Influence of calculated doses of mineral fertilizers and biological products during presowing seed treatment on barley yield

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Abstract. The research found that the best field germination of seeds and the safety of plants for harvesting was noted in the variant with the introduction of calculated doses of mineral fertilizers (N\textsuperscript{139}P\textsuperscript{72}K\textsuperscript{83}) and spraying of crops with a biological product Azotovit JO, 0.3 l/ha and amounted to 87.6 and 86.9 %, against 83.3 and 82.5 % on the variant without the treatment of seeds and crops with biologics. The maximum contamination of barley crops was noted on the background without mineral fertilizers and seed treatment and biopreparations in the tillering stage amounted to 30-37 pcs./m\textsuperscript{2}, and high rates of weeds air-dry mass were in the variant with mineral fertilizers (N\textsubscript{139}P\textsubscript{72}K\textsubscript{83}) and amounted to 3.56 g/m\textsuperscript{2} on the version without treatment of seeds and crops with biological products. The introduction of calculated doses of mineral fertilizers N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} and N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} and seed treatment with Trichodermine, F and Azotovit JO led to a greater decrease in the infestation of plants with root rot. The best development of the leaf surface area occurred in the earing phase of plants with the introduction of calculated doses of mineral fertilizers N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} and the presowing treatment of seeds with Azotovit JO and amounted to 37.4 thousand m\textsuperscript{2}/ha. High yield of barley grain (3.88 t/ha) was formed with the application of mineral fertilizers N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} and the pre-sowing treatment of seeds with the Azotovit Zh0 biological preparation, the increase from the application of fertilizers was 2.10 t/ha, from the pre-sowing treatment of seeds – 0.32 t/ha. The best indicators of grain quality were noted with the introduction of mineral fertilizers N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} and pre-sowing treatment of seeds with the biological preparation Trichodermin, J.

1. Introduction
Biopreparations (Nitrogen, 0.2 l/ha; Pseudobacterin 2, F, 1 l/t; Bactophosphine, F, 0.2 l/ha; Trichodermine, F, 1 l/t) are widely used in treating seeds and vegetative plants of agricultural crops in various soil-climatic zones of the Russian Federation. The results of the research of many authors in the use of microbiological preparations of the brand Azotovit, Pseudobacterin, Bactophosphine, Trichodermine allow achieving the following results:

- security of NP and K in a form accessible to plants;
- increase digestibility and minimize the consumption (up to 30 %) of mineral fertilizers;
- to increase the yield of agricultural crops;
- increase the quality and increase the time of preservation of the crop;
- Suppression of the pathogenic microflora causing diseases of the root and vegetative system of plants.
To improve the efficiency of agricultural production by increasing yields and quality of grown products in recent years, technology has been developed with the use of biologics, whose actions improve plant nutrition (increased utilization of nutrients from fertilizers and soil), optimizing the phosphorus nutrition of plants; fixation of atmospheric nitrogen (improvement of nitrogen nutrition), stimulation of plant growth and development, suppression of the development of pathogens (control over the development of diseases and reduction of plant affliction with them, improvement of product storage), increasing plant resistance to stressful conditions (possibility of increasing plant productivity against the background of water deficiency adverse temperatures, increased acidity, salinity or soil pollution) [1-3].

Currently, there is no doubt about the need for directional regulation of the activity of microorganisms in the soil with the help of various microbiological preparations. The use of biological preparations against the background of mineral fertilizers stimulated an increase in the yield of all varieties of spring barley. The most effective biopreparations were Gumistim and Biocomposite-correction, where the yield was 43.8 and 45.5 c/ha, the level of profitability, respectively, 114.2-116.5 %. The use of mineral fertilizers and biological products in the cultivation of spring barley made it possible to obtain a protein content of 11.3 % N\textsubscript{a0}P\textsubscript{a0}K\textsubscript{a0} to 11.9 % (Biocomposite-correction), which made it possible to classify all varieties as brewers. The largest mass of 1000 barley grains was found in varieties MIK-1, depending on this, the maximum yield of 45.5 c/ha was obtained. According to other quality indicators of barley grain, there were no significant changes in varieties on the variants of the experiment [4, 5].

