The effect of mineral fertilizers and pesticides on the yield and quality of spring barley grain in the conditions of the Krasnoyarsk forest-steppe

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Abstract. The study was conducted in the Krasnoyarsk forest-steppe on leached chernozem. The scheme of the experiment included the introduction of ammonium nitrate and azophoska. The spring barley protection scheme was studied, represented by the preparations Hat Trick, SC, Ballerina Super, SE, Lastik Extra, CE, Reggie, VRK, Baliy, KME, Borey Neo, SC. The repetition of the experience is 4 – fold. The registered area of the plot is 45 m². Seeding rate - 5.0 mln. The humus content in the soil was determined in accordance with GOST 26213-84, nitrate nitrogen according to GOST 26951-86, mobile compounds of phosphorus and potassium - according to GOST 26204-91. The protein content in the grain was carried out in accordance with GOST 10846-91, the nature of the grain - GOST 10840-64, the mass of 1000 grains - GOST 10842-89. Preliminary studies have established that the maximum yield of barley was obtained with the introduction of azofoski (N₆₀P₆₀K₆₀) and the use of protective equipment - 5.93 t/ha, compared with the control, the increase was 1.82 t/ha or 30.6%. The highest value of the protein content was noted when azofoski was applied - 13.40%. The pre-sowing application of azofoski and the use of plant protection products increased the mass of 1000 grains by 3.2 - 4.8 g, the grain nature by 18 - 26 g/l compared with the control.

1 Introduction

Barley of the leading grain crops, ranking fourth in the world after wheat, rice and corn. Grain is used in brewing, food, pharmaceutical, textile and light industries, for the production of synthetic polymers. Barley straw is used for the production of feed, pulp, fuel, partial production of cardboard, in the chemical industry. Currently, the main amount of barley is used for fodder purposes, and its importance as a fodder crop is increasing in the northern regions [1-2].

In order to obtain maximum yields of barley with high technological qualities, the introduction of mineral fertilizers is a prerequisite. Nitrogen fertilizers affect the
productivity and quality of the resulting grain. The presence of phosphorus in the soil in sufficient quantities makes it possible to form a powerful root system and a large ear, in addition, the quality of the resulting grain is significantly improved.

Fertilizers are the leading environmental factor influencing the quality of the crop. Mineral fertilizers have a significant impact on the quality of the resulting grain. In order to obtain maximum crop productivity and reduce production costs, it is necessary to apply mineral fertilizers in the recommended doses after conducting an agrochemical soil survey. The optimal doses of fertilizers are developed not only on the basis of yield increases, but also according to their effect on product quality. Improving nutrition contributes to the mobilization of the physiological resources of the plant and increase yields [3-4].

However, for each variety there is a limit to the biological possibilities of yield growth. The introduction of the highest doses of mineral fertilizers leads to a deterioration in the quality of products and an increase in costs. This is due not only to increased doses of fertilizers, but also to the imbalance of mineral nutrition elements, improper selection of macroelement forms, as well as the use of microelements without taking into account their content in the soil and crop requirements. [5-6].

Another factor in increasing the yield of barley and improving the quality of grain is the protection of plants from weeds, pests and diseases. Cereal crops are affected by a wide range of pests. The variety of natural and climatic conditions of Siberia, the abundance of pests, pathogens and weeds determine the need for a differentiated approach to the formation of a plant protection system. Yield losses with a moderate development of a complex of diseases, the transmission of which is carried out with the help of seeds, are 15-17%, and against the background of epiphytoties - up to 40%. Surveys conducted in various zones of the Krasnoyarsk Territory found that about 70% of arable land is clogged to a strong or weak degree. A large weediness of crops is the cause of a significant shortage of grain and loss of soil fertility [7-9].

When cultivating spring barley, along with yield indicators, grain quality is of no small importance. The quality of the products obtained largely determines the economic efficiency of cultivation, the competitiveness of products [10].

