Biological Products to Improve the Adaptability and Productivity of Grain and Leguminous Crops

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Abstract. The basis of environmental management is the balance of resources consumed and the possibility of their restoration. In agroecosystems, the main resources consumed are plant nutrients, the main of which is nitrogen. Among the sources of nitrogen reduction, the main role belongs to mineral fertilizers, but the only safe source of nitrogen supply to plants is biological nitrogen.

To increase the activity of symbiotrophic microorganisms and increase the amount of biological nitrogen, biological preparations are used. The action of biological preparations is specific and is determined by agroecological factors, the genotype of plants and the cultivated agricultural crop. The article presents data on the study of the effect of biological preparations (rhizoagrin, azorizine, rizotorfin and huminatrin) on varieties of spring common wheat, oats and pea. The influence of drugs on adaptability is determined, the determining indicators of which are plant survival and grain yield. As a result of the studies, the most responsive varieties were identified for drug processing, more effective drugs, as well as the processing method — separate or joint use.

1. Introduction

Mankind cannot refuse to receive high crop yields. If the solution of the energy problem of nitrogen fertilizer production in the future is possible (although it is associated with such difficult issues as thermal «pollution» of the planet), then the tasks associated with protecting the environment from excess compounds will remain relevant for a long time time. The task is to use nitrogen fertilizers more rationally, to lower their norms, and in order to prevent a sharp drop in yields, it is necessary to search for alternative sources of plant nutrition with nitrogen.

The only alternative to mineral nitrogen is biological nitrogen. It completely enters the organic matter of plants, without exerting a negative impact on the ecological environment. In this sense, microbiological preparations can solve the problem, the use of which can help preserve natural ecological systems and realize the potential productivity of plants due to adaptive properties, i.e. by increasing the immune status - the general non-specific resistance of plants to adverse factors by inducing natural protective mechanisms. Activation of the symbiotrophic assimilation of atmospheric nitrogen makes it possible to increase the resistance of plants to damage by pathogens and to improve their economic and biological indicators without the use of agrochemicals. [1-5].
Biological products have a positive effect on crop yields, improve the quality of the resulting crop, increase photosynthetic and symbiotic efficacy, increase plant survival, improve the sowing quality of seeds [6-9]. At the same time, the use of microbiological biological products is largely restrained due to the lack of necessary knowledge in the ecology of these microorganisms, the role of agroecological factors, the responsiveness of individual genotypes, cultures that determine the effective functioning of plant-bacterial associations. In this regard, research in this direction is relevant.

2. Materials and methods

The studies were conducted in 2011-2018 on the experimental fields of the seed department of the Siberian Research Institute Agriculture, located in the southern forest-steppe of Western Siberia. The soil of the experimental plot is meadow-chernozemic medium-thick medium-humus medium-loamy, with a neutral reaction of the environment, the availability of nitrate nitrogen is low, mobile phosphorus is high, and exchange potassium is very high. The years of research were quite contrasting. As the object of research used:

- 9 varieties of spring soft wheat breeding Siberian Research Institute agriculture of 3 ripeness groups: medium early (Pamyat Aziev, Katayusha, Omsk anniversary (G 2755/04), medium ripe (Duet, Svetlanka, Melody), medium late (Omskaya 35, Silver, Voloshina (G 540/05);
- 6 varieties of sowing oats of two groups: membranous (Orion, Mutika 4021, Irtysh 23) and naked grains (Siberian Holozerny, Progress, TR 12-115);
- 5 varieties of peas: Omsk 9, Omsk 18, Blagovest, Demos and Yamal.

Rizoagrin (spring wheat, oats), azorizin (oats), rhizotorfin, huminatrin (peas) were used for seed inoculation. Peas used both separate treatment with rhizotorfin and huminatrin, as well as the combined use of drugs. The experiments were laid on plots with an area of 3-5 m², the repetition of the experiment 5-fold. The sowing of the plots was carried out by the SSFK seeder - 7.0, with a sowing rate of 5 million (grain) and 1.2 million germinating grains per hectare (peas). Cereal precursor (second crop after steam). Biological treatment of seeds was carried out on the day of sowing. Harvesting was carried out by the «Hege125» combine. Statistical processing of experimental data was carried out by the method of analysis of variance and correlation analysis as presented by B A Dospekhov [10].

