Influence of zircon, mineral fertilizers on spring wheat yield in gray forest soils of the Republic of Tatarstan

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Abstract. The formation of the yield by crops is influenced by many factors and the state of the plant itself. The purpose of the study is to determine the efficacy of the preparation Zircon in combination with mineral fertilizers and seed protectant for the formation of spring wheat yield. The research is conducted at the experimental field of the Kazan State Agrarian University in years 2016-2018, with Yoldyz, a regional variety of spring wheat. Seed treatment with growth regulator Zircon increases yield on the background without fertilizers amounts to 0.14 t/ha and 0.21 t/ha without fertilizers and with fertilizers, respectively. Seed treatment with growth regulator Zircon and protectant Dospekh 3 provides the yield increase of 0.18 t/ha without fertilizer additions. When fertilizers are added yield increases by 0.29 t/ha and 0.35 t/ha, for N61P55K55 and N120P126K97, respectively. In this case, return of fertilizers of the grain per 1 kg D. V. makes fertilizers N61P55K55 increase to 7.89 kg, while N120P126K97 amount to 5.57 kg.

1. Introduction
Development of technologies for the production of high-quality grain of spring wheat remains one of the most important tasks of Tatarstan farmers. For this early spring crop it is very important to form even, good quality shoots on the field at the very beginning of vegetation [1-3]. Spring wheat in the phase of seedlings is sensitive and suffers from insufficient quantities of nutrients and moisture in the soil, competes poorly with weeds. The possibility of assimilation of macro- and microelements is influenced by the physical and chemical properties of the soil, water, temperature and air regimes, the life activity of soil organisms and the state of the plants themselves [4-6].

One of the attractive ways to increase crop productivity is the use of growth regulators seed and vegetating plant treatment. Among the various chemicals used in agriculture, Zircon has a certain value as a tool that is used in small doses (0.1–4 mg/ha). It is classified as biologically active compound of the new generation active substances which is a mixture of hydroxycinnamic acids extracted from Echinacea purpurea [7-9]. Research in biochemistry of phenolic compounds, including hydroxycinnamic acids proves that these compounds are actively involved in the major life processes of plants. They participate in the processes of growth, regulating the level of auxins, in the process of plant respiration and in the protective mechanisms of plant resistance to the attack of the pathogen [10, 11].
The purpose of the study is to determine the effectiveness of the preparation of Zircon in combination with mineral fertilizers and seed protectant for the formation of spring wheat crop.

2. Material and methods
Field experiments and laboratory studies were carried out in 2016-2018, on the basis of the "Kazan state agrarian university". The soil of experimental field is grey forest, medium loamy. The content of easily hydrolyzed nitrogen in the arable horizon (according to Cornfield) is 105-122 mg/kg of soil, mobile phosphorus and exchangeable potassium according to the Kirsanov method, respectively – 204-208 and 91-98 mg/kg of soil; the pH of the salt extract was 5.5.

Two-factor field experiments were carried out according to the following scheme:
Factor a (fertilizer) – without fertilizer (control) fertilizer (N61P55K55) balance method at the planned grain yield of 3 t/ha; fertilizer (N120P126K97) balance method at the planned grain yield of 4 t/ha;
Factor B (seed pre-treatment) – without treatment (control); growth regulator Zircon (1.2 l/t); protectant fungicide Armor 3 (1.5 l/t); growth regulator Zircon (1.2 l/t) + protectant fungicide Armor 3 (1.5 l/t). Seeds were treated with growth regulator Zircon (D. V. 0.1 g/l) dose of 1.2 l/t and fungicide with protectant Armor 3, CS (60 g/l of thiabendazole + 60 g/l of tebuconazole + 40 g/l imazalil) dose of 1.5 l/t semi-dry method with the working solution flow rate of 10 l/T. the Experiments were designed in triplicates. The placement of plots is sequential. The accounting area of plots is 25 m2. Predecessor – winter rye. Seeded varieties of spring soft wheat are Yoldyz. Primary tillage consisted of plowing the plough PN-4-35 to a depth of 22-24 cm, with a preliminary shallow plowing 6-8 cm

Economic indicators of wheat cultivation were calculated on the basis of technological maps for each option. The purchase price of 1 ton of grain is 6000 rubles.

Mathematical processing of the results of the field experiment was carried out by B. A. Dospekhov using a program for Microsoft Excel [12].

Increased temperatures and insufficient rainfall in May and June 2016 had a negative impact on spring wheat crops, a reduction in the growing season and a decrease in yield. Weather conditions in 2017 were favorable for the formation of the wheat crop. The late arrival of spring in 2018 did not have a strong negative impact on the yield of spring wheat in Tatarstan.

3. Results and discussions
In laboratory studies to determine the energy of germination and germination of spring wheat seeds revealed that at a temperature in the thermostat +10°C on the control is relatively large germination energy – 88 %, and the minimum value of 68 %, at a temperature of 20°C (Figure 1).

![Figure 1. The energy of germination of spring wheat seeds depending on the treatment of Zircon and the temperature in the thermostat, %.

When seeds were treated with Zircon, the germination energy and laboratory germination increased in comparison with the control (Figure 2). Different concentrations of the drug on the above indicators were not significantly affected.

Figure 2. Laboratory germination of spring wheat seeds depending on the treatment with Zircon and temperature in the thermostat, %.

Field experiments conducted in different years in the beginning of spring differ in the temperature regime, the heating of the upper soil layer. The introduction of calculated doses of mineral fertilizers contributed to the increase in the safety of spring wheat seedlings at the time of harvesting by 10-12 %.