Under the conditions of the reformed agricultural sector of Russia, in order to stabilize the favorable phytosanitary condition of agro-ecosystems with insufficient provision of chemical pesticides, the possibilities of using biopesticides and non-biocidal agents that stimulate the protective functions of plants in grain agro-ecosystems are determined. The promising areas of their development, the possible effective use of 20 % of the area of grain crops while increasing the use of chemical pesticides [6, 7] were evaluated.

The purpose of the experiment is to determine the effect of biological products and estimated doses of mineral fertilizers on the productivity and quality of barley grain in the conditions of the Pre-Kama region of the Republic of Tatarstan.

2. Materials and methods

Studies were conducted on the experimental field of the Kazan State Agrarian University in 2017–2018. Experiments lay in triplicate, with the consistent placement of plots. The soil is gray forest with the following agrochemical characteristics: humus content – 2.26 %, determined according to Tyurin in the modification of CINAO (GOST 26213-84), mobile phosphorus 156 mg / 1000 g of soil and exchangeable potassium 148 mg per 1000 g of soil, (mobile forms in Kirsanov extract, phosphorus - by colorimetric method, exchangeable potassium - on flame photometer (GOST 26207-84). Soil acidity is pH\textsubscript{sol} - by potentiometric method (GOST 26483-85); hydrolytic acidity - by Kappen (GOST 26212-84); amount exchange bases – according to Kappen-Gilkovitsu (GOST 27821-88); quantities The specific and specific composition of root rot pathogens in mixed soil samples is according to the methodology of the All-Russian Institute of Agricultural Microbiology: before sowing, in the phase of flowering and full maturation on Chapek agar. The qualitative characteristics of barley grain were determined according to State Standard 28672-90, State Standard 12042-80. The data were performed by the method of variance analysis according to B. A. Dospekhov (1985).

For sowing, the Raushan barley variety was used, the area of one plot - 62 m2, accounting - 60 m².

The vegetation period of barley in 2017 was characterized by sufficient precipitation and average daily air temperature, and 2018 in May and June was insufficient precipitation, which led to insufficient provision of moisture during critical periods (tilling, going into a pipe and heading) of plant development and lack of harvest grains.

The pattern of experience included two factors. Factor A – estimated doses of fertilizers for the planned yield: 1) control (without treatments); 2) mineral fertilizers for the planned yield of 3.5 t/ha -
N\textsubscript{113}P\textsubscript{60}K\textsubscript{68}, 3) mineral fertilizers for the planned yield of 4.5 t/ha - N\textsubscript{139}P\textsubscript{72}K\textsubscript{83}. Calculation of doses of mineral fertilizers was performed by the calculation and balance method.

Factor B – biopreparations for treating seeds and crops: 1) control (without treatments); 2) spraying of crops in the tillering phase with Nitrogen dioxide, 0.3 l/ha; 3) presowing treatment of seeds with Pseudobacterin 2, F, 1 l/t; 4) spraying the soil before sowing Baktofoshin, F, 0.3 l/ha; 5) seed treatment before sowing Trikhodermin, F, 1 l/t.

3. Results and discussion

The density of the productive stem in experiments depended on both the applied calculated doses N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} and N\textsubscript{139}P\textsubscript{72}K\textsubscript{83}, as well as the presowing treatment of seeds and plants with biological preparations. Studies have found that in a more favorable weather conditions year [2017], field seed germination and plant safety for harvesting was higher than in 2018 with a shortage of precipitation in the tube and heading phases of barley. On the background without fertilization, field seed germination, depending on the methods of treatment of seeds and plants with biologics, was 70.2-69.8 %, while making calculated doses of mineral fertilizers (N\textsubscript{113}P\textsubscript{60}K\textsubscript{68}) it was 77.6-80.3 % and against the background introduction (N\textsubscript{139}P\textsubscript{72}K\textsubscript{83}) - 83.3-87.6 % (Table 1).

