwheat straw) were introduced into soil after harvesting the precursor using disk tools. Green manure crop (mustard) was sown as an early crop. At the appropriate stage (flowering stage) stems were cut with disk tools. Seeds were treated with BIO-GEL, besides top-dressing with BIO-GEL was performed at IV, VII and IX.

The size of the field was 25-50 m^2.

Millet and buckwheat seeds were treated with Azogran NANO (nitrogen-fixing and phosphorous- mobilizing strains of associative bacteria), while bean seeds were treated with БТУ-р (strain of nitrogen-fixing symbiotic bacteria).

For solving the experiment task the following analysis, control and records were carried out:

- the main phases of plants growth and development and organogenesis stages were noted. The phase beginning was fixed at its onset with 10% plants, while the full phase was fixed with 75% plants;
- plants height was measured in the dynamics according to the main growth stages in two non-adjacent ones by measurements made in ten equally spaced areas of the field;
- the accumulation of the vegetative mass and dry matter in the dynamics according to the main phases of plant growth and development was registered;
- leaf surface area was measured in the dynamics of the main phases;
- the analysis of the crop structure elements was made on test sheaves in order to determine the ratio between non-market and basic products, the weight and number of grains in a bean, the number of beans per plant, the weight of 1000 grains.

Table 1.1. Spatial scheme of the experiment aimed at developing the scientific bases of innovative agrarian technologies for leguminous and cereal crops cultivation in organic farming, 2016

	Haricot			Millet			Buckwheat		
Control	Seed treatment with БТУ-р	Treatment of seeds and plants with BIO-GEL	Control (no fertilizer)	Seed treatment with Azogran Nano+BIO-GEL (top dressing)	Treatment of seeds and plants with BIO-GEL	Control (no fertilizer)	Seed treatment with Azogran Nano+BIO-GEL (top dressing)	Treatment of seeds and plants with BIO-GEL	Control (no fertilizer)

- analysis of haricot grains on the content of protein, fat, ash was made by the infrared spectroscopy method using the NIR-4500 Scanner 4250 with computer software ADI DM 3114 and settlement method;
- recording grain harvest was performed by continuous threshing of each field followed by weighing and subsequent recalculation to standard humidity and dockage;
- direct harvesting was carried out in the period of ripening (leaves dropping, stems and beans browning, seed separation from pods, grain moisture reduction to 14-16%) by Sampo 130 combine harvester;

- mathematical processing of experimental data was carried out using dispersion and correlation-regression methods and a package of mathematical analysis programs of the "Statistica-6" type;
- calculation of the economic efficiency of the cultivation technology elements was carried out by the economics department of the Institute of Agriculture, NAAS;
- chemical analysis of grain was performed at the agroecology and analytical research department of the Institute of Agriculture, NAAS.

SECTION 2. EXPERIMENTAL PART

2.1 Studying the efficiency of BIO-GEL use in cereal crop (buckwheat, millet) cultivation technology in organic farming

Experiment results

In modern agricultural production the number of microorganisms in soil which play an important role in providing plants with natural nitrogen, mobilize phosphorus and potassium has significantly decreased. At present recommendations mention microbial products based on nitrogen-fixing, phosphate-mobilizing bacteria. An alternative to the nitrogen in mineral fertilizers is the nitrogen of natural origin which a plant gets due to associative interaction with nitrogen-fixing microorganisms. The level of nitrogen accumulation in the rhizosphere of non-legume plants due to associative nitrogen fixation is 20-35 kg/ha on average.

Due to actively secreting organic acids by the root system, buckwheat assimilates well poorly soluble phosphorous and potassium compounds from the soil, these compounds being unavailable for most cultivated plants [1].

During the flowering period in the arable soil layer (0-20 cm) soil samples were taken to determine the content of total nitrogen, mobile phosphorous and exchangeable potassium. The lowest total nitrogen content was in the sample taken in the control and amounted to 50.4 mg/kg. Seeds inoculation with nitrogen-fixing and phosphorous-mobilizing bacteria accompanied by plant extra nutrition with BIO-GEL contributed to the 11.1% increase in this element content in the soil. Its content in the soil was a bit lower during the year when seeds were treated and plants were additionally fertilized only with BIO-GEL (57.4 mg/kg) (table 2.1).