The use of the Zircon growth regulator in pre-sowing treatment of seeds on the background without fertilizers and on fertilized backgrounds improved the safety of seedlings by 1 and 2 % (Figure 3). This trend of influence on the safety of plants was and the joint use of growth regulator Zircon and protectant Armor 3.

During the years of research, the moisture reserves in the meter layer of soil by the time of sowing were 162-170 mm, and by the phase of exit into the tube decreased to 80-83 mm, by the time of harvesting to 67-70 mm. During the growing season of spring wheat in 2016, only 72 mm of precipitation fell, and in 2017 – 188 mm, in 2018 – 112 mm.

Figure 3. Safety of the seedlings of spring wheat to harvest, depending on the use of growth regulator, fungicide and fertilizer, 2016-2018.
The average yield of spring wheat for 2016-2018 against the background of no fertilizer was 1.48 t/ha, fertilized N61P55K55 – 2.61 t/ha, fertilized N120P126K97 – 3.13 t/ha (Table 1).

**Table 1.** Productivity of spring wheat with the use of Zircon and fertilizers, 2016-2018.

| Nutrients (Factor A) | Seed treatment (Factor B) | Yield, t/ha | ± difference from background | ± difference from seed treatment |
|---------------------|---------------------------|-------------|-----------------------------|-------------------------------|
|                     |                           | 2016        | 2017 | 2018 | Average |                               |                               |
| Without fertilizers |                           |             |      |      |         |                               |                               |
| Zircon              | Control                   | 1.35        | 1.52 | 1.27 | 1.38    | -                              | -                              |
|                     | Zircon                    | 1.44        | 1.69 | 1.42 | 1.52    | -                              | +0.14                          |
|                     | Protectant                | 1.42        | 1.65 | 1.35 | 1.47    | -                              | +0.09                          |
|                     | Zircon + Protectant       | 1.46        | 1.73 | 1.48 | 1.56    | -                              | +0.18                          |
|                     | Average                   | 1.42        | 1.65 | 1.38 | 1.48    | -                              | -                              |
| N61P55K55 per 3 t of seeds | Control                   | 1.91        | 2.96 | 2.46 | 2.44    | +1.06                          | -                              |
|                     | Zircon                    | 2.06        | 3.19 | 2.69 | 2.65    | +1.27                          | +0.21                          |
|                     | Protectant                | 2.05        | 3.16 | 2.65 | 2.62    | +1.24                          | +0.18                          |
|                     | Zircon + Protectant       | 2.14        | 3.28 | 2.76 | 2.73    | +1.35                          | +0.29                          |
|                     | Average                   | 2.04        | 3.15 | 2.64 | 2.61    | +1.13                          | -                              |
| N120P126K97 per 4 t of seeds | Control                   | 2.17        | 3.93 | 2.73 | 2.94    | +1.56                          | -                              |
|                     | Zircon                    | 2.33        | 4.16 | 2.96 | 3.15    | +1.77                          | +0.21                          |
|                     | Protectant                | 2.32        | 4.15 | 2.93 | 3.13    | +1.75                          | +0.19                          |
|                     | Zircon + Protectant       | 2.43        | 4.32 | 3.12 | 3.29    | +1.91                          | +0.35                          |
|                     | Average                   | 2.31        | 4.14 | 2.93 | 3.13    | +1.65                          | -                              |
| Average             |                           |             |      |      |         |                               |                               |
| Control             |                           | 1.81        | 2.80 | 2.15 | 2.25    | -                              | -                              |
|                     | Zircon                    | 1.94        | 3.01 | 2.36 | 2.44    | -                              | +0.19                          |
|                     | Protectant                | 1.93        | 2.99 | 2.31 | 2.41    | -                              | +0.16                          |
|                     | Zircon + Protectant       | 2.01        | 3.11 | 2.45 | 2.53    | -                              | +0.28                          |
|                     | Average                   | 1.92        | 2.98 | 2.32 | 2.32    | -                              | -                              |
| HCP05 (A)           |                           | 0.13        | 0.35 | 0.25 | 0.25    |                              |                               |
| HCP05 (B, AB)       |                           | 0.05        | 0.12 | 0.08 | 0.08    |                              |                               |
| HCP05 (for part. average) |                     | 0.05        | 0.14 | 0.10 | 0.10    |                              |                               |

When using N61P55K55 was made to 171 kg/ha mineral fertilizers, providing on average 1.13 t/ha increase. The payment of the grain 1 kg D. V. fertilizer averaged 6.6 kg against the background N120P126K97 the payment of the grain 1 kg D. V. fertilizer averaged 4.8 kg. seed treatment with growth regulator Zircon yield increase on the background without fertilizers amounted to 0.14 t/ha on fertilized backgrounds – 0.21 t/ha. Presowing seed treatment with growth regulator Zircon and protectant Armor 3 provided the yield increase in fertilized without the background of 0.18, and the fertilized N61P55K55 and N120P126K97, respectively, at 0.29 and 0.35 t/ha. In this case, the payment of the grain 1 kg D. V. made fertilizers when N61P55K55 increased to 7.89 kg, while N120P126K97 amounted to 5.57 kg.
4. Conclusions
The use of mineral fertilizers in combination with the use of Zircon growth regulator and seed protectant provided an increase in plant safety by 12-14%, an increase in the yield of spring wheat by 0.29 and 0.35 t/ha, grain payment of 1 kg of mineral fertilizer to 7.89 kg.

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