A perspective method of garlic enrichment (*Allium Sativum* L.) with selenium

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**Abstract.** Obtaining high-quality products is one of the most important tasks of agricultural enterprises of all forms of ownership. Quality indicators are not only organoleptic indicators, but first of all, the chemical composition of the products manufactured. Quality food should contain the necessary macro- and micronutrients in a dose that meets the needs of the human body in them. In this regard, the development of methods for obtaining products containing microelements, in the quantity necessary to ensure the normal functioning of a person is a particularly important area at present. We have found that preplant treatment of chives and vegetative plants with a 0.1% solution of potassium selenite in combination with SAS and DMSO makes it possible to produce bulbs in which the content of selenium exceeds the control by 29.4 and 145.3 times. A similar treatment of cloves and plants with sodium selenite leads to an increase in the selenium content in the bulbs to 8.0 mg / kg and 7.3 mg / kg, or 169.8 and 157.2 times in comparison with the control. The proposed method of enrichment of garlic with selenium allows to improve the qualitative composition of this culture and increase its economic significance.

1. **Introduction**

*Allium sativum* L. is a widely cultivated crop. Worldwide, garlic production is more than 28 million tons per year, more than 20 million tons of them are produced in China.

Numerous studies currently being conducted are aimed at finding and studying effective methods for obtaining high yields of garlic. The search for such techniques is associated with the high labor intensity of growing this crop. The vegetative method of breeding garlic does not allow to quickly fill the market with planting material and leads to the fact that all planting material must be completely updated every 3-5 years.

Unfortunately, there are very few studies related to the development of methods for improving product quality. An important indicator of quality is the mineral and organic composition of products. However, both the absence of components harmful to human health and the availability of useful elements should be considered. Therefore, a lot of attention should be paid to the methods of saturation of garlic and other crop production with individual essential elements and, in particular, with selenium.
Selenium has a similar structure of the atom with sulfur, so in some organic compounds it is able to replace it. The biological activity of such selenium-containing organic compounds is higher than that of the initial ones containing sulfur, which is of great importance for human health [5].

Garlic, enriched with selenium, exhibits a high degree of biological activity, namely, it protects against the toxic effects of heavy metals – As, Cd, Hg, Sn, etc., and it also has antioxidant, anti-inflammatory, and antibacterial effects [1]. The recommended daily intake of selenium depends on the gender and age of a person and ranges from 30 µg to 70 µg [2]. The aim of our study was to find effective ways to enrich garlic with Selenium.

2. Materials and Methods

Studies were conducted in the Department of Biotechnology and Innovative Projects of the All-Russian Research Institute for Vegetable Growing – Branch of the Federal Scientific Center for Vegetable Growing (Moscow Region, Ramensky District, Vereya Village) in open ground conditions.

The material for the study was the cloves and plants of garlic (winter Gladiator variety) [3].

The study design included preplant treatment of the cloves and double treatment of vegetative plants with sodium selenite and potassium selenite solutions. The concentration of our solutions was 0.1%. Selenites dissolved in DMSO or SAS.

The cloves were soaked in a solution of selenites for 30 minutes; with subsequent treatments, the plants were sprayed with solutions as follows: they were sprayed in the phase of the onset of intensive leaf growth for the first time and the second time, and then they were sprayed after 3 weeks. The experiment was laid in the fourfold repetition; the accounting area of one plot was 1 m²; the distance between the rows was 25 cm; between the plants in a row – 10 cm; the length of one row is 1 m. The flow rate of the working fluid was 100 ml / m².

3. Results and Discussion

Our studies conducted earlier [4] in greenhouses clearly shows that Selenium from solutions for non-root and root treatment is used unequally effectively (Table 1).

| Experience option         | Non-root top dressing | Root top dressing |
|---------------------------|-----------------------|-------------------|
| Control                   | 0.040±0.006           | 0.040±0.005       |
| Sodium selenite           | 0.470±0.057           | 0.200±0.024       |
| Potassium selenite        | 0.580±0.069           | 0.100±0.013       |
| Zinc selenite             | 0.070±0.010           | 0.030±0.004       |

It was established that the root and non-root top-dressing of plants with sodium, potassium and zinc selenites was very effective and allowed to significantly increase the selenium content in the bulbs (2.5 - 14.5 times). At the same time, the content of selenium in the control samples was 0.040 mg / kg, and for non-root treatment with potassium selenite was 0.580 mg / kg. Studies have shown that non-root top dressing with sodium and potassium selenite was 2.3–5.8 times more effective than root. So, when using sodium and potassium selenite with a non-root top dressing, the content of selenium in the bulbs was 0.470 mg / kg and 0.580 mg / kg, and with the root was 0.200 mg / kg and 0.100 mg / kg, respectively.

