Evaluation of the effectiveness of the action of organic substances on agricultural crops

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Abstract. The article presents the results of laboratory model and vegetation experiments to study the biological responsiveness of agricultural crops to new synthesized organic compound (growth regulator). The treatment of seeds of cucumber, lettuce, tomato and radish with succinic acid and the test substance X at a concentration of 0.001% had a positive effect on the germination energy and seed germination. Soaking seeds in the test substance at a concentration of 0.0001% did not have a significant effect on germination energy and germination. Soaking corn seeds in substance X is ineffective, there were no significant yield of green mass increases. Soaking corn seeds in a solution of substance X did not affect the height of the plants, but significantly increased the leaf surface area.

1 Introduction

The main tasks of scientists around the world are to increase the yield of agricultural crops, reduce the cost of the products obtained and crop losses during plant cultivation and harvesting [1-3]. One way to solve these problems is to use growth regulators [4, 5]. The latter are designed to increase the germination and energy of seed germination, help to increase plant immunity, resistance to adverse growth conditions and stressful situations, accelerate flowering, fruiting, increase yields, and ensure environmental cleanliness of the crop. All this makes plant growth regulators indispensable in the cultivation of crops [6-9]. The effectiveness of growth regulators depends on many factors: soil and climatic conditions, the content of nutrients in the soil, the biological characteristics of cultivated crops, the active ingredient of the regulator and its concentration [10, 11]. Despite the numerous positive aspects of regulators, the volumes of their application in Russia are small. The main reasons for this are: high cost, lack of knowledge of the mechanism of action of drugs, non-compliance with the technology of application for a particular crop [12].

The purpose of the research is to establish the responsiveness of agricultural crops to seed treatment with a new synthesized organic compound.

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2 Materials and methods

At the Department of General Chemistry T.A. Akent’eva synthesized a new substance X, the action and effectiveness of which was tested in laboratory model experiments and in a vegetative experiment. This substance was obtained using reductive tropylation. It includes the tropilium cycle (Fig. 1), it is he who exhibits biological and chemical activity.

![Fig. 1. 2-hydroxy-n-benzyl-4-(7-cyclohepta-1,3,5-trienyl)aniline.](image)

The test substance is a yellowish crystalline mass, insoluble in water, but soluble in 1% ethanol solution. When X was used, a significant decrease in the diversity of fungi of the genus *Fusarium graminearum*, *Fusarium gibbosum*, *Septoria nodorum*, *Alternaria tenuis*, *Trichothecium roseum* and *Penicillium glaucum* on spring wheat seeds was noted.

In laboratory model experiments, we studied the growth-regulating effect on agricultural crops at the initial stages of their development. The objects of research in experiments 1-4 were the seeds of cucumber, tomato, radish, lettuce. Experimental scheme: 1. Distilled water (absolute control); 2. 0.002% Succinic acid (control); 3. 0.001% substance X; 4. 0.0001% substance X. The repetition of variants in the experiment is fourfold. The sample of seeds was 100 pieces. Seeds were soaked in prepared solutions for 12 hours. Seeds of cultures were placed in Petri dishes on filter paper previously moistened with water and covered with a second layer of paper. As the paper dried, 10 ml of distilled water was added to each Petri dish. The seeds were germinated for 7 days in the dark, on the third day the germination energy was calculated (GOST 12038-84), and on the seventh day – germination (GOST 12038-84).

In a vegetative experiment, the influence of substance X on the growth and development of corn plants was studied. The experimental scheme included the following options: 1. Distilled water (absolute control); 2. N$_{0.15}$P$_{0.1}$K$_{0.15}$ – background; 3. Background + 0.002% Succinic acid; 4. Background + 0.001% substance X. The repetition of variants in the experiment is fourfold. Background – from mineral fertilizers, ammonium nitrate (N = 34.6%), double superphosphate (P$_2$O$_5$ = 40%) and potassium chloride (K$_2$O = 60%) were added. Fertilizers were applied when filling vessels with soil. Seeds were soaked in prepared solutions for 12 hours at 22°C. Sowing was carried out with 5 grains of corn in each vessel. Fortified plants were thinned out and three pieces were left in the vessel. During the growing season, plants were watered up to 60% of the total soil moisture capacity and weeded. Harvesting was carried out by the direct method simultaneously from all vessels.

