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ИСПОЛЬЗОВАНИЕ БИОЛОГИЧЕСКИХ ПРЕПАРАТОВ В ПОСЕВАХ СОИ

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Приведены результаты исследований по изучению влияния биопрепаратов на растения сои в условиях Приморского края. Эксперимент проведен в 2020, 2021 гг. в условиях деляночного опыта. Изучение препаратов производили на растениях сои сорта Приморская 86. Объекты исследований – микробиологический препарат Биокомпозит-коррект, органоминеральное удобрение Биостим Старт. Схема опыта включала следующие варианты: без обработки (контроль); обработка семян Биокомпозит-корректом; обработка семян и опрыскивание растений Биокомпозит-корректом; обработка семян Биокомпозит-корректом + Биостим Стартом; обработка семян Биокомпозит-корректом и Биостим Стартом + опрыскивание растений Биокомпозит-корректом. Применение биопрепаратов способствовало снижению интенсивности развития септориоза относительно контроля (29,8%) на 5,2–6,8%. Максимальная в опыте биологическая эффективность (23,1%) отмечена в варианте с обработкой семян сои Биокомпозит-коррект. Комплексная обработка препаратом Биокомпозит-коррект обеспечивала снижение проявлений пероноспороза на 8,2%, биологическая эффективность составила 37,8%. Биопрепараты положительно сказались на росте и развитии растений. Наибольший прирост растений в фазу полной спелости отмечен в варианте с применением Биокомпозит-корректа + Биостим Старта + опрыскивание растений Биокомпозит-корректом (56,6 см), в контроле – 49,3 см. При использовании биопрепаратов количество клубеньков превышало контроль на 17,4–34,1%, количество листьев – на 28,3–39,5%. Масса 1000 семян по вариантам опыта варьировала в пределах 180,0–190,6 г, в контроле – 157,5 г. Масса семян с одного растения в вариантах опыта была выше контрольной на 41,3–70,6%. Изучаемые препараты обеспечивали увеличение урожайности во всех вариантах опыта. Биологическая урожайность составила от 3,3–3,7 т/га при урожайности в контроле 2,5 т/га.

Ключевые слова: соя, биопрепараты, развитие болезни, эффективность, структура урожая, урожайность

THE USE OF BIOLOGICAL PRODUCTS IN SOYBEAN CROPS

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The results of research on the effect of biopreparations on soybean plants in the Primorsky Territory are presented. The experiment was conducted in 2020, 2021 under the conditions of a plot experiment. The preparations were studied on soybean plants of the Primorskaya 86 variety. The objects of research are microbiological preparation Biocomposite-correct and organomineral fertilizer Biostim Start. The experiment scheme included the following variants: without treatment (control); treatment of seeds with Biocomposite Correct; treatment of seeds and plants spraying with Biocomposite Correct; treatment of seeds with Biocomposite Correct + Biostim Start; treatment of seeds with Biocomposite Correct and Biostim Start + plants spraying with Biocomposite Correct. The use of biopreparations contributed to a decrease in the intensity of septoriosis development relative to the control (29.8%) by 5.2-6.8%. The maximum biological efficiency in the experiment

(23.1%) was observed in the variant with treatment of soybean seeds with Biocomposite-correct. Complex treatment with Biocomposite-correct provided a reduction of downy mildew manifestations by 8.2%, the biological effectiveness was 37.8%. The biological products had a positive effect on the plant growth and development. The largest plant growth in the phase of full maturity was noted in the variant with Biocomposite Correct + Biostim Start + plant spraying with Biocomposite Correct (56.6 cm), in the control - 49.3 cm. When using biopreparations, the number of nodules exceeded the control by 17.4-34.1%, the number of leaves by 28.3-39.5%. The thousand-seed weight varied between 180.0-190.6 g in the experimental variants, and 157.5 g in the control. The seed weight per plant in the experimental variants was higher than the control by 41.3-70.6%. The studied preparations provided an increase in the yield in all the variants of the experiment. The biological yield was 3.3-3.7 t/ha with the yield of 2.5 t/ha in the control.

