Application of silicon-containing preparations for foliar feeding of spring wheat

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Abstract. The results of using silicon-containing preparations: siliplant, controlfit Si and kelik-K-Si for foliar feeding of spring wheat in sod-podzolic soils are presented. It has been confirmed that foliar dressing is an effective technique that provides an increase in yield, mechanical strength of the stem, leaf area and 1000 grain weight. Siliplant has the best result.

1. Introduction

At present, there is a lot of information indicating the complex positive effect of silicon on the growth and development of plants, yield and product quality [1-10], plant resistance to unfavorable environmental factors. The effect of Si is especially pronounced under stressful conditions of plant growing [8].

Silicon improves the nutritional conditions of plants, affects many physiological and biochemical processes: transpiration, photosynthesis, synthesis of carbohydrates, proteins, increases the chemical resistance of DNA, RNA [1], chlorophyll, and the functional activity of cell organelles [2]. It participates in the optimization of transport and redistribution of substances inside the plant, promotes better assimilation and metabolism of nitrogen and phosphorus in plant tissues [5], increases the consumption of boron, ensures a decrease in the intake of nitrates and heavy metals into products [4]. In addition, Si gives plants mechanical strength, strengthens the walls of epidermal cells, which helps to reduce the risk of lodging of plants and damage to them by diseases and pests [3].

Thus, the functions of silicon in plants are expressed in the formation of a complex defense against biotic and abiotic stresses. It was found that its active redistribution occurs in plants with transfer to tissues that are more susceptible to stress [6].

Silicon enters plants from the soil, where it occupies the second place (after oxygen) in its prevalence and is present in the form of quartz, amorphous silicon dioxide, feldspars, vermiculite, smectite, kaolin, orthoclase and other compounds. Its gross content depends on the granulometric composition and genesis of the soil. The solubility of these Si forms is low and they are mostly immobile. Soluble are polysilicic and monosilicic acids [7].

Replenishment of losses of mobile forms of silicon is possible by the introduction of silicon fertilizers. An important technique for using fertilizers is foliar feeding - one of the methods of fertilizing, in which nutrients are absorbed by plants through the leaf. When applied to a leaf, fertilizers are consumed more efficiently than when applied to the soil; they are not lost due to leaching, the formation of gaseous products or binding into poorly soluble compounds, as is the case when applied to the soil. As a result, they are assimilated by plants more fully and are less dispersed into the environment.
At the same time, the effectiveness of foliar feeding of plants is associated with both the composition of the fertilizer and the properties of the leaf surface, phases of plant development and external growing conditions [3].

The use of silicon fertilizers has not yet received widespread use in agricultural practice, this is due to the lack of information on the content of mobile forms of silicon in soils and control of the silicon content in plant tissues; in addition, there are very few studies characterizing the effectiveness of silicon use.

All these factors determine the relevance of the research topic. The main purpose of which is to assess the agronomic efficiency of the use of silicon-containing preparations on sod-podzolic soil for foliar dressing when growing spring wheat. Revealing the effect of the drugs used on the yield and grain quality.

2. Materials and methods

The methodological basis of the study was a field experiment conducted in 2019 with a siliceous culture - soft spring wheat of the Sudarynya variety. A zoned mid-season variety of spring wheat, recommended for cultivation in the Bryansk, Vladimir and Smolensk regions. The average yield of the Sudarynya variety in the Central Region is 25.2 centers / ha. The maximum yield of the Sudarynya variety - 53.6 centers / ha was obtained in 2010 in the Vladimir region. The mass of 1000 grains of wheat variety Sudarynya is 29–40 g.