3. Results and discussion

An environmentally significant sign of adaptation is plant survival, which is due to climatic conditions during the passage of the main phases of growth and development by plants. The highest survival rate of spring soft wheat plants was noted in 2012, on average, for varieties, this indicator was 95.4% in the control variant and 96.6% in the variant with inoculation. Varieties Voloshinka and Pamyat Aziev exceeded control by 12% and 14%, respectively (table 1). In 2011, there was a decrease in survival on average for varieties in inoculated plants, but in varieties: Duet and Serebryristaya there was an excess to the control of 8% and 11%, respectively. In 2013, the average varietal survival rate in both variants was 80%, while with a significant increase in control, the following varieties were distinguished: Pamyati Aziev (6%), Omsk anniversary (13%), Svetlanka (5%), Melody (7%) On average, over the years of research, the variety cultivars were characterized by the highest values of field germination: Pamyat Aziev and Omsk anniversary.
Table 1. Survival of spring soft wheat plants, %.

| Grade             | 2011 C* | 2012 C | 2013 I | The average | 2012 I** | 2013 I | The average |
|-------------------|---------|--------|--------|-------------|---------|--------|-------------|
| In memory of Aziev| 91,0    | 84,0   | 85,0   | 89,0        | 84      | 91     | 86,7        |
| Katyusha         | 93,0    | 82,0   | 98,4   | 97,6        | 93      | 82     | 94,8        |
| Omsk Yubileynaya | 86,0    | 81,0   | 100    | 100         | 73      | 86     | 86,3        |
| Duet              | 80,0    | 88,0   | 100    | 99,0        | 91      | 86     | 90,3        |
| Melody            | 76,0    | 71,0   | 96,8   | 92,0        | 85      | 90     | 85,9        |
| Svetlanka         | 74,0    | 73,0   | 99,0   | 94,0        | 61      | 68     | 78,0        |
| Omskaya 35        | 75,0    | 76,0   | 100    | 99,0        | 77      | 74     | 84,0        |
| Serebristaya      | 67,0    | 78,0   | 97,0   | 95,0        | 81      | 72     | 81,7        |
| Voloshinka        | 97,0    | 82,0   | 82,0   | 94,0        | 79      | 74     | 86,0        |
| The average       | 82,0    | 79,0   | 95,4   | 96,6        | 80      | 80     | 86,0        |

*control, **inoculation

The treatment of seeds with rhizoagin had an ambiguous effect on the grain yield of the studied varieties of spring common wheat. On average, over the years of study, the largest increase in yield from inoculation was provided by the varieties of Pamyat Aziev (from +0.10 to +0.39 t / ha, depending on the year of cultivation) and Duet (from +0.01 to +0.47 t / ha) (table 2). The excess in yield was due to an increase in such structural elements as plant height, productive bushiness, spike productivity and a mass of 1000 grains.

Table 2. Grain productivity of spring soft wheat varieties, t / ha, on average for 2011-2013.

| Grade              | Control | Inoculation | ± to control |
|--------------------|---------|-------------|--------------|
| In memory of Aziev | 1,68    | 1,97        | 0,29         |
| Katyusha           | 2,30    | 2,23        | -0,07        |
| Omsk Yubileynaya   | 2,25    | 2,21        | -0,04        |
| x the average      | 2,08    | 2,14        |              |
| Duet               | 2,19    | 2,42        | 0,23         |
| Svetlanka          | 2,30    | 2,18        | -0,12        |
| Melody             | 2,40    | 2,49        | 0,09         |
| x the average      | 2,30    | 2,36        |              |
| Omskaya 35         | 2,25    | 1,94        | -0,31        |
| Serebristaya       | 2,62    | 2,69        | 0,07         |
| Voloshinka         | 2,32    | 2,33        | 0,01         |
| x the average      | 2,40    | 2,32        |              |
| Variety average    | 2,26    | 2,27        | 0,01         |
| HCP 0.5 A          | 0,34    |             |              |
| HCP 0.5 B          | 0,16    |             |              |
| HCP 0.5 AB         | 0,47    |             |              |

