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Application of fertilization and microbiological preparations in ecological technologies of agricultural enterprises

A M Trufanov, A N Voronin and S V Schukin

Department of Agronomy, Yaroslavl State Agricultural Academy, 58, Tutaevskoe highway, Yaroslavl, 150042, Russia

E-mail: a.trufanov@yarcx.ru

Abstract. One of the methods of agricultural enterprises ecologization is the use of fertilization and microbiological preparations. The paper presents the results of the field studies into the effectiveness of seeds preparation for sowing soybeans, amaranth and buckwheat by treatment with Baikal EM-1 and potassium humate. It was found to improve the biological properties of the soil and reduce the incidence of weediness of crops when using the Baikal EM-1, as well as increasing the growth and development of plants. As a result, the use of Baikal EM-1 led to an increase in green mass yield of soybeans by 8.5% and yield of its seeds by 7.9%. For amaranth, the values are 24.6 and 24.2%, respectively, and for buckwheat they are 4.9 and 32.5%. The effectiveness of potassium humate was lower: the green mass yield of amaranth increased by 5.9%, seeds – by 5.5%; the values for buckwheat were 3.9 and 30.7%, respectively. The results indicate the prospects for use of preparations in ecological crops technologies in agricultural enterprises.

1. Introduction

An integral part of the sustainable development of rural areas is ecological agriculture [1, 2]. Now ecological agriculture is becoming a real trend in our country. One of its directions is organic agriculture, which is steadily developing in Russia. It is based on the use of alternative means of production, since the use of synthetic agrochemicals is deemed unacceptable [3].

This is due to the negative consequences of the use of pesticides: the emergence of resistant forms of phytophages and phytopathogens and, as a result, increased pesticidal pressure; disruption of biological equilibrium in agrocenoses. The use of pesticides is associated with an increase in toxicological and ecotoxicological risks to the environment and human health [4]. They significantly limit the biological activity of soils, in particular, the activity of soil enzymes and microorganisms producing them.

However, it is allowed to use a variety of biological fungicides and insecticides in organic farming, which, subject to the application regulations, are effective for control of harmful objects [5, 6].

The fertilizer system in organic farming also requires a science-based approach. For example, one of the mechanisms to increase the availability of elements of soil improving agents approved for use in organic production is to increase the biological activity of the soil, including through microbiological and organic fertilizers [7]. Unlike chemical preparations, biological preparations are recognized as harmless to humans, animals, bees, birds, and fish. They quickly decompose and do not induce tolerance in insects.

The first preparations were created more than 30 years ago and have been widely recognized throughout the world. More than 110 countries use them in technology to increase yield and improve the quality of farmed products [8]. This necessitates monitoring and research support.

In this regard, the aim of the research was to establish the effectiveness of seed preparation with the Baikal EM-1 and potassium humate preparations in terms of the effect of this method on changes in the biological properties of the soil, resistance of cultivated crops to stress factors and their development and productivity in sod-podzolic soils of the Yaroslavl region.

2. Materials and methods

The studies were carried out in 2019 in the field experiment of the department of Agronomy of the FSBEI HE Yaroslavl State Agricultural Academy in the crop rotation: legumes – row crops – spring grains. The experiment was establish by the method of split plots with randomized placement of variants, the experiment have three-time repetition. Scheme of three-factor experience: factor A – group of crops (legumes, in 2019 - soybeans (*Glycine max L.*), Svetlaya variety; row crops, in 2019 - amaranth (*Amaranthus L.*), Kinelsky 254 variety; spring crops, in 2019 - buckwheat (*Fagopyrum esculentum Moench*), Kalininskaya variety); factor B – the system of tillage (plowing, surface); factor C – preparations (without preparations; preparation 1, in 2019 - Baikal EM-1; preparation 2, in 2019 - Potassium Humate). The soil is sod-podzolic gley, medium loamy. The area of elementary plots is 12 m², the total area of the experiment is 648 m². The article describe data on the variant of surface tillage, which meets the requirements of ecological farming as a resource-saving system to a higher degree.

The objects of research were preparations of various operating principles: Baikal EM-1 (manufacturer LLC NPO EM-CENTER) containing microorganisms, and Potassium Humate Sakhalin BP 2.5% (manufacturer LLC Biofit), which is a fertilizer based on humic acid salts with a set of nutrient elements.

The following agricultural processes were carried out: surface treatment (disking) – with a disk tool, plowing - with a plow PLN-3-35, pre-sowing cultivation with a cultivator KBM-4.2, harrowing with a tooth harrow BZTS-1.0, sowing – seeder SPU-3, inter-row processing – KRN-4,2. Mineral fertilizers and pesticides were not used.

Experimental variables were determined by research methods generally accepted in the experimental work: the activity of cellulose decomposition – by the application method; the number of earthworms (family *Lumbricidae*) – by the method of trial plots, ground beetles (family *Carabidae*) - by Barber traps; the number of weeds – according to the method of B.A. Smirnov; crop diseases – according to the methodology of VNIIZR; germination was determined by the ratio of the germinated plants to the number of seeds sown (in%); the height of the plants was determined by measuring at constant sites; yields – by the plot method with conversion to standard humidity. Statistical processing used the analysis of variance (ANOVA).