Keywords: soybean, biological products, disease progression, effectiveness, yield parameters, yield

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INTRODUCTION

Soybean is a valuable crop in many countries of the world. It is grown in the main agricultural regions of 90 countries. Global production of this crop reaches 253 million tons. Soybean is the main cultivated crop in the agricultural structure of the Far Eastern regions of Russia. The Primorsky Territory and the Amur Region are the leading regions of the Far East in soybean cultivation. Soybean and corn are the main export crops for the Primorsky Territory. The main buyers of soybeans are China, Japan and South Korea. There are 43.5% (1.2 mln ha) of the total area of soybean cultivation in the country on the territory of the Far Eastern Federal District. Of these, 22.3%, or 277 thousand hectares, of the land sown with this crop is located in the Primorsky Territory. The Primorsky Territory accounts for 387,000 tonnes, or 8.6% of the gross soybean yield. The soybean yield is 18 cwt/ha. The gross yield of soybeans in the Far East can be increased both by increasing the yield and by increasing the sown areas. The growth of soybean production largely depends on the efficiency of plant protection against numerous pests, the use of modern methods of phytosanitary monitoring, and the introduction of modern cultivation technologies [1–3].

At the turn of the XX-XXI centuries the interest in biological preparations has increased in the world. The use of biological achievements is recognized as one of the effective ways of development of agricultural technologies, solving the problems arising in the process of modern agricultural production [1]. The use of short rotation crop rotations leads to a number of problems that are not solved by chemical preparations. High load leads to a decrease in fertility, degradation of useful soil microflora, slow decomposition of plant residues, accumulation of pathogenic infection. These processes lead to increased infectious background of soils, high contamination of seed material. These problems can be solved by using biopreparations - microbiological agents [2-4].

Optimization of nutrition and stimulation of plant growth and development is an important

[1] https://www.oilworld.ru oilworld.ru (accessed on: 21.11.2022).
[2] https://milknews.ru/index/fermerstvo/primore-soya.html Milknews (accessed on: 20.11.2022).
[3] https://vladnews.ru/ Vladnews.ru (accessed on: 21.11.2022).

agronomic technique to obtain good and stable soybean yields. Such studies are carried out regularly, but become particularly relevant in certain climatic and production-economic conditions [5-9].

Performance tests in the Central Black Earth zone (Belgorod, Voronezh and Orel regions) showed that the application of Biocomposite-correct in the soil directly during the sowing of sugar beet in the rate of 2.0 l/ha gives an increase in sugar yield by 0.6-1.48 t/ha. In most experiments, along with the increase in yields, the sugar content of root crops increased by 0.1-1.6%. In the Rostov region the reliable increase on winter wheat with the treatment of crops at the rate of 1-2 l/ha reached 4 c/ha. In the Kurgan region on spring wheat with the drug application rate of 1 l/ha the increase was 9 cwt/ha. In soybeans, the yield increase of 2 cwt/ha was observed with the seed treatment at the rate of 1 l/ha [10-13].

The purpose of the work is to obtain experimental data on testing biological preparations for pre-sowing treatment of seeds and vegetative soybean plants against diseases, to determine the effect on productivity and yield of the crop.

MATERIAL AND METHODS

The studies were carried out on the experimental fields of the Seed Production Department of the Federal Scientific Center of Agricultural Biotechnology of the Far East named after A.K. Chaiki in 2020, 2021. The research objects were microbiological preparation Biocomposite-correct, organomineral fertilizer Biostim Start provided by the employees of AO "Shchelkovo Agrokhim", and the released variety of soybean Primorskaya 86. The variety Primorskaya 86 was created by a team of authors from the Primorsky Agricultural Research Institute (A.P. Vashchenko, N.V. Mudrik, O.I. Khasbiullina, L.A. Dega, E.S. Butovets). The variety of medium maturity (120-124 days). Plants of medium height - 82 cm, the height of the beans attachment 16.0-18.2 cm. Leaves are ternate, medium-sized, oval in shape. The flower corona is white. The bean sparsity is light gray, and the coloring of the beans is dark gray at full maturity. The shape of the seeds is oval-elongated, the seeds are yellow, dull with a brown scar. Weight of 1000 seeds is 185-190 g. Oil content is 19.6-20.6%, protein 39.2-40.1%. In 2014, the variety was included in the State Register of breeding achievements approved for use in the Russian Federation. For the study, soybean seeds were treated with biopreparations one day before sowing (May 19) by hand by semi-dry method. For this purpose, preparations were diluted in pure water (at the rate of 10 l/t) and, without allowing the suspension to settle, it was applied to the seeds, which were then thoroughly mixed until the preparation was evenly distributed. Sowing of soybean seeds was carried out on May 20. The plants were sprayed in the phase of full sprouts and in the phase of budding - the beginning of flowering by hand pneumatic sprayer OP-207.