Table 1. Field germination and preservation of plants for harvesting, depending on the estimated doses of mineral fertilizers and seed treatment and planting biopreparations

| Seed Treatment Option (Factor A) | The density of the stalks, pieces / m\textsuperscript{2} | Field germination, % | Number of plants to be cleaned, pieces / m\textsuperscript{2} | Safety of plants, % |
|----------------------------------|--------------------------|-------------------|--------------------------|-------------------|
|                                  | 2017 | 2018 | average |                                |                                |                                |
| No fertilizer (factor A)         |      |      |         |                                |                                |                                |
| Control                          | 424  | 348  | 386     | 70.2                          | 308                            | 79.8                           |
| Nitrogen JO                      | 437  | 373  | 405     | 73.6                          | 331                            | 81.7                           |
| Pseudobacterin 2, F              | 436  | 368  | 402     | 73.1                          | 325                            | 80.8                           |
| Baktofoshin, F                   | 441  | 359  | 400     | 72.7                          | 322                            | 80.5                           |
| Trichodermin, F                  | 452  | 384  | 418     | 76.0                          | 344                            | 82.3                           |
|                                  |      |      |         |                                |                                |                                |
| N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} (factor A) |      |      |         |                                |                                |                                |
| Control                          | 466  | 388  | 427     | 77.6                          | 356                            | 83.4                           |
| Nitrogen JO                      | 469  | 402  | 436     | 79.2                          | 369                            | 84.6                           |
| Pseudobacterin 2, F              | 461  | 399  | 430     | 78.2                          | 364                            | 84.7                           |
| Baktofoshin, F                   | 465  | 401  | 433     | 78.7                          | 371                            | 85.7                           |
| Trichodermin, F                  | 472  | 412  | 442     | 80.4                          | 385                            | 87.1                           |
|                                  |      |      |         |                                |                                |                                |
| N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} (factor A) |      |      |         |                                |                                |                                |
| Control                          | 477  | 439  | 458     | 83.3                          | 378                            | 82.5                           |
| Nitrogen JO                      | 497  | 467  | 482     | 87.6                          | 419                            | 86.9                           |
| Pseudobacterin 2, F              | 488  | 444  | 466     | 84.7                          | 397                            | 85.2                           |
| Baktofoshin, F                   | 484  | 446  | 465     | 84.5                          | 394                            | 84.7                           |
| Trichodermin, F                  | 482  | 456  | 469     | 85.3                          | 401                            | 85.5                           |
| HCP\textsubscript{0.05} factor A | 18.84| 16.35| -       | -                             | 16.02                          | -                              |
| HCP\textsubscript{0.05} factor B | 2.88 | 3.72 | -       | -                             | 7.23                           | -                              |
| HCP\textsubscript{0.05} interaction AB | 0.89 | 1.16 | -       | -                             | 8.79                           | -                              |

The best field germination of plants and the preservation of plants for harvesting on the background without fertilizing were noted on the variant of pre-sowing seed treatment with Trichodermine, W, 1 l/t and was 76.0 and 82.3 %, against 70.2 and 79.8 % at the control. With the introduction of calculated
doses of mineral fertilizers (N\textsubscript{113}P\textsubscript{60}K\textsubscript{68}), field seed germination increased, and there was a similar situation for biologics, where Trichodermin was applied, F, 1 l/t for seedbed seed pre-sowing treatment amounted to 80.4 %, plant safety for harvesting 87.1 %, against 77.6 and 83.4 % at control. In the future, there was a change in the indicators of field germination and safety of plants for harvesting. Higher values of field germination and preservation of plants for harvesting were noted with the application of mineral fertilizers N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} and spraying of crops with the Nitrogen Chemical, 0.3 l/ha, and amounted to 87.6 and 86.9 %, against 83.3 and 82.5 %.