The weather conditions of the growing season of 2019 in the study region were characterized by increased temperature at the beginning of the growing season (May-June) and lower temperatures at the end (July-August), while the amount of precipitation was significantly different from the average annual observations in July – the excess was 77%. In general, meteorological conditions can be characterized as atypical.

3. Results and Discussion

One of the indicators characterizing the energy of mobilization of soil processes in general, the activity of cellulose decomposition is of interest for studying [9], due to the fact that the characteristics of the studied preparation Baikal EM-1 included the activation of beneficial soil microflora.

The results of determining this indicator showed that the use of Baikal EM-1 increased the activity of soil microorganisms under field of amaranth by 6.5%, under buckwheat - by 2.4%, but in soybean field the indicator decreased (by 6.5%), which is likely, due to an ability of soybeans as a legume plant to independently create focus of activity of soil microflora in their rhizosphere (Table 1).

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An important indicator of soil fertility especially that of sod-podzolic soils characterized by low natural fertility, is the number of earthworms. As it is known, they have a very positive effect on agrophysical properties, decreasing soil density and hardness, improving soil structure and water permeability, as well as influencing the processing of organic matter and accumulation of humus [10, 11].

Table 1. Biological properties of the soil

		8 F F			
Variant		Biological properties of the soil			
		(on average for the growing season of crops)			
		Cellulose	The number of	Number of ground	
Crop	Preparation	decomposing	earthworms,	beetles, pcs. / 10	
-		activity, %	pcs. / m ²	trap-day	
Legumes (soybeans)	Control	76.0	66.7	13.8	
	Baikal EM-1	69.5	66.7	12.6	
	Potassium Humate	-	100.0	10.9	
Row crops (amaranth)	Control	66.4	91.7	9.7	
	Baikal EM-1	72.9	100.0	11.6	
	Potassium Humate	-	75.0	11.2	
Spring grains (buckwheat)	Control	65.5	83.3	12.1	
	Baikal EM-1	67.9	108.3	15.7	
	Potassium Humate	-	108.3	12.2	

The positive effect of Baikal EM-1 in comparison with the variant without preparations was noted in amaranth field – the number of earthworms increased by 9.1%, in the buckwheat field it increased by 30.0%; Potassium Humate was effective in soybean (the indicator significantly exceeded the control by 49.9%) and buckwheat. This suggests the creation of favorable microbiological and nutritional conditions for earthworms when using preparations.

Other representatives of the useful soil fauna – predatory ground beetles, which are considered bioindicators of the ecological well-being of phytocenoses [12].

On average during the growing season of crops, it was found that the use of the Baikal EM-1 and Potassium Humate preparations increased the number of ground beetles under the crops of amaranth, by 19.6 and 15.5% and under buckwheat by 29.8 and 0.8% respectively, in comparison with the control. Under soybean, the indicator was declining by 9.5% for Baikal EM-1 and by 26.6% for potassium Humate.

In ecological farming systems, where the use of pesticides is unacceptable, an important link is the maintenance of a favorable phytosanitary situation through mechanical and biological methods [13].

One of such methods can be the use of preparations that increase the resistance of cultivated plants to phytopathogens and competitiveness to weeds due to the improvement of soil microbiota and optimization of the nutritional regime.

Accounting for the prevalence and intensity of diseases was carried out on soybeans and buckwheat. Amaranth plants did not show signs of any diseases (Table 2).

Soybean plants were exposed to phytopathogens to a small extent – ascochytosis (pathogen *Ascochyta sojaecola Abramov*) and Septoria blight (pathogen *Septoria glycines Hemmi*) were detected. It is noteworthy that the beneficial effect of using Baikal EM-1 was seen in comparison with the variant without it in the decrease in the rate of disease development – it decreased by 4.0 and 0.3%, respectively, for ascochytosis and Septoria blight, while the prevalence was the same (5.0-7.0%). The use of the Humate Potassium, on the contrary, increased the prevalence of diseases (by 66.0-74.6%) simultaneously with a decrease in their intensity (1.1-2.0 times) in comparison with the control.

On buckwheat, ascochytosis (pathogen Ascochyta fagopyri Bres.), bacteriosis (pathogen Pseudomonas syringae van Hali) and downy mildew (peronosporosis) (pathogen Peronospora fagopyri Elenev) were determined. In general, it can be noted that the prevalence of buckwheat diseases did not

exceed 12.0%, and the intensity was 6.0%. At the same time, the use of the biological product Baikal EM-1 reduced the rates of disease development in comparison with the variant without its use. So, the prevalence of ascochytosis decreased by 1.7%, its intensity – by 2.8%; disease rates of bacteriosis, respectively, by 1.7 and 0.2%, peronosporosis - by 3.3 and 2.0%. In the variants using Potassium Humate, the phytosanitary situation was slightly worse: the prevalence of ascochytosis was higher not only compared to the Baikal EM-1 application (41.0%), but also compared to the control (17.0%). The intensity of bacteriosis was also higher when using the Potassium Humate preparation; in other cases, the rates of buckwheat disease development was lower than the control.

