



Microflora, Provision of Ordinary Chernozem with Nutrients and Barley Productivity when Inoculating the “Agrobionov” Preparation

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ABSTRACT

Modern agriculture in Kazakhstan is carried out by an extensive method and accompanied by a noticeable decrease in soil fertility, in particular the biological and agrochemical properties as the main reason of insufficient fertilizer applications. The objectives of the research were to study the Agrobionov doses effect applied during soil preparation on microflora species composition, microbiological activity, availability of plant nutrients in soil, and barley grain yield. The preparation substances are produced from industrial wastes - coal ash, slag and carbon black. The experiments were carried out in the Northern Kazakhstan on the experimental field of Ualikhanov Kokshetau State University. The soil is represented by ordinary chernozem, carbonate, medium-power, low-humus, heavy-loam. The cellulose-decomposing activity of soil bacteria was determined by the application of flax cloth. Microflora was studied on solid nutrient media, the productivity of barley grain by the continuous method. It has been established that preparation substances promote an increase in the total number of microorganisms, including nitrogen consuming microorganisms, oligonitrophils, phosphorus mobilizing, cellulose-decomposing, fungi, nitrogen nutrition improvement of soil, the increase of grain yield. The preparation substances improve biological properties, nutritional regime of soil, raises barley productivity, and also has ecological significance in terms of production waste utilization.

INTRODUCTION

Currently, one of the main global environmental problems is land degradation, soil dehumification. This process has been particularly intensive in the Republic of Kazakhstan, where since 1953, during the period of massive development of virgin and fallow lands and the manifestation of wind erosion, humus losses on chernozem soils amounted to 25-27%. Currently, the tendency to decrease in soil fertility continues. These were worsened by the non-compliance with the basic law of agriculture - the law of return of which there is little mineral fertilizer applied in the Republic of Kazakhstan and organic and micronutrient fertilizers are practically not applied (Khussainov, 2019).

In the conditions of intensive development of industrial and energy production, waste is generated

in large volumes, including ash-and-slag waste. Cereals are cultivated in a variety of geographical conditions. This is due to the wide genetic diversity of this group of crops thus adaptive in a wide range of soil and climatic conditions. Cereals most actively react to fertilizers, tillage, irrigation, etc. than other cultivated plants by significant increase of crop properties.

The Republic of Kazakhstan positions as the second grain exporter that are distributed to 44 countries around the world. But the yield of grain crops remains low and unstable over the years. This is due to a weak crop culture, low provision of mineral fertilizers, as a result of decrease in potential soil fertility. The modern agriculture in Kazakhstan is also characterized by a noticeable decrease in soil fertility. Currently, on average 6-8

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kg reactant of mineral fertilizers is brought in 1 ha of arable land at all, compared to the Russian Federation and USA with the values of -45kg and -135 kg, respectively. Over the past 30 years, livestock numbers have declined. A sharp reduction in livestock led to the decrease of manure volume. Due to the low solvency, agricultural producers are not able to purchase the required amount of mineral fertilizers. Microfertilizers are also practically not used (Yelyubaev, Khussainov, & Seydalina, 2016).

The world has accumulated vast experience in the use of ash-and-slag in various sectors of the economy, including in agriculture for fertilizing the soil. In England and Germany, the entire annual ash-and-slag output is used. In America, waste management accounts for 70%, in Poland up to 80%, and over 80% is recycled in China. The world leader in recycling is India. In China, ash is used as fertilizer (Maiti & Prasad, 2016) for various purposes. Mukhanbet, Khusainov, Elubayev, Balgabayev, & Khusainova (2016) have established the effectiveness of ash-and-slag application as fertilizer in spring wheat crops in the chernozem zone of Northern Kazakhstan.

Development of modern technologies for the agricultural production are aimed to increase and stabilize the grain production, as well as maintaining and improving the soil fertility, which is not possible without microorganisms living in the soil. They participate in the decomposition of mineral and organic compounds that are difficult to be absorbed by plants and enrich the soil with plant nutrients. In this regard, at the development of technological measures, in particular, fertilizer application methods, it is necessary to study the biological activity of the soil (Khamova, Yushkevich, Voronkova, Boiko, & Shuliko, 2019). Therefore, the study of the effect of the "Agrobionov" preparation on the soil microflora is of great scientific and practical interest.

The aim of our study is to study the effect of the multicomponent carbon-containing preparation "Agrobionov" on the microflora and the availability of ordinary chernozem with nutrients, as well as barley yield.

Specifically, the study focused on the effect of Agrobionov dosages in on the microflora species composition, cellulose-degrading activity of soil bacteria and the availability of common chernozem with plant nutrition elements, as well as the yield of barley grain. Ram & Masto (2014) indicate that

the use of ash and slag improves the physical, chemical and biological properties of the soil. They emphasized the features of its application depending on the properties of ash and soil. It is also noted that there are a number of researches on the study of mixtures of ash and slag with organic and inorganic materials, such as lime, gypsum, sludge, bird droppings, biohumus, biochar, bioinoculants, etc. The use of these mixtures has several advantages such as increasing the availability of nutrients, microbiological activity of the soil, and improvement of physical soil characteristics (Ram & Masto, 2014). In this study, the ash and slag were mixed with carbon black, which forms the basis of the organic world, and is a part of all organic substances.