The maximum contamination of barley crops was noted against the background without mineral fertilizers and depending on the pre-sowing treatment of seeds and the spraying of crops with biological products in the tillering stage amounted to 30-37 pieces / m\textsuperscript{2}, to harvest it decreased to 14-20 pieces/m\textsuperscript{2} (Table 2). With an increase in the calculated doses of mineral fertilizers, the contamination of crops decreased to 29–36 and 27–34 pcs/m\textsuperscript{2} in the tillering phase and to 12–21 and 15–18 pcs/m\textsuperscript{2} before harvest, depending on the presowing treatment of seeds and spraying of biopreparations. Less infestation of barley crops was observed when applying calculated doses of mineral fertilizers at 4.5 t/ha (N\textsubscript{139}P\textsubscript{72}K\textsubscript{83}) and treating seeds before sowing with a biopreparation Trichodermin, W and made 27 pieces / m\textsuperscript{2} in the tillering phase, 15 pieces/m\textsuperscript{2} before harvesting. The air-dry weight of weeds increased with the introduction of calculated doses of fertilizers. So, against the background without fertilizing and depending on the options with seed treatment before sowing and spraying of plants during the growing season with biological preparations, the air-dry weed mass was 2.07-2.44 g/m\textsuperscript{2}, with mineral fertilizers N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} it increased to 2.18-3.01 g/m\textsuperscript{2} and with the introduction of N\textsubscript{139}P\textsubscript{72}K\textsubscript{83}, it increased to 2.86-3.56 g/m\textsuperscript{2}. Consequently, high contamination of barley crops was observed against the background without mineral fertilizer application and seed and bioremediation treatment, and the maximum accumulation of air-dry weed mass was observed when N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} was introduced in the version without seed and plant treatment during the growing season and amounted to 3.56 g/m\textsuperscript{2}.

| Seed Treatment Option (Factor B) | Number of weeds, pieces/m\textsuperscript{2} in the tillering stage before cleaning | Mass of weed plants in air-dry condition, g/m\textsuperscript{2} | No fertilizer (factor A) |
|--------------------------------|---------------------------------|-----------------|----------------|
| Control                        | 37                              | 20              | 2.34           |
| Nitrogen JO                    | 33                              | 17              | 2.13           |
| Pseudobacterin 2, F            | 35                              | 14              | 2.44           |
| Baktofosfin, F                 | 31                              | 16              | 2.11           |
| Trichodermin, F               | 30                              | 14              | 2.07           |
|                                | \(N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} \) (factor A) | | |
| Control                        | 36                              | 21              | 3.01           |
| Nitrogen JO                    | 32                              | 18              | 2.89           |
| Pseudobacterin 2, F            | 33                              | 16              | 2.78           |
| Baktofosfin, F                 | 35                              | 15              | 2.49           |
| Trichodermin, F               | 29                              | 12              | 2.18           |
|                                | \(N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} \) (factor A) | | |
| Control                        | 34                              | 18              | 3.56           |
| Nitrogen JO                    | 29                              | 12              | 2.86           |
| Pseudobacterin 2, F            | 31                              | 16              | 3.16           |
| Baktofosfin, F                 | 33                              | 14              | 3.44           |
| Trichodermin, F               | 27                              | 15              | 3.25           |
|                                | HCP\textsubscript{0.05}factor A | 1.67            | 1.18           |
|                                | HCP\textsubscript{0.05} factor B | 1.88            | 1.12           |
|                                | HCP\textsubscript{0.05} interaction AB | 4.56            | 2.29           |

Table 2. Weediness of barley crops, pieces/m\textsuperscript{2} (average for 2017–2018)
Before harvesting, the most strongly barley was affected by root rot in 2018, the spread of the disease in the background without fertilizers was at the level of 36-60 %, and the development of the disease was 14.2-19.3 % (Table 3). On average, over two years, the incidence of plants with root rot on the background without fertilizers was: prevalence of 33-50 %, disease progression – 11.2-16.3 %. The smallest damage to the plants was noted in the pre-sowing treatment of seeds with the biological preparation Trichodermin, F, the spread of the disease was 33 %, the development of the disease was 11.2 %, with an economic threshold of damage 5-10 %. With the introduction of calculated doses of mineral N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} and N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} plant affection by root rot decreased.

