Influence of bio-preparations and their multiplicity of application on stability of soybean yield in Amur region

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Abstract. The article presents data on the influence of Borogum Mo and Phytosporin-M biopreparations on the yield and composition of oil soybean admixture in different meteorological conditions of Amur region. The experiment included options: Factor A (preparations) - 1. Without preparation (water); 2. Borogum Mo; 3. Phytosporin-M; 4. Borogum Mo + Phytosporin-M; Factor B (number of treatments) - 1. Without treatment. 2. One time. 3. Two times. The conducted researches have shown that the greatest yield of soybean sowing is provided on the average for two years at spraying of plants once in the end of June with Borogum-Mo and a mixture of Borogum-Mo + Phytosporin-M preparations - 2.87 t/ha. When Borogum-Mo is treated, the number of frost seeds decreases, and when treated with Phytosporin-M, the number of affected diseases decreases in comparison with control plots. According to the basic norm of oilseed admixture all used preparations provided the yield of pure soybean seeds.

1. Introduction
In recent years, microbial preparations have been increasingly used to produce agricultural products in Russia [1]. In order to protect winter wheat crops from the pathogens of fusariasis and other economically significant diseases, environmentally friendly bacterial bio preparations have been proposed based on strains of Bacillus subtilis BZR 336g and Bacillus subtilis BZR 517 bacteria [2,3]. Manufacturers of Phytosporin and agrarians have noted that the new generation microbiological preparation is very effective against fungal and bacterial diseases in fruit and berry, ornamental, and vegetable crops [4,5]. Its active ingredient is the bacteria Bacillus subtilis 26 D, 100 million cells/year [4, 5]. Strains of Bacillus subtilis bacteria are harmless to humans and animals. The Food and Drug Administration of the USA has granted them the GRAS status (generally regarded as safe). They are the active ingredient in the medicinal product Biosporin, designed to treat intestinal infections, including in children.

Borogum - special borogano-humic fertilizers, which provide active development of the final system and the above-ground part of plants. It has a complex of protective, fungicidal, anti-stress, immunostimulating properties and increases the coefficient of soil nutrients use. Borogum-Mo has a preparation form of liquid, which includes - a micro-element complex: B-7.0%, Mo - 3%, Co-0.002%, Cu-0.01%, Zn-0.01%, Mn-0.04%, Ni-0.002%, Li-0.0004%, S - 0.01%, Se-0.0001%, Cr-0.0005%; trace elements Co, Cu, Mn, Zn, Cr, Ni, Li, Cr in chelate form; BMW-humates - 3%,
Phytosporin-M - 1%. In leguminous crops, it stimulates the development of strawberry nitrogen-fixing bacteria and enhances photosynthesis (http://bashinkom.ru/english/).

At present, the directions of organic crop production are promising in the world agriculture, which significantly reduce the pesticide load on agrocenoses and promote the production of ecologically clean products [6]. Bio-preparations can be used as plant protection means and as fertilizers. Application of bio-preparations both separately and together with each other, as well as multiplicity of treatment of crops with bio-preparations provides yield increase of cereals and potatoes [7]. There are no data on application of bio-preparations (Borogum Mo and Phytosporin-M) on soybean crops in the Amur region.

In the given work the researches on influence of biological preparations Borogum Mo and Phytosporin-M on productivity and composition of oil soy impurity in various meteorological conditions of Amur region are presented.

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2. Materials and methods

Experimental work was carried out in 2018-2019 in the experimental field of Far Eastern Research Institute of Agricultural Mechanization and Electrification (FERIAME) in the Amur region. Soil type - meadow black earth. The agrochemical characteristics: humus content (according to Tyurin) - 4.5 - 4.7%, NO3 - 40.2 - 44.7 mg/kg of soil; P2O (according to Kirsanov) - 55 - 58 mg/kg, K2O potassium (according to Kirsanov) 150 - 190 mg/kg of soil; acidity of pHKCI 5.0 - 5.2.

As can be seen from table 1, summer weather conditions in 2018 exceeded the long-term data by 0.3°C in terms of temperature, and precipitation was 137 mm above the norm. In summer 2019 air temperature was 0.3°C less than the long-term average, and precipitation was 152 mm higher than the long-term average. The greatest amount of precipitation occurred in mid-summer July and early August.

Table 1. Weather conditions in the summer soybean vegetation period.

| Month   | Temperature of air, °C (GMS data from Blagoveschensk) | Precipitation, mm (GMS data c. Sadovoe) |
|---------|-------------------------------------------------------|----------------------------------------|
|         | 2018        | 2019        | long-term average | 2018        | 2019        | long-term average |
| June    | 17.9        | 18.3        | 18.8              | 188         | 94          | 85              |
| July    | 22.3        | 21.3        | 21.5              | 182         | 247         | 106             |
| August  | 20.1        | 18.9        | 19.2              | 61          | 105         | 103             |
| In the summer | 20.1      | 19.5        | 19.8              | 431         | 446         | 294             |

In the field experiment we studied the effect of bio-preparations and their multiplicity of application on soybean yield. The scheme of experience included variants: Factor A (preparations) - 1. Without preparation (water); 2. Borogum Mo; 3. Phytosporin-M; 4. Borogum Mo + Phytosporin-M; Factor B (number of treatments) - 1. Without treatment. 2. Once (at the end of June). 3. Two times (at the end of June and at the end of July). As biopreparations used: bio-fertilizer Borogum Mo - provides the development of the root system and the land part of plants (rate of introduction - 0.5 l/ha); microbiological preparation Phytosporin-M - against fungal and bacterial diseases (rate of introduction - 1.0-1.5 kg/ha). Consumption of working solution 300 l per 1 hectare.

