Dependence of winter wheat productivity on mineral nutrition and growth stimulants

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Abstract. In the experiment, four varieties of winter wheat (Don 93 – standard, Krasa of Don, Lilit, Kapitan) and four levels of mineral nutrition (1. Ammophos 60 kg/ha when sowing; 2. Ammophos 60 kg/ha when sowing, Polydon Biouniversal 0.5 l/ha in the tillering phase, Polydon Biouniversal 0.5 l/ha in the earing phase; 3. Ammophos 60 kg/ha when sowing, spring tillering ammonium nitrate 130 kg/ha, Polydon Biouniversal 0.5 l/ha in the tillering phase, Polydon Biouniversal 0.5 l/ha in the earing phase; 4. Ammophos 60 kg/ha during sowing, spring tillering ammonium nitrate 130 kg/ha) were considered. According to the level of mineral nutrition, the lowest biological yield was formed at the first level of nutrition. At the third level of nutrition, the largest biological yield was formed. On average, for three years of research, it was in the Don-93 variety by 0.54 t/ha more than at the first level, in the Kapitan variety by 0.66 t/ha more than at the first level, in the Krasa of Don variety by 0.81 t/ha more than at the first level and in the Lilit variety by 0.89 t/ha more than at the first level.

1. Introduction
Almost all over the world, wheat is considered to be the most valuable food and feed crop. Winter wheat grain, as a rule, occupies the main place, as it is rich in gluten proteins and other valuable substances, so it is very often used in the food industry, especially in baking, as well as in the production of such cereals as semolina, artek, poltava, spelt and other grocery products. In addition, alcohol, pasta, vermicelli, pectin, glue can be obtained from wheat grain [1, 2].

Wheat grain in its composition contains quite a lot of substances that are very necessary for humanity for life support. The main of these substances, which determine the main nutritional value of grain, are rightfully considered to be proteins and carbohydrates, as well as fiber and minerals [3, 4, 5].

The basis of any technology of cultivation of a particular crop is a complex of agrotechnical techniques that are performed in a certain sequence, and are primarily aimed at meeting the requirements of the biology of the culture. In this regard, it is important to know the biological and morphological features of the cultivated crop [6, 7, 8].

The use of optimal doses of mineral fertilizers and the use of growth regulators and stimulators of a new generation with the use of nanotechnologies makes it possible to form guaranteed yields and high-quality grain [9, 10, 11, 12].
In this regard, it is important to have new knowledge about the effectiveness of the use of mineral fertilizers in the cultivation of winter wheat.

2. Materials and methods

The soil of the experimental site according to the granulometric composition is an average loam, the humus content in the arable soil layer is 3.7-3.8%, the content of P₂O₅ - 20.25-21.6 mg/kg of soil, K₂O - 335-315 mg/kg of soil, hydrolyzable nitrogen 84-68.6 mg/kg of soil, the reaction of water extraction (pH 7.4), the content of B - 0.8-1.2, Mn - 4.2-7.2, Zn - 0.2-0.45, Si - 0.03-0.04, Co - 0.03-0.04 mg/kg of dry soil.

The hydrothermal coefficient, which is the most perfect indicator of the level of moisture supply of the territory, during the spring vegetation of winter wheat in 2017 was 0.8 units, in 2018 0.6 units, in 2019 0.8 units, which characterizes the growing conditions of winter wheat in the experiment in 2017 and 2019 as dry, in 2018 as very dry.

In the experiments, along with traditional fertilizers (ammophos, ammonium nitrate), a multicomponent organomineral complex of the latest generation Polydon Biouniversal is used. Complexes of food elements with polysaccharides that have a fast penetrating effect, antidotes, immunomodulators and selected taking into account the needs of each culture. The active ingredients of Polydon Biouniversal are humic and fulvic acids, growth substances of natural origin (auxins, cytokinins, brassinolides), trace elements, amino acids and polysaccharides. The introduction of the drug Polydon Biouniversal was carried out by fine spraying. The optimal dosages in this zone with the existing level of moisture supply are 0.5 liters/ha, that is, 0.5 liters per 10,000 square meters, or 4 million plants, which from our point of view allows them to be attributed to nano-particles. For comparison, we can say that the rate of application of ammonium nitrate in one top dressing is on average 100 kg/ha in physical weight, that is, 200 times more.

In the experiment, four varieties of winter wheat (Don 93 – standard, Krasa of Don, Lilit, Kapitan) and four levels of mineral nutrition (1. Ammophos 60 kg/ha when sowing; 2. Ammophos 60 kg/ha when sowing, Polydon Biouniversal 0.5 l/ha in the tillering phase, Polydon Biouniversal 0.5 l/ha in the earing phase; 3. Ammophos 60 kg/ha when sowing, spring tillering ammonium nitrate 130 kg/ha, Polydon Biouniversal 0.5 l/ha in the tillering phase, Polydon Biouniversal 0.5 l/ha in the earing phase; 4. Ammophos 60 kg/ha during sowing, spring tillering ammonium nitrate 130 kg/ha) were considered.

