Growth-stimulating role of chelates and organic acids

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Abstract. The effect of chelating forms of copper and zinc and organic acids on germination, germination energy, and morphometric parameters of Triticum aestivum seedlings in an in vitro culture was experimentally established. The most effective growth regulators were identified, and their optimal doses for pre-sowing treatment of seeds were also established.

1. Introduction

Research on the effectiveness of the use of various growth regulators in agricultural technologies in the conditions of risky farming in the Omsk region is relevant and practically significant. One of the reserves for increasing the productivity of agricultural crops is the use of physiologically active substances that have a regulatory effect on the growth and development of plants, activate the metabolism of biochemical processes in them and increase the adaptive properties of the plant organism to environmental factors [1, 2]. Studies in this direction indicate a positive effect of chelates, growth stimulants on drought and frost resistance of plants, increased immunity against pathogenic microflora [3-5].

Agrochemical science fruitfully develops and recommends modern plant growth regulators to the agricultural sector, and their volumes are steadily increasing. In the Russian Federation, more than 40 growth regulators of various chemical nature are registered. Substances of this class have high physiological activity during critical periods of plant ontogenesis. Seed germination is a complex multi-stage process of transition of the future plant from heterotrophic to autotrophic type of nutrition, the formation of the most important structures from the seed embryo that determine its ability to develop in the soil [3, 4]. Activation of the process of seed germination using growth regulators ensures, according to the authors of [2, 6, 7], the homogeneity of the morphological and physiological parameters of plants.

In plant growing, microelements and organic acids are widely used as growth-promoting preparations. It is known that trace elements have a significant effect on the course of biochemical processes associated with enzyme activity [8, 9]. Cereal crops, including spring soft wheat, are especially sensitive to a deficiency of Cu and Zn and therefore are responsive to fertilizer with these trace elements. Among the agrochemicals containing trace elements currently on the market, chelates
are promising. The question of choosing the optimal concentration of a solution of the chelated form of copper and zinc for pre-sowing seed treatment depending on soil and climatic conditions, culture, and other factors has not been resolved [9, 10].

Bifunctional carboxylic acids (succinic and citric) also have biostimulating properties of plant growth and development and are used in crop production in the form of aqueous solutions with a concentration of $10^{-2} - 10^{-3}$% for presowing treatment of seeds and spraying plants [11].

In our experiment, when choosing the concentration of solutions for seed treatment, we relied not only on published data, but also on our previous studies [10].

The purpose of the work is to study the effect of presowing seed treatment with growth stimulants (chelates and organic acids) on the parameters of seed germination of spring common wheat.

2. Conditions of the experiment
The studies were conducted at the Federal State Budgetary Scientific Institution “Omsk ANC” in the laboratory of agrochemistry and plant protection. The object of research is spring soft wheat, lat. *Triticum aestivum*. The influence of growth regulators on germination energy, seed germination and germination intensity was studied under laboratory conditions (at the level of seedlings) in 2017-2018. Chelate forms of micronutrient fertilizers (organic compounds Cu-EDTA, Zn-EDTA based on ethylenediaminetetraacetic acid EDTA) and organic growth stimulants: succinic acid (*ethane-1,2-dicarboxylic acid*) and citric acid (*2-hydroxypropane-1,2,3-tricarboxylic acid*) were used as growth regulators.

Laboratory experiments to determine the sowing qualities of seeds were carried out according to GOST 12038-84. Seeds were germinated in Petri dishes on filter paper in a thermostat at a temperature of 20 °C. In each cup were placed 10 seeds treated with distilled water (control version) and solutions of the drugs in the studied concentrations (experimental versions): chelates: 2) Zn-EDTA (0.1%); 3) Cu-EDTA (0.02%); 4) Zn-EDTA (0.24%); 5) Cu-EDTA (0.25%); organic acids: 6) succinic acid (0.02%); 7) citric acid (0.02%). The repetition of the experiment was 8-fold; the seeds were treated with a working solution of 7 l per 100 kg of grain. Calculation of the concentrations of the chelates used was performed per element. Treated and dried seeds were poured with distilled water in a volume of 7 ml for each Petri dish. Accounting for germinated seeds was carried out in two terms. In the first (after the 3rd day) germination energy was determined, during the second (on the 7th day) - germination. Germinating seeds included those in which a sprout and normal root development were noted. In this case, the main root along the length should be no less than the seed, and the sprout should be no less than half the seed. After the experiment (on the 7th day), the length of the sprout and root and their mass per 100 seedlings were determined. Statistical processing and graphical presentation of the results was performed using Microsoft Office Excel 7.0.

3. Results of the experiment
Russian and foreign experience of researchers indicates that the germination energy acts as one of the essential parameters of seed viability and is the most sensitive element of their condition. However, in agronomic practice, the indicator of laboratory germination serves as the main criterion for assessing the quality of seed, because the result of a laboratory test shows the percentage of seeds that gave seedlings under standardized conditions of substrate, humidity, temperature and guarantees reproducibility of the result.

It was experimentally established that growth regulators during the juvenile ontogenesis of wheat seedlings did not significantly affect the energy of seed germination. It should be noted that in this case, a positive tendency was found to increase laboratory germination of seeds in pre-sowing seed treatment with Zn-EDTA solutions at a concentration of 0.1%, while Zn-EDTA at a concentration of 0.24%, citric acid at a concentration of 0.02% (figure 1). When treating seeds with a Cu-EDTA solution at a concentration of 0.25%, there was a tendency to a decrease in the germination energy and laboratory germination of seeds relative to the control by 4.4% and 1.7%, respectively. The increase in
germination, especially in uncontrolled conditions, is important, as it determines the density of standing, the size of the assimilation surface, and hence the crop as a whole.

