Productivity and grain quality indicators of white lupine (Lupinus albus L.) variety Degas when using sodium selenite

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Abstract. The aim of the research was to study the sodium selenite using various methods effect on the yield and quality of Degas variety white lupine grain. To solve these issues microfield experiment on the experimental plot of the Department of agronomic, biological chemistry and radiology of the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy was carried out. Thus, it was found that the use of sodium selenite for foliar treatment of plants contributed to the greatest increase in the yield of white lupine plants. The increase in the grain yield of 27% compared to the control was obtained. The increase in the weight of the beans was revealed by almost 2 times. This indicates the influence of sodium selenite on the processes of fruit formation and the process of laying the seed productivity of lupine plants. The greatest effect of foliar treatment of plants with sodium selenite was found. In this variant, the largest increase in grain yield and the highest content of crude protein in the lupine grain were obtained. It is concluded that the use of selenium affects the formation of beans and grains in them, which determines the increase in plant yield.

1. Introduction
At present, the issue of providing animal husbandry with compound feed balanced in terms of protein content remains quite relevant. One of the solutions to this problem is the cultivation of such legumes as lupine. Lupine grain is characterized by a good protein content, balanced in quality, practically not inferior to soy. Therefore, lupine grain is used in compound feed in poultry and livestock farming.

Evaluating the value of lupine in agriculture, Academician D.N. Pryanishnikov highly appreciated the value of lupine in agriculture. He believed that the cultivation of lupine will acquire particular importance on light soils, while the need for organic fertilizers will decrease and the possibility of using phosphate rock will increase [1, 2].

Lupine, being one of the most high-protein crops, accumulates protein in grain up to 32-46%, depending on the species, which is higher than that of peas, soybeans, vetch and other fodder crops. 1 kg of lupine grain contains 3 times more protein than cereals, and 1.5 times more than peas. At the same time, the quality of protein in terms of the content of essential amino acids in lupine grain is superior in comparison with other legumes [3, 4].
The vegetative mass of lupine is also of great importance as the source of scraped protein feed for animals. The dry matter of the vegetative mass contains 18-23% protein. It should be noted that the seeds and green mass of all types of lupine contain physiologically active substances - alkaloids. In nature, there is no lupine without alkaloids, and there are no types of lupine that contain more than 3.5% alkaloids. For fodder varieties of lupine, the maximum permissible content of alkaloids is no more than 0.3% in grain and no more than 0.14% in vegetative mass. In the grain of modern varieties of lupine, the content of alkaloids is in the range of 0.02-0.05%; in green mass in the range of 0.01-0.04% on dry matter. Therefore, varieties that are part of the group of low-alkaloid crops are used for the production of concentrated, thick and juicy feed, which are used without restrictions for all types of livestock and poultry [5, 6].

Plants of the legume family, both cultivated and wild, are the most active selenium accumulators. A high content of selenium was found in such species as chickpea, astragalus, lyadvenets, etc., which makes it possible to recommend its introduction in order to reduce the lack of selenium in animal feed [7].

Selenium compounds can be used for soil application, seed treatment, or plant spraying. The most economical method of seed treatment has proven itself, so researchers are trying to establish the optimal concentration of trace elements [8].

The purpose of our research is to study the effect of various methods of sodium selenite application on the yield and grain quality of white lupine of Degas variety.

2. Materials and methods
To solve the questions posed, a microfield experiment was carried out at the experimental site of the Department of Agronomic, Biological Chemistry and Radiology of the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy. The object of the study was white lupine (Lupinus albus L.) of Degas variety. The soil of the experimental plot is typical urban soil with agrochemical characteristics: pHKCl - 6.0 (State Standard 26483-85), hydrolytic acidity of the soil is 0.9 mg·eq/100 g of soil (State Standard 26212), the sum of the absorbed bases is 24.3 (State Standard 27821-88). The humus content was 3.3% (State Standard 26213-91), the content of alkaline hydrolyzable nitrogen is 90 mg/kg of soil (according to Cornfield). The availability of mobile forms of phosphorus is 125 mg/kg of soil (IV class), potassium is 120 mg/kg of soil (IV class) (according to Kirsanov) (State Standard 26207-91). The laying and carrying out of microfield and vegetation experiments was carried out in accordance with the methodology [7]. Plants were grown on plots with a total area of 1 m², accounting plot area – 25 m². All experiments were repeated four times.