Table 2.1. Major mineral elements content in soil under cereals, 2016, mg/kg soil

Variant	N	P_2O_5	K_2O
Control	50.4	120.0	103.3
Control (no treatments)	53.2	105.0	87.0
Seed treatment with BIO-GEL (1 l/t) +extra nutrition (1 l/ha)	51.8	80.0	80.0
Seed treatment with BIO-GEL (1 l/t) + extra nutrition (twice) (1 l/ha)	57.4	100.0	93.5
Seed treatment with BIO-GEL (1 l/t) + extra nutrition (three times) (1 l/ha)	56.0	90.0	98.8
Seed treatment with Azogran Nano + extra nutrition with BIO-GEL (1 l/ha)	51.8	100.0	98.8
Seed treatment with Azogran Nano + extra nutrition with BIO-GEL (twice) (1 l/ha)	58.8	100.0	112.0

The laboratory tests showed that the cultivation technology and weather conditions influenced the content of mobile phosphorus and exchangeable potassium in the soil. So when cultivating buckwheat, the content of mobile phosphorous in soil samples was higher with BIO-GEL applied, amounting to 100 mg/kg on average.

In determining the content of exchangeable potassium in soil samples, it was found that its content depended on the technology and was higher on inoculating seeds with nitrogen-fixing and phosphorous-mobilizing bacteria accompanied by plant nutrition with BIO-GEL, amounting to 98.8 – 112 mg/1000 g.

According to the table of soils grouped regarding the mobile phosphorous content, it was average. As to exchangeable potassium, the soil was provided with it throughout the vegetation period, its content being higher.

According to the results of the analysis, it can be stated that for cereals the content of alkaline hydrolyzed nitrogen in the soil is very low.

Buckwheat is characterized by high intensity of major mineral elements assimilation during the period of maximum vegetation. Therefore, the level of plants provision with them influences the crop productivity. Of great importance in fertilizing was also top-dressing.

Top-dressing with BIO-GEL was an effective way of buckwheat fertilization which increased nutrients availability for plants and stimulated their assimilation from soil. But this efficiency depended on external factors: soil moisture and air temperature. Thus, HTC at the time of the first nutrition (two true leaves stage) made 0.5 with buckwheat and 0.1 with millet (tillering stage). Fertilizing plants with BIO-GEL increased nitrogen assimilation only by 4% with buckwheat and by 19% with millet compared with the control. While fertilization at the buckwheat flowering stage (HTC = 0.78) accompanied by seed treatment with nitrogen-fixing bacteria stimulated nitrogen assimilation, its content was 3.17%, the rate at the control being 2.71%. Two top-dressings resulted in high nitrogen accumulation in millet (table 2.2).

The absorption of phosphoric acid by buckwheat plants varied considerably in variants, its content in plants amounting to 0.60 - 0.80%. The content of phosphorus in the plant depended on three top-dressings increasing its amount by 20% after seed treatment with the Azogran product and by 9% after seed treatment with BIO-GEL. Buckwheat needs phosphorous especially at the time of above-ground organs formation, its consumption continuing while buds and flowers are formed. More intensive phosphorous assimilation by millet plants took place after three top-dressings (by 19%) and seed treatment with Azogran.

Potassium assimilation by plants was more effective after seed treatment with BIO-GEL and plant extra nutrition with BIO-GEL, it was 23% more effective than the control variant.

Table 2.2. Content of major mineral elements in millet and buckwheat on applying BIO-GEL and nitrogen-fixing bacteria, 2016, % dry substance

Variant	Millet			Buckwheat		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Control (no treatment)	1.39	0.42	2.20	2.71	0.65	3.07
Control (no treatment)	1.66	0.43	2.47	2.61	0.69	2.77
Seed treatment with BIO-GEL (1 l/t)+ extra nutrition (1 l/ha)	1.96	0.48	2.83	1.88	0.64	3.58
Seed treatment with BIO-GEL (1 l/t)+ extra nutrition (twice) (1l/ha)	1.39	0.46	2.86	2.17	0.71	3.15
Seed treatment with BIO-GEL (1 l/t)+ extra nutrition (3 times) (1 l/ha)	1.44	0.43	2.42	2.07	0.64	3.11
Seed treatment with Azogran Nano + nutrition with BIO-GEL (1 l/ha)	2.06	0.46	2.60	2.79	0.60	3.33
Seed treatment with Azogran Nano + nutrition with BIO-GEL (twice) (1 l/ha)	1.74	0.50	2.27	3.17	0.80	3.71

Humic acids that are part of the BIO-GEL product activate the supply of phosphorus to the plant. Therefore, there is no significant difference in K_2O and P_2O_5 accumulation between variants when seeds are treated with BIO-GEL and nitrogen-fixing and phosphate-mobilizing bacteria are used.