In the studies of Ning et al. (2017) the use of mineral fertilizers with the addition of organic fertilizers (CF60 + OM20, CF40 + OM40) significantly increased the content of organic substances in the soil, the activity of catalase, urease and acid phosphatase in the soil.

In our experiment, mineral fertilizers (double granular superphosphate) were used with the addition of the Agrobionov preparation, which is an analogue of organic fertilizers in terms of its carbon content.

García-Orenes, Caravaca, Morugán-Coronado, & Roldán (2015) studied the effectiveness of wastewater, as a fertilizer. Analyzes showed a significant increase in the number of bacteria, especially bacteria that utilize organic nitrogen compounds. Bezuglova, Polienko, Gorovtsov, Lyhman, & Pavlov (2017) found that treating plants with humic substances increases the number of microorganisms in the soil, which leads to mobilization of phosphorus available to plants.

The above experimental data are based on the use of carbon to optimize the biological properties of the soil and the nutritional regime of the soil. In our experiments, carbon black was used for these purposes.

Our studies have established a positive effect of the doses of the Agrobionov preparation on the microflora, microbiological activity and the supply of nutrients for ordinary chernozem, as well as the yield of barley grain. The use of the preparation from ash-and-slag and carbon black for fertilizing chernozemic soils on barley crops contributed to an increase in soil fertility due to the activation of microbiological processes in the soil, its enrichment with easily hydrolyzed nitrogen, carbon and

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microelements. The studies are subjected to the scientific justification for the doses of the Agrobionov preparation for fertilizing ordinary chernozem on barley crops in specific climatic conditions of the steppe zone of Northern Kazakhstan.

MATERIALS AND METHODS

The experiment was carried out at the experimental field of the Educational-Scientific-Production Center "Elite" of Ualikhanov Kokshetau State University located 32 km north of Kokshetau city, the Republic of Kazakhstan from 2018 to 2019. The research objects are ordinary chernozem, spring barley cultivar "Astana-2000".

The subject of the study is the Agrobionov preparation, which includes ash loss of coal from the Ekibastuz coal deposit and carbon black - waste from the tire factory. The chemical composition of ash-and-slag are: SiO₂-62.9%, Fe₂O₃-6.35%, Al₂O₃-26.35%, CaO-1.9%, MgO-0.9%, SO₃-1.2%, Na₂O-0.23%. Carbon black is 99% of carbon. The drug has a powder form (Sarsenova, 2013).

The soil cover of the field is ordinary chernozem, carbonate, medium-power, low humus, heavy loam. A soil layer of 0-20 cm contains 3.8% of humus, 46.0 mg/kg of easily hydrolyzable nitrogen, 17.0 mg/kg of mobile phosphorus and 582 mg/kg of exchange potassium. According to the provision degree with easily hydrolyzable nitrogen (according to the Tyurin and Kononova classification), it refers to medium, mobile phosphorus and low and high exchange potassium (according to the Machigin's classification). The reaction of the soil solution is slightly alkaline (pH – 7.8).

The experiment of the influence of the preparation substance dosages made from ash-and-slag and technical nanocarbon on ordinary chernozem for barley crops was based on the scheme of 1) control - no fertilizer; 2) P16 (1/10 of the estimated dose) - ground; 3) ground + Agrobionov 100 kg/ha; 4) ground + Agrobionov 200 kg/ha; 5) ground + Agrobionov 300 kg/ha; 6) ground + Agrobionov 400 kg/ha; 7) ground + Agrobionov 500 kg/ha. Plot area is 125 m², the accounting area is 100 m²; the experiment is repeated 4 times.

Experiment plots are placed in a randomized method and arranged in two tiers.

Agricultural technology adopted in the experiment was according to the region. Fertilizers were applied according to the experimental scheme in spring for pre-sowing cultivation. A regionalized

barley variety "Astana-2000" was used in the field experiment.

All the data were gathered by the continuous method and analyzed using the SNEDEKOR software package for applied statistics, version 4.7 according to O.D. Sorokin; easily hydrolyzable nitrogen was determined using the Tyurin and Kononova method. The mobile phosphorus and exchange potassium were observed base on Machigin method in the modification of Central Research Institute of Agrochemical Services, GOST 26205-91, pH of an aqueous extract using potentiometric method, and the content of heavy metals (GOST 50686-94-GOST 50683-94) and radionuclides in soil and plants by the inverse voltammetry method.