The experiment was laid on soddy-podzolic heavy loamy soil. The soil was characterized by a low content of humus (3.3%), a neutral reaction of the environment (6.4), a low supply of mineral nitrogen (37.8 mg/kg), increased mobile phosphorus (110 mg/kg) and potassium (120 mg/kg).

Mathematical processing of the research results was carried out by the method of analysis of variance.

3 Results

Figures 2 and 3 show the results of germination energy and germination of cucumber, lettuce, tomato and radish seeds when treated with growth regulators.
Table 1 shows the effect of growth regulators on the average length of the sprout and radicle of the studied crops.
Table 1. Effect of substance X on the crop seedlings.

<table>
<thead>
<tr>
<th>Variants</th>
<th>Part of a seedling</th>
<th>Agricultural crops</th>
<th>Length, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sprout</td>
<td>cucumber</td>
<td>lettuce</td>
</tr>
<tr>
<td>Distilled water (absolute control)</td>
<td>sprout</td>
<td>0.57</td>
<td>1.21</td>
</tr>
<tr>
<td></td>
<td>radicle</td>
<td>0.24</td>
<td>1.61</td>
</tr>
<tr>
<td>0.002% Succinic acid (control)</td>
<td>sprout</td>
<td>2.26</td>
<td>2.67</td>
</tr>
<tr>
<td></td>
<td>radicle</td>
<td>1.38</td>
<td>3.13</td>
</tr>
<tr>
<td>0.001% substance X</td>
<td>sprout</td>
<td>1.34</td>
<td>2.32</td>
</tr>
<tr>
<td></td>
<td>radicle</td>
<td>2.88</td>
<td>3.41</td>
</tr>
<tr>
<td>0.0001% substance X</td>
<td>sprout</td>
<td>0.95</td>
<td>1.92</td>
</tr>
<tr>
<td></td>
<td>radicle</td>
<td>0.64</td>
<td>2.46</td>
</tr>
</tbody>
</table>

The yield of green mass of corn when soaking seeds in the test substances is presented in Table 2.

Table 2. Effect of substance X on the corn plants.

<table>
<thead>
<tr>
<th>Variants</th>
<th>Productivity, g/vessel</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g/vessel</td>
<td></td>
</tr>
<tr>
<td>Distilled water (absolute control)</td>
<td>276</td>
<td>-</td>
</tr>
<tr>
<td>N_{0.15}P_{0.1}K_{0.15} – background</td>
<td>418</td>
<td>142</td>
</tr>
<tr>
<td>Background + 0.002% Succinic acid</td>
<td>430</td>
<td>154</td>
</tr>
<tr>
<td>Background + 0.001% substance X</td>
<td>315</td>
<td>39</td>
</tr>
<tr>
<td>SSD_{0.05}</td>
<td>-</td>
<td>37</td>
</tr>
</tbody>
</table>

The effect of seed treatment on plant height and leaf surface area of corn green mass is shown in Figures 4 and 5.

**Fig. 4.** The effect of seed treatment and mineral fertilizers on plant height of corn.

1. Distilled water (absolute control); 2. N_{0.15}P_{0.1}K_{0.15} – background; 3. Background + 0.002% Succinic acid; 4. Background + 0.001% substance X
1. Distilled water (absolute control); 2. N\textsubscript{0.15}P\textsubscript{0.1}K\textsubscript{0.15} – background; 3. Background + 0.002% Succinic acid; 4. Background + 0.001% substance X

**Fig. 5.** The effect of seed treatment and mineral fertilizers leaf surface area of corn green mass.

**4 Discussion**

In the control variant, the germination energy of cucumber, lettuce, tomato, and radish seeds was 54.1-57.9%, 59.1-60.9, 62.1-65.9, and 56.7-63.3%, respectively (Fig. 2). Treatment of seeds with succinic acid contributed to an increase in the germination energy of cucumber up to 70.8-77.2%; lettuce up to 69.1-70.9, tomato up to 66.3-73.2% and radish up to 72.4-75.6%. The treatment of seeds with the test substance X at a concentration of 0.001% contributed to a significant decrease in the germination energy on radish seeds. On cucumber, lettuce and tomato, the test substance worked at the level of succinic acid. The use of the test substance X at a concentration of 0.0001% contributed to a significant decrease in the germination energy of lettuce, tomato and radish seeds. The values were at the control level.