According to V.V. Cerling scale [14] this corresponds to their sufficient content in plant organs and testifies to proper conditions for mineral nutrition in addition to nitrogen availability at the initial stages of growth.

It is known that the main role in the crop formation belongs to photosynthesis as the only source of accumulation of organic substances, accounting for about 95% of the plant dry weight. The main organ of photosynthesis is a leaf. Under favorable conditions the buckwheat leaf surface can increase considerably. Although there is no direct correlation between the leafy surface and the yield it is established that the more leaves, the more accumulated organic matter.

The results of the research have shown that the increase in the leaf surface area of buckwheat crops is largely dependent on the plant fertilization (Table 2.3).

Seed inoculation initially restrained plant and the leaf surface growth, but in the next stage the biomass increase in these variants significantly exceeds the control version and the results of seed treatment with BIO-GEL. The highest values (16.7 thousand m^2 / ha) in the flowering phase are noted after the complex action of the Azogran biological preparation and triple plants spraying with BIO-GEL.

Table 2.3. Effect of buckwheat seed inoculation and BIO-GEL on leaf surface increase, 2016, thousand m^2/ha

Variant	Development stages		
	budding	flowering	fruit formation
Control (no treatment)	7.42	12.9	6.89
Control (no treatment)	9.75	13.9	15.8
Seed treatment with BIO-GEL (1l/t) + extranutrition (1 l/ha)	9.19	15.8	20.9
Seed treatment with BIO-GEL (1l/t) + two-time extranutrition (1 l/ha)	7.85	15.7	18.2
Seed treatment with BIO-GEL (1l/t) + three-time extranutrition (1 l/ha)	7.79	16.5	16.7
Seed treatment with Azogran Nano + extranutrition with BIO-GEL (1 l/ha)	8.31	15.3	14.5
Seed treatment with Azogran Nano + two-time extranutrition with BIO-GEL (1 l/ha)	7.49	16.7	19.8

Analyzing the dynamics of the assimilation apparatus area growth, it should be noted that as the phases progressed the leaf surface area increased and reached its maximum in the flowering – fruit formation stages. Depending on the cultivation technology it varied within 14.5-20.9 thousand m^2/ha. The largest leaf surface in the flowering phase was after seed treatment with BIO-GEL and foliar spraying with it.

The use of BIO-GEL in the cereals cultivation technologies stimulates growth processes and vital functions, the duration of the photosynthetic apparatus activity, which affects the accumulation of dry matter by plants.

The better the leaf surface is developed; the drier substance is accumulated in plants.

Dry substance accumulation during cereals vegetation is not even. Before buckwheat flowering and millet panicle formation plants grow slowly and dry substance is accumulated slowly too. The most intensive accumulation of dry substance in buckwheat plants occurs in the phase of mass flowering - fruit formation and its largest mass (11.54 t / ha) is after seed treatment with BIO-GEL and plants two-time extra nutrition with BIO-GEL.

The accumulation of the millet dry substance was recorded after seed treatment with nitrogen-fixing and phosphorous-mobilizing bacteria and two-time nutrition with BIO-GEL. In the early stages of growth and development this indicator was 0.77 t / ha, which is 30% more than the control variant and 60% - in the ripening phase and amounted to 11.08 t / ha.

The amount of dry substance accumulated by buckwheat plants is due to BIO-GEL effect. In the phase of buckwheat mass flowering the amount of dry substance per hectare was 2.55 t while in the control it was 2.06 t/ha (table 2.4).

