Application of microbiological fertilizers in barley cultivation technology

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Abstract. The current research was aimed at assessing the yield and grain quality of spring barley inoculated during sowing with microbiological fertilizers "Azotovit" and "Phosphatovit" on leached chernozem in the forest-steppe conditions of the Middle Volga region at a dose of 2 l/t. These microbiological fertilizers "Azotovit" and "Phosphatovit" used for seed inoculation had practically no effect on field germination and safety of spring barley. With the pre-sowing treatment of Azotovit seeds, the sparseness of crops averaged 11.1%, with the treatment of Phosphatovit seeds - 9.5%, and with the treatment of both Azotovit and Phosphatovit seeds amounted to 7.4% at 15.7% on control. The use of the fertilizers led to an increase in the productivity of spring barley seeds up to 3.25 t/ha. The highest grain yield was obtained with the combined use of "Azotovit" and "Phosphatovit", where the yield was higher than in the control by 0.36 t/ha (12.3%). The number of seeds per 1 crop and the mass of seeds per 1 crop, with the combined use of "Azotovit" and "Phosphatovit", on average over two years of research increased by 2.8 pcs and 0.108 g, relatively, compared with the control group. Grain quality indicators have improved. Treatment of seeds of spring barley before sowing with micronutrient fertilizers increased the weight of 1000 grains by 3.5 g in comparison with the control group; increased the grain size by 2.7-13.1 g/l. The smallest increase in the grain productivity was observed in the case with seed treatment before sowing "Azotovit" and "Phosphatovit" by 2.7 g/l and 3.9 g/l, relatively, and the greatest increase in the grain productivity was obtained in the case with the combined use of both fertilizers by 13.1 g/l. This indicates a positive effect from the use of microbiological fertilizers in the barley cultivation technology.

1. Introduction.
Currently, new generation biological products have been developed in the world that have a wide range of innovations for stimulating growth and suppressing the development of phytopathogens, increasing resistance to various environmental factors, reducing the intake of heavy metals, pesticides and radionuclides into crops [1-3].

The use of chemical fertilizers is partly related to environmental hazards and costs. The use of inoculants containing bacteria is an alternative for increasing the efficiency of nitrogen and phosphorus fertilizers and allows reducing their use in agriculture [4-7].

Among the main nutrients, phosphorus is noted as the least accessible and mobile in most soil conditions. Although in soils, the content of its organic and inorganic forms is often the main limiting factor for crop growing. In the rhizosphere, the bioavailability of inorganic phosphorus varies significantly depending on the state of the soil, crop varieties, and environmental conditions. To
circumvent phosphorus deficiency, phosphate-mobilizing microorganisms could play an important part in providing phosphorus to grains in a more environmentally friendly and sustainable manner [8].

Modern microbiological fertilizers have mobilizing properties, i.e. by dissolving silicate minerals they release phosphorus and potassium from complex compounds, converting them into forms accessible to crops.

Their versatility in any technological operation of agricultural crops cultivation is an advantage of these microbiological fertilizers and give a positive effect on any plant organism [9-10].

Nitrogen fixing bacteria is generally well known for the ability to fix atmospheric nitrogen and is widely used worldwide for inoculating legumes. However, the ability to release phosphorus has also been found in some nitrogen fixing genera such as *Rhizohium, Bradyhizobium,* and *Sinorhizobium* [11-12].

2. Materials and methods
The current research was carried out in 2018-2019 in a field stationary experiment to study the effect of microbiological fertilizers "Azotovit" and "Phosphatovit" on the productivity and quality of spring barley sown in 2018 under the soil and climatic conditions of the Penza region (Russia).

The method of application of microbiological fertilizers "Azotovit" and "Phosphatovit" consisted in the treatment of spring barley seeds before sowing with microbiological fertilizers at a dose of 2 l/t each according to the following experimental scheme:

1. Treatment of seeds with water (control); 2. Treatment of the seeds with "Azotovit"; 3. Treatment of the seeds with "Phosphatovit"; 4. Treatment of seeds with both "Azotovit" + Phosphatovite.

Microorganisms *Azotobakter chroococcum*, which are part of the microbiological fertilizer "Azotovit", have nitrogen-fixing properties, i.e. it promotes the conversion of atmospheric nitrogen into a form suitable for crop nutrition.

The composition of "Phosphatovit" includes soil bacteria of *Bacillus*, the number of viable cells of the B-8966 strain is not less than 120 million/cm + a complex of plant metabolites (useful soil microflora).

The total area of the plot in the experiment was 15 hectares, the accounting area was 10 hectares. The placement of variants is randomized, the replication is threefold.

The agrotechnology of the experiment was based on the pre-sowing tillage; sowing was carried out according to the scheme of the experiment with a seeding rate of 5.5 million viable seeds per hectare. After sowing, rolling was carried out. During the growing season, chemical weeding of crops was organized to remove weeds with continuing harvesting. The yield was converted to standard moisture content (Figure 1).

![Picture 1](image_url)

**Picture 1.** Air temperature and precipitation during the growing season in the years of research.
As an object of research, we used the spring barley variety Margret, originator Margret Saaeten (Germany).

In the experiment, observations, records and analyzes were carried out according to generally accepted methods. The digital material was processed by mathematical methods of correlation, regression, and variance analyzes using the Excel 2000, Statistica 4.5, Statgraphics Plus for Windows 2.1 software package.

The main limiting factors in the Penza region are temperature and precipitation, the amount of which was sufficient for the cultivation of spring barley.