Microbiological studies were performed by the following methods:

1. Quantification of microorganisms in a dense nutrient medium, deep sowing: meat peptone agar (MPA) - for bacteria that utilize organic nitrogen compounds - dilution 10⁻⁵; starch-ammonia agar (SAA) - for microorganisms consuming nitrogen in the mineral form (NH₃) - dilution 10⁻⁵; Mishustina's medium - for oligonitrophils - dilution 10⁻⁶; Muromtsev-Gerretsen's medium - for microorganisms mobilizing mineral phosphates - dilution 10⁻⁶; Hetchinson's medium - for cellulose-fermenting microorganisms - dilution 10⁻³ (surface sowing); aqueous leached agar with the addition of a double - ammonium-magnesium salt of phosphoric acid - for nitrifiers - dilution 10⁻¹ (surface sowing); Chapek's medium acidified with lactic acid for mushrooms - dilution 10⁻³.
2. The rate of cellulose fermentation was determined by the application method of Tikhomirova (Khamova, Boiko, Timokhin, & Shuliko, 2018) in the field for the decomposition of a cellophane film.
3. Nitrification ability of the soil was determined according to Kravkov with incubation for 21 days (Arinushkina, 1970).
4. The method of relative values was used to assess the biological activity of the soil as a total result. Soil samples were taken 3 times during the growing season of barley, during tillering, heading and grain ripe at a depth of 0-20 and 20-40 cm.

Statistical processing of the observation results was carried out by the Fischer analysis of variance as presented by B.A. Dospekhov with the use of Microsoft Excel. The correlation dependence between two signs, the numerical indicator of which was the correlation coefficient was calculated in the Microsoft Excel program. Meteorological conditions during the years of the study were slightly different. In 2018, 236 mm of precipitation fell during the growing season with an average long-term data of 162 mm; the year was humid, precipitation was 74 mm or 31.3% above normal; the average air temperature was 15.90C, at normal 18.60C. The year 2019 was moderately dry, the average air temperature was -18.20C, the amount of precipitation was 123.1 mm (Pogoda 360, 2019).

RESULTS AND DISCUSSION

Microflora Content and Composition

In the conditions of 2018, initiation and application of phosphorus fertilizer at 16 kg/ha contributed to a significant increase in the total number of microorganisms in the soil by more than 2 times (up to 431.3 million CFU/g) from the control (176.3 million CFU/g). The introduction of the Agrobionov preparation on the ground of P16 with an increase dosage from 100 to 300 kg/ha.

Promote the increase in the number of microorganisms from 498 to 1204 million CFU/g. A very close correlation was established between the preparation dosage within these limits and the number of microorganisms (the correlation coefficient was 0.94). On the dosage of 400 and 500 kg/ha, the number of microorganisms decreased (Table 1).

Table 1. The effect of Agrobionov dosage introduction on the microflora of soil under barley, 2018

Indicators	Control	Ground – P ₁₆	Ground + Agrobionov (kg/ha)					r ² – correlation coefficient
			100	200	300	400	500	
Bacteria utilizing organic nitrogen compounds million CFU/g	24.9	44.1	57.1	80.9	96.5	56.1	43.6	r ² - 0,30 r ² (0-300) – 0.99 LSD _{0,95} – 2.59
Microorganisms consuming nitrogen, million CFU/g	20.6	40.2	46.6	61.4	58.5	42.0	37.2	r ² - 0,26 r ² (0-300) – 0.88 LSD _{0,95} – 1.97
Oligonitrophils, million CFU/g	64.2	227.4	223.0	237.2	446.0	245.2	137,0	r ² - 0,24 r ² (0-300) – 0.90 LSD _{0,95} – 10.16
Phosphorus mobilizing, thousand CFU/g	66.5	119.4	171.3	216.3	602.8	261.9	108.2	r ² - 0,31 r ² (0-300) – 0.92 LSD _{0,95} – 0.95
Cellulose-fermenting, thousand CFU/g	107.0	119.1	126.7	135.3	134.5	113.5	106.5	r ² - -0,14 r ² (0-300) – 0.90 LSD _{0,95} – 5.42
Nitrification, thousand CFU/g	0.4	0.6	0.7	0.7	1.9	0.1	<0.1	r ² - -0,17 r ² (0-300) – 0.88 LSD _{0,95} – 0.03
Fungi, thousand CFU/g	12.6	53.1	62.6	72.7	72.3	19.6	22.3	r ² - -0,19 r ² (0-300) – 0.80 LSD _{0,95} – 2.03
The total number of microorganisms, million CFU/g	176.3	431.3	498.1	596.0	1203.9	617.6	326.1	r ² - 0,30 r ² (0-300) – 0.94 LSD _{0,95} – 24.75
Nitrogen nitrates, mg/kg	0.2	0.3	0.4	0.5	0.7	0.6	0.8	r ² - 0,95 r ² (0-300) – 0.99 LSD _{0,95} – 0.02