Table 2.4. The effect of BIO-GEL and buckwheat and millet seeds inoculation on dry substance accumulation, 2016, t/ha

Variant	Millet			Buckwheat		
	stooling	flowering	ripening	budding	flowering	ripening
Control(no treatments)	0.59	2.98	6.67	0.57	2.06	6.70
Seed treatment with BIO-GEL (1 l/t) + extranutrition (1l/ha)	0.64	2.69	5.42	0.71	1.92	10.01
Seed treatment with BIO-GEL (1 l/t) + 2 extranutritions(1l/ha)	0.56	4.90	9.01	0.59	2.55	11.54
Seed treatment with BIO-GEL (1 l/t) + 3 extranutritions(1l/ha)	1.08	3.31	9.27	0.57	2.02	9.86
Seed treatment with Azogran Nano + extranutrition with BIO-GEL (1 l/ha)	0.76	4.10	10.72	0.47	2.20	9.34
Seed treatment with Azogran Nano + 2 extranutritions with BIO-GEL (1 l/ha)	0.77	5.95	11.08	0.56	2.01	7.97
Seed treatment with Azogran Nano + 3 extranutritions with BIO-GEL (1 l/ha)	0.71	5.23	8.64	0.43	2.15	9.89

Cereal yields are dependent mainly on two biological factors: plants density and their individual productivity; the number of inflorescences per plant, the number of filled grains, the grain mass from one plant, the mass of a thousand grains. Maximum grain yield depends on their optimal balance.

Therefore, to substantiate yield rates under the established conditions we have analyzed the buckwheat and millet plant structures. Studies of the crop structure make it possible to determine the elements which affect the millet yield under various nutrition conditions. The above data shows that BIO-GEL and Azogran use affect favorably certain crop structure characteristics. In particular, the density of millet plants ranged from 77 pc/m^2 to 97 pc/m^2. The minimum values of this indicator (72 pc/m^2) were in the control.

Panicle branching, the number of plant arms influence the grain production. The main features of these components are the number and weight of grains in the panicle.

The experiment showed the dependence of the grain number in the panicle on plant nutrition. The value (7.84 g) appeared to be high when seeds were inoculated with nitrogen-fixing bacteria and plants were fertilized additionally with BIO-GEL three times, the control value being 5.8 g. More effective for millet growth were variants with seed treatment with nitrogen-fixing and phosphorous-mobilizing bacteria followed by top-dressing with BIO-GEL. In this case plant height increased by 40%, panicle length – by 10% and the number of the first and second order plant arms – by 36% (table 2.5).

Table 2.5. Millet crop structure characteristics in organic farming, 2016

Variants	Panicle weight, g	Panicle length, cm	Number of panicle arms, order, pc		Grain weight, g
			I	II	
Control (no treatments)	6.7	25.9	9.6	59.0	5.8
Control (no treatments)	8.7	33.2	11.4	75.0	7.47
Seed treatment with BIO-GEL (1 l/t) + extranutrition (1 l/ha)	8.0	25.2	13.6	71.2	6.22
Seed treatment with BIO-GEL (1 l/t) + 2 extranutritions (1 l/ha)	8.8	26.1	14.4	71.8	7.10
Seed treatment with BIO-GEL (1 l/t) +3 extranutritions (1 l/ha)	9.4	28.4	13.6	79.6	6.77
Seed treatment with Azogran Nano + extranutrition with BIO-GEL (1 l/ha)	9.1	28.5	11.4	78.8	7.00
Seed treatment with Azogran Nano + 2 extranutrition with BIO-GEL (1 l/ha)	10.3	27.6	14.4	90.0	7.84

The effect of Azogran on buckwheat main characteristics was more pronounced: plant height, weight, number of inflorescences and grains were greater. These characteristics also depended on top-dressing with BIO-GEL. Three-time top-dressing with BIO-GEL in addition to seed treatment with nitrogen-fixing and phosphorous-mobilizing bacteria increased the number of grains up to 96 and their weight – to 2.67 g. In the control these characteristics were 60 pc and 1.64 g. Extranutrition with BIO-GEL at the start of the budding phase (the second extranutrition) was not so effective: the number of inflorescences (98.2 pc), the number of arms (2.04 pc) and the number of grains

(70.9 pc) were smaller. In our opinion it was due to the rain that started some hours after nutrition (table 2.6).

According to the research the highest buckwheat yield (1.31 t/ha) was obtained after seed treatment with BIO-GEL followed by plants spraying with BIO-GEL at the vegetation beginning. The variants with seed treatment and plant double or triple extranutrition during the vegetation period were not so successful (1.08 t/ha).

