Efficiency of humic and mineral fertilizers in the technology of spring wheat cultivation

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Abstract. The article presents the results of studies on the effect of humic fertilizer Gumostim and mineral fertilizers on the formation of productivity of spring soft wheat varieties Tulaykovskaya 108. The work performed allows us to expand our understanding of the effect of humic acid salts in humic fertilizers on the development of spring wheat and give recommendations on methods for their use in order to increase the yield and quality of household products, preserving the ecological cleanliness of the environment. The research objective is to improve the elements of spring wheat cultivation technology under the conditions of the forest steppe of the Middle Volga region, which allow to optimize the conditions of growth and development through the integrated use of humic and mineral fertilizers. Studies have found that the use of humic fertilizer Gumostim increases field germination of spring wheat seeds by 0.8-1.2%, the net productivity of photosynthesis to 5.16 g/m² × day, ear grain content by 13%, grain weight per plant by 15%, yield by 0.55 t/ha. Mineral fertilizers increase the net productivity of photosynthesis to 5.30 g/m² × day, ear grain content by 36%, spring wheat yield by 1.01 t/ha. The combined use of Gumostim and mineral fertilizers increases the net productivity of photosynthesis to 5.47 g/m² × day, ear grain content by 83%, grain weight per plant by 45.8%, spring wheat yield by 1.55 t/ha.

1. Introduction
In modern conditions of agricultural production, increasing the productivity and quality of agricultural products is a relevant issue. It can be solved using inexpensive organic fertilizers and plant growth stimulants. (Vinogradova et al., 2015). An effective way to apply humic fertilizers is both pre-sowing seed treatment and foliar application. As studies show, humic substances have a positive effect on seed germination, growth, plant development, crop resistance to diseases and adverse environmental conditions, which subsequently leads to an increase in crop yields and the quality of the product (Vinogradova et al., 2015; Pashkova et al., 2016). There are various scientific reports on the use of humic substances for crops. Humic preparations are increasingly used as plant growth stimulants and have a significant effect on plant growth and wheat productivity. (Ložek et al., 1997; Mackowiak et al., 2001; Mirzamasumzadeh, 2011; Shahryari and Mollasadeghi, 2011; Ren et al., 2013; Bezuglova et al., 2019; Marenych et al., 2019; Shakirova et al., 2014; Shahryari et al., 2011; Agafonova et al., 2015).

2. Materials and Methods
The studies were conducted in a stationary field experiment. The soil of the experimental plot is heavy-loamy leached chernozem in terms of particle size distribution. The average humus content in
the arable layer is 5.92%, the soil solution in the arable horizon is slightly acidic (pH salt 5.0–5.1), the content of alkaline hydrolyzable nitrogen is from 81 to 98 mg per 1 kg of soil, the content of mobile phosphorus is average, and the content of potassium is increased.

As an object of research, the spring soft wheat variety Tulaykovskaya 108 was used. Variety of the steppe type. A kind of lutescens. Mid-season, highly stable, medium resistant to lodging. It has complex resistance to brown, stem, yellow rust and powdery mildew. It has good technological and baking qualities.

In accordance with the research program, a two-factor field experiment was laid down according to the following scheme:

Factor A - timing and dose of humic fertilizer Gumostim:
- A<sub>0</sub> - Without fertilizer (control);
- A<sub>1</sub> - Seed treatment (100 ml/t);
- A<sub>2</sub> - Foliar treatment of crops in phase 23* (300 ml/ha);
- A<sub>3</sub> - Seed treatment (100 ml/t) + foliar treatment of crops in phase 23* (300 ml/ha);

Factor B - doses of mineral fertilizers under the predicted yield - 4.0 t/ha:
- B<sub>0</sub> – N<sub>0</sub>P<sub>0</sub>K<sub>0</sub> (control);
- B<sub>1</sub> – N<sub>50</sub>P<sub>25</sub>K<sub>35</sub>.

* Crop development stage scale (international code BBCH 51).

The seeding rate is 5.0 million germinating grains per hectare.

Options in the experiment were placed by the method of split plots. The repetition of the experiment is fourfold. Nitrogen fertilizers were applied for pre-sowing cultivation, phosphate-potassium fertilizers were applied for the main tillage.

One of the new types of fertilizers is peat-based humic fertilizer Gumostim. The preparation is intended to improve the quality and productivity of agricultural crops. Fertilizer is used for seed treatment, foliar application, leguminous, industrial and vegetable crops.