For foliar feeding of plants, silicon-containing preparations were used:

- Siliplant; Controlfit Si, Kelik-potassium Si. Siliplant brand "Universal" - a solution containing 7.5–7.8% silicon in mineral form (potassium / sodium silicate), as well as magnesium and chelates of microelements Cu, Zn, Mn, B, Mo, Fe. Registrant - NNPP "NEST M", Russia.
- Controlfit Si is a solution containing 17% water-soluble silicon and 7% potassium, pH 11-11.5. Country of origin - Spain.
- Kelik-K-Si is a solution containing in the chelated form 15% potassium, 10% silicon, chelating agent EDTA (2%), pH 12., density 1.34 g / cm3. Possesses immunoprotective properties. Country of origin - Spain.

The used consumption rates of the preparations correspond to the recommended ones: siliplant - (25% solution), 0.8 l / ha at each feeding period; solutions of controlfit Si and Kelik-K-Si (at the rate of 300 l / ha of working solution at the recommended consumption rate of preparations of 1 l / ha at each feeding period). The treatment was carried out with a knapsack sprayer.

When using siliplant, the dose of Si was 60 g / ha, kelik-K-Si - 200 g / ha Si and 300 g / ha K₂O, controlfit Si -340 g / ha Si and 140 g / ha K₂O.

The soil was soddy-podzolic medium loamy, had the following agrochemical characteristics: the reaction of the medium was weakly acidic (pH_KCl 5.5), the humus content according to Tyurin was 1.8%, the content (according to Kirsanov) of mobile phosphates was high (151 mg / kg), potassium - average (95 mg / kg). Hydrolytic acidity - 8.0 meq / 100 g, the amount of absorbed bases - 14.3 meq / 100 g, the degree of saturation of the soil with bases - 64%.

The background for the experiment was an azophoska with doses of N60P60K60. The repetition of the experiment was 4-fold, the placement of options was systematic. Accounting area - 5 m².

The treatment with the above preparations was carried out in the form of a double foliar feeding of spring wheat in the tillering phase and in the tube.

The linear growth of plants was measured with a tape measure, the diameter of the first internode of the shoots (vernier caliper), the total area of the flag and pre-flag leaf (by the method of numerical integration), the yield (by the test sheaf method), and the weight of 1000 grains (by the weight method). Grain quality was assessed by moisture content (GOST 13586.5-2015).

In 2019, in the first months of wheat growth and development, the air temperature was increased (by 1.5-3.2 °C), and in July-August there was a shortage of positive temperatures. The total amount of
precipitation in May-August amounted to 92% of the long-term average values, especially little in June and July - 70% of the norm (table 1).

Table 1. Agrometeorological conditions for the growing season 2019.

| Month  | Air temperature, °C | Precipitation, mm |
|--------|----------------------|-------------------|
|        | The actual | Middle-long ± of the norm | The actual | Middle-long ± of the norm |
| May    | 14.0       | 12.5 ± 1.5 | 80       | 61 ± 131 |
| June   | 19.0       | 15.8 ± 3.2 | 62       | 87 ± 71  |
| July   | 15.3       | 17.8 ± 2.5 | 62       | 90 ± 67  |
| August | 15.5       | 16.3 ± 0.8 | 93       | 85 ± 109 |

3. Results
The test of foliar feeding of spring wheat plants with various silicon-containing preparations under the conditions of 2019 showed that Kelik-K-Si had a noticeable effect on the linear growth of plants. Compared to the background plants, the experimental plants turned out to be significantly higher (table 2).

Table 2. Influence of foliar feeding with silicon-containing preparations on biometric parameters * and yield of spring wheat Sudarynya, 2019.

| Option   | Leaf area, cm²/plant | Plant height, cm (h) | Stem diameter, mm (d) | h:d ratio | Grain yield, centers / ha | M1000, g |
|----------|----------------------|----------------------|-----------------------|-----------|--------------------------|----------|
| The control | 20.3 ± 1.9 | 100.1±1.8 | 3,98±0,23 | 251 | 48,0 | 45,6 |
| Kelik-K-Si | 24.9 ± 1.6 | 108.7±1.4 | 4,09±0,17 | 265 | 53,8 | 45,8 |
| ControlFit Si | 24.1 ± 1.8 | 101.3±2.3 | 4,27±0,18 | 237 | 56,8 | 45,0 |
| Siliplant | 26.4 ± 2.2 | 102.9±1.4 | 4,02±0,16 | 255 | 58,3 | 47,8 |
| HCP95 | 2.9 |

Note: * phase of milk ripeness

Treatment of plants with all preparations promoted the growth of leaf area. The best way to increase the leaf area was feeding the plants with siliplant, and the mechanical strength of the stems to break was more influenced by Controlfit-Si.