The survival of planting oats was largely influenced by the genotype, soil and climatic conditions, and biotic factors (diseases and pests). Data on plant survival are presented in table 3.
Table 3. Survival of plants of oats sowing, on average for 2015-2017, %.

| Grade     | Control | Rhizoagrin | ± to control | Azorizine | ± to control |
|-----------|---------|------------|--------------|-----------|-------------|
| Orion     | 82,0    | 85,7       | 3,7*         | 84,7      | 2,7         |
| Mutika 4021 | 85,7    | 84,7       | -1,0         | 90,0      | 4,3*        |
| Irysh 23  | 85,3    | 86,0       | 0,7          | 87,0      | 1,7         |
| Siberian  |         |            |              |           |             |
| Golozernyi | 78,7    | 80,0       | 1,3          | 75,3      | -3,3        |
| TR12-115  | 76,0    | 77,7       | 1,7          | 80,0      | 4,0*        |
| Average   | 81,5    | 82,8       | 1,3          | 83,4      | 1,9         |
| HCP 0,5   | 3,6     |            |              |           |             |

*reliably at P=0,05

The studied indicator ranged from 75.7% in rainy 2016 to 84.0 in 2015 and 87.8% in 2017, which were characterized by the most favorable combination of hydro-thermal factors. On average, over the years of research, the survival rate of plants was 82.5%. Inoculation with biologics favorably influenced this indicator and contributed to its increase in the Orion variety (+3.7%), inoculated with rizoagrin and the Mutika 4021 (+4.3%) and TR12-115 (+4.0%) varieties. treated with azorizine.

Studies conducted on oats showed that, like on wheat, the effect of drugs is not the same in contrasting agroecological conditions (table 4).

Table 4. Grain productivity of sowing oats varieties, on average for 2015-2017, in t/ha.

| Grade     | Control | Rhizoagrin | ± to control | Azorizine | ± to control |
|-----------|---------|------------|--------------|-----------|-------------|
| Orion     | 2,60    | 3,21       | 0,61         | 3,11      | 0,51        |
| Mutika 4021 | 3,69    | 4,04       | 0,35         | 4,43      | 0,75        |
| Irysh 23  | 3,98    | 3,90       | -0,08        | 4,22      | 0,24        |
| Siberian  |         |            |              |           |             |
| Golozernyi | 2,42    | 2,21       | -0,21        | 2,29      | -0,13       |
| TR12-115  | 2,58    | 2,84       | 0,26         | 2,41      | -0,17       |
| Average   | 3,05    | 3,24       | 0,19         | 3,29      | 0,24        |
| HCP 0,5B* | 0,25    | 3,24       | 0,19         | 3,29      | 0,24        |
| HCP 0,5C  | 0,31    |            |              |           |             |

*By factor: B * - inoculation, C-grade

Holoserous varieties negatively react to processing. On average for 2015-2017 the most effective was the drug azorizine. Varietal specificity for inoculation with biological products was revealed. The highest responsiveness to treatment with both drugs was shown by the Orion oats variety (+0.61 and +0.51 t/ha). A high yield increase (+0.75 t/ha) when treated with azorizine was noted for the Mutika 4021 line, a slightly smaller, but reliable - 0.35 t/ha was obtained when this variety was treated with rhizoagrin. The TR12-115 line also responded positively to rhizoagrin treatment, with a yield of 2.84 t/ha, which significantly exceeded the control by 0.26 t/ha.

The effect of inoculation and growing conditions on the survival rate of plants of different varieties of peas was studied during 2016-2018. Studies have shown a significant variation in the studied parameter depending on the genotype, growing conditions, the processing method and the type of
preparation. Analyzing the data presented (table 5), we can conclude that the studied varieties had a high degree of plant survival (83.4–93.7%).