The level of mineral nutrition was created by scattering ammonophos (NH₄H₂PO₄) and monobasic potassium phosphate (KH₂PO₄) manually to the depth of 7-10 cm. In all the variants, phosphorus and potassium were added at the rate of 115 and 145 kg of element per ha, respectively. The nitrogen nutrition level was created at the rate of 20 kg/ha.

In the experiment, we studied two methods of using sodium selenite, seed treatment before sowing and foliar treatment of plants. Treatment of seeds with sodium selenite (Na₂SeO₃) before sowing was carried out by soaking in a 0.01% salt solution, taken at the rate of 5% of the grain weight. Foliar treatment of plants was carried out before the onset of the flowering phase with a solution of sodium selenite of the same concentration. In the control, seeds were not treated with sodium selenite. During the growing season, mandatory and additional observations and care of crops were carried out. For sowing, it is necessary to use high-quality seeds with a laboratory germination rate of at least 90-93%.

Cleaning was carried out by a continuous method, manually. After harvesting white lupine plants, the weight of grain, beans, and stems was recalculated in g/m². To assess the quality indicators of white lupine grain, analytical studies were carried out on a SpectraStar 2500XL-R device. Lupine grain sampling, as well as preparation for the analysis of samples using the method of near infrared spectroscopy was carried out in accordance with State Standard 32040-2012.

All research results were statistically processed by using the one-way analysis of variance.
3. Results and discussion

As the result of the research, the effect of various methods of using sodium selenite on the productivity of white lupine varieties Degas was studied (Table 1). The results of studies on the effect of selenium on the yield of grain, beans and stems of white lupine are presented in Table 2.

Table 1. Yield of white lupine when using selenium.

| Experience options      | Weight, g/m² |          |          |          |
|-------------------------|--------------|----------|----------|----------|
|                         |              | grains   | beans    | stems    |
| Control                 | 45.0         | 64.0     | 430      |
| Seed treatment before sowing | 57.5         | 134.0    | 455      |
| Foliar treatment of plants | 80.0         | 100.0    | 370      |
| LSD₀₅                   | 7.0          | 26.0     | 35       |

* Note: LSD₀₅ - the lowest significant difference.

Evaluation of the research results showed that in the variant with seed treatment before sowing, the grain yield is 27% higher than in the control. The mass of beans in this variant increased 2 times as compared with the control. This was due to the increase in the mass of fruit valves, as well as the result of the increase in the number of beans on one plant, while maintaining the number of grains in one bean. The weight gain of the stem was not significant.

When foliar treatment of plants with 0.01% sodium selenite solution was used before the onset of the flowering phase, an increase in grain yield was revealed by 1.7 times compared with control as a result of an increase in the number of seeds per plant. It was revealed that in this variant the mass of fruits is more than 1.5 times, which indicates an increase in the number of fruits per plant. The stem weight has decreased by 14%. This indicates an increase in the proportion of grain in the structure of the aboveground part of plants.

Thus, it was found that the use of sodium selenite for foliar treatment of plants contributed to the greatest increase in the productivity of white lupine plants. The increase in grain yield of 27% compared to the control was obtained. The increase in the mass of beans was revealed by almost 2 times. This testifies to the effect of sodium selenite on the processes of fruit formation and the processes of setting the seed productivity of lupine plants. This ensures maximum plant yield and the best plant structure for white lupine.

In agricultural production in many countries, lupine is considered not only as a crop for the production of high-quality feed protein, but also as a means of protecting energy and protecting the environment. Lupine is primarily a protein source. In this regard, the objectives of our research were to assess the effect of sodium selenite on the content of crude protein in lupine grain and other indicators. The research results are presented in Table 2.