Sowing was carried out on time with a seeder SZ-3.6 with the same seeding rate - 4.0 million pcs/ha of germinating seeds and a seed depth of 5-6 cm.

In the experiment, phenological observations were carried out, the study of biometric indicators, such as plant height, ear length, counting the elements of the crop structure – the number of productive stems, the mass of 1000 grains, the number of grains in the ear, the weight of grain from one ear.

3. Results and discussion

On average, for three years, the largest number of productive stems, 487 pieces per square meter, was formed in the Krasa of Don variety at the third level of mineral nutrition. In the Lilit variety, at the same level of nutrition, productive stems were formed by 12 pcs/m² less, in the Kapitan variety, at the same level of nutrition, productive stems were formed by 19 pcs/m² less than in the Krasa of Don variety. The Don 93 variety, which is considered the standard in the region, had 443 productive stems/m² at the first level of nutrition.

According to the level of mineral nutrition, the smallest number of productive stems was formed at the first level of nutrition, at which no fertilizing was carried out, only 60 kg/ha of ammophos was introduced during sowing. The smallest number of productive stems at this level of nutrition was in the Don 93 variety. In 2017, it was 442 pcs/m². In 2018, 449 pcs/m². In the Kapitan variety, the number of productive stems was 6 pcs/m² more, in the Lilit variety by 10 pcs/m² more, in the Krasa of Don variety by 24 pcs/m² more. In 2019, the number of productive stems was 437 pcs/m². In the Kapitan variety, the number of productive stems was 2 pcs/m² more, in the Lilit variety 6 pcs/m² more, in the Krasa of
Don variety 20 pcs/m² more. On average, in 2017-2019, the number of productive stems of the Don 93 variety at the first nutrition level was 443 pcs/m². The Kapitan variety had 4 more productive stems per m², the Lilit variety had 8 more stems per m², and the Krasa of Don variety had 22 more stems per m² (Figure 1).

Figure 1. The number of productive stems, average for 2017-2019, pcs/m².

On average, for 2017-2019, the weight of grain from one ear of winter wheat ranged from 0.93 grams for the Don 93 variety at the first level of mineral nutrition to 1.16 grams for the Krasa of Don variety at the third level of nutrition. At the first level of mineral nutrition, the weight of grain from one ear was from 0.93 grams for the Don 93 variety to 1.04 grams for the Krasa of Don variety.

At the second level of mineral nutrition, the weight of grain from one ear of the Don 93 variety and the Krasa of Don was 0.04 grams more, the Kapitan variety was 0.06 grams more, and the Lilit variety was 0.08 grams more than at the first level. At the fourth level of mineral nutrition, the weight of grain from one ear of the Don 93 variety was 0.07 grams more than at the first level, the Kapitan variety was 0.08 grams more than at the first level, the Krasa of Don variety was 0.10 grams more than at the first level and the Lilit variety was 0.13 grams more than at the first level.

At the third level of nutrition, the largest mass of grain from one ear was formed. On average, for three years of research, it was in the Don 93 variety by 0.09 grams more than at the first level, in the Kapitan variety by 0.10 grams more than at the first level, in the Krasa of Don variety by 0.12 grams more than at the first level and in the Lilit variety by 0.14 grams more than at the first level (Figure 2).

In 2017, the highest biological yield of 5.64 t/ha was formed at the third level of mineral nutrition in the Krasa of Don variety. In the Lilit variety, at the same level of nutrition, the biological yield was formed by 0.48 t/ha less, in the Kapitan variety, at the same level of nutrition, the biological yield was 0.75 t/ha less than in the Krasa of Don variety. The Don 93 variety, which is considered the standard in our region, at the same level of nutrition, the biological yield was less than that of all other varieties and was equal to 4.67 t/ha.
According to the level of mineral nutrition, the lowest biological yield was formed at the first level of nutrition, at which no fertilizing was carried out, only 60 kg/ha of ammophos was introduced during sowing. The lowest biological yield of 4.11 t/ha at this level of nutrition was in the Don-93 variety. In the Kapitan variety, the biological yield was 0.14 t/ha higher, in the Lilit variety by 0.20 t/ha more, in the Krasa of Don variety by 0.71 t/ha more (Figure 3).