Gumostim is a dark brown liquid that is highly soluble in water. Metabolic acidity is pH 7-9. Mass fraction of humic acids is 2.4-2.7%.

Meteorological conditions for the entire period of research (2016-2018) were generally favorable for the growth and development of spring wheat. The average air temperature was in the range of long-term average values. The largest amount of precipitation during the growing season (239 mm) was noted in 2016. Compared with the average-summer values, the deviation of the indicator was +24 mm. In 2017, the amount of precipitation during the growing season was 175 mm, which is 40 mm lower than the average annual value. In 2018, the amount of precipitation during the growing season was 137.3 mm, which is 18.7 mm lower than the annual average.

3. Results and Discussion

The most important element of the productivity of grain agrocenosis is the formation of its optimal density, i.e., the number of plants per unit area. The density of agrocenosis is largely determined by such basic agrotechnical techniques as the predecessor, tillage, the method of sowing and the seeding rate, which create various conditions for providing plants with ecological resources.

Plant standing density is the main element of agrocenosis productivity, which is formed beginning with the very first stages of plant growth and development till harvesting. The initial indicator of the formation of plant standing density is field germination.

Studies have found that on average over three years of research, pre-sowing seed treatment with humic fertilizer Gumostim increased field germination of spring wheat seeds by 0.8-1.2%. The percentage of plants remained for harvesting was at the same level as compared to the control.

Correlation analysis showed there is an average correlation ratio between field germination of spring wheat plants and gradations of factor A. Moreover, the correlation coefficient was 0.6, and the determination coefficient was 0.36.
Among the totality of factors that determine the growth, development, and overall productivity of plants, the leading role belongs to photosynthesis. Creating optimal conditions for the operation of the photosynthetic apparatus throughout the growing season of plants is a necessary condition for the formation of their high yield.

Management of photosynthesis processes, their regulation is one of the most effective ways to control the production processes of plants, respectively affecting productivity. Plant productivity is determined by the general nature of the growth processes and the growth rate of individual organs, the duration of the plant growing season and the active life of individual organs.

Table 1. Leaf area and photosynthetic activity of spring wheat crops in phase BBCH 51, 2016-2018.

| Factor | Leaf area, thousand m²/ha | Photosynthetic potential (PP), thousand m²/ha×day | Net photosynthesis productivity (NPP), g/m²×day |
|--------|---------------------------|-----------------------------------------------|-----------------------------------------------|
| Without fertilizer (control) | N₀P₀K₀ | 33.68 | 1012.74 | 4.99 |
| | N₅₀P₂₅K₃₅ | 44.90 | 1308.81 | 5.30 |
| | N₀P₀K₀ | 38.68 | 1144.55 | 5.13 |
| | N₅₀P₂₅K₃₅ | 48.63 | 1407.17 | 5.41 |
| Seed treatment (100 ml/t) | N₀P₀K₀ | 36.44 | 1085.53 | 5.07 |
| | N₅₀P₂₅K₃₅ | 46.39 | 1348.15 | 5.34 |
| Foliar treatment of crops in phase 23 (300 ml/ha) | N₀P₀K₀ | 39.83 | 1175.04 | 5.16 |
| | N₅₀P₂₅K₃₅ | 51.02 | 1470.12 | 5.47 |
| Seed treatment (100 ml/t) + foliar treatment of crops in phase 23 (300 ml/ha) | N₀P₀K₀ | 38.68 | 1144.55 | 5.13 |
| | N₅₀P₂₅K₃₅ | 48.63 | 1407.17 | 5.41 |

On average, over three years of research, seed treatment with Gumostim fertilizer increased the assimilation surface by 8.3-14.8%, compared with the control variant. The treatment of crops with Gumostim fertilizer in phase 23 increased the leaf area by 3.3–8.1%. In variants with the combined treatment of seeds and crops with Gumostim fertilizer, the leaf area was formed in the range of 39.83 thousand m²/ha. Mineral fertilizers increased leaf area by an average of 25.7-33.3%. The largest leaf area was noted in the variants with the combined treatment of seeds and crops with Gumostim fertilizer and mineral fertilizers (51.02 thousand m²/ha).

For the formation of a high crop, a long activity of the assimilating surface is necessary, that is, a high value of the photosynthetic potential, the highest value of which (1470.12 thousand m²/ha × day) was noted in the variants with the combined treatment of seeds and crops with Gumostim fertilizer and mineral fertilizers.