Table 2.6. Buckwheat crop structure characteristics in organic farming, 2016

#	Plant height, cm	Plant weight, g	Inflorescences pc	Number of branches, pc		Number of grains, pc		Grain weight, g
				I	II	perfect	imperfect	
1	68	4.5	8.2	1.5	0.5	60.0	16.6	1.64
2	68	4.8	8.5	2.2	0.6	87.4	18.2	2.37
3	64	4.5	9.2	2.2	0.4	61.7	28.8	1.81
4	71	5.6	9.1	1.9	0.2	92.4	11.9	2.64
5	72	5.5	11.1	2.5	0.6	73.9	7.1	2.10
6	70	5.0	8.2	2.0	0.4	70.9	10.6	2.05
7	74	10.0	13.8	3.0	0.8	95.9	26.0	2.67

The best conditions for millet growth and development were registered after seed treatment with BIO-GEL and two-time plant extranutrition during the vegetation period, this increased crop productivity by 7.1% in organic farming. The economic results obtained were the best: the cost of 1 t crop was 1500 UAH, the profit amounted to 8570 UAH, the profitability was 178% (table 2.7).

Seed bacterization with Azogran Nano complex preparation (nitrogen-fixing and phosphorous mobilizing bacteria) and plant nutrition with BIO-GEL increased buckwheat yield by 0.07 t/ha and millet yield – by 0.34 t/ha. The best millet yield of 3.51 t/ha was obtained after seed treatment and two-time plant extranutrition during the growth period. Seed bacterization and three-time plant spraying (at organogenesis stages IV, VII and IX) appeared the most effective, the yield amounting to 1.13 t/ha). The economic results at such cultivation technology were as follows: the cost of 1 t yield – 6430 UAH, profit - 12500 UAH / ha, profitability 172%.

One of the organic farming elements in cereal crops cultivation is the use of humates which are used in pre-sowing seed treatment and plant extranutrition during the vegetation period as well as seed bacterization with Azogran Nano and plant extranutrition with with BIO-GEL.

Table 2.7. Buckwheat and millet yields in organic farming, 2016, t/ha

Variant	Buckwheat		Millet	
	yield	± to control	yield	± to control
Control (no treatment)	0.88	-	3.07	-
Control (no treatment)	1.31	+0.43	3.15	+0.08
Seed treatment with BIO-GEL (1 l/t) + extranutrition (1 l/ha)	0.87	-0.01	3.29	+0.22
Seed treatment with BIO-GEL (1 l/t) + 2 extranutritions (1 l/ha)	1.08	+0.20	3.19	+0.12
Seed treatment with BIO-GEL (1 l/t) + 3 extranutritions (1 l/ha)	0.95	+0.07	3.41	+0.34
Seed treatment with Azogran Nano + extranutrition with BIO-GEL (1 l/ha)	0.85	-0.03	3.51	+0.44
Seed treatment with Azogran Nano + 2 extranutritions with BIO-GEL (1 l/ha)	1.13	+0.25	3.34	+0.27
HIP$_{0.5}$	***0.05***	-	***0.14***	-

The peculiarities of the cereals cultivation technologies in organic farming also affected the crop quality. The crop technological qualities (1000 grains weight, film content) determine the characteristics of its further processing. The maximum weight of 1000 buckwheat grains (29.9 g) and millet grains (7.68 g) was obtained in the experiments with 2 extranutritions with BIO-GEL after seed inoculation with nitrogen-fixing and phosphorous-mobilizing bacteria. After buckwheat seeds inoculation the weight of 1000 grains increased by 4%, while that of 1000 millet grains – by 3%.

The amount and quality of grains is also affected by film content. The film content depends on the amount of buckwheat membranes, which characterizes the grain value for its processing into cereals. Film content is the variety peculiarity [1]. The greater the film content, the lower the grain core, the less cereal is obtained. As a rule, the film content of large grains is smaller than of that of small ones. It is the small fractions that contain a lot of film. Quality cereals are produced from well-filled grains.

As for millet, this factor was influenced by nutrition. In our experiment the grain with the lowest film content was formed after pre-sowing seed treatment with BIO-GEL and three-time extranutrition during the vegetation period. Seed treatment with BIO-GEL had a greater effect on grain filling and accordingly on film content reducing this coefficient by 6.2% while seed treatment with Azogran reduced it by 3%. The film content in buckwheat was low, in the range of 20.0-20.4%, only the control variant showed 21.8%. Consequently, the factors studied in the experiment reduced the film content by 7.3%.