Under the influence of the preparation substances application, an increase in the number of almost all groups of microorganisms was noted including nitrogen consumption by microorganism. The margins were observed from 46.6 to 58.5 million CFU/g (20.6 million CFU/g) under control), 223 to 446 million CFU/g on oligonitrophils from the control (64.2 million CFU/g), 171 to 603 thousand CFU/g on phosphorus mobilizing from the control (66 thousand CFU/g), 119 to 135 thousand CFU/g on cellulose-fermenting from the control (107 thousand CFU/g), 0.6 to 1.9 thousand CFU/g on nitrifying agents from the control (0.4 thousand CFU/g) and 20 to 73 thousand CFU/g on fungi from the control (13 thousand CFU/g). The maximum increase in the number of all types of microorganisms was noted

on the ground + Agrobionov 300 kg/ha. A close ($r^2 = 0.88$) and very close ($r^2 = 0.90-0.99$) correlation was detected between the substance dosages from 100 to 300 kg/ha and the number of all the above groups of microorganisms. The preparation substances dosage increase up to 400-500 kg/ha led to a decrease in the soil biological activity, both in total number and in the microorganisms species composition.

In the conditions 2019, there was also an increase in the number of microorganisms at options of the preparation substances at 100 kg/ha against the ground of P16 up to 81 million CFU/g (72 million CFU/g on control). There was also an increase in the number of all types of microorganisms (Fig. 1), with the exception of fungi (Fig. 2).

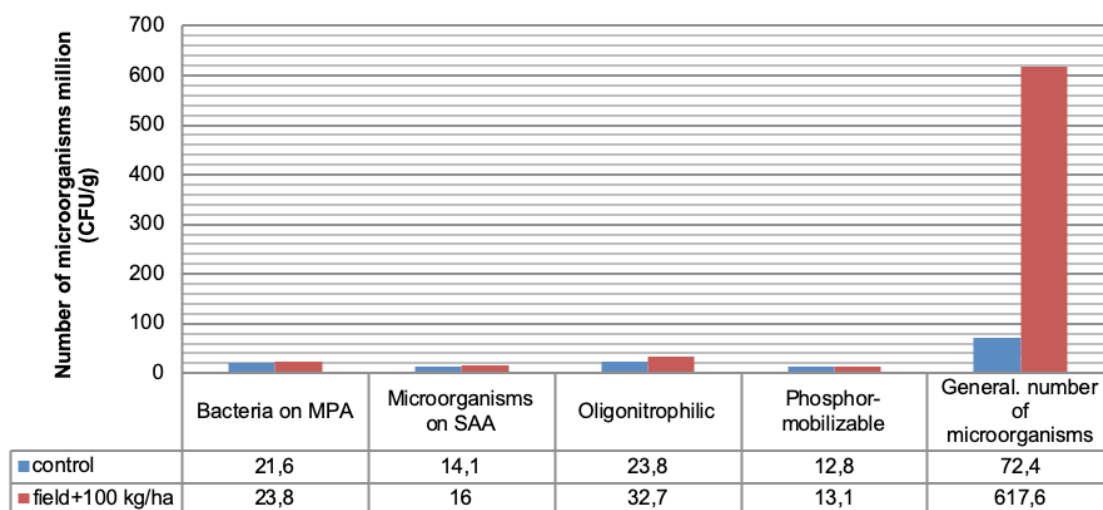


Fig. 1. Agrobionov effect on the number of microorganisms in ordinary chernozem, 2018

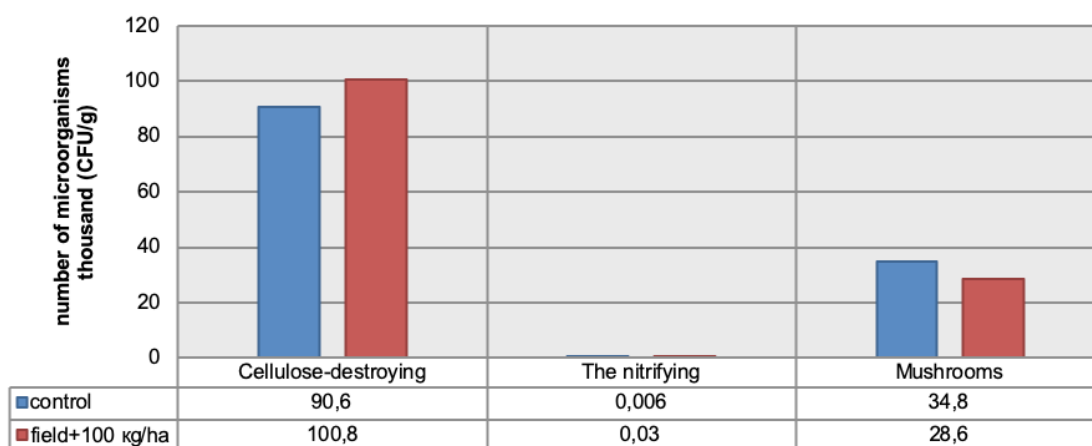


Fig. 2. Agrobionov effect on the number of cellulose-fermenting, nitrifying bacteria and fungi in ordinary chernozem, 2019

We calculated the mineralization coefficient of organic substances in the soil, which is calculated as the ratio of the microorganisms' number using mineral forms of nitrogen and bacteria that utilize organic nitrogen compounds.

