Influence of biomodified mineral fertilizers on sawing quality of spring barley

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Abstract. Nowadays, the ability to demonstrate the achievement of Russian spring barley selection is significantly limited. The reason for this is the poor use on the fields of agricultural enterprises of the possibility of increasing productivity by improving sowing qualities.

1. Introduction

The improvement of the quality of seeds of grain crops largely determines the effectiveness of grain farming. In this regard the organization of the production process in order to obtain seeds with high sowing qualities leads to the increase in the profitability of agricultural complex. The seed industry in Russia is currently developing quite dynamically. Selection achievements are expressed in the high genetic potential of seeds. Thus many varieties of spring barley demonstrate a potential above 100–110 kg/ha. At the same time, production potential is often limited to 30–40 % of the possible maximum.

In this matter, the introduction of production technologies, including through the improvement of fertilizer system, is a key factor in the achievement of the goals.

The effectiveness of modernization of the existing fertilizer system is associated with the possibility of including biological and organic components in it, the lack of which in soil is increasingly noted as a factor limiting production efficiency.

Seed quality maintaining is closely related to the use of a biological factor and is also the least expensive way to increase grain production [1].

The response of cultivated plants to the applied fertilizers depends on many factors, including the biological activity of soil. One of the methods that contribute to its increase is seed inoculation. With a number of advantages of this technique, there are also disadvantages. Microbiologist S.A. Samtsevich (1902–1985) noted: “as soon as a plant weakens and becomes unable to satisfy the needs of a microbe, the effect of the latter is enhanced; saprophyte essentially turns into a parasite and can lead ultimately a plant to death.” [2].

However, K.A. Timiryazev was the first, who noticed the presence of competition between a plant and microorganisms [3]. Accordingly, the inoculations of mineral and organic-mineral fertilizers,
which, in fact, are a growing medium for microorganisms, reduce the risk of the above mentioned competition.

Research relevance
The ability to demonstrate the achievement of Russian spring barley selection is currently significantly limited. The reason for this is the poor use on the fields of agricultural enterprises of the possibility of increasing productivity by improving sowing qualities.

2. Methods and materials
The studies were carried out in 2017 under production conditions in “Zelenogradskoye enterprise” of the Pushkin District of Moscow Region. In the experiment, spring barley was sown – the variety “Nur”. The fertilizer system is represented by sowing application of nitrogen-phosphorus-potassium fertilizer (NPK 16:16:16) in the norm of 200 kg/ha. Fertilization was carried out with ammonium nitrate in a dose of 100 kg/ha.

The total area of the field was 27 ha. Cadastral number is 50: 13: 0040243: 4. Sowing was carried out on May 6, 2017 with a sowing complex with a seeding rate of 300 kg/ha. The area of the experimental plots was 2 ha.

The experimental scheme included 3 options.
Option 1 – background – nitrogen-phosphorus-potassium fertilizer (200 kg/ha)
Option 2 – background + a complex of soil microorganisms in dry form in the norm of 1 kg/ton of fertilizer. The bacteria Azotobacter chroococcum VI 8, Pseudomonas asplenii VI 7, Bacillus subtilis SG 12 were used for biomodification of mineral fertilizers. The carrier was diatomite. The total concentration of cells was 8 x 10^9 – 200 kg/ha.
Option 3 – Background (120 kg/ha) + granular organic compost (40 kg/ha)

The site soil was sod-podzolic, the thickness of the humus horizon was 25 cm, organic matter was 2.1 %, mobile phosphorus was 281 mg/kg of soil, exchange potassium was 156 mg/kg of soil, pH (KCl) was 5.8, hydrolytic acidity – 1.8 mg-equiv./100 g of soil, soil density – 1.4 g/cm^3. The content of mobile forms of Ca was 8.6 mg/kg, Mg – 3.8 mg/kg of soil.

Meteorological conditions after sowing were unfavorable (excess moisture and a long period with low temperatures). Single sprouting appeared on May 18, 2017, full sprouting appeared on May 29, 2017.

Accounting for biological productivity and selection of barley seeds was carried out on August 9, 2017.

The assessment of sowing qualities of seeds was carried out in May 2018 in laboratory conditions. The energy of seed germination and laboratory germination was determined in accordance with GOST 12038-84. Seeds were germinated by the between paper method (BP). The number of seeds in each repetition was 50 pcs. The experiment was repeated 3 times.

3. Results
The results of production experiment indicate that the modification of mineral fertilizers with biological (option 2) and organic (option 3) components positively affects the productivity of spring barley, stimulates the growth and development of plants (Table 1).