Most of the buckwheat and millet ash elements are potassium and phosphorous. The results of the experiments showed that seed treatment with BIO-GEL and seed inoculation with nitrogen-fixing and phosphorous-mobilizing bacteria did not significantly affect the content of ash elements. The highest level of potassium accumulation in buckwheat grains was from 0.59 to 0.65% on dry matter basis, in millet - from 0.49 to 0.51%, and phosphorus - from 0.80 to 0.86% in buckwheat and 0. 63-0.68% on dry matter basis in millet.

The results of the experiment show that the greatest effect on the protein content is caused by extranutrition. In addition, it is known that higher protein content in the grain is formed in clear and hot weather, so its content in buckwheat grains was high. With a protein content of 14.16-14.3% in buckwheat and 9.63-10.7% in millet, the best grain was obtained after three-time foliar spraying with BIO-GEL after seed treatment with BIO-GEL and nitrogen-fixing bacteria. One-time buckwheat and millet extranutrition proved to be less effective compared to other applications. The amount of starch and fiber changed insignificantly in the variants, the values ranging from 6.5-6.98 and 54.91-55.6% respectively (Table 2.8).

Table 2.8. Millet crop quality in organic farming, 2016

Variant	Protein	Fat	Fiber	Starch	P_2O_5	K_2O	Weight of 1000 grains, g	Film content, %
	% on dry matter basis							
Control (no treatment)	9.05	3.67	6.82	55.33	0.63	0.49	7.36	16.8
Control (no treatment)	9.11	3.76	6.52	55.85	0.67	0.51	7.47	15.9
Seed treatment with BIO-GEL (1 l/t) + extranutrition (1 l/ha)	9.48	3.56	6.94	54.94	0.68	0.51	7.58	15.8
Seed treatment with BIO-GEL (1 l/t) + 2 extranutritions (1 l/ha)	10.7	3.59	6.68	55.60	0.68	0.50	7.56	15.6
Seed treatment with BIO-GEL (1 l/t) + 3 extranutritions (1 l/ha)	9.34	3.57	7.02	55.65	0.67	0.51	7.50	16.4
Seed treatment with Azogran Nano + extranutrition with BIO-GEL (1 l/ha)	9.22	3.54	6.98	55.90	0.67	0.51	7.68	16.0
Seed treatment with Azogran Nano + 2 extranutritions with BIO-GEL (1 l/ha)	9.63	3.61	6.94	54.91	0.68	0.51	7.42	16.6

Given the increased efficiency of technological measures that contribute to buckwheat and millet crops productivity, the production per area unit can be raised at the lowest cost, thus increasing profits and profitability [15]. The economic characteristics of the agro-measures under study are an important indicator which helps to determine the best elements of cultivation technology. The economic efficiency of the cultivation technology elements was calculated at the Institute Economics Department. The calculations included direct material and monetary expenses: cost of seeds, labor, fertilizers, fuel and lubricants, depreciation and current repairs. The calculations are based on the prices as of October this year.

The results of the studies showed the positive effect of BIO-GEL use in organic farming and of seeds inoculation with nitrogen-fixing and phosphorous-mobilizing bacteria. Seeds inoculation with Azogran Nano increased additionally the production cost by 1200-1400 UAH (table 2.9).

Table 2.9. Economic efficiency of buckwheat and millet cultivation in organic farming, 2016

Variant	Millet			Buckwheat		
	Profit, UAH/ha	Cost, UAH/t	Profitability, %	Profit, UAH/ha	Cost, UAH/t	Profitability, %
Control	8539	1418	196	9037	7231	142
Control (no treatments)	8631	1460	188	16283	5070	245
Seed treatment with BIO-GEL (1 l/t)+ extranutrition (1 l/ha)	8571	1513	178	8394	7852	123
Seed treatment with BIO-GEL (1 l/t)+ 2 extranutritions (1 l/ha)	8758	1538	173	11825	6551	167
Seed treatment with BIO-GEL (1 l/t)+3 extranutritions (1 l/ha)	9521	1408	198	9827	7156	145
Seed treatment with Azogran Nano + extranutrition with BIO-GEL (1 l/ha)	9709	1434	193	7859	8254	112
Seed treatment with Azogran Nano + 2 extranutritions with BIO-GEL (1 l/ha)	8779	1572	167	12509	6430	172

Extranutritions increased millet and buckwheat cultivation cost. The variant with seeds inoculation with nitrogen-fixing and phosphorous-mobilizing bacteria + two-time extranutrition with BIO-GEL resulted in the lowest millet cost: 1434 UAH/t, the net operating profit was the highest: 9709 UAH/ha (that of the control – 8539 UAH/ha) and the profitability was 193%. These characteristics were similar after one extranutrition: 1408, 9521 and 198, respectively.