**Table 5.** Survival of plants of sowing peas, on average for 2016 - 2018.

| Grade       | Control   | Rhizotorfin | Guminatrin | Rhizotorfin + Guminatrin |
|-------------|-----------|-------------|------------|--------------------------|
| Omskiy 9    | 88.9      | 91.4        | 92.0       | 92.4                     |
| Omskiy 18   | 91.6      | 93.7        | 93.3       | 92.9                     |
| Blagovest   | 86.1      | 88.7        | 90.9*      | 86.9                     |
| Demos       | 83.4      | 84.6        | 88.2*      | 84.8                     |
| Ymal        | 84.1      | 87.0        | 87.7       | 89.4*                    |
| The average | 86.8      | 89.0        | 90.4       | 89.3                     |

* - reliably at P<0.05

On average, over the years of research it was found that peas Omskiy 18 were characterized by the highest plant survival. On average, in the experience, drug treatment did not significantly affect the value of the indicator. At the same time, a significant increase in survival was observed in the Blagovest and Demos cultivars when seeds were inoculated with guminatrin, and the Yamal cultivars, when combined with drugs. The results of the studied factors on the yield of pea grain are presented in table 6.

**Table 6.** Grain productivity of various pea varieties upon inoculation with biological products, on average for 2016-2018, in t/ha.

| Grade       | Control, t/ha | Inoculation | Inoculation | Joint treatment |
|-------------|----------------|-------------|-------------|-----------------|
|             |                | rizotorfin  | guminatrin  | t/ha            | in% of control |
|             |                | t/ha        | t/ha        | t/ha            | in% of control |
| Omskiy 9    | 2.90           | 2.86        | 98.6        | 2.95            | 101.7          | 3.37          | 116.2        |
| Omskiy 18   | 2.83           | 3.15        | **111.3**   | 3.16            | 111.7          | 3.44          | 121.5        |
| Blagovest   | 2.96           | 2.98        | 100.7       | 3.03            | 102.4          | 3.12          | **105.4**    |
| Demos       | 2.51           | 2.62        | 104.4       | **2.71**        | **108.0**      | 2.58          | 102.8        |
| Ymal        | 2.66           | **3.05**    | **114.7**   | 2.58            | 97.0           | **2.95**      | **110.9**    |
| The average | **2.77**       | **2.93**    | **105.8**   | **2.95**        | **106.5**      | **3.09**      | **111.5**    |

The greatest efficiency was characterized by the option of joint treatment with rhizotrin fin and numinatrin; on average, for varieties over the years of study, the yield in this variant was 3.09 t/ha or 115.5% of the control. The values with treatment with rizotorfin and guminatrin were characterized by close values - 2.93 t/ha (105.8% of the control), 2.95 t/ha (106.5% of the control), respectively. A different reaction of pea varieties to the treatment with a particular drug and its method was revealed. So, varieties Omskiy 9 and Blagovest formed the maximum yield when combined with the drugs, the Demos variety when treated with guminatrin, and the Yamal variety was the most responsive to...
rhizotorfin treatment, and also positively responded to the joint inoculation of seeds with both drugs. The Omsk 18 pea variety deserves special attention, which responded positively primarily to joint seed treatment (121.5% to control), as well as to inoculation with guminatrin (111.7% to control) and rhizotorfin (111.3% to control). The data obtained allowed us to highlight the most responsive varieties for inoculation. First of all, this is the Omsky 18 variety, which formed the maximum grain yield in all variants of the experiment. Noteworthy are the varieties Omsky 9, Blagovest and Yamal, which exceeded the control for the studied parameter in the variant of joint treatment with drugs. Analysis of the elements of the crop structure showed that a higher level of yield during inoculation was due to an increase in the number of productive nodes, beans and the mass of seeds from the plant.

The collection of protein per hectare is an important indicator characterizing the value of leguminous crops. The positive effect of inoculation on this indicator was noted primarily when combined with drugs (varieties Omskiy 9, Omskiy 18 and Yamal), as well as when inoculated with guminatrin (Omskiy 18 and Demos) and rhizotorfin (Omskiy 18, Demos and Yamal). Of particular interest is the Omskiy 18 pea variety, which on average over 3 years ensured the maximum protein yield from ha - 659.29 kg/ha. Inoculation of seeds with rhizo-peat provided a significant increase of 55.02 kg/ha; guminatrin - at 72.42 kg/ha and cotreatment with drugs - at 122.35 kg / ha.

4. Conclusions
The use of diazotrophic bacterization is of undoubted interest for increasing adaptability and, as a consequence, the level of productivity of grain and leguminous crops. The action of the preparations is quite specific, to a large extent determined by the genotype, culture, agro-ecological conditions of cultivation, as well as by the method of treatment (separate or joint inoculation).

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