The germination of seeds of cucumber, lettuce, tomato and radish in the control variant was 74.8-81.2, 71.4-76.6, 74.2-85.8 and 65.5-74.5% (Fig. 3). Soaking seeds with succinic acid contributed to an increase in seed germination in cucumber up to 84.7-91.3%, in lettuce up to 79.5-88.5, tomato and radish up to 81.4-86.6%. When seeds were soaked in a solution of the test substance X at a concentration of 0.001%, the germination of seeds was at the level of seed treatment with succinic acid. When seeds were soaked in the test substance X at a concentration of 0.0001%, a significant decrease in seed germination was noted. The test substance in this concentration worked at the level of the control variant.

The length of sprouts of cucumber, lettuce, tomato and radish in the control variant was 0.54-0.60, 1.15-1.27, 1.48-1.54 and 2.88-2.94 cm (Table 1). When seeds were soaked in a solution of succinic acid, the length of sprouts increased to 2.13-2.39, 2.58-2.76, 2.42-2.52 and 4.14-4.52 cm. An increase in the average length of a tomato sprout was noted in the variant with soaking in the test substance X at a concentration of 0.001% and amounted to 92.1%. On the sprouts of cucumber, lettuce and radish, the test substance, in comparison with succinic acid, had a negative effect. When seeds are soaked in the test substance X at a concentration of 0.0001%, a significant decrease in the average length of cucumber sprouts by 59.5, lettuce by 28.1, tomato by 12.9, and radish by 17.8% can be noted.
The length of the radicle of cucumber, lettuce, tomato and radish in the control variant was 0.22-0.26, 1.54-1.68, 1.32-1.90 and 4.07-4.25 cm. When seeds were soaked in a solution of succinic acid, the radicle of sprouts increased to 1.31-1.45, 3.09-3.17, 2.76-2.86 и 5.07-5.25 cm. A mathematically proven increase in the average length of the radicle was noted when treated with the test substance X at a concentration of 0.001%. The average length of cucumber and lettuce radicle increased by 8.69 and 8.94% relative to the radicle length in the variant with succinic acid. The largest increase in the average radicle length was noted in radish and amounted to 17.8% relative to the radicle length in the variant with succinic acid. Soaking the seeds in a solution of the test substance at a concentration of 0.0001% had a negative effect on the average length of the radicle of the studied crops. The length of the radicle during treatment with the substance was lower than in the control variant.

The yield of corn in the control variant was minimal in the experiment and amounted to 276 g/vessel (Table 2). The introduction of mineral fertilizers led to an increase in the yield of corn green mass by 51.4%. When soaking corn seeds in succinic acid, an increase in yield can be noted compared to the variant with mineral fertilizers by 27.5%, and with treatment in the substance X, a decrease by 24.6%.

In the control variant, the plant height was 92.3-95.7 cm (Fig. 4). The application of mineral fertilizers led to an increase in the indicator to 122.0-129.0 cm. Soaking corn seeds in solutions of growth regulators did not have a significant effect on the height of corn plants relative to the background variant.

The leaf surface area in the control variant was 3345.5 cm² (Fig. 5). With the introduction of mineral fertilizers on the soil this figure increased by 16.7%. Soaking corn seeds with substance X had a positive effect on the leaf surface area – the figure increased by 31%, and compared with soaking in succinic acid by 17.4%.

5 Conclusion

Thus, on the basis of the conducted research, the following conclusions can be drawn. The concentration of substance X 0.001% had a positive effect on the germination energy and germination of seeds of cucumber, lettuce, radish and tomato, contributed to obtaining reliable increases in the length of the radicle of cucumber (8.69%), lettuce (8.94%) and radish (17.8%) and increased the sprout of tomato (17.4%). When soaking seeds with substance X, there is a tendency to increase the yield (an increase of 14 g) with HCP_05=36.6 g/vessel. The largest area of the leaf surface of corn was noted in the variant with soaking the seeds in substance X, the increase relative to the control was 31%, the background variant – 12.3%.

References


7. T. V. Knyazeva, Plant growth regulators in the Krasnodar Territory (Krasnodar: EDVI) 128 (2013)


