Influence of biopolymeric modification of mineral fertilizers on the productivity and quality of winter wheat grain

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Abstract. Improving the profitability of the crop industry is associated with the introduction of adapted innovative solutions, including in the field of plant nutrition. Existing scientific achievements in the fertilizer system make it possible to achieve a solution to a set of interrelated tasks: increasing the responsiveness of cultivated plants to the fertilizers used, improving agrochemical and agroecological soil parameters and limiting the outstripping growth of costs for the plant nutrition system.

1. Introduction
Maintaining a balance between an acceptable profitability of production and the potential of soil resources remains one of the most urgent tasks in modern agriculture.

Speaking about the ability of the soil to produce a satisfactory yield, the main condition under which the soil functions as an effective agroecosystem should be identified. This condition is the presence of an optimal ratio of its three main components - mineral, organic and microbiological, where as its biological activity is increasingly considered to be an integral parameter of soil fertility. The biological activity of the soil is expressed in increasing the availability of mineral nutrients to plants by increasing the content of nutrients, carbon in particular, involved in the formation of organo-mineral compounds effective in nutrition. The success of agriculture is directly related to the level of microbiological activity, which grows with an increase in organic matter in it [1].

The most common methods of increasing organic matter in the soil are the introduction of organic fertilizers and the use of green manure. Unfortunately, the implementation of these techniques is limited by the financial capabilities of agricultural enterprises. As a rule, the cost of acquiring, logistics, and applying organic fertilizers rarely pays off with additional increases in yield. As an example, we present the results of a study on the effect of mineral organic fertilizers in 2010-2012 in the Topchikhinsky district of the Altai Territory. It turned out that the use of N60P60K60 allowed to obtain an increase in winter wheat yield of 1.5 t / he (44.8%). The introduction of 30 t / he of manure against the background of N60P60K60 led to an additional increase in yield of only 0.15 t / he [2]. In the case of the use of green manure, one more limiting factor needs to be considered, associated with a
slight increase in soil toxicity during their use. So, according to Linkov S.A. et al., soil toxicity with the use of green manure was on average 9.3% higher than in the variants without them. [3].

Polymer substances can be used as alternative sources of carbohydrates suitable for the modernization of the fertilizer system of agricultural crops, solving all the mentioned earlier problems. For example, the interaction of a polymer hydrogel as a chemical compound with mineral fertilizers was studied at the Volgograd State Agrarian University. As a result, its positive effect on the productivity and quality of winter wheat grain was revealed [4].

In the present work, the use of corn starch, which is a mixture of polysaccharides of amylose and amylopectin, the monomer of which is alpha-glucose, is proposed as a biopolymer substance as a carbohydrate source. The enrichment of existing traditional mineral fertilizers with organic substances entails a more complete development of cultivated plants and the formation of a better crop, since carbon compounds positively affect the sequence of nitrogen transformation processes in the plant body and accelerate the formation of protein substances.

2. Materials and research methods
The impact of biopolymer modification on the productivity of winter wheat and grain quality was assessed under the conditions of “Stavagrokom” LLC in the Kursk region, Stavropol Territory in a micro-plot experiment. The plot area was 0.25 m². 3 times repetition. Feeding was carried out with complex mineral fertilizer (NPK - 16:16:16) at the rate of 200 kg / he. The biopolymer was applied to the fertilizer by dusting with preliminary wetting of the granules. In order to avoid dissolution of the fertilizer granules between spraying and moisture and applying the biopolymer, a minimum time was maintained. The biopolymer was fixed in a microwave oven. The consumption rate of the biopolymer was based on the calculation of 5 kg per 1 ton of fertilizer.

| Table 1. Scheme of experience. |
|-------------------------------|
| Control | Without feeding |
| Variation 1 | NPK - 16:16:16 |
| Variation 2 | NPK - 16:16:16 + biopolymer + water |
| Variation 3 | NPK - 16:16:16 + biopolymer + citric acid solution (5%) |

Evaluation of the effectiveness of biopolymer modification was carried out according to the following parameters: average weight of the sample from the plot, weight of 1000 grains, moisture, protein content, gluten content. The analyses were carried out in the laboratory of MUP "Agroindustrial Business Incubator" (Russian Federation, KBR, Baksansky district, Baksan, Revolutionsnaya St., 1. E-mail: agrolab.ldi@yandex.ru) using near infrared spectroscopy with using the INFRASCAN analyser - 105. GOST 9353-2016. Wheat. Technical conditions Date of analysis 03.07.2019

3. Results and discussion
The results of the experiment indicate that the use of a biopolymer - corn starch as a modifier of mineral fertilizers, entails an increase in the productivity of winter wheat and a change in the qualitative characteristics of grain (table 2).

| Table 2. Mass fraction of protein, moisture, gluten in the grain of wheat. |
|-----------------|-----|------------|--------|-------|--------|
| Variation       | Repetition | Mass sample of 1000 grain weight | Moisture, % | Protein, % | Gluten, % |
| Control         | 1   | 50,26      | 22,0   | 8,7   | 11,76   | 26,95   |
|                 | 2   | 63,34      | 30,0   | 8,5   | 13,00   | 28,65   |
|                 | 3   | 45,06      | 34,0   | 9,1   | 11,65   | 23,68   |
|                 | 1   | 62,72      | 36,0   | 9,0   | 11,23   | 24,38   |
The use of biopolymer in the plant nutrition system significantly increased the productivity of winter wheat, not only in terms of productivity in the control variant, but also in the variant using complex mineral fertilizer (Variation 1). The supply system presented in variation 1, usually is considered as a reference in farms, in connection with which it is more correct to compare the effectiveness of modified supply systems with standard systems.