In 2018 the mineralization coefficient on control was 0.83, while on the option of phosphorus fertilizer application (P16), the degree of mineralization increased to 0.91. On the options of preparation substances application in dosages from 100 to 500 kg/ha, a significant increase in the degree of mineralization was not observed. Here, an inverse close correlation was established ($r^2 = 0.90$) between the preparation substances in the range from 0 to 300 kg/ha and the mineralization coefficient. This should be considered as a positive process, from the point of preservation view of the organic matter of the soil during its operation (Table 2).

In the options fertilized, the number of agronomically valuable microorganisms in our experiment increased to 84–155 million CFU/g compared to control (45 million CFU/g). The maximum number of microorganisms was observed on the ground + preparation option 300 kg/ha – 155 million CFU/g.

The ratio of the bacteria number to the number of groups of microorganisms using mineral forms of nitrogen indicates the process of mineral nitrogen immobilization (NH₃), which is formed during the decomposition of organic nitrogen-containing compounds of microorganisms. In preparation introduction option and, in particular, in the ground

+ Agrobionov 300 kg/ha option, the immobilization process intensity increases to 1.23-1.65, compared with the control 1.21.

The transformation coefficient of organic substances (PM) is calculated as the ratio product of the bacteria number utilizing organic nitrogen compounds by the number of microorganisms consumed by nitrogen in mineral form (NH₃) by their total amount.

This coefficient on the control was relatively low 55.0. On fertilized options, this coefficient significantly increased from 93 to 256. The highest coefficient – 256 was obtained on the ground + preparation option 300 kg/ha. The functional dependence of the preparation substances dosage from 0 to 300 kg/ha and the transformation coefficients of organic matter was established ($r^2 = 1.0$).

During 2019, the mineralization coefficient on control was 0.65; in the option introduction of the ground + preparation of 100 kg/ha, the mineralization degree was slightly higher at 0.67 (Table 3).

In the ground + preparation 100 kg/ha option, the number of agronomically valuable microorganisms increased to 40 million CFU/g compared to the control (38 million CFU/g).

The ratio between number of bacteria and number of microorganism groups using mineral forms of nitrogen did not differ significantly with the control and in the fertilized option (1.53-1.49 million CFU/g). The transformation coefficient of organic matter on control was 55.0, and in the ground + preparation option 100 kg/ha, the value increased to 59.

Table 2. Agrobionov effect on the direction of microbiological processes, 2018

Option	Vegetation Average		SAA / MPA	MPA + SAA	MPA / SAA	PM
	per MPA million CFU/g	per SAA million CFU/g				
Control	24.9	20.6	0.83	45.5	1.21	55.0
Ground	44.1	40.2	0.91	84.3	1.10	92.7
Ground + 100	57.0	46.6	0.82	103.7	1.23	127.6
Ground + 200	80.9	61.4	0.76	142.3	1.32	187.8
Ground + 300	96.5	58.5	0.61	155.0	1.65	255.8
Ground + 400	56.1	42.0	0.75	98.1	1.30	127.5
Ground + 500	43.6	37.2	0.85	80.8	1.17	94.5
r ²	0.30	0.26	-0.34	0.29	0.26	0.28
r ² - (0-300)	0.98	0.88	-0.90	0.96	0.90	1.00
LSD _{0.95}	2.59	1.97	0.04	4.56	0.06	6.05

Remarks: MPA: meat peptone agar, SAA: starch-ammonia agar, PM: transformation coefficient of organic substances

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Table 3. Agrobionov doses effect on the microbiological processes of common chernozem under barley, 2019

Option	Vegetation average		SAA /MPA	MPA + SAA	MPA /SAA	PM
	per MPA million CFU/g	per SAA million CFU/g				
Control	21.6	14.1	0.65	35.7	1.53	54.62
Ground + 100	23.8	16.0	0.67	39.8	1.49	59.30

Remarks: MPA: meat peptone agar, SAA: starch-ammonia agar, PM: transformation coefficient of organic substances