The experiment scheme included the following variants: without treatment (control); treatment of seeds with Biocomposite-correct; treatment of seeds and spraying of plants with Biocomposite-correct; treatment of seeds with Biocomposite-correct + Biostim Start; treatment of seeds with Biocomposite-correct and Biostim Start + spraying of plants with Biocomposite-correct. The area of the plot is 10 m^2. Repeatability of the experiment is fourfold, the plot arrangement is systematic. Biocomposite-correct is a consortium of five economically valuable strains of several species of beneficial bacteria with a total titer of at least 1 × 10 CFU/ml. It is used for any cropping systems and all links of crop rotation and has fungicidal, growth-stimulating, destructive, antagonistic, nitrogen-fixing and phosphate-mobilizing properties. This makes it possible its wide practical application: from stubble decomposition, suppression of soil phytopathogens and protection against diseases to increased soil fertility and restoration of their beneficial microflora.

Organomineral fertilizer Biostim Start is an amino acid biostimulator. It activates sprouting and germination of seeds, stimulates the development of beneficial microflora in the rhizosphere, is an additional source of energy at the initial stage of seedling development, provides plants with a starter complex of nutrients,

increases immunity and reduces the effects of stress factors[4].

The soil of the experimental plot is meadow-brown, by mechanical composition - heavy loam. Agrochemical characteristics of the soil were as follows: humus content was 3.08-3.13%; easily hydrolyzable nitrogen was 9.5 mg/100 g of soil; P2O5 was 14.12 mg/100 g of soil; pH of the salt solution was 5.3. Soil treatment: autumn plowing at the depth of 22 cm, early spring harrowing, two cultivations and pre-sowing tillage. The forecrop - cereals. No fertilizers were used. Sowing of soybeans was carried out by SKS 6-10 seeder. Seed rate - 90 kg/ha (500 thousand pcs/ha).

Agronomic techniques of soybean cultivation in the experiment were common for the Primorsky Territory[5]. The experiment was laid in accordance with the requirements of the field experiment methodology. The harvesting was carried out manually by variants in one pass. Sheaf samples were collected in each plot from two sites 0.25 m^2 in size (0.35 × 0.71). Plant biometry and yield structure were determined in 40 plants of each experiment variant under laboratory conditions. All records and observations in field experiments were performed according to the current methods and guidelines, preparations were used according to the instructions, and the results were processed by analysis of variance [6-9].

RESULTS AND DISCUSSION

Meteorological conditions differed in the years of the experiments. Meteorological conditions 2020 were unfavorable for soybean in terms of precipitation. Abundance of precipitation was recorded for summer months, and its distribution by ten-day periods was noted to be uneven. July was dry, with precipitation 17.4 mm below normal. Precipitation was 193.5 and 140.1 mm in June and August, respectively, and was 109.5 and 19.1 mm above average. Temperatures were 1.1-2.9°C above the long-term average in each month. Precipitation conditions in 2021 were unfavorable for soybeans. July was dry and rainfall was 74.1 mm below normal. Precipitation in June and August was 78.7 and 79.7 mm (2.3 and 54.3 mm less than normal). Temperatures were 1.8-3.7°C above the long-term average in each month.

In the years of study, fungal diseases had no significant effect on the formation of morphological and economic traits of soybean. Soybean crops were affected by septoriose (*Septoria glycines* Hemmi) and downy mildew (*Peronospora manshurica* Naum). Septoria blight in soybean crops appeared in the primordial leaf phase. The spreading of septoriose was noted in all the variants of the experiment, it was 100%. All tested biopreparations showed a positive effect on the resistance of plants against septoriose in comparison with the control. The use of biopreparations contributed to a decrease in the intensity of disease development, relative to the control (29.8%), by 5.2-6.8%. The maximum biological efficiency (23.1%) was noted in the variant with pre-sowing treatment of soybean seeds with Biocomposite-correct.