### Table 3. Affection of barley plants with root rot before harvesting, %

| Seed Treatment Option (Factor B) | 2017          | 2018          | average |
|----------------------------------|---------------|---------------|---------|
|                                  | P  | R  | P  | R  | P  | R  |
| No fertilizer (factor A)         |    |    |    |    |    |    |
| Control                          | 40 | 13.2| 60 | 19.3| 50 | 16.3 |
| Nitrogen JO                      | 36 | 12.8| 49 | 18.1| 43 | 15.5 |
| Pseudobacterin 2, F              | 33 | 10.6| 47 | 16.7| 40 | 13.6 |
| Baktofosfin, F                   | 32 | 9.8 | 38 | 15.5| 35 | 12.6 |
| Trichodermin, F                 | 30 | 8.1 | 36 | 14.2| 33 | 11.2 |
| N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} (factor A) |    |    |    |    |    |    |
| Control                          | 35 | 11.8| 51 | 14.6| 43 | 13.2 |
| Nitrogen JO                      | 33 | 10.4| 45 | 13.4| 39 | 11.9 |
| Pseudobacterin 2, F              | 30 | 9.6 | 43 | 12.8| 37 | 11.2 |
| Baktofosfin, F                   | 29 | 8.8 | 41 | 11.3| 35 | 10.1 |
| Trichodermin, F                 | 27 | 7.6 | 38 | 10.2| 32 | 8.9 |
| N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} (factor A) |    |    |    |    |    |    |
| Control                          | 32 | 10.9| 48 | 13.5| 40 | 12.2 |
| Nitrogen JO                      | 25 | 7.6 | 33 | 9.9 | 29 | 8.8 |
| Pseudobacterin 2, F              | 30 | 9.1 | 38 | 12.1| 34 | 10.6 |
| Baktofosfin, F                   | 28 | 8.4 | 36 | 11.4| 32 | 9.9 |
| Trichodermin, F                 | 26 | 7.9 | 34 | 10.6| 30 | 9.3 |
| HCP\textsubscript{0.05} factor A | 1.9| 0.8 | 2.2| 0.8 | -  | -   |
| HCP\textsubscript{0.05} factor B | 0.6| 0.7 | 0.9| 0.7 | -  | -   |
| HCP\textsubscript{0.05} interaction AB | 1.8| 0.9 | 2.6| 1.1| -  | -   |

P – distribution, R – development of the disease.

Thus, against the background of N\textsubscript{113}P\textsubscript{60}K\textsubscript{68}, the spread of the disease with root rot, depending on the options for pre-sowing seed treatment and spraying of crops, decreased to 32-43 %, the progression of the disease to 8.9-13.2 %. As well as on the background without fertilizers, the smallest damage to plants against this background was noted in the variant of seed treatment with Trichodermin, F, (the spread of the disease is 32 %, the development of the disease is 8.9 %). And on the background of the introduction of mineral fertilizers N\textsubscript{139}R\textsubscript{72}K\textsubscript{83}, the smallest damage to plants by root rot was observed during the presowing treatment of seeds with Azotite JO and amounted to 29 and 8.8 %, respectively.

Consequently, the introduction of calculated doses of mineral fertilizers N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} and N\textsubscript{139}P\textsubscript{72}K\textsubscript{83} and the treatment of seeds and crops with biopreparations Trichodermin, F and Azotovite JO led to a decrease in the infestation of plants with root rot.