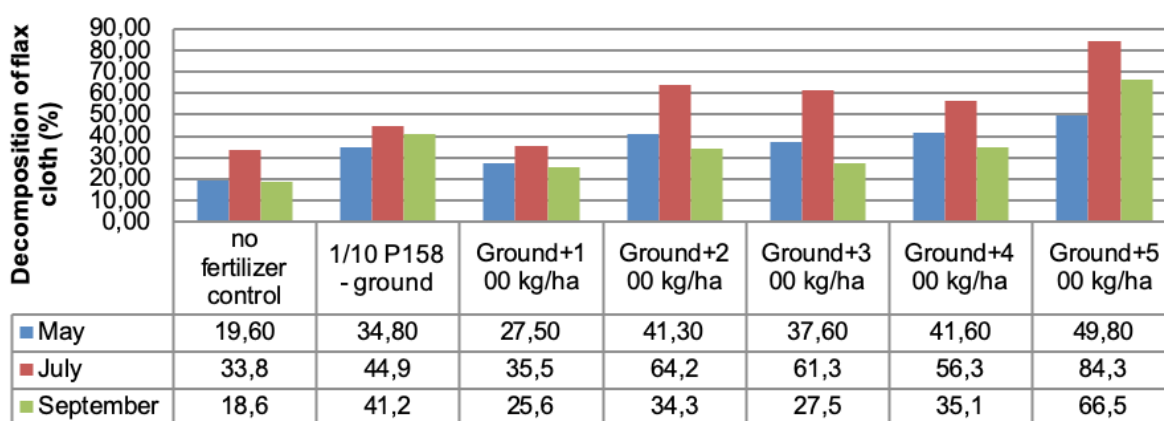


Fig. 3. Agrobionov doses effect on the microbiological activity of ordinary chernozem in barley crops (%), 2018

According to Korobova, Shindelov, Tanatova, & Ferapontova (2013), an increase in the transformation coefficient of organic matter reflects the potential rate of humic substances accumulation in the soil. In other words, the introduction of the Agrobionov potentially contributes to the intensification of the humic substances accumulation in the soil.

Khadem & Raiesi (2017) found out that the application of biochar improves the soil microbiological characteristics. The number of soil bacteria increased with the addition of biochar, but the number of soil fungi decreased. In these experiments, the improvement of the soil microbiological properties was due to the presence of organic substances in the fertilized materials. In our case, the role of this “catalyst” is played by carbon black and trace elements of ash-and-slag.

In the experiments by Leclercq-Dransart et al. (2019) when fly ash was added to the soil, the fungal activity of the soil increased. In the studies of Meena et al. (2019) using compost of municipal solid waste improved the biological, physico-chemical properties of the soil. Sewage sludge is also used as fertilizer (Ociepa, Mrowiec, & Lach,

2017). In our experiment, carbon was an analogue of organic substances.

Crop Productivity

In spring 2018 on barley crops of control treatment showed a low microbiological activity of the soil and the proportion of flax cloth decomposition was only 19.6%. While, on fertilized options, the value was significantly higher 27.5-49.8%. These processes took place in options with the preparation doses from 200 to 500 kg/ha (37.6-49.8%). In the summer, microbiological processes were activated and on control the decomposition activity of flax-cloth was 33.8%, and on fertilized options 33.5-84.3%. The highest soil microbiological activity was noted in the ground + preparation 500 kg/ha option. In this option, the decomposition activity was 84.3%, and higher than the control by 2.5 times. In autumn, microbiological processes slowed down, the activity of flax cloth decomposition under control was 18.6%. On fertilized options, microbiological processes proceeded more intensively at 25.6-66.5%. The maximum soil microbiological activity was noted on the option ground + preparation 500 kg/ha – 66.5%, which is 3.6 times higher than the control (Fig. 3).

In the spring 2019, in barley crops, soil microbiological activity on control was not high, the flax cloth decomposition proportion was only 10.4% while in fertilized options it was higher than 38.2-48.0%. The most active microbiological processes were observed on the dosage options of 200 and 300 kg/ha, where the activity of the flax-cloth decomposition was 46.7 and 48.0%, respectively. In summer, microbiological processes became more active as detected on control of 28.7% and in the fertilized options of 32.7-40.0%. The highest microbiological activity was observed in the option of ground + preparation 300 kg/ha - 40%. During autumn, the flax cloth decomposition was 41.3% on the control, slightly higher 43.8-87.4% under fertilized options. The maximum result was obtained on the option of ground + preparation 300 kg/ha - 87.4%, which is 2.1 times higher than the control (Fig. 4). Mandpe, Paliya, Kumar, & Kumar (2019) found that with the addition of volatisole, the microbial enzymatic activity of organic waste increases when they are composted. And when the preparation is added, the soil microbiological activity itself increases.

Jambhulkar, Shaikh, & Kumar (2018) argue that trace elements of ash-and-slag provide the soil with nutrients for plant growth and improve its biological properties. Woch, Radwańska, Stanek, Łopata, & Stefanowicz (2018) reported in the land reclamation area in ash areas, that is, with a high concentration of ash, the microbial biomass and the enzymatic activity in the ash-and-sludge were low. It follows that large dosage of ash-and-

slag, will contribute to a decrease in the number of microorganisms. Therefore, we studied the preparation optimal dosage in our experiment.

In the research by Nayak et al. (2015) ash-and-slag application in small fractions (from ten to twenty percent of the soil volume) increased the microelement content, microbial activity in the soil and rice productivity. In our experiment, a positive effect was obtained at dosage of 100-500 kg/ha, that is lesser than the above authors.