The grain weight in plots where the biopolymer was used was 71.0 and 68.4 g / plot, which is 22% and 17.5% more than in the reference model (Variation 1).

The change in the mass of 1000 grains under the influence of biopolymer modification of mineral fertilizers depends on the type of liquid that was used in the preparation of the fertilizer. Similarly, in Variation 3, a 5% solution of citric acid was used, in contrast to variation 2 with water. In the case of productivity, the difference between variations 2 and 3 was only 3.8% (figure 1). At the same time, the difference in the mass of 1000 grains in these variants was 9.6% (figure 2). The correlation between the productivity of wheat and a mass of 1000 grains was only \( r = 0.46 \).

| Variation  | 1   | 2   | 3   | 1   | 2   | 3   |
|------------|-----|-----|-----|-----|-----|-----|
| 1          | 2   | 43.12 | 34.0 | 9.3 | 13.54 | 31.79 |
| 2          | 3   | 68.82 | 35.0 | 9.2 | 12.59 | 28.74 |
| 3          | 1   | 61.12 | 34.0 | 9.1 | 10.82 | 23.92 |
| Variation 2| 2   | 77.0  | 36.0 | 9.6 | 11.75 | 23.07 |
| 3          | 3   | 74.84 | 33.0 | 9.4 | 12.09 | 23.68 |
| 1          | 1   | 57.06 | 36.0 | 9.3 | 12.68 | 25.49 |
| Variation 3| 2   | 74.08 | 28.0 | 9.3 | 12.92 | 26.09 |
| 3          | 3   | 74.58 | 30.0 | 9.3 | 13.00 | 26.40 |

Figure 1. Wheat productivity, g / plot.

Figure 2. Mass of 1000 grains (grams).
At the same time, wheat productivity showed a high correlation with the number of stems and amounted to \( r = 0.99 \) (table 2).

**Table 2. The number of stems of wheat. [5].**

| Experiment | Variation | Repetitions | Average |
|------------|-----------|-------------|---------|
| Control    |           | 162, 130, 143 | 145.0   |
| Variation 1|           | 146, 149, 169 | 154.7   |
| Variation 2|           | 192, 167, 155 | 171.3   |
| Variation 3|           | 155, 192, 168 | 171.3   |

The most important indicators of wheat grain quality are protein and gluten content. These parameters determine the nutritional value of the grain.

Assessing the effect of biopolymer modification of the fertilizer system on the quality of winter wheat grain, it should be noted that there is no general pattern in quality parameters. In the case of protein content, the grain selected in variation 3 contains its maximum amount and is 12.9%, which is 0.8% higher than in the control, 0.4 in variation 1 and 1.3% than in variant 2. It also should be noted that during the “earing phase” in the soil samples of variation 3, the maximum content of mineral nitrogen was found to be present (figure 4).

Therefore, the combination of a biopolymer with organic acid allows creation of conditions for plants to incorporate soil nitrogen and mineral fertilizers into their own protein compounds.

In the case of gluten, its minimum proportion is contained in variation 2 using the same biopolymer, but with water, and reaches 23.6%, which is 3.4% less than in the control version and in variation 1 using mineral fertilizers by 4, 7% Biopolymer modification of fertilizers together with citric acid (Variation 3) allows to increase the gluten content in relation to variation 2 by 2.4%. The share of gluten is equivalent to the control variation - 26%, but is inferior to variation 1 using unmodified fertilizers - by 2.3%.
4. Conclusion

Given that the share of high-quality grain in Russia in relation to the total mass remains low, the task of introducing innovative solutions in the field of crop production and agriculture remains relevant. The results of the experiment suggest that biopolymer modification of plant nutrition systems can solve a number of problems: significantly reduce the cost of introducing organic fertilizers, maintain an acceptable ecological and economic balance, increase crop productivity and obtain food grain with acceptable quality characteristics. The work revealed that the combination of organic citric acid and starch as a biopolymer substance for the modification of mineral fertilizers (Variation 3) made it possible to increase grain productivity in relation to the reference option (Variation 1) by 17.5%, to obtain grade 3 grain in accordance with the requirements of GOST R 52554-2006 (protein - 12.9%, gluten 26.0%), as well as increase the supply of mineral nitrogen in the soil by the end of the growing season by 74% (figure 4).

References

[1] Kuznecova L N, Shiryaev A G, Stupakov A V 2016 Biological activity of typical Chernozem depending on the method of processing Saharnaya svekla 1 36-41
[2] Ellert D Y, Reichert E V 2014 The accumulation of nitrates in plants and the quality of winter wheat during the systematic use of fertilizers in the conditions of the Topchikhinsky district of the Altai Territory Bulletin of Altai State University. Series: Biological Sciences. Earth sciences. Chemistry 3/1 (83) 110-3
[3] Linkov S A, Kuznetsova L N, Akinchin A V 2017 Changes in the toxicity and microbiological activity of the soil under the influence of green manure crops and methods of their incorporation Innovations in the agricultural sector: Problems and prospects 3(15) 108-15
[4] Tibirkov A P, Filin V I 2012 The effect of polymer hydrogel and mineral nutrition conditions on the yield and grain quality of winter wheat on light chestnut soils Bulletin of the Lower Volga Agricultural University 3 (27) 1-5
[5] Bamatov I M, Rumyantsev E V, Zanilov A Kh 2019 The influence of biopolymer modification of mineral fertilizers on main agrochemical parameters of soil IOP Conf. Series: Earth and Environmental Science 315 052059