Figure 1. Increase of laboratory germination of seeds in pre-sowing seed treatment with Zn-EDTA solutions.

The response of seedlings to various types of growth stimulators was evaluated by a change in the most important morphometric indicators. The formation of biomass at the germination stage was estimated by measuring the mass of seedlings and roots. An analysis of the data showed that the values of the morphometric parameters of spring wheat varied depending on the factors studied. An important indicator of plant rhizogenesis in an in vitro culture is the length of the roots. A significant increase in the length of the roots in the variants of the use of chelates has been established. Presowing treatment with Cu-EDTA (0.02%) provided an increase in root length by 6% compared to the control. An increase in the length of the seedling was also in this variant - by 12.5% (table 1).

Table 1. The effect of presowing treatment with copper and zinc chelates on the morphometric parameters of wheat seedlings.

| Option                  | Root length, cm | Length of seedling, cm | Wet weight, g/100pcs | Dry mass, g/100pcs |
|-------------------------|-----------------|------------------------|----------------------|-------------------|
|                         |                 |                        | seedlings            | roots             |
| Control                 | 11.7±0.4        | 8.0±0.3                | 5.46±0.01            | 0.61±0.01         |
| Zn-EDTA (0.1%)          | 10.8±0.5        | 7.9±0.1                | 5.40±0.07            | 0.65±0.01         |
| Cu-EDTA (0.02%)         | 12.4±0.5        | 9.0±0.0                | 5.80±0.20            | 0.63±0.00         |
| Zn-EDTA (0.24%)         | 11.2±0.6        | 8.0±0.1                | 5.73±0.33            | 0.64±0.01         |
| Cu-EDTA (0.25%)         | 10.4±0.9        | 8.7±0.2                | 6.07±0.13            | 0.70±0.05         |
| HCP05                   | 0.50            | 0.46                   | 0.32                 | 0.05              |

The treatment of seeds with growth stimulants also influenced the accumulation of organic matter - the mass of seedlings and roots. The mass of seedlings and roots was determined by the average value in terms of 100 plants, and showed that, in comparison with the control, the best results were found in the variants Cu-EDTA (0.02%) and Cu-EDTA (0.25%). Seeds have a more developed powerful root
system in the Cu-EDTA variant (0.25%), while the wet and dry weight of the seedlings of 100 plants was maximum - 6.07 g and 0.70 g, respectively. Also in this variant, the maximum wet weight of the roots was noted — 3.47 g (30% higher than the control variant). The dry root mass index was also maximum when treated with a Cu-EDTA solution, but at a concentration of 0.02%.

The stimulating effect of organic acids on the growth processes of spring wheat was more pronounced than when treated with chelated forms of copper and zinc. The maximum seedling length in the experiment was 9.0 cm when treated with citric acid, which is 10% higher than in the control version (table 2).

**Table 2.** The effect of presowing treatment with organic acids on the morphometric parameters of wheat seedlings.

| Option             | Root length, cm | Length of seedling, cm | Wet weight, g/100 pcs | Dry mass, g/100 pcs |
|--------------------|-----------------|------------------------|-----------------------|---------------------|
| Control            | 13,0±0,1        | 8,2±0,1                | 5,60±0,18             | 0,61±0,01           |
| Succinic acid (0,02%) | 13,6±0,4        | 8,2±0,1                | 5,80±0,48             | 0,60±0,03           |
| Lemon acid (0,02%) | 13,2±0,1        | 9,0±0,1                | 6,12±0,28             | 0,68±0,03           |
| HCP05              | 0,35            | 0,96                   | 0,99                  | 0,09                |

The effect of citric acid was also reflected in the wet weight of plant seedlings. In this embodiment, it was maximum and amounted to 6.12 g/100 pcs, which is 9% higher than the control. The fresh mass of the roots did not differ significantly in the experimental variants. However, in variants with presowing treatment with acids, there was a tendency to increase the accumulation of organic mass of roots, to increase rhizogenesis (by 6% in both treatment options). The dry weight of 100 seedlings was maximum in the variant of citric acid treatment and amounted to 0.68 g, which is 11% higher than the control variant. There were no differences in the accumulation of air-dry root mass during pre-sowing treatment with organic acids in our experience.

**4. Conclusion**

Thus, we experimentally established that the use of growth regulators in recommended concentrations has a positive effect on the sowing quality of spring soft wheat seeds. In vitro growth regulators affect the germination energy, field germination of seeds, and affect the development of seedlings of spring common wheat. The best option for treating seeds with chelates was a solution of Cu-EDTA at a concentration of 0.25%, which formed the maximum morphometric parameters — the length of the seedling, the wet and dry mass of the seedlings, and the wet mass of the roots. At the same time, there was no significant effect of treatment with a Cu-EDTA solution at a concentration of 0.25% on germination energy, germination, and root length. The best option for seed treatment with organic acids is presowing seed treatment with a solution of citric acid in a concentration of 0.02%. At the same time, an increase in germination, seed germination energy and stimulation of seedling development were noted. In the variant of seed treatment with citric acid, the indicators of the length of the seedling, its raw and dry organic matter were maximum. Studies have shown the feasibility of using growth regulators to improve plant development by activating biochemical processes.

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