The efficiency of the leaf apparatus of plants finds its final expression in the net productivity of photosynthesis (NPP). The highest value of this indicator (5.47 g/m² × day) was noted in the variants with the combined treatment of seeds and crops with Gumostim fertilizer and mineral fertilizers.

Crop yield is mainly determined by three components: the number of productive stems per area unit, the number of grains in the ear and the weight of the grain. The research results show that the studied factors have an uneven effect on the elements of the structure of the spring soft wheat crop.

Productive bushiness during the research period changed insignificantly and was within the limits of the mathematical error of the experiment. Another important indicator determining the yield of wheat is the number of grains in the ear. The treatment of seeds and crops with Gumostim fertilizer increased the ear grain content by 2.8 pcs. compared to control. The introduction of doses of mineral fertilizers led to an increase in spike grains by 36%. An indicator closely related to the ear grain content is the weight of grain per plant, which increased by 1.45 times in the variants with combined application of humic (seed treatment + foliar treatment of crops) and mineral fertilizers.
Crop yield is a relative manifestation of potential productivity under given conditions of plant growth and development.

Table 2. The yield of spring wheat according to the options of experience, t/ha.

| Factor | A - term and dose of application of humic fertilizer Gumostim | B - the dose of mineral fertilizers for the predicted yield | Year         | Average |
|--------|------------------------------------------------------------|----------------------------------------------------------|--------------|---------|
|        |                                                             |                                                          | 2016         | 2017    | 2018    |        |
| Without fertilizer (control) | N₀P₀K₀ | 3.01 | 3.38 | 3.10 | 3.16 |
| Seed treatment (100 ml/t) | N₀P₀K₀ | 3.46 | 3.83 | 3.54 | 3.61 |
| Foliar treatment of crops in phase 23 (300 ml/ha) | N₀P₀K₀ | 4.12 | 5.15 | 4.23 | 4.50 |
| Seed treatment (100 ml/t) | N₀P₀K₀ | 3.33 | 3.49 | 3.41 | 3.41 |
| + foliar treatment of crops in phase 23 (300 ml/ha) | N₀P₀K₀ | 3.91 | 4.97 | 4.02 | 4.30 |
| least significant difference (LSD) for factor A | N₀P₀K₀ | 3.56 | 3.91 | 3.67 | 3.71 |
| p = 0.05 for the interaction of factors A and B | N₀P₀K₀ | 4.37 | 5.27 | 4.50 | 4.71 |

Studies have established the influence of the studied factors on the yield of spring wheat. Presowing seed treatment with the Gumostim fertilizer (100 ml/t) on average over the years of research led to an increase in yield by 0.45 t/ha in variants without mineral fertilizers and by 1.34 t/ha with mineral fertilizers. Foliar treatment of crops in phase 23 (300 ml/ha) provided an increase in productivity at the level of 0.25 t/ha in variants without mineral fertilizers and 1.14 t/ha with mineral fertilizers. Combined treatment of seeds and vegetative plants led to an increase in productivity by 0.55 t/ha and 1.55 t/ha, respectively.

Mineral fertilizers in a dose of N₀P₀K₀ increased the yield of spring wheat to 4.17 t/ha in the variants without Gumostim fertilizer; up to 4.50 t/ha in variants with presowing seed treatment with Gumostim fertilizer; up to 4.71 t/ha in variants with combined treatment of seeds and vegetative plants with Gumostim fertilizer.

4. Conclusion

Studies have established the effectiveness of humic fertilizer Gumostim. Presowing seed treatment with humic fertilizer Gumostim increased field germination of spring wheat seeds by 0.8-1.2%. The treatment of seeds and crops with Gumostim fertilizer in variants without the use of mineral fertilizers increased the net productivity of photosynthesis to 5.16 g/m² × day, ear grain content by 2.8 pcs., grain weight per plant by 15%. In the variants with application of Gumostim and mineral fertilizers, the net productivity of photosynthesis increased to 5.47 g/m² × day, the ear grain content by 17.6 pcs., the grain weight per plant by 45.8%. The greatest increase in spring wheat productivity (1.55 t/ha) was observed in the variants with application of Gumostim and mineral fertilizers. Thus, it should be noted that humic fertilizer Gumostim does not have such a significant effect on crop productivity, in comparison with mineral fertilizers. However, due to their low cost, they can be quite effectively used in agricultural production.

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