In addition, an analysis of the quality of grain for compliance with the class was carried out (table 3).

4. Discussion
The silicon-containing preparation Controlfit was studied mainly on rice - the most silicon-philic culture and made it possible to obtain an increase in grain yield of 0.6 t / ha.

The use of this preparation for foliar feeding of spring wheat Lyubava in cold and excessively humid 2017 also gave a positive effect [9]. With a rather low yield (3.1 t / ha), which is due to the late sowing period (May 19) and low air temperatures in May-July, foliar feeding of plants with a controlfit-Si solution gave an increase of 16.5% to increase grain yield relative to control ... This preparation had no effect on the weight of 1000 grains and plant height, but under conditions of strong gusts of wind, 100% lodging of control plants was noted, and in the variant with feeding with Controlfit Si, only 25% lodging was observed.

The indicator of the ratio of the height of shoots to the diameter of the stem is the best for the preparation Controlfit-Si by 6–11% less than in other variants, ie. increased mechanical strength of the stem to break, which is important from the point of view of plant resistance to lodging.
Table 3. Grain quality of spring wheat.

| Indicator        | Normative document (ND) for the test method | Value of indicators when tested |
|------------------|---------------------------------------------|---------------------------------|
| Humidity, %      | GOST 13586.5-2015                           | no more 14.0                    |
| Gluten content, %| GOST 13586.1-2014                           | not less 23.0                   |
| Protein content, %| GOST 10846-91                              | not less 12.0                   |

Fon + Kelik K-Si

| Humidity, %      | GOST 13586.5-2015                           | no more 14.0                    |
| Gluten content, %| GOST 13586.1-2014                           | not less 23.0                   |
| Protein content, %| GOST 10846-91                              | not less 12.0                   |

Fon + ControlFit Si

| Humidity, %      | GOST 13586.5-2015                           | no more 14.0                    |
| Gluten content, %| GOST 13586.1-2014                           | not less 23.0                   |
| Protein content, %| GOST 10846-91                              | not less 12.0                   |

Fon + Siliplant

| Humidity, %      | GOST 13586.5-2015                           | no more 14.0                    |
| Gluten content, %| GOST 13586.1-2014                           | not less 23.0                   |
| Protein content, %| GOST 10846-91                              | not less 12.0                   |

Thus, evaluating the results, we can conclude that feeding with Siliplant and Controlfit-Si solutions significantly increased the yield of spring wheat (12–20% compared to the NPK background) with the best value in the variant with siliplant, where the maximum weight of 1000 grains was also noted, which is 21% higher compared to the background and not 3-9% higher than other drugs. The use of these preparations also increased the mechanical strength of the stems.

Treatment with all preparations ensured the production of grain that meets the 3rd quality class: moisture content did not exceed 14%, the protein content was within 14.3% at a rate of 12%, the gluten content exceeded 23%. Therefore, the grain can be used in baking without any improvement.

5. Conclusion

The use of silicon-containing preparations for foliar feeding of spring wheat in sod-podzolic soils (in the tillering and stemming phases) is an effective technique that improves the mechanical stability of the stem, an increase in the photosynthetic leaf area and a significant increase in grain yield (in comparison with the background - by 12-20%). In addition, foliar feeding ensured the production of grain that meets the 3rd quality class, which allows it to be used in baking without improvement. Siliplant became the best drug in terms of the set of parameters studied. This is explained by the presence of a complex of trace elements in the siliplant.

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