Yield and quality of hulles barley when using foliar fertilizing with macro- and micro-fertilizers in the steppe zone

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Abstract. The studies found that doses of nitrogen fertilizers and zinc and copper chelates positively affected the yield of hulles barley grain with foliar fertilizing on ordinary chernozem of the steppe zone of the Omsk region. With a yield of 1.34 t/ha in the control variant, the application of macro- and micro-fertilizers contributed to the formation of 1.40-1.56 t/ha of grain. Nitrogen fertilizing without micronutrients is effective and has led to a significant increase in yield (0.09 - 0.15), as well as the use of micronutrients against nitrogen: 0.09 together with 15 kg of nitrogen and 0.11 together with 30 kg of nitrogen. The increase in yield from the application of zinc and copper separately was also noted, but less significant: 0.04 - 0.07 t/ha. The highest yield was formed when using N_{30}Zn_{20}Cu_{20}. The improvement of plant nutrition conditions with the help of fertilizers mainly has a positive effect on the protein content in grain and nature. It was revealed that the sum of amino acids in the protein increases from 8.39% without fertilizing to a maximum of 10.59 (variants with foliar fertilizing in the tillering phase N_{15}Zn_{20} and N_{30}Zn_{20}Cu_{20}).

1. Introduction

The development of measures aimed at reproducing and increasing soil fertility of agricultural lands to obtain high and stable yields is the main goal of agrochemical science and practice [1-3].

As evidenced by numerous experimental data, the effectiveness of liquid mineral fertilizers is equal to, and in some cases greater than, the efficiency of an equivalent amount of solid mineral fertilizers. They have a number of advantages over solid fertilizers both in production and storage, and when they are applied. In soils, there is often a lack of available nitrogen and trace elements for cultivated plants. It has been shown that foliar fertilizing with liquid complex mineral fertilizers, including these nutrients, increases the yield and quality of crop production [4-6].

According to the results of an agrochemical survey of the chernozems of the Omsk region, only a couple of crops are satisfactorily provided with nitrate nitrogen, a low level of mobile forms of zinc is noted on 98.9% of the area, low and medium – copper – on 99.4%. Therefore, in the soils of the region, nitrate nitrogen, zinc, and copper are acutely deficient nutrients [7-9].

The purpose of the research is to establish the effect of foliar fertilizing with macro- and micro-fertilizers on the yield and quality of spring hulles barley grain in the steppe zone.

2. Materials and methods

The experiment was conducted at a pilot site in the steppe zone in the Poltava district of the Omsk
region (IE Kobzar) in 2021 on ordinary medium-thick medium-humus heavy loam chernozem. Barley variety – Omskiy golozerniy 1. The objects of research were mineral fertilizers (carbamide, zinc and copper chelates). The content of N-NO₃ in the soil is 1.87, P₂O₅ – 34, K₂O – 180 mg/kg. The location of plots is systematic. The repetition is threefold. Plot area - 20 m². Agricultural equipment - generally accepted for the zone. The precrop is the second spring wheat on fallow. Main treatment in autumn - fall plowing with PN-4-35 to a depth of 20-22 cm. Pre-sowing tillage - early spring harrowing with spike-tooth harrows in two tracks when the soil reaches the state of physical ripeness and pre-sowing cultivation of KPS-4 to the depth of seeding, sowing with a seeding rate of 5.5 million seeds with a seeder SN-16, rolling with ring rollers ZKK-3A. Treatment with herbicides Lastik Top and Balerina, the application dose 0.3 t/ha in the tillering phase.

The content of N-NO₃ in the soil was determined by Grandval-Lage; mobile P₂O₅ and K₂O – according to Chirikov. Quality indicators were determined by generally accepted methods, the content of amino acids in grain - according to GOST R 55569-2013.

3. Research results

In the steppe zone, the use of carbamide (kg r.a./ha) and zinc and copper chelates (g r.a./ha) for foliar fertilizing of hulles barley in the tillering phase was studied (Table 1).