The first signs of downy mildew were observed in the second ten-day period of July. Application of the studied preparations reduced spreading of downy mildew to 45.2-53.4% against 69.0% in the control. According to the variants of the experiment, the development of the disease varied from 8,2% (complex treatment with Biocomposite-correct) to 9,9% (treatment of seeds with Biocomposite-correct and Biostim Start) while the indicator value was 13,2% in the control. The most effective was treatment of seeds and spraying of vegetative plants with Biocomposite-correct, where the efficiency was 37,8%.

[4]List of pesticides and agrochemicals permitted for use in the Russian Federation. M., 2022. 1046 p.

[5]System of Agroindustrial Production of the Primorsky Territory. Edited by A.K. Chayka. Novosibirsk, 2001. 364 p.

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[9]*James B.* Sinclair. Compendium of Souben Diseases. Published by The American Phytopathological Society. 1982. 104 p.

The research results show that treatment of seeds with a biological preparation and a biostimulant had a positive effect on the main indicators determining plant productivity (see Table 1). In the experimental variants, a significant effect of increasing the activity of nodule bacteria and formation of nodules on the roots of the root system of plants was noted. According to the research data, the use of the studied preparations increased the number of nodules by 17.4-34.1% in comparison with the control. The root length was 13.7-14.4 cm for the experimental variants, and 12.3 cm for the control. The number of leaves exceeded the control variant by 28.3-39.5%.

Analysis of sample sheaves showed that on average in 2 years soybean plants after the application of preparations were larger than the control variant by 4.7-7.3 cm (see Table 2). The number of beans per plant averaged 28,0 pcs./plant (treatment of seeds with Biocomposite-correct + Biostim Start); 31,1 pcs./plant (treatment of seeds and spraying of plants with Biocomposite-correct), which was higher than the control by 10,3-13,4 pcs respectively. The number of seeds per plant increased by 73,5-85,8%. The best on this indicator was the variant with the application of Biocomposite-correct in the growing season in combination with the presowing seed treatment.

The quality indicator of soybean seed material is the weight of 1000 seeds of the variety, which largely depends on soil moisture and precipitation during the growing season, as well as on the provision of plants with other factors of life. Weight of 1000 seeds varied from 180,0 to 190,6 g. The maximum values of this indicator (190,6 g) were noted in the variant with treatment of seeds with Biocomposite-correct. Seed weight per plant in the experimental variants was higher than the control by 41,3-70,6%.

The yield record showed a significant increase in seed productivity of soybean in all the variants of the experiment. The studied biological preparations provided an increase in soybean yield due to an increase in the indicators of the elements of yield structure and a reduction of disease infestation. The increase of the soybean yield in comparison with the control was 0.8-1.2 t/ha (see figure). The studied preparations increased the crop capacity in all the variants of the experiment. Biological yield was 3.3-3.7 t/ha with a yield of 2.5 t/ha in the control (LSD_{05} = 0.5 t/ha).