3. Results and discussions

The research results showed that the total duration from the sowing period to full ripeness of spring barley in 2018 was 82-83 days, in 2019 - 73-77 days. Differences in the timing of the spring barley growing periods were not noticed during the whole period of the experiment.

The microbiological fertilizers "Azotovit" and "Phosphatovit" used for seed inoculation had practically no effect on the field germination and safety of spring barley. The sparseness of spring barley crops varied depending on the year of research in the range of 5.1-19.1%. The greatest sparseness was observed in 2019. With the pre-sowing treatment of the Azotovit seeds, the sparseness of crops was on average 11.1%, with the treatment of the Phosphatovit seeds it was 9.5%, and with the treatment of the both Azotovit and Phosphatovit seeds, the result was 7.4% (Table 1).

Table 1. Biological resistance of spring barley.

| Experience Option                                      | Vegetative period | Germination, % | Crop density, thousand pcs/ha | Sparseness,% |
|--------------------------------------------------------|-------------------|----------------|------------------------------|--------------|
| Seed treatment with water (control group)              |                   | 80             | 90.2                        | 80.1         |
| Seed treatment with "Azotovit"                        |                   | 78             | 95.4                        | 84.4         |
| Seed treatment with Phosphatovit                       |                   | 79             | 95.9                        | 84.8         |
| Seed treatment with "Azotovit" + Phosphatovit          |                   | 78             | 96.7                        | 86.4         |

Organized field experiment on the effect of microbiological fertilizers "Azotovit" and "Phosphatovit" on the productivity of spring barley showed that pre-sowing inoculation of seeds is an effective agricultural method for growing crops, which affected their yields (Table 2).

Table 2. Spring barley yields.

| Option                                      | Productivity, t/ha | Increase t/ha | %   |
|--------------------------------------------|--------------------|---------------|-----|
| Seed treatment with water (control)        | 2.90               | -             | -   |
| Seed treatment with "Azotovit"             | 3.15               | 0.25          | 8.6 |
| Seed treatment with "Phosphatovit"         | 3.10               | 0.21          | 7.1 |
| Seed treatment with "Azotovit" + Phosphatovit | 3.25             | 0.36          | 12.3|

During the years of the research with the combined use of "Azotovit" and "Phosphatovit", an increase in the yields of spring barley was obtained not only in the control group (seed treatment with water), but in the experiments with pure seed treatment. The highest crop yield was obtained with the combined use of "Azotovit" and "Phosphatovit", where the yield was higher than the control one by
0.36 t/ha, while the crop yield in the control group was 2.90 t/ha, which was 12.3% to the control option (the treatment of spring barley before sowing with water).

Analyzing the data obtained on the effect of microbiological fertilizers on the number of seeds per crop and grain weight per crop, it could be concluded that the inoculation of spring barley with both "Azotovit" and "Phosphatovit" increased the number of grains per crop by 2.8 pcs and grain weight from 1 crop to 0.108 g compared to the control group, where the seeds of spring barley were treated with water only before sowing.

Analyzing the data obtained on the effect of microbiological fertilizers "Azotovit" and "Phosphatovit" on the weight of 1000 seeds, it could be concluded that the treatment of spring barley seeds before sowing, on average for two years of the research, increased by 3.5 g in comparison with the control group, where the treatment of spring barley seeds before sowing with water.

The data obtained on the effect of fertilizers on the spring barley seeds productivity indicated its increase by 2.7-13.1 g/l. The smallest increase in the seeds productivity was observed in the variant with seed treatment before sowing with both Azotovit and Phosphatovit by 2.7 g/l and 3.9 g/l, relatively, and the greatest increase in the productivity occurred in the variant with the combined use of fertilizers by 13.1 g/l. The applied microbiological fertilizers "Azotovit" and "Phosphatovit" had a positive effect on the quality of spring barley (Table 3).

| Option                                      | Indicators                |
|---------------------------------------------|---------------------------|
| Treatment of seeds before sowing with water (control group) | crude protein 11.87  protein 10.70  extractivity 66.85  lysine 0.39 |
| Seed treatment before sowing with "Azotovit" | crude protein 11.70  protein 10.45  extractivity 59.00  lysine 0.42 |
| Seed treatment before sowing with "Phosphatovit" | crude protein 11.60  protein 10.30  extractivity 57.75  lysine 0.42 |
| Seed treatment before sowing with "Azotovit" + "Phosphatovit" | crude protein 11.58  protein 10.10  extractivity 55.45  lysine 0.43 |

During the growing season, spring barley seeds accumulated protein from 10.1 to 10.7%. So, on average, over two years from the application of both microbiological fertilizers "Azotovit" and "Phosphatovit", the content of crude protein was up to 11.58, and from "Azotovit" and "Phosphatovit" each separately - up to 11.70 and 11.60 apart. The indicator of grain extractiveness is closely related to the protein content in the grains of agricultural crops. In the current research, it was noted that the use of microbiological fertilizers "Azotovit" and "Phosphatovit" increases the percentage of protein, and the extract of grain decreases. The studied techniques in the spring barley cultivation technology practically did not affect the lysine content in the spring barley seeds.

In conclusion, it should be stated that the reaction of crops to microbiological fertilizers "Azotovit" and "Phosphatovit" depends to a greater extent on the conditions of crops growing, since they determine the nature of metabolic processes in the soil, and the metabolites released by microorganisms only increase or decrease the rate of these processes. Thus the application of the studied fertilizers in barley cultivation technology had a positive impact.

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