2 Materials and methods

The study was conducted in the Krasnoyarsk forest-steppe on leached chernozem. Agrochemical characteristics of the soil of the experimental site showed that the humus content is 4.6%. Provision of soil with nitrogen nitrogen up to 4.5 mg/kg of soil, mobile phosphorus up to 170 mg/1000 g of soil and exchangeable potassium up to 150 mg/1000 g.

The scheme of the experiment on the study of plant protection products provided for 2 options: Control (without the use of plant protection products) and plant protection products: a mordant, herbicides, fungicides and insecticides.

Against these backgrounds, the scheme of plant protection was studied in comparison with the control:

- Control (no pesticide treatment).
- Plant protection scheme: Hat-Trick seed treater, SC - 1.3 l/ha; herbicides Ballerina Super, SE - 0.5 l/ha and Lastik Extra, EC - 1.0 l/ha; growth regulator Reggie, VRK - 1.5 l/ha; fungicide Baly, KME - 0.4 l/ha, insecticide Borey Neo, SC - 0.2 l/ha [11].

Characteristics of the studied preparations for plant protection:

- Hat-Trick, UK: a three-component insect and fungicidal systemic seed treater for grain crops for pest and disease control. Active ingredients - imidacloprid, 333 g/l + difenoconazole, 67 g/l + tebuconazole, 17 g/l.
Ballerina Super, SE: herbicide against annual dicotyledonous and perennial root weeds. Active ingredients: Complex 2-ethylhexyl ester of 2,4-D acid, 410 g/l (in terms of 2,4-D tatu) and florasulam, 15 g/l.

Lastik Extra, EC: herbicide against grass weeds. Active ingredients: Phenoxaprop-P-ethyl, 70 g/l + antidote cloquintosetmexil, 40 g/l.

Reggie, VK: plant growth regulator to prevent lodging of crops, as well as increase their yield. Active ingredient: Chlormequat chloride, 750 g/l.

Baly, KME: two-component fungicide with greening effect for the protection of cereals from a wide range of diseases. Active ingredients: Propiconazole, 180 g/l + Azoxystrobin, 120 g/l.

Borey Neo, SK: three-component insecticide for the protection of a wide range of crops from a complex of pests. Active ingredients: Alpha-cypermethrin 125 g/l, imidacloprid 100 g/l and clothianidin 50 g/l.

The repetition of the experience is 4–fold. The registered area of the plot is 45 m². The treatment of spring barley crops with pesticides was carried out with sprayer Demorol - 600.

The determination of the protein content in the grain was carried out in accordance with GOST 10846-91, determination of grain size - GOST 10840-64, weight of 1000 grains - GOST 10842-89.

Statistical processing of the obtained results was carried out by the method of variance analysis.

In 2022 temperature of the first decade of June was 5.3 °C lower than long-term values, the second and third decades of the month were warm, the temperature was 20.1 and 20.4 °C, respectively (Figure 1). The first and second decades of July were cool; the temperature during this period it was below the long-term values, the temperature of the 3rd decade was close to the long-term values. The temperature in August was below the long-term values by 0.4 - 1.0 °C.

May 2022 turned out to be dry (Figure 2). The amount of precipitation in June was 72.3 mm, which is 6.8 mm higher than the long-term value, the wettest was the second decade of the month, when 17.2 mm fell. In July, the amount of precipitation was 49.4 mm, which is 31.4 mm lower than the long-term value, the 3rd decade of the month it was the driest. The amount of precipitation in August was 65.0 mm. The most important was the second decade of the month, when 40 mm of precipitation fell. The amount of precipitation in September was 62.8 mm, which is 24.9 mm more than the long-term norm.

The hydrothermal moisture coefficient according to Selyaniniv (HTC) for the growing season of 2022 was 1.84.

Fig. 1. Temperature regime of the growing season 2022.
3 Results and Discussion

The introduction of azofoski at a dose of 60 kg. d.v./ha allowed to form the yield of spring barley in 4.85 t/ha (increase to the control 1.49 t/ha or 30.7%), the maximum yield was noted when applying azofoski and using plant protection products - 5.93 t/ha (increase to control 1.82 t/ha or 30.6%) by improving the mineral nutrition of plants during the growing season and reducing the adverse effects of harmful organisms in the sowing of spring barley.