Table 1. The hulles barley yield depending on the foliar fertilizing with macro- and micro-fertilizers in the steppe zone of the Omsk region.

| Foliar fertilizing | Yield, t/ha | Increase | Payback of fertilizer, kg/kg |
|---------------------|-------------|----------|-----------------------------|
| Without fertilizing | 1.47        | -        | -                           |
| N₁₅                 | 1.56        | 0.09     | 6.1                         | 6.00 |
| N₁₅Zn₂₀              | 1.60        | 0.13     | 8.8                         | 8.67 |
| N₁₅Cu₂₀              | 1.61        | 0.14     | 9.5                         | 8.30 |
| N₁₅Zn₂₀Cu₂₀          | 1.65        | 0.18     | 12.2                        | 12.0 |
| N₃₀                 | 1.62        | 0.15     | 10.2                        | 5.0  |
| N₃₀Zn₂₀              | 1.68        | 0.19     | 12.9                        | 6.33 |
| N₃₀Cu₂₀              | 1.69        | 0.22     | 15.0                        | 7.33 |
| N₃₀Zn₂₀Cu₂₀          | 1.73        | 0.26     | 17.7                        | 8.67 |
| LSD₀₅               | 0.06        |          |                             |

It was found that doses of nitrogen fertilizers and zinc and copper chelates positively affected the yield of barley grain with foliar fertilizing on ordinary chernozem of the steppe zone of the Omsk region. With a yield of 1.47 t/ha in the control, the application of macro- and micro-fertilizers contributed to the formation of 1.56-1.73 t/ha of grain.

A significant increase in yield is observed from foliar fertilizing with nitrogen and micro-fertilizers - increases amounted to 0.9-0.26 t/ha. Nitrogen fertilizing without micronutrients is effective and has led to a significant increase in yield (0.09 - 0.15), as well as the use of micronutrients against nitrogen: 0.09 together with 15 kg of nitrogen and 0.11 together with 30 kg of nitrogen. The increase in yield from the application of zinc and copper separately was also noted, but less significant: 0.04 - 0.07 t/ha. The maximum yield was formed when N₃₀Zn₂₀Cu₂₀ was used during the growing season.

The highest payback of 1 kg of fertilizer is 12.0, obtained from the use of foliar fertilizing with N₃₀Zn₂₀Cu₂₀, the use of N₃₀Zn₂₀Cu₂₀ allowed to obtain a payback of 1 kg of fertilizer only 8.67 kg of grain.

The change in the yield value is accompanied by the transformation of the indicators of the hulles barley yield structure. The productive tilling capacity was 1.8-2.0, the weight of 1000 grains was 46.3–49.9 g, these indicators increased slightly with the use of fertilizers (Table 2).
Table 2. The structure of the hulls barley yield depending on fertilizers on ordinary chernozem of the steppe zone.

| Foliar fertilizing | Productive tilling capacity | Seed weight from one plant, g | Weight of 1000 seeds, g |
|--------------------|-----------------------------|-------------------------------|------------------------|
| Without fertilizing| 1.8                         | 6.5                           | 46.3                   |
| N15                | 2.0                         | 5.6                           | 46.8                   |
| N15Zn20            | 1.9                         | 5.7                           | 46.5                   |
| N15Cu20            | 1.9                         | 5.8                           | 46.9                   |
| N15Zn20Cu20        | 1.9                         | 5.6                           | 49.1                   |
| N30                | 2.0                         | 5.5                           | 47.4                   |
| N30Zn20            | 1.9                         | 5.4                           | 46.5                   |
| N30Cu20            | 1.8                         | 5.6                           | 48.3                   |
| N30Zn20Cu20        | 1.9                         | 5.5                           | 49.9                   |

The quality of products depends significantly on the quantity and method of fertilizer application [10-12]. The protein content in the grain of hulls barley in the control variant is 12.4 (Table 3). Additional application of nitrogen and microfertilizers at a dose of 30 kg/ha provides an increase in the protein content of grain by 0.4-0.5%. The application of 15 kg/ha of nitrogen provided less effect or had no effect. At the same time, the grain nature increased from 618 to 622-651 g/l.

Table 3. The quality of hulls barley grain depending on fertilizers.

| Foliar fertilizing | Nature, g/l | Vitreousness, % | Protein, % |
|--------------------|-------------|-----------------|------------|
| Without fertilizing| 618         | 45              | 12.4       |
| N15                | 628         | 47              | 12.3       |
| N15Zn20            | 622         | 45              | 12.5       |
| N15Cu20            | 631         | 48              | 12.7       |
| N15Zn20Cu20        | 633         | 44              | 12.7       |
| N30                | 644         | 44              | 12.8       |
| N30Zn20            | 645         | 46              | 12.8       |
| N30Cu20            | 633         | 45              | 12.7       |
| N30Zn20Cu20        | 651         | 47              | 12.9       |

In the experiment, the amino acid composition of the protein was studied depending on the fertilizers used, which affected the quantitative content of amino acids (Table 4).