The leaf surface area in the tillering stage was the smallest, on the variant without fertilization and seed treatment and planting with biological products and amounted to 12.2 thousand m\textsuperscript{2}/ha, with seed treatment and planting with biological preparations it increased to 13.1-14.8 thousand m\textsuperscript{2}/ha (Table 4). A higher leaf surface area in this phase was formed against the background of the calculated N\textsubscript{139}R\textsubscript{72}K\textsubscript{83}...
and pre-sowing treatment of seeds with the Nitolovit XO biopreparations and amounted to 23.1 thousand m²/ha or more than on the version without fertilizer and seed treatment and biopreparations by 10.9 thousand m²/ha. In the heading phase, the maximum growth of the leaf surface area was noted against the background without fertilizer, depending on the methods of pre-sowing treatment of seeds and crops with biological products, it was 28.9–34.7 thousand m²/ha, on the N₁₁₃P₆₀K₆₈ application option 32.4-35.7 thousand m²/ha or more than on the version without fertilization by 3.5-1.0 thousand m²/ha and on the variant with N₁₃⁹R₇₂K₈₃ – 33.2-37.4 thousand m²/ha, more than background without fertilizer at 4.3-2.7 thousand m²/ha.

**Table 4.** The leaf surface area by phases of development of barley plants, thousand m² / ha, (average for 2017-2018)

| Seed treatment option (factor B) | Tillering | Tube entering | Heading | Milky ripeness |
|----------------------------------|-----------|---------------|---------|---------------|
| No fertilizer (factor A)         |           |               |         |               |
| Control                          | 12.2      | 24.6          | 28.9    | 18.4          |
| Nitrogen JO                      | 13.8      | 25.8          | 31.5    | 21.4          |
| Pseudobacterin 2, F              | 13.1      | 25.4          | 32.3    | 22.3          |
| Baktofosfin, F                   | 14.2      | 26.7          | 33.9    | 22.9          |
| Trichodermin, F                  | 14.8      | 27.8          | 34.7    | 23.4          |
| N₁₁₃P₆₀K₆₈ (factor A)            |           |               |         |               |
| Control                          | 17.6      | 28.6          | 32.4    | 22.6          |
| Nitrogen JO                      | 19.8      | 29.7          | 35.7    | 24.8          |
| Pseudobacterin 2, F              | 18.7      | 29.1          | 34.7    | 23.7          |
| Baktofosfin, F                   | 19.4      | 28.9          | 33.4    | 23.1          |
| Trichodermin, F                  | 20.8      | 30.5          | 35.3    | 25.8          |
| N₁₃⁹P₇₂K₈₃ (factor A)            |           |               |         |               |
| Control                          | 18.9      | 31.2          | 33.2    | 24.8          |
| Nitrogen JO                      | 23.1      | 34.5          | 37.4    | 27.9          |
| Pseudobacterin 2, F              | 22.7      | 33.7          | 35.7    | 25.7          |
| Baktofosfin, F                   | 21.9      | 32.7          | 34.8    | 25.1          |
| Trichodermin, F                  | 22.9      | 35.8          | 36.4    | 26.8          |
| HCP (factor A)                   | 0.85      | 0.68          | 0.88    | 0.94          |
| HCP (factor B)                   | 0.38      | 0.42          | 0.49    | 0.61          |
| HCP interaction AB               | 0.72      | 0.82          | 0.54    | 0.72          |

In the future, due to the drying of the lower leaves, the value of this indicator decreased. In the phase of milky ripeness on the background without fertilizers, depending on the presowing treatment of seeds and spraying of plants, it varied from 18.4 to 23.4 thousand m²/ha, while applying N₁₁₃P₆₀K₆₈ - from 22.6 to 25.8 thousand m²/ha and on the background of the introduction of N₁₃⁹P₇₂K₈₃ – from 24.8 to 27.9 thousand m²/ha. Therefore, the introduction of calculated doses of mineral fertilizers and the treatment of seeds and plants during the growing season with biological preparations significantly increases the leaf area of the barley plants.