The economic analysis of BIO-GEL effect on crop yield after seed treatment and plants extranutrition testifies to the fact that BIO-GEL application to millet and buckwheat cultivation in organic farming is fully justified. Due to buckwheat yield (1.31 t/ha) and millet yield (3.29 t/ha), the lowest cost of buckwheat (5000UAH/t) and millet (1400 UAH/t) the profit amounted to 16200 UAH/ha and 8600 UAH/ha, respectively.

Seed inoculation with nitrogen-fixing and phosphorous-mobilizing bacteria appeared more profitable economically in millet cultivation providing the net operating profit of 9500-9700 UAH/ha, the profitability being 193-198%. In buckwheat cultivation these indicators were 9800-12500 UAH/ha and 145-172%.

2.2 Study of BIO-GEL effectiveness in haricot cultivation technology in organic farming

In the technology of leguminous crops cultivation of greatest importance is biologization, in particular more wide-spread use of non-food crop products including legumes as well as livestock wastes, organic mineral bioactive fertilizers (sapropel, peat, litter manure, compost, siderates), biological products of associative and symbiotic action in order to intensify the atmospheric nitrogen fixation in the root system rhizosphere [6, 7]. Nitrogen-fixing and phosphorous-mobilizing bacteria as well as plant growth stimulants are getting more important in organic farming [2].

This year we studied BIO-GEL which was used in seed treatment and in extranutrition at organogenesis stages IV, VII and IX, the rate being 1 l/ha at each stage. Besides, seeds were treated with nitrogen-fixing bacteria.

According to the research results it was established that the use of pre-sowing seed inoculation and plant spraying had different effects on haricot growth and development.

Pre-sowing seed treatment increased plant height by 5.3%, leaf area – by 33.0%, dry matter – by 17%, while the indicators at the control were 38 cm, 521.8 cm^2/plant, 11.8 g/plant, respectively. In the experiment variant in which BIO-GEL was applied at tillering and budding stages plant growth characteristics were not affected significantly, the leaf area increasing only by 9.3% and plant height remaining the same. The three-time extranutrition with BIO-GEL at the tillering, budding and flowering stages increased plant height by 9.0%, leaf area – by 26.0%, dry matter – by 11% compared to the control (table 2.10).

When BIO-GEL was applied four times during the vegetation period (tillering, budding, flowering and ripening) these characteristics increased by 7.6%, 17.4% and 9.3%, respectively.

The studied elements of the cultivation technology had different effects on crop structure elements.

Table 2.10. Characteristics of the Perlina haricot variety growth at the flowering stage in organic farming, 2016

Experiment variant	Plant height	Leaf surface, cm^2/plant	Dry matter, g/plant
Control (treatment with water)	38.0	521.8	11.8
Seed inoculation (nitrogen-fixing bacteria)	40.0	693.7	13.8
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha)	37.3	570.2	12.9
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha)	41.4	657.2	13.1
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha) + at ripening stage (1 l/ha)	40.9	612.6	12.9

In case of four-time BIO-GEL application during vegetation period (tillering, budding, flowering and ripening) the results increased by 7.6%, 17.4%, 9.3%, respectively.

The effect of the studied cultivation technology elements on the yield structure was different.

The highest values, including the number of pods per plant (14.0), number of beans in a pod (3.9, 4.0), beans weight per plant (8.5 g; 8.8 g) were obtained in the variant where seeds were inoculated with nitrogen-fixing bacteria and in the variant with four-time plant spraying at the stage of tillering, budding, flowering and ripening (table 2.11).