The data in table 1 indicate the increase in indicators determining the productivity of barley. Thus, the total and productive number of stems in option 2 exceeds the indicators in the background by 28.1 and 16.5 %, respectively. In option 3, the excess is – 16.5 and 13.5 %. Morphological signs also indicate better conditions for the development of plants. The length of the stems in the variant with the use of microorganisms (option 2) is more by 5.4 %, in the variant with organic granules (option 3) – by 13.5 %.
Table 1. Comparative evaluation of the effectiveness of biomodified mineral fertilizers.

| Experimental scheme | The amount of stems pcs/m² | The number of productive stems, pcs/m² | The length of stems, cm | Seed humidity, % | Biological productivity in terms of 14 %, kg/ha | The mass of 1000 seeds in terms of 14 % |
|---------------------|----------------------------|----------------------------------------|------------------------|-----------------|-----------------------------------------------|---------------------------------------|
| Option 1 (background) | 690                        | 690                                    | 74                     | 26.9            | 64.3                                          | 47.0                                  |
| Option 2            | 884                        | 804                                    | 78                     | 29.6            | 69.1                                          | 47.5                                  |
| Option 3            | 804                        | 783                                    | 84                     | 26.5            | 72.0                                          | 48.1                                  |

The biological productivity in option 2 is higher by 7.5 %, in option 3 – by 12 %. However, the most important indicator affecting the sowing quality of the seed material is considered to be the mass of 1000 seeds. Despite the tendency to increase seed weight depending on the modification options for mineral fertilizers, from the point of view of statistical reliability, the indicators are within the limits of error – 1.1 and 2.3 % for the studied options. Nevertheless, the assessment of germination and growth energy indicates a significant dependence on the used means of modifying mineral fertilizers (Table 2).

Table 2. Germination energy and laboratory germination of barley seeds in various forms.

| Option         | Germination energy, % | Difference, % | Laboratory germination, % | Difference, % |
|----------------|-----------------------|---------------|---------------------------|---------------|
| Option 1 (Background) | 50                    | –             | 80                        | –             |
| Option 2       | 60                    | 20            | 86                        | 7.5           |
| Option 3       | 76                    | 52            | 94                        | 17.5          |

Figure 1. Sprouts of barley on the 7th day.

The germination energy of barley seeds under favorable conditions is considered acceptable if it is in the range from 90–95 %. Adverse weather conditions significantly limit the quality indicators of the seed material. It should be noted that 2017 Moscow region was characterized as unfavorable at the beginning of the growing season. This was due to low atmospheric temperatures and excessive soil moisture during the first month after sowing spring barley. Under standard conditions, the sprouting of seedlings of barley plants of the Nur variety occurs on the 6th day. In our experiment, seedlings appeared after 12 days. For another 11 days, low temperatures prevented full germination.

Thus, the reduction of the growing season led to the limitation of potential. A similar negative effect was observed in dry years. The experiments performed in All-Russian Research Institute of Culture named after I.G. Kalinenko in order to determine the effect of mineral fertilizers on the sowing qualities of malting barley revealed that the germination energy of seeds obtained in the dry year of 2010 turned out to be lower lower than in the favorable year 2011 in the control variant by 63.0 and by 43.7 % in the variant with mineral fertilizers. [4].

In field cultivation, an agricultural producer does not have the ability to influence climatic conditions. Accordingly, he has to look for ways to reduce the negative impact of adverse weather...
conditions. In our experiment, the possibility of improving the quality of barley seed grain through the modification of mineral fertilizers is demonstrated.

Dusting of the granules of mineral fertilizers with a consortium of agronomically valuable microorganisms increased the germination energy by 20%, laboratory germination by 7.5% in relation to the background. However, the greatest effect was manifested in the case of the combination of mineral fertilizers with organic granules (option 3). Germination energy reached 76%, which was 52% higher than in the background, and laboratory germination reached 94% (+17.5%). The yield increase reached +12%. It should be noted that from the point of view of economic efficiency, option 3 is most preferable. This is due not only to the increase in yield and sowing characteristics of seeds, but also to the decrease in the cost of fertilizers per unit area. During the course of the experiment, the sowing complex was adjusted for the application of 200 kg of mineral fertilizers. Since organic granules had a lower density, the seeding rate of the organo-mineral mixture was 160 kg/ha.

4. Conclusion
Along with the use of adapted varieties of crops to specific production conditions, the most important task in agriculture is to create conditions for the fullest manifestation of the potential advantages of the variety. Recently, it has been increasingly noted that soil factor limiting productivity shifted from the mineral component to organic and biological components. Mineral fertilizers account for up to 30–40% of all farm expenses.

Accordingly, the improvement of fertilizer system based on the main soil parameters – agrochemical, physical, and biological – is a guarantee of increased response in the production of grain for both commercial and seed purposes. The inclusion of microbiological agents and technologically prepared (fermentation, granulation, heat treatment) organic fertilizers in the mineral nutrition system of plants meets the needs of modern production while minimizing the financial costs of its improvement.

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