CONCLUSION

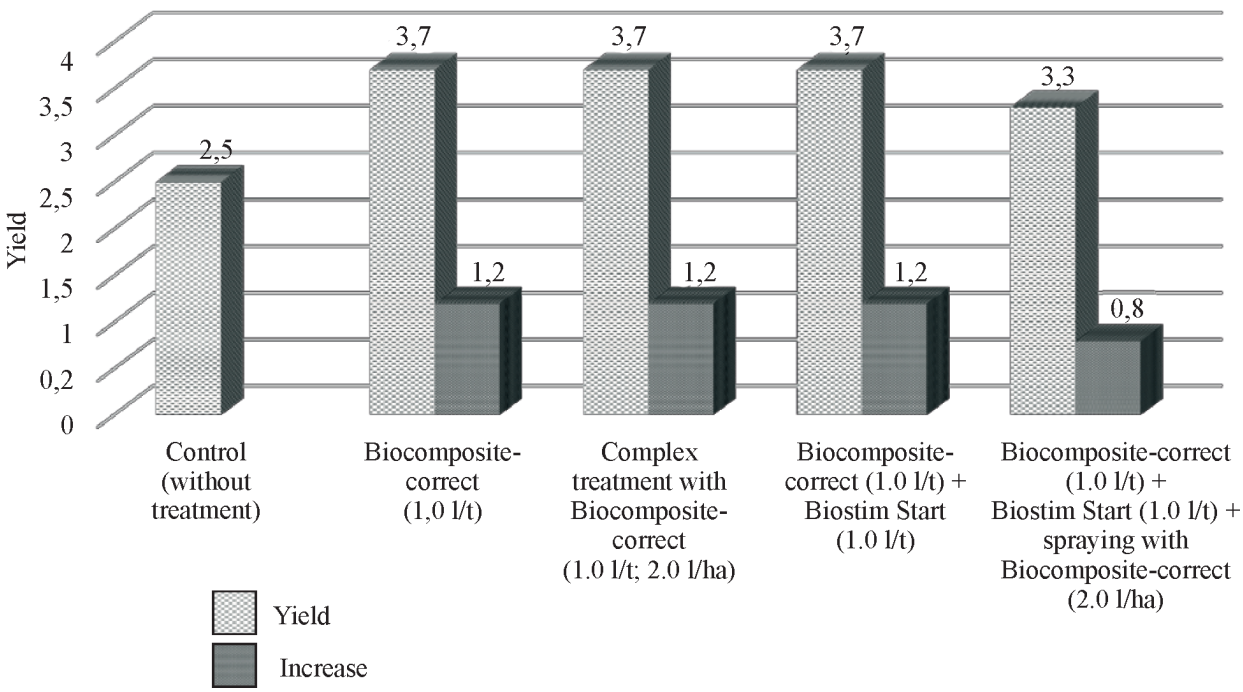
In the course of the research in the Primorsky Territory conditions it was established that the use of biological preparations is promising for using in soybean variety Primorskaya 86. The studied preparations contributed to the reduction of septoriose intensity (29.8% in the control) by 5.2-6.8% and downy mildew (69.0% in the control) by 45.2-53.4%. The use of biological preparations contributed to a significant increase in the weight of 1000 seeds compared to

Табл. 1. Биометрические показатели растений сои в фазу цветения (среднее за 2020, 2021 гг.)
Table 1. Biometric parameters of soybean plants during the flowering stage (average for 2020, 2021)

Experiment variant	Tubercles, pcs.	Root length, cm	Leaves, pcs.
Control (without treatment)	56,3	12,3	24,0
Seed treatment with Biocomposite-correct (1,0 l/t)	66,1	14,1	30,8
Seed treatment and plant spraying with Biocomposite-correct (1.0 l/t; 2.0 l/ha)	74,6	14,4	32,4
Seed treatment with Biocomposite-correct (1.0 l/t) and Biostim Start (1.0 l/t)	73,5	13,7	31,3
Seed treatment with Biocomposite Correct (1.0 l/t) and Biostim Start (1.0 l/t) and plant spraying with Biocomposite Correct (2.0 l/ha)	75,5	14,2	33,5
LSD_{05}	0,7	0,3	2,1

Табл. 2. Структурные показатели сои в зависимости от обработки семян (среднее за 2020, 2021 гг.)
Table 2. Structural parameters of soybean depending on the treatment of seeds (average for 2020, 2021)

Variant	Plants height, cm	Number of beans, pcs./plant	Number of seeds, pcs./plant	Weight of seeds per plant, g/ plant	Thousand-kernel weight, g
Control (without treatment)	49,3	17,7	40,5	5,8	157,5
Seed treatment with Biocomposite-correct (1,0 l/t)	54,0	31,0	75,2	8,8	190,6
Seed treatment and plant spraying with Biocomposite-correct (1.0 l/t; 2.0 l/ha)	55,4	31,1	75,1	9,9	186,2
Seed treatment with Biocomposite-correct (1.0 l/t) and Biostim Start (1.0 l/t)	56,1	28,0	70,3	8,2	183,7
Seed treatment with Biocomposite Correct (1.0 l/t) and Biostim Start (1.0 l/t) and plant spraying with Biocomposite Correct (2.0 l/ha)	56,6	29,1	72,4	8,7	180,0
LSD_{05}	2,3	6,0	18,8	0,8	7,1



Влияние препаратов на урожайность сои (среднее за 2020, 2021 гг.), т/га
Effect of biological products on soybean yield (average for 2020, 2021), t/ha

the control (157.5 g) by 22,5-30,0%. The studied preparations provided an increase in yield in all the variants of the experiment. Biological yield was 3.3-3.7 t/ha with a yield of 2.5 t/ha in the control.

Treatment of seeds with environmentally safe preparations Biocomposite-Correct and Biostim Start, as well as spraying them on crops (flowering phase) contributes to obtaining more highly productive plants while reducing environmental pollution.

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