Table 4. Amino acid composition of hulls barley grain protein depending on fertilizers in the conditions of the steppe zone of the Omsk region, %.

| Amino acid | Variant | Without fertilizing | N15 | N15Zn20 | N15Cu20 | N15Zn20Cu20 | N30 | N30Zn20 | N30Cu20 | N30Zn20Cu20 |
|------------|---------|---------------------|-----|---------|---------|-------------|-----|---------|---------|-------------|
| Arginine   | 0.79    | 0.80                | 0.80| 0.84    | 0.85    | 0.82        | 0.79| 0.80    | 0.80    | 0.80        |
| Lysine     | 0.39    | 0.41                | 0.42| 0.44    | 0.49    | 0.46        | 0.39| 0.41    | 0.42    | 0.42        |
| Tyrosine   | 0.39    | 0.45                | 0.52| 0.50    | 0.58    | 0.44        | 0.39| 0.45    | 0.52    | 0.52        |
When studying the effect of nitrogen and micronutrients on the qualitative characteristics of barley grain protein in the steppe zone, it was revealed that the sum of amino acids increases from 8.39% without fertilizing to a maximum of 10.59 (variants with foliar fertilizing in the tillering phase with N$_{15}$Zn$_{20}$ and N$_{30}$Zn$_{20}$Cu$_{20}$).

### 4. Conclusion

The experiment established that doses of nitrogen fertilizers and zinc and copper chelates positively affected the yield of hulls barley grain with foliar fertilizing on ordinary chernozem of the steppe zone of the Omsk region. With a yield of 1.47 t/ha in the control, the application of macro- and micro-fertilizers contributed to the formation of 1.56-1.73 t/ha of grain.

The highest yield was formed when using N$_{30}$Zn$_{20}$Cu$_{20}$ in fertilizing. The improvement of plant nutrition conditions with the help of fertilizers mainly has a positive effect on the protein content in grain and nature. It was revealed that the sum of amino acids in the protein increases from 8.39% without fertilizing to a maximum of 10.59 (variants with foliar fertilizing in the tillering phase N$_{15}$Zn$_{20}$ and N$_{30}$Zn$_{20}$Cu$_{20}$).

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| Amino Acid | Variants without fertilizing | Variants with foliar fertilizing | Variants with foliar fertilizing in the tillering phase | Variants with foliar fertilizing in the tillering phase with N$_{15}$Zn$_{20}$ | Variants with foliar fertilizing in the tillering phase with N$_{30}$Zn$_{20}$Cu$_{20}$ |
|------------|-----------------------------|---------------------------------|------------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Phenylalanine | 0.60 | 0.64 | 0.74 | 0.74 | 0.80 | 0.69 | 0.60 | 0.64 | 0.74 |
| Histidine | 0.30 | 0.31 | 0.29 | 0.35 | 0.30 | 0.31 | 0.30 | 0.31 | 0.29 |
| Leucine+iso-leucine | 1.26 | 1.34 | 1.69 | 1.48 | 1.30 | 1.54 | 1.26 | 1.34 | 1.69 |
| Methionine | 0.25 | 0.27 | 0.32 | 0.30 | 0.31 | 0.35 | 0.25 | 0.27 | 0.32 |
| Valine | 0.56 | 0.60 | 0.90 | 0.65 | 0.74 | 0.75 | 0.56 | 0.60 | 0.90 |
| Proline | 1.69 | 1.74 | 2.30 | 1.99 | 1.75 | 2.04 | 1.69 | 1.74 | 2.30 |
| Threonine | 0.42 | 0.44 | 0.59 | 0.57 | 0.43 | 0.50 | 0.42 | 0.44 | 0.59 |
| Serine | 0.56 | 0.60 | 0.80 | 0.78 | 0.59 | 0.60 | 0.56 | 0.60 | 0.80 |
| Alanine | 0.79 | 0.80 | 0.80 | 0.84 | 0.85 | 0.82 | 0.79 | 0.80 | 0.80 |
| Glycine | 0.39 | 0.41 | 0.42 | 0.44 | 0.49 | 0.46 | 0.39 | 0.41 | 0.42 |
| Sum of amino acids | 8.39 | 8.81 | 10.59 | 9.92 | 9.48 | 9.78 | 8.39 | 8.81 | 10.59 |
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