Table 2.11. Characteristics of the Perlina haricot variety yield structure in organic farming, 2016

Experiment variant	Number, pc		Weight, g	
	pods/plant	beans/pod	beans/plant	1000 beans
Control (treatment with water)	10	3.3	5.6	164.9
Seed inoculation (nitrogen-fixing bacteria)	14	4.0	8.8	156.1
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha)	14	3.9	8.6	156.8
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha)	11	3.8	6.6	151.9
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha) + at ripening stage (1 l/ha)	14	3.9	8.5	152.0

The increase of these values compared to the control amounts to: number of pods – 40%, the number of beans in a pod – 18-21%, bean weight – 57.0%.

The studies performed testify to the fact that three-time BIO-GEL application to haricot plants at the stage of tillering, budding and flowering resulted in the yield increase by 35.4% compared to the control and amounted to 1.53 t/ha.

The four-time BIO-GEL application to haricot plants at the stage of tillering, budding, flowering and ripening was less effective under this year conditions (about 16.8%) compared to the control 1.13 t/ha (table 2.12).

Table 2.12. Perlina haricot variety yield in organic farming, 2016, t/ha

Experiment variant	Yield, t/ha	± to control
Control (treatment with water)	1.13	-
Seed inoculation (nitrogen-fixing bacteria)	1.39	+0.26
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha)	1.31	+0.18
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha)	1.53	+0.40
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha) + at ripening stage (1 l/ha)	1.32	+0.19
$HIP_{0.5}$	0.10	-

The technology involving pre-sowing seed treatment with nitrogen-fixing bacteria resulted in the crop yield of 1.39 t/ha, the increase to the control being 0.26 t/ha. The best characteristics of the crop quality (21.42% protein quantity) were obtained on BIO-GEL application at the stages of tillering, budding and flowering.

The amount of protein in the variant with pre-sowing seed inoculation with nitrogen-fixing bacteria was 20.55%.

In the variant with plant spraying at the stage of tillering and budding the effect of BIO-GEL on the yield quality was not essential.

The analysis of the economical efficiency of haricot cultivation showed that the greatest effect was achieved on seed inoculation and on the three-time plant spraying with BIO-GEL (tillering, budding, flowering). In this cases the profits amounted to 19347.4 UAH/ha and 17228.9 UAH/ha, the profitability – 236% and 221%, respectively (table 2.13).

Table 2.13. Economic efficiency of the Perlina haricot variety cultivation in organic farming, 2016

Variant	Yield cost, UAH/ha	Net cost, UAH/ha	Net cost of 1 t, UAH	Profit, UAH/ha	Profitability, %
Control (treatment with water)	20340	7714.3	6826.8	12625.7	164
Seed inoculation (nitrogen-fixing bacteria)	25020	7791.1	5605.1	17228.9	221
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha)	23580	7956.2	6073.4	15623.8	196
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha)	27540	8192.6	5354.6	19347.4	236
BIO-GEL – seed treatment (1 l/t) + spraying at tillering phase (1 l/ha) + at budding stage (1 l/ha) + at flowering stage (1 l/ha) + at ripening stage (1 l/ha)	23760	8408.1	6369.8	15351.9	183

CONCLUSIONS

1. It has been established that BIO-GEL, cereal straw, green manure use in cereals and leguminous plants cultivation technologies in organic farming causes positive changes in vegetative and generative development of millet, buckwheat and haricot beans, namely, it promotes their growth, increases their leaf surface and dry matter amount as well as provides favorable conditions for generative organs formation.

2. The complex effect of seed treatment and top-dressing with BIO-GEL has been determined, which ensured the millet yield of 3.15-3.29 t/ha, that is, 7% higher than the control. The highest buckwheat yield has been 1.31 t/ha, that is, by 48% higher than the control.

3. It has been proved that seed inoculation with Azogran bacterial product increases buckwheat yield by 11% and millet yield – by 14% on average. It has been proved that from the standpoint of economy the application of Azorgan Nano bacterial product in seed inoculation together with BIO-GEL is expedient.

4. The highest haricot yield has been obtained after spraying vegetating plants with BIO-GEL during branching, budding and flowering stages. In this case the haricot yield amounted to 1.53 t/ha, that is, by 35% higher than in the control.

5. It has been established that pre-sowing haricot seed treatment with БТУ-р (nitrogen fixing bacteria) is conducive to the yield increase by 0.26 t/ha.