Based on these results, further work on the enrichment of garlic with selenium was carried out using non-root top dressing. To facilitate the penetration of solutions into plant tissue, surfactants, namely DMSO and SAS were added to the studied solutions.

Studies have shown that the use of 0.1% solutions of sodium selenite and potassium selenite, dissolved in DMSO or SAS, did not have a significant effect on plant height, average weight, yield of bulbs and inflorescences (Table 2).
The developed effective method of enrichment of garlic with Selenium allows to improve the qualitative composition of this crop and increase its economic significance.

The proposed method, based on preplant treatment of the teeth and the subsequent double treatment of plants with 0.1% sodium selenite solution with SAS, allows to obtain cloves containing up to 8.0 mg / kg of selenium.

4. Conclusion

The chemical analysis of the grown bulbs showed that the use of solutions of sodium selenite and potassium selenite contributed to an increase in the selenium content in comparison with control. It was noted that the use of sodium selenite was more effective in comparison with potassium selenite. Thus, the use of potassium selenite in combination with SAS contributed to an increase in the selenium content in the cloves by 29.4 times, and in combination with DMSO by 145.3 times.

Table 2. Effect of Se-containing preparations on the growth and yield of winter garlic bulbs.

| Experience option | Plant height | Average bulbs weight | Productivity bulbs | The average mass of inflorescences | Yields aerial bulbils |
|------------------|-------------|----------------------|--------------------|-----------------------------------|-----------------------|
|                  | cm          | kg                   | kg / m²            | g %                               | kg / m²    | %                        |
| Control          | 103±7       | 31.6                 | 100.0              | 1.230 100.0                       | 8.8 100.0  | 0.359 100.0             |
| Na₂SeO₃+ DMSO    | 104±10      | 31.3                 | 99.1               | 1.221 99.3                        | 8.0 90.9   | 0.312 86.9             |
| Na₂SeO₃+ SAS     | 110±12      | 32.3                 | 102.2              | 1.260 102.4                       | 8.5 96.6   | 0.331 92.2             |
| K₂SeO₃+ DMSO     | 97±10       | 29.9                 | 94.6               | 1.166 94.8                        | 8.8 100.0  | 0.343 95.5             |
| K₂SeO₃+ SAS      | 97±8        | 32.0                 | 101.3              | 1.248 101.5                       | 8.5 96.6   | 0.331 92.2             |

The average mass of inflorescences and yields of aerial bulbils were noted that the use of solutions of sodium selenate and DMSO increased the selenium level by 157.2 and 169.8 times, respectively.

Table 3. Selenium content in winter garlic cloves when using selenites, µg / kg.

| Processing option | Selenium content | mg / kg | excess ratio |
|-------------------|------------------|---------|--------------|
| Control           | 0.047±0.007      | -       |
| Sodium selenite + DMSO | 7.390±0.740 | 157.2   |
| Sodium selenite + SAS  | 7.980±0.800   | 169.8   |
| Potassium selenite + DMSO | 6.830±0.680 | 145.3   |
| Potassium selenite + SAS | 1.380±0.140 | 29.4    |

It should be noted that earlier, the researchers could not get such a high content of selenium in the bulbs. So, N. A. Golubkina and co-workers [1] found that with the joint application of sodium selenate and liquid fertilizers Fertika lux (N – 1.6; P₂O₅ – 2.0; K₂O – 2.7; Fe – 0.01; B – 0.002; Cu – 0.001; Mn – 0.01; Mo – 0.002; Zn – 0.001%), the total dose of sodium selenate was 75 mg / m². The introduction was carried out in parts for 2.5 months. With each addition, 25 ml of Fertika fertilizer was added to 7.5 mg of sodium selenate and the solution was adjusted to 10 liters per 1 m². As a result of the experiment, the content of selenium (powder obtained from bulbs) increased 16.7 times in the final product in comparison with the control and amounted to 1.5 + 0.1 mg / kg of dry weight.

The proposed method showed high efficiency. It allows one to increase the content of selenium in the chives of garlic to 8.0 mg / kg, which will allow to fill the daily need of the body in this element with an average daily intake of garlic 10 g.

4. Conclusion

The developed effective method of enrichment of garlic with Selenium allows to improve the qualitative composition of this crop and increase its economic significance.

The proposed method, based on preplant treatment of the teeth and the subsequent double treatment of plants with 0.1% sodium selenite solution with SAS, allows to obtain cloves containing up to 8.0 mg / kg of selenium.

References

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