Table 2. Influence of selenium on grain quality indicators of white lupine variety Degas.

| Experience options      | Crude protein, % | Harvest crude protein, g/m² | Crude ash, % | Mass moisture content, % | Alkaloids content, % |
|-------------------------|------------------|----------------------------|--------------|--------------------------|----------------------|
| Control                 | 31.4             | 14.1                       | 3.9          | 11.2                     | 0.067                |
| Seed treatment before sowing | 33.8             | 19.4                       | 3.9          | 11.8                     | 0.068                |
| Foliar treatment of plants | 39.5             | 31.3                       | 3.1          | 12.5                     | 0.039                |
| LSD₀₅                   | 0.7              | -                          | 0.2          | 0.9                      | 0.02                 |
The main quality indicator for assessing the nutritional value of white lupine plants is the crude protein content. In accordance with State Standard R 54632-2011, the lowest value of this indicator for white lupine grain of the 3rd class is 34%. Grains grade 1 or 2, subject to other requirements, must contain 38% and 36% crude protein, respectively. As can be seen from the results of Table 2, the treatment of white lupine seeds before sowing with selenium contributed to the increase in the crude protein content in the grain by 1.08 times. The content of crude ash, alkaloids and mass fraction of moisture, in this variant, practically did not change in comparison with the control. When using foliar treatment of plants with sodium selenite before the beginning of the flowering phase, the increase in the content of crude protein in grain was obtained by 1.25 times compared to the control. In this embodiment, the obtained grain can be classified as class 1 in terms of technological quality indicators. The decrease in the content of alkaloids in lupine grain was also revealed. Since the content of alkaloids does not exceed the permissible limits in all variants of the experiment, the obtained grain can be used for the preparation of animal feed.

The fodder value of the obtained lupine grain can be estimated by the collection of crude protein with the grain yield (Table 2). The analysis of the research results showed that the use of selenium contributed to the increase in the collection of crude protein by the yield of white lupine grain. The increase in the collection of crude protein with grain yield was obtained when using seed treatment before sowing by 37% compared to control, when using foliar treatment of plants by more than 2 times. This is due to the influence of selenium on the processes of nitrogen entry into lupine plants, as well as redistribution between plant organs, and the increase in grain yield. In addition, it was found that the use of sodium selenite contributed to an increase in the yield of crude protein with the yield of the entire aboveground mass of lupine plants. Thus, it was concluded that the use of selenium had a positive effect on improving the nutritional value of the resulting harvest of Degas lupine plants, as the result of stimulating the processes of nitrogen intake and redistribution of nitrogen from vegetative organs to generative organs.

4. Conclusion
The studies carried out made it possible to study the effect of various methods of using sodium selenite on the yield and quality indicators of white lupine of Degas variety. Two methods of sodium selenite application were studied: seed treatment before sowing and foliar treatment of plants before the onset of the flowering phase. The positive effect of both methods of sodium selenite application on the yield and quality indicators of white lupine grain is shown.

The greatest positive effect of sodium selenite was obtained when using foliar treatment of plants before the beginning of the flowering phase. It was revealed that the use of foliar treatment of plants resulted in the increase in grain weight by 27% compared to the control without the use of selenium. An almost twofold increase in the mass of beans was revealed, which is due to an increase in the number of beans on one plant. This testifies to the effect of sodium selenite on the processes of fruit formation and the processes of setting the seed productivity of lupine plants. This ensures maximum plant yield and the best plant structure for white lupine.

Evaluation of the quality indicators of lupine grain showed the increase in the crude protein content when using selenium. The greatest increase in the content of crude protein in lupine grain was obtained when using foliar treatment of plants with sodium selenite. In this variant, grain with a crude protein content of 39.5% was treated. In this regard, the obtained grain can be attributed to the 1st class of the commodity classification. The content of alkaloids in all the variants of the experiment was less than the maximum permissible value, which makes it possible to use grain for feed purposes.

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