In 2018, the highest biological yield of 5.72 t/ha was formed at the third level of mineral nutrition in the Krasa of Don variety. In the Lilit variety, at the same level of nutrition, the biological yield was formed by 0.48 t/ha less, in the Kapitan variety, at the same level of nutrition, the biological yield was 0.78 t/ha less than in the Krasa of Don variety. At the same level of nutrition, the biological yield of the Don 93 variety was less than that of all other varieties and was equal to 4.73 t/ha.

According to the level of mineral nutrition, the lowest biological yield was formed at the first level of nutrition, at which no fertilizing was carried out, only 60 kg/ha of ammophos was introduced during sowing. The lowest biological yield of 4.19 t/ha at this level of nutrition was in the Don-93 variety. In the Kapitan variety, the biological yield was 0.16 t/ha higher, in the Lilit variety by 0.24 t/ha more, in the Krasa of Don variety by 0.75 t/ha more.

In 2019, the highest biological yield of 5.58 t/ha was also formed at the third level of mineral nutrition in the Krasa of Don variety. In the Lilit variety, at the same level of nutrition, the biological yield was formed by 0.38 t/ha less, in the Kapitan variety, at the same level of nutrition, the biological yield was 0.70 t/ha less than in the Krasa of Don variety. In the Don 93 variety, at the same level of nutrition, the biological yield was less than in all other varieties and was equal to 4.59 t/ha.

According to the level of mineral nutrition, the lowest biological yield was formed at the first level of nutrition, at which no fertilizing was carried out, only 60 kg/ha of ammophos was introduced during sowing. The lowest biological yield of 4.05 t/ha at this level of nutrition was in the Don 93 variety. In the Kapitan variety, the biological yield was 0.10 t/ha higher, in the Lilit variety by 0.18 t/ha more, in the Krasa of Don variety by 0.69 t/ha more.

On average, in 2017-2019, the highest biological yield of 5.65 t/ha was formed in the Krasa of Don variety at the third level of mineral nutrition. In the Lilit variety, at the same level of nutrition, the biological yield was formed by 0.43 t/ha less, in the Kapitan variety, at the same level of nutrition, the biological yield on average for 2018-2019 was 0.74 t/ha less than in the Krasa of Don variety. The Don
93 variety, which is considered the standard in our region, at the same level of nutrition, the biological yield was less than that of all other varieties and was equal to 4.66 t/ha.

According to the level of mineral nutrition, the lowest biological yield was formed at the first level of nutrition, at which no fertilizing was carried out, only 60 kg/ha of ammophos was introduced during sowing. At the first level of mineral nutrition, the biological yield was from 4.12 t/ha for the Don 93 variety to 4.84 t/ha for the Krasa of Don variety.

At the second level of mineral nutrition, the biological yield of the Krasa of Don variety was 0.23 t/ha, the Don 93 variety was 0.24 t/ha, the Kapitan variety was 0.34 t/ha, and the Lilit variety was 0.50 t/ha higher than at the first level. At the fourth level of mineral nutrition, the biological yield of the Don 93 variety was 0.39 t/ha more than at the first level, the Kapitan variety was 0.54 t/ha more than at the first level, the Krasa of Don variety was 0.55 t/ha more than at the first level and the Lilit variety was 0.68 t/ha more than at the first level.

At the third level of nutrition, the largest biological yield was formed. On average, for three years of research, it was in the Don 93 variety by 0.54 t/ha more than at the first level, in the Kapitan variety by 0.66 t/ha more than at the first level, in the Krasa of Don variety by 0.81 t/ha more than at the first level and in the Lilit variety by 0.89 t/ha more than at the first level.

![Figure 3. Biological yield, average for 2017-2019, t/ha.](image)

On average, in 2017-2019, in our experiments, the lowest protein content was observed at the first nutrition level from 10.4% in the Don 93 variety and Lilit variety to 11.5% in the Kapitan variety. At the second level of nutrition, the protein content was from 10.6% in the Don 93 variety to 11.6% in the Kapitan variety. At the fourth level of mineral nutrition, the protein content of all varieties was higher than at the first and second levels of nutrition, but less than at the third level. The highest protein content was at the third level with the use of ammophos, ammonium nitrate and Polydon Biouniversal from 11.0% in the Don 93 variety to 12.3% in the Kapitan variety (Figure 4).
4. Conclusion
Thus, in our experiments in 2017-2019, the advantage of the drug Polydon Biouniversal was proved, which was used in the phase of spring tillering and earing of various varieties of winter wheat at a dose of 0.5 liters per hectare. In the variant with the use of Ammophos 60 kg/ha for sowing, ammonium nitrate 130 kg/ha in the spring tillering phase and Polydon Biouniversal 0.5 l/ha in the tillering phase, all four studied varieties of soft winter wheat Don 93, Krasa of Don, Lilit and Kapitan showed a greater number of productive stems per unit area, the largest grain weight per ear, the maximum biological yield, the highest protein content in the grain.

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