On average, over 2 years, 1.49-1.80 tons of grain per 1 ha were obtained on the non-fertilized variant and seed and plant treatment with biological products; the maximum yield against this background was formed during seed treatment before sowing with Trichodermine, F, 1 l/t and amounted to 1.80 t/ha, or more than the control at 0.31 t/ha (Table 5). With the introduction of calculated doses N₁₁₃P₆₀K₆₈ received 2.70-3.09 t / ha, or more than the background without fertilizer at 1.21-1.29 t/ha, and its maximum value was observed during seed treatment before sowing Trichodermine, F, 11l/t and received
3.09 t/ha. The maximum yield of barley grain (3.88 t/ha) was formed with the application of mineral fertilizers $N_{139}P_{72}K_{83}$ and the presowing treatment of seeds with the Azotovit JO biological preparation, the increase from the application of fertilizers was 2.10 t/ha, and from the presowing treatment of seeds - 0.32 t/ha.

**Table 5.** Barley yield, depending on the calculated doses of fertilizers and pre-sowing treatment of seeds and crops with biological products, t/ha

| Seed treatment option | 2017  | 2018  | Average |
|------------------------|-------|-------|---------|
| Control                | 1.56  | 1.42  | 1.49    |
| Nitrogen JO            | 1.87  | 1.69  | 1.78    |
| Pseudobacterin 2, F    | 1.78  | 1.62  | 1.70    |
| Baktofosfin, F         | 1.82  | 1.71  | 1.76    |
| Trichodermin, F        | 1.85  | 1.76  | 1.80    |
| **N_{113}P_{66}K_{68} (factor A)** |       |       |         |
| Control                | 3.21  | 2.19  | 2.70    |
| Nitrogen JO            | 3.53  | 2.44  | 2.98    |
| Pseudobacterin 2, F    | 3.56  | 2.53  | 2.94    |
| Baktofosfin, F         | 3.48  | 2.61  | 3.00    |
| Trichodermin, F        | 3.50  | 2.69  | 3.09    |
| **N_{139}P_{72}K_{83} (factor A)** |       |       |         |
| Control                | 4.00  | 3.12  | 3.56    |
| Nitrogen JO            | 4.25  | 3.34  | 3.88    |
| Pseudobacterin 2, F    | 4.18  | 3.3   | 3.79    |
| Baktofosfin, F         | 4.20  | 3.32  | 3.76    |
| Trichodermin, F        | 4.17  | 3.29  | 3.73    |
| **HCP_{05}** factor A  | 0.06  | 0.09  |         |
| **HCP_{05}** factor B  | 0.11  | 0.14  |         |
| **HCP_{05}** interaction AB | 0.08  | 0.09  |         |

The number of plants to be harvested on the non-mineral fertilizer version was 308–344 pcs./m², depending on the methods of biopreparations application, and the maximum value was observed during the presowing treatment of seeds with Trichodermine, W and 344 pcs/m² (Table 5). With the introduction of calculated doses of mineral fertilizers $N_{113}P_{66}K_{68}$, the number of plants for harvesting increased to 356-371 pcs/m² (more than on the background without fertilizers by 48-27 pcs/m²). The maximum number of plants to be harvested was noted when applying $N_{139}P_{72}K_{83}$ and amounted to 378-401 pcs/m², or more than the control by 70-57 pcs/m². High indicators of grain mass per spike and 1000 grain mass were noted on the variant with the introduction of $N_{139}P_{72}K_{83}$ and the pre-sowing treatment of seeds with Trichodermin, F biological preparation and amounted to 0.93 and 34.6 g, or more than on the variant without fertilizers and the treatment of seeds and plants with biological preparations 0.45 and 9.3 g, respectively.

4. Conclusion

High field germination of seeds of 87.6 % and the safety of plants for harvesting 86.9 % was noted on the variant with the introduction of $N_{139}P_{72}K_{83}$ and spraying of crops with a biological product Azotovit JO, 0.3 l/ha. The maximum contamination of barley crops with 37 pcs/m² was noted against the background without mineral fertilizers and seed treatment and biopreparations. The lesser infestation of plants with root rots (P-29 %, R-8.8 %) on barley crops was observed in the variant with $N_{139}P_{72}K_{83}$ and pre-sowing seed treatment with Azotovit JO; the same development showed better leaf surface development (37.4 thousand m²/ha) and the formation of high grain yield of barley 3.88 t/ha, against
1.49 t/ha on the variants without fertilizer application and seed treatment and sowing with biological preparations.