Term of soybean sowing - May 25. Quality - Azure. Soybean sowing rate - 750 - 800 thousand germinated seeds per 1 hectare. The depth of soybean seeds - 4-5 cm. Width of row spacing 60 cm, width of soybean sowing strip 20 cm. Seeding care included harrowing in the sprouts and subsequent...
mowing of plants between soybean strips. Harvesting was performed by Sampo-500 combine harvester. The yield from each plot was taken into account by weight method. The area of the registered plot was 25.2 m². Repeatability of options is 3 times, placement of plots by the method of rendering. The obtained data were processed by the method of dispersion analysis by Dospelhov [8].

3. Studies on the effect of bio-preparations on yield and composition of soybean oilseed impurity

During the vegetation period soybean noted significant differences from 3 to 5 days in the passage of the phases of growth and development of plants in variants with the use of various bio-preparations and control. The differences in the phases of growth and development of soybeans in the single and double treatment of soybeans with solutions of bio-preparations were not so significant from 2 to 3 days. Depending on the meteorological conditions of the year the deviation in the onset phases of soybean growth and development in the variants of experience was from 14 to 22 days. The used preparations and meteorological conditions of the year influenced the yield and composition of oil soybean impurity.

As can be seen from table 2, the highest yield of soybean sowing was provided on average for two years by the variants of experience with spraying of plants once in the end of June by Borogum-Mo and a mixture of Borogum-Mo + Phytosporin-M preparations - 2.87 t/ha. Depending on weather conditions, the efficiency of application of the preparations on soybean crops differed. The highest yield in relatively warm and wet 2018 was obtained with Borogum-Mo soybean treatment once - 3.82 t/ha, and in cool excessively wet 2019 with single spraying of Borogum-Mo + Phytosporin-M mixture - 2.18 t/ha.

| Experiment option | Yields, t/ha. | Yield increase |
|-------------------|---------------|----------------|
|                   | Processing    | 2018 | 2019 | middle | t/ha | %        |
| Control - without | processing    | 3.00 | 1.71 | 2.36   | -    | -        |
| Control - water   | One time      | 2.83 | 1.45 | 2.14   | -0.22| -9.32    |
| Control - water   | Twice         | 2.55 | 1.30 | 1.93   | -0.43| -18.22   |
| Borogum-Mo        | One time      | 3.82 | 1.91 | 2.87   | +0.51| +21.61   |
| Borogum-Mo        | Twice         | 3.49 | 1.89 | 2.69   | +0.33| +13.98   |
| Phytosporin-M     | One time      | 3.67 | 2.03 | 2.85   | +0.49| +20.76   |
| Phytosporin-M     | Twice         | 3.42 | 1.76 | 2.59   | +0.23| +9.75    |
| Borogum-Mo +      | One time      | 3.55 | 2.18 | 2.87   | +0.51| +21.61   |
| Phytosporin-M     | Twice         | 3.02 | 2.15 | 2.59   | +0.23| +9.75    |
| LSD_{0.05}, t/ha. | 0.336          | 0.204|

In the experiment $F$, the actual value of Fisher’s criterion $F$ is greater than $F_{0.05} = 2.12$ of the table value of criterion $F$ for 5% significance level, therefore, there are significant differences in the variants at 5% significance level, and the null hypothesis for Tukey $H_0: d = 0$ is discarded. When assessing the essentiality of private differences in 2018, the difference error of average $S_d = 0.158$ t/ha was calculated. This year we have received the smallest significant difference of LSD_{0.05} for 5% level of significance in absolute indicators 0.336 t/ha and relative - 10.3%. In 2019, the figures corresponded by mistake to the difference in average $S_d = 0.096$ t/ha, the smallest significant difference of the LSD_{0.05} in absolute figures of 0.204 t/ha and in relative figures of 11.2%.

Treatment of vegetative soybean plants with water at the end of June reduces yields by 0.22 t/ha once on average in two years, and re-spraying significantly reduces soybean yields by almost half by 0.43 t/ha compared to control (untreated plots). Regular decrease of soybean yield by 0.18 t/ha at the end of July in Borogum-Mo, by 0.26 t/ha in Phytosporin-M and by 0.28 t/ha in joint application was noted. These deviations were most significant for the drugs in 2018 from 0.25 to 0.53 t/ha, less significant in 2019 from 0.02 to 0.28 t/ha. Borogum-Mo showed insignificant advantage over Phytosporin-M in case of single treatment, yields increased by 0.02 t/ha or 0.7%, and in case of
double treatment - by 0.1 t/ha or 3.9%, respectively. There is practically no effect from the use of Phytosporin-M when sprayed together both once and twice per vegetation.