On average, during 2018–2019, in the spring before initiation of experiments, the availability of soil with easily hydrolyzable nitrogen and mobile phosphorus was very low in the studied chernozem, on average it was 13 and 10 mg/kg, respectively, and with high exchange potassium (582 mg/kg).

The potential fertility of the studied chernozem is not high. The humus availability in soil is low. The humus content amounted to 3.7-3.8% on control and 3.2-4.0% in fertilized options. Differentiation of options according to the humus content is associated with the diversity of soil fertility on the experimental plot (Table 4).

The result of laboratory test showed that the application of preparation substance had a significant effect on the soil availability with plant nutrients. In the tillering phase of barley, when the dosage increases from 100 to 500 kg/ha, the content of easily hydrolyzable nitrogen in the soil increased from 12 to 18 mg/kg. While under control plot 13 mg/kg against the ground 1/10 of the calculated fertilizer dosage, the nitrogen content was close to the control.

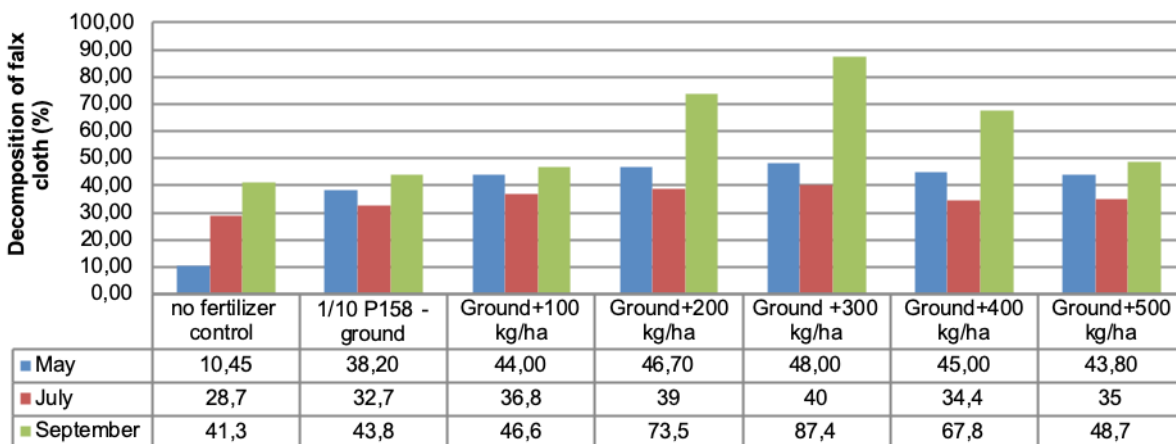


Fig. 4. Agrobionov doses effect on the microbiological activity of ordinary chernozem in barley crops (%) 2019

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A good correlation was obtained ($r^2 = 0.66$) between these indicators, and within the preparation dosage from 0 to 300 kg/ha even a close relationship ($r^2 = 0.80$) nitrogen was higher 64-67 mg/kg than on control 60 mg/kg. In the estimated dosage option 1/10, the nitrogen content was at the level of control 59 mg/kg. At the end of the vegetative season between the preparation dosage, the content of readily hydrolyzable nitrogen did not show a significant difference.

In the tillering phase of barley in the control option, the content of mobile phosphorus was very low 10 mg/kg. The preparation doses did not significantly affect the mobile phosphorus availability in the soil and the P_2O_5 content amounted to 6-9 mg/kg. A similar pattern was observed in autumn, where the P_2O_5 content on control was 17 mg/kg, and in the fertilized options it ranged from 9-15 mg/kg (Table 4).

The exchange potassium content in the studied chernozem ranged from 521-710 mg/kg and the content of K_2O in the soil was considered high (Table 4).

According to the grouping of soils under the gross content of trace elements, the zinc content in the studied soil (0.37 mg/kg), copper and cadmium (traces) is very low. Therefore, Agrobionov introduction is an alternative to micronutrients. The increase total number of microorganisms, the agronomic valuable microflora in the soil and the content improvement with easily hydrolyzed nitrogen

in the soil contributed to an increase in barley yield. Bezuglova, Polienko, Gorovtsov, Lyhman, & Pavlov (2017) found that pre-sowing seed treatment and treatment of vegetative plants and soil with the humic preparation "Bio-Don" contributed to an increase in winter wheat grain yield. In our experiment, Agrobionov introduction in the soil, which contains carbon and trace elements of ash, helps to increase barley yield. Dangi, Gao, Duan, & Wang (2020) said that the biochar introduction in soil or the organic fertilizers application affected the biomass of microbial community, its composition and productivity.