Table 1. Influence of mineral fertilizers and plant protection products on the yield of spring barley.

<table>
<thead>
<tr>
<th>Fertilizer background</th>
<th>Mineral fertilizers</th>
<th>Mineral fertilizers + crop protection scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Productivity, t/ha</td>
<td>Increase, t/ha</td>
</tr>
<tr>
<td>Without fertilizer</td>
<td>3.36</td>
<td>control</td>
</tr>
<tr>
<td>N&lt;sub&gt;60&lt;/sub&gt;</td>
<td>4.49</td>
<td>+ 1.13</td>
</tr>
<tr>
<td>N&lt;sub&gt;60&lt;/sub&gt;P&lt;sub&gt;60&lt;/sub&gt;K&lt;sub&gt;60&lt;/sub&gt;</td>
<td>4.85</td>
<td>+ 1.49</td>
</tr>
<tr>
<td>HCP&lt;sub&gt;05&lt;/sub&gt;</td>
<td>0.49</td>
<td>0.61</td>
</tr>
<tr>
<td></td>
<td>4.11</td>
<td>control</td>
</tr>
<tr>
<td></td>
<td>5.32</td>
<td>+ 1.21</td>
</tr>
<tr>
<td></td>
<td>5.93</td>
<td>+ 1.82</td>
</tr>
</tbody>
</table>

The lack of nutrients in the soil can negatively affect the yield and quality of the resulting grain. The results of the research showed that the improvement of nitrogen nutrition of plants had a great influence on the formation of grain with high technological qualities. The protein content in barley grain increased by an average of 1.04 - 1.90% from the application of mineral fertilizers. The highest protein content in the grain was noted when azofoski was applied - 13.40%

One of the most important technological qualities of grain is the nature of grain. According to the results of the conducted studies, the nature of barley grain changed according to the variants of the experiment from 632 to 678 g/l. Pre-sowing application allowed to increase the studied indicators by 25-39 g/l, and mineral fertilizers and pesticides by 18-26 g/l. The maximum grain size was obtained when applying azophoska - 678 g/l.

The mass of 1000 grains significantly affects the technological qualities of the grain. Grain with a higher mass and good workmanship gives the highest yield of flour. In comparison with the control, the weight of 1000 grains in the variants of the experiment with the use of mineral fertilizers increased by 2.8 - 7.4 g, mineral fertilizers and protective equipment by 3.2 – 4.8 g.
Table 2. Technological qualities of barley grain depending on the use of mineral fertilizers and plant protection products.

<table>
<thead>
<tr>
<th>Experience Variant</th>
<th>Protein, %</th>
<th>Weight of 1000 grains, g.</th>
<th>Nature, g/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>OOO (without fertilizer)</td>
<td>11.50</td>
<td>33.4</td>
<td>639</td>
</tr>
<tr>
<td>Protection scheme</td>
<td>11.60</td>
<td>41.2</td>
<td>653</td>
</tr>
<tr>
<td>N₀₅₀</td>
<td>12.54</td>
<td>36.2</td>
<td>632</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protection scheme</td>
<td>13.17</td>
<td>38.2</td>
<td>665</td>
</tr>
<tr>
<td>N₆₀P₀₆₀K₀₆₀</td>
<td>13.40</td>
<td>40.8</td>
<td>678</td>
</tr>
<tr>
<td>Protection scheme</td>
<td>11.73</td>
<td>36.6</td>
<td>657</td>
</tr>
</tbody>
</table>

4 Conclusion

- The maximum yield of spring barley was obtained with the introduction of azofoski (N₆₀P₀₆₀K₀₆₀) and the use of protective equipment - 5.93 t/ha, in comparison with the control, the increase was 1.82 t/ha or 30.6%.
- The use of mineral fertilizers has improved the technological qualities of barley grain. The maximum value of the protein content was noted when applying azofoski - 13.40%. Pre-sowing application of azofoski and the use of plant protection products increased the mass of 1000 grains by 3.2 - 4.8 g, grain nature by 18 - 26 g/l in comparison with the control.

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