Table 6. Barley crop structure (average for 2017–2018)

| Seed Treatment Option (Factor B) | Number of plants to be cleaned, pcs/m² | The number of productive stems before cleaning, pcs/m² | Productive tillering | Grain mass from 1 plant, g | The number of grains per plant, pcs. | Grain mass from 1 spike, g | Weight 1000 seeds, g |
|----------------------------------|----------------------------------------|-------------------------------------------------------|----------------------|--------------------------|--------------------------------------|--------------------------|----------------------|
| Control                          | 308                                    | 320                                                   | 1.04                 | 0.48                     | 18.2                                 | 0.46                     | 25.3                 |
| Nitrogen JO                      | 331                                    | 354                                                   | 1.07                 | 0.54                     | 17.8                                 | 0.5                      | 28.1                 |
| Pseudobacterin 2, F              | 325                                    | 341                                                   | 1.05                 | 0.52                     | 17.9                                 | 0.49                     | 27.4                 |
| Baktofosfin, F                   | 322                                    | 348                                                   | 1.08                 | 0.55                     | 18.3                                 | 0.51                     | 27.9                 |
| Trichodermin, F                 | 344                                    | 374                                                   | 1.09                 | 0.52                     | 18.1                                 | 0.48                     | 26.5                 |
|                                  |                                        |                                                       |                      |                          | N\textsubscript{113}P\textsubscript{60}K\textsubscript{68} (factor A) |                                        |                      |
| Control                          | 356                                    | 399                                                   | 1.12                 | 0.76                     | 20.4                                 | 0.68                     | 33.3                 |
| Nitrogen JO                      | 369                                    | 439                                                   | 1.19                 | 0.81                     | 20.2                                 | 0.68                     | 33.7                 |
| Pseudobacterin 2, F              | 364                                    | 440                                                   | 1.21                 | 0.81                     | 19.8                                 | 0.67                     | 33.8                 |
| Baktofosfin, F                   | 371                                    | 445                                                   | 1.2                  | 0.81                     | 19.8                                 | 0.68                     | 34.3                 |
| Trichodermin, F                 | 385                                    | 469                                                   | 1.22                 | 0.80                     | 18.6                                 | 0.66                     | 35.5                 |
|                                  |                                        |                                                       |                      |                          | N\textsubscript{113}P\textsubscript{72}K\textsubscript{83} (factor A) |                                        |                      |
| Control                          | 378                                    | 461                                                   | 1.22                 | 0.94                     | 22.1                                 | 0.77                     | 34.8                 |
| Nitrogen JO                      | 419                                    | 541                                                   | 1.29                 | 0.93                     | 21.4                                 | 0.72                     | 33.6                 |
| Pseudobacterin 2, F              | 397                                    | 504                                                   | 1.27                 | 0.95                     | 22.3                                 | 0.75                     | 33.6                 |
| Baktofosfin, F                   | 394                                    | 489                                                   | 1.24                 | 0.95                     | 22.8                                 | 0.77                     | 33.8                 |
| Trichodermin, F                 | 401                                    | 505                                                   | 1.26                 | 0.93                     | 21.4                                 | 0.74                     | 34.6                 |
| HCP\textsubscript{0.05} factor A | 18.5                                   | 22.3                                                  | -                    | 0.05                     | 0.37                                 | 0.09                     | 1.29                 |
| HCP\textsubscript{0.05} factor B | 2.78                                   | 11.4                                                  | -                    | 0.07                     | 0.26                                 | 0.11                     | 0.14                 |
| HCP\textsubscript{0.05} interaction AB | 0.93                             | 10.9                                                  | -                    | 0.06                     | 0.81                                 | 0.07                     | 0.87                 |

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