Ociepa, Mrowiec, & Lach (2017) used a mixture of wastewater for the soil fertilizing with spent soil fractions of brown coal, brown coal ash, enriched with mineral potash fertilizer. The yield in the first year was 1.6, and 2.7 times higher in the third year when fertilizing the soil with the test mixture, compared with the control (Ociepa, Mrowiec, & Lach, 2017). Schönegger et al. (2018) suggest that fly ash contains important macronutrients such as P, K, Mg, Ca, S, and trace elements, including Fe, Mn, Zn, and Cu can provide the soil with a sufficient amount of mineral nutrients. Therefore, the authors propose to introduce fly ash into soil, which leads to soil improvement in the nutrient regime thus increase the number and species composition of the microbial community and crop yields (Schönegger et al., 2018). Our research also confirms the ash use effectiveness in barley crops.

Table 4. Agrobionov doses effect on the nutritional regime of ordinary chernozem in the layer 0-40 cm, mg/kg

No.	Options	In tillering phase				After harvesting			
		Humus (%)	N_{light} (mg/kg)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Humus (%)	N_{light} (mg/kg)	P_2O_5 (mg/kg)	K_2O (mg/kg)
1	No fertilizer Control	3.78	13.0	10.0	643	3.70	60.0	17.0	626
2	1/10 P_{161} - ground	3.5	12.0	9.0	615	3.49	59.0	15.0	613
3	Ground + 100 kg/ha	3.21	12.5	6.0	654	3.07	67.0	9.0	626
4	Ground + 200 kg/ha	3.98	13.0	6.0	631	3.84	67.0	15.0	613
5	Ground + 300 kg/ha	3.90	17.0	9.0	612	3.28	66.0	12.0	642
6	Ground + 400 kg/ha	3.55	17.0	9.0	521	3.85	64.0	12.0	701
7	Ground + 500 kg/ha	3.2	18.0	8.0	710	3.22	66.0	13.0	630
	r^2	0.20	0.66	-0.22	0.59	-0.47	0.58	-0.20	-0.16
	r^2 - (0-300)	0.48	0.80	-0.28	-0.48	-0.17	0.72	-0.39	0.49
	$LSD_{0.95}$	0.16	0.66	0.37	28.20	0.16	2.89	0.60	28.61

Table 5. Agribionov doses effect on the productivity of barley

No.	Option	Productivity (t/ha)			Increase in control	
		2018	2019	Average	c/ha	%
1	Fertilizer-free control	1.38	0.75	1.06	-	-
2	1/10 P ₂ O ₅ -ground	1.40	0.93	1.16	0.10	9.4
3	Ground + 100kg/ha	1.88	1.04	1.46	0.40	37.7
4	Ground + 200 kg/ha	1.79	1.00	1.40	0.34	32.1
5	Ground + 300 kg/ha	1.84	1.10	1.47	0.41	38.7
6	Ground + 400 kg/ha	1.90	1.01	1.45	0.39	36.8
7	Ground + 500 kg/ha	1.92	0.92	1.42	0.36	34.0
	HCP _{0.05}	0.08	0.1	0.09	-	

A number of authors note the positive effect of production wastes on microflora, the nutritional regime of the soil, and crop yields. For example, digested from biogas production (García-Sánchez et al., 2015), food waste (Chojnacka, Moustakas, & Witek-Krowiak, 2020) and waste from an olive plant (Regni et al., 2017) increase crop yields. All of them serve as a source of carbon and other nutrients for soil. In our research, these sources are ash-and-slag and carbon black.

The crop capacity in 2018, the barley grain yield on control was 1.38 t/ha. On the application of preparation substances, the yield increment was obtained in the range of 0.41-0.54 t/ha or 29.7-39.1%. The dosage of preparation substances did not significantly affect the yield (Table 5).

In 2019, the barley grain yield in the control amounted to 0.75 t/ha. On other fertilized options, a significant increase in yield was obtained in the range of 0.17-0.35 t/ha or 22.7-46.7%. The maximum yield was obtained in the option of the ground + 300 kg/ha – 1.1 t/ha, which is 46.7% higher than the control.

On average, over two years, the increase from the use of Agrobionov amounted to 0.10-0.41 t/ha or 32.1-38.7%. From an economic point of view, the optimal dose of the preparation is 1/10 of the calculated dosage of P₂O₅ + 100 kg/ha preparation.

Commercialization of the technology offered is restrained by the powder form of Agrobionov preparation. Vincevica-Gaile et al. (2019) indicate that granulating waste products for soil fertilizer is a cost-effective and environmentally friendly method.

CONCLUSION AND SUGGESTION

The use of Agrobionov preparation increases the fertility of chernozem and the yield of barley.

The application of Agribionov induced the increase of total number of microorganisms up to 1204 million CFU/g (on the control 176 million CFU/g), the number of bacteria utilizing organic nitrogen compounds up to 96 million CFU/g (on the control 25 million CFU/g), the content of easily hydrolyzable nitrogen in the soil up to 18 ml/kg (in the control 13 ml/kg) and the yield of barley up to 1.47 t/ha (by 38.7% compared to the control).

The prospects for using this preparation are unlimited, since the reserves of ash-and-slag and carbon black do not decrease, but accumulate.

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