Variant		Diseases, % (prevalence / intensity)				The
						number of
Crop	Preparation	Ascochytosis	Septoria blight	Bacteriosis	Peronosporo sis	weeds, pcs. / m ²
Legumes (soybeans)	Control	5.0/5.7	6.7/7.8	-	-	39.0
	Baikal EM-1	5.0/1.7	6.7/7.5	-	-	25.7
	Potassium Humate	8.3/2.8	11.7/6.9	-	-	31.3
Row crops (amaranth)	Control	-	-	-	-	53.0
	Baikal EM-1	-	-	-	-	31.3
	Potassium Humate	-	-	-	-	38.7
Spring cereals (buckwheat)	Control	10.0/5.3	-	8.3/1.8	8.3/4.0	36.3
	Baikal EM-1	8.3/2.5	-	6.7/1.7	5.0/2.0	25.3
	Potassium Humate	11.7/4.0	-	6.7/2.7	6.7/2.3	29.3

Table 2.	Phytosanitary	condition	of crops
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The weed component of agrophytocenoses significantly affects the decrease in crop yields, the deterioration of their quality due to competition for life factors [14]. The management strategies for this component differ significantly in intensive and ecological technologies. In the first case, it is based on chemical suppression of undesirable vegetation, which is very effective, but unsafe from an environmental point of view [15]. In the second case, weed control is carried out on the basis of mechanical techniques and biological methods that do not adversely affect product quality [16–18].

In our experience, the total number of weed plants was much higher in the amaranth planting due to its wide-row sowing, while buckwheat showed the smallest weed count, which is due to its rapid growth in the initial phases of development and suppression of weeds. An interesting regularity is the decrease in the total number of weeds on the variants using preparations in comparison with the options without them – when using both Baikal EM-1 and Potassium Humate, the indicator decreased significantly for all the studied crops. So, in soybean planting, the decrease was 51.6% in the variants with Baikal EM-1 and 24.6% in the variants with Potassium Humate; in the crop of amaranth, respectively, by 69.3 and 37.0%; buckwheat – by 43.5 and 23.9%, which confirms the increased competitiveness of cultivated plants against weeds due to the creation of more favorable conditions, however, the effect of improving the microbiological regime when applying Baikal EM-1 was higher than that of optimization of nutritional conditions when using Potassium Humate.

Thus, due to the creation of optimal conditions, the indicators of growth and development of cultivated plants during the growing season were mainly higher when using preparations (Table 3).

Soybean development rates were higher when using the Baikal EM-1 biological product – germination increased by 15.6%, plant height at the beginning of the growing season by 3.9%, as a result, green mass yield was characterized by an increase of 8.5%, seed yield – 7.9 %. The use of Potassium Humate did not lead to a positive effect on development of soybean plants and its productivity in comparison with the control, which is probably due to the lower need to improve the nutritional conditions for soybeans as a culture capable of symbiotic nitrogen fixation.

The studied preparations had a positive effect on the growth and development indicators of amaranth and buckwheat plants, providing averaged increase in amaranth germination of 3.8%, in buckwheat –

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5.0%, plant height increased by 18.1 and 1.4%, respectively. As a result, the preparations determined a tendency to increase the yield of amaranth green mass – Baikal EM-1 by 24.6%, Potassium Humate – by 5.9% and buckwheat green mass, by 4.9 and 3.9%, respectively. The seed yield of the studied crops also increased when using Potassium Humate (amaranth by 5.5%, buckwheat by 30.7%), and especially Baikal EM-1 (amaranth by 24.2%, buckwheat by 32.5%).

Variant		Field	Plant height	The yield of	The yield of
Crop	Preparation	germination, %	at the beginning of the growing season, cm	green mass, t / ha	seeds, t / ha
Legumes (soybeans)	Control	60.3	30.9	7.31	1.01
	Baikal EM-1	75.9	32.1	7.93	1.09
	Potassium Humate	65.8	27.2	6.19	0.85
Row crops (amaranth)	Control	69.5	17.7	6.58	0.16
	Baikal EM-1	65.2	21.1	8.20	0.20
	Potassium Humate	81.4	20.7	6.97	0.17
Spring cereals (buckwheat)	Control	60.3	35.4	10.59	1.14
	Baikal EM-1	62.8	35.3	11.11	1.51
	Potassium Humate	67.7	36.5	11.00	1.49

Table 3. Indicators of the cultivated plants development and yield

4. Conclusion

The use of preparations that improve microbiological and nutritional regimes has a positive effect. A greater effect was noted when treating the seeds with a Baikal EM-1 biological product solution, which improves the biological properties of the soil, reduces the harm from phytopathogens, optimizes the conditions for growth and development of cultivated plants, which ultimately leads to an increase in seed yield of crops grown on average 21.5%, which confirms the prospects of this method in ecological crops cultivation technologies in agricultural enterprises.

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