Soybean plants begin to shape the harvest in the second half of summer. This time is characterized by the highest heat stress and maximum rainfall. This favours a rapid increase in vegetative weight and the formation of soybeans. However, heavy monsoon rains cause temporary over-wetting of the soil. Saturation of the air with water vapor in high temperatures increases the spread of dangerous diseases of soybean (fusariasis causes the pathogen fungi - genus Fusarium, anthracnose - pathogenic fungus Coitetricym domatium, Peronospora manshuria (Naum), Ascochyta sojaecola Abr, bacterialoses - caused by the bacteria Pseudomonas solanacearu, Pseudomonas syrindae and Xanthomonas phaseoli).

The oilseed is always present in the freshly harvested soybean crop. Russian national standard (GOST) 170988: Soybean. "Requirements for procurement and delivery" to the oilseed impurity are attributed regardless of size in the residue on a sieve diameter of 3 mm soybean seeds: broken and pressed, eaten by pests, frostbite, immature, sprouted, damaged by drying, self-warming or disease (rotten, mouldy), as well as sunflower seeds.

As can be seen from table 3, bio-preparations affect the weight and composition of oilseed impurities in the freshly harvested soybean crop. Single application of Borogum-Mo in average for two years reduces the weight of oilseed mixture by 0.61% compared to control and by 1.57% compared to single spraying with water, Phytosporin-M by 2.0% and 2.96% respectively, and their mixtures by 2.73% and 3.69%. Double application of Borogum-Mo in two years on average reduced the weight of oilseed mixture by 1.45% compared to the control and by 3.91% compared to double spraying with Phytosporin-M by 2.12% and 4.58%, respectively, and their mixtures by 2.88% and 5.34%. In 2018, all the used preparations ensured the yield of pure soybean seeds according to the basic oilseed impurity rate (not > 6.0%), and in the control version and during water spraying the seeds were of medium purity (6.1-10.0%). In 2019 with single spraying with Borogum-Mo soybean seeds were obtained with medium purity, in other variants of experience according to the basic oilseed impurity rate the seeds were clean, and in control - weed seeds (10.1 and > %).

| Experiment option                  | Number of treatments | 2018 | 2019 |
|------------------------------------|----------------------|------|------|
|                                    |                      |      |      |
| Control - without processing       | One                  | 6.15 | 39.5 |
|                                    | Two                  | 8.46 | 42.7 |
| Control - water spraying           |                      |      |      |
| Borogum-Mo                         | One                  | 5.56 | 34.6 |
|                                    | Two                  | 5.17 | 31.1 |
| Phytosporin-M                      | One                  | 4.03 | 23.8 |
|                                    | Two                  | 4.98 | 22.7 |
| Borogum-Mo + Phytosporin-M         | One                  | 3.81 | 23.2 |
|                                    | Two                  | 3.54 | 22.4 |

LSD_{0.05} % 0.88 1.12

When estimating the materiality of private differences in oilseed admixture weight in 2018, we obtained the difference error of average $S_d = 0.415 \%$, and relative LSD_{0.05} = 16.6 %. In 2019, the absolute oilseed impurity mass error was $S_d = 0.432 \%$ and the relative LSD_{0.05} = 18.4 %.
In the control variant, the oilseed impurities content in the yield is 0.91-1.76 times higher, and in the case of water spraying of soybean crops it is 1.75-2.40 times higher than in the variants with biopreparation treatment. When treated with Borogum-Mo, the number of frostbitten seeds decreases, and when treated with Phytosporin-M, the number of diseases affected as compared to control plots.

The use of bio-preparations depends on weather conditions:
- In relatively dry summer period of soybean sowing it is reasonable to treat with bio-fertilizer once (Borogum Mo).
- In the wet summer period it is effective to carry out joint single treatment with a mixture of bioformulations Phytosporin-M + Borogum Mo.

4. Conclusion
After studies to identify the impact of bio-preparations on yield and composition of oilseed soybeans, it can be concluded that the greatest yield of soybean sowing provides an average of two years of options for the experience with spraying plants once in late June with Borogum-Mo and a mixture of Borogum-Mo + Phytosporin-M - 2.87 t/ha. In relatively warm and humid 2018, the highest soybean yield was obtained by treating soybean with Borogum-Mo once - 3.82 t/ha, and in cool excessively humid 2019 with a single spraying with a mixture of Borogum-Mo + Phytosporin-M - 2.18 t/ha.

In the control version, the content of oilseed impurities in the yield is 0.91-1.76 times higher, and in the case of water spraying of soybean crops is 1.75-2.40 times higher than in the versions with biopreparation treatment. When treated with Borogum-Mo, the number of frostbitten seeds decreases, and when treated with Phytosporin-M, the number of diseases affected as compared to control plots. According to the basic norm of oilseed impurities all used preparations provided the yield of pure soybean seeds.

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