The effect of foliage spraying with complex micronutrient fertilizers and humate on quantitative losses of potatoes during storage

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Abstract. The article examines the effect of foliage spraying with complex micronutrient fertilizers Strada N, Strada R and humate Ekorost on the preservation of potato tubers of Gala and Latona varieties. The data on natural loss and total quantitative losses of experimental and control tubers after eight months of storage are given. A decrease in the natural loss of mass and absolute waste of tubers in the variants with the use of complex micronutrients has been revealed. Micronutrient Strada R with predominating phosphorus had the greatest effect on increasing the preservation of tubers. It is shown that the use of Ekorost humate does not have a pronounced effect on increasing the storage capacity of tubers, although it leads to a slight decrease in the natural loss of mass of two potato varieties.

1. Introduction
Storage of crop products is a complex process, the results of which are affected by many factors [1]. High preservation of products, including potatoes, is laid even during the cultivation period. A significant role belongs to the rational organization of the plant nutrition system. The correct selection of types, forms and doses of fertilizers, timing and methods of their introduction, considering the biology of the crop, has a significant impact not only on yield, but also on product quality [2-7]. In turn, the high quality of stored products increases its preservation [8]. This is especially important for ware potatoes with a long shelf life.

In recent years, much attention has been paid to the use of humic preparations and liquid complex micronutrients for topdressing of vegetative plants. Many authors point to the effectiveness of this technique not only for increasing yields and product quality, but also for reducing economic costs and environmental load on soil and products when growing crops [9-10]. The study of the influence of this agrotechnical method on the quantitative losses of potatoes during long-term storage is of wide practical interest.
2. Materials and methods
The object of the research was two short-season varieties of potatoes - Gala and Latona. The potatoes were grown at the educational farm of Ryazan State Agrotechnological University on gray forest soil, being heavy loamy in texture, and the depth of the arable layer was 27-30 cm. Agrochemical characteristics of the soil of the experimental plot were as follows: humus content according to Tyurin was 3.3%, the reaction of the soil solution was weakly acidic (pH of the salt extract was 5.3), the content of mobile phosphorus was 16.4±0.72 mg/100 g of soil and that of potassium was 9.3±0.72 mg/100 g of soil.

The experiment investigated the effect of vegetative treatments of potato plants with liquid complex micronutrients Strada N, Strada R and humic preparation Ekorost on the preservation of tubers during autumn-winter storage.

Complex micronutrients Strada N and Strada R are highly concentrated suspensions of nutrients. Strada N contains 27% nitrogen, 5% phosphorus, 3% potassium, 0.15% MgO, 1.26% S and other elements. Strada R contains 18% phosphorus, 4.5% nitrogen, 4.5% potassium, as well as other elements.

Humates are used to stimulate plant growth and development. They consist of substances of natural origin, formed during the decay of plant residues in the soil. Humates do not belong to fertilizers, but they can replace them, because supply plants with a number of essential trace elements and have a beneficial effect on the soil.

Humate Ekorost is a dark brown liquid suspension of neutral reaction (pH - 6.5-7.5), containing potassium salts of humic acids at a concentration of 70 g/l and a complex of trace elements. It is made from low-lying peat with a moisture content of about 50% with the addition of water.

The scheme of vegetative treatments for potato plants included the following variants:

- Control - without treatment;
- Treatment with humate Ekorost (0.2-0.4 l/ha);
- Treatment with complex micronutrient Strada N (3-5 l/ha);
- Treatment with complex micronutrient Strada R (3-5 l/ha).

Foliage spraying of potato plants with these types of micronutrients was carried out in two steps: in the phase of full germination and in 2 weeks after the previous treatment. The rest of the elements of potato farming did not differ according to the variants and were generally accepted for the growing zone.

Studies of the effect of the studied methods of treating potato plants on the preservation of tubers were carried out during the storage period of 2018-2019. After the treatment period, the harvested tubers of the experimental and control variants were stored in a stationary training and experimental storage of a semi-buried type, where they were stored for 8 months - from September to May. Tubers of all variants, when placed for storage, were intact, healthy and fully complied with GOST 7176-2017. The temperature during the main storage period was +4...+6°C when relative humidity of 90%.

In the course of the research, the effect of foliage spraying on natural weight loss and total quantitative loss of tubers was assessed. To consider the natural loss, five nets with a mass of 5 kg of tubers of the experimental and control variants were stored under the same conditions. The nets were weighed twice: at the beginning (September) and at the end of storage (May). Natural weight loss was calculated from the average value of the weight loss of tubers from five parallel determinations. To consider the total quantitative losses at the end of storage, the potato tubers in the nets were analyzed according to GOST 28372-93.

3. Results
The structure of the total quantitative losses of potatoes according to the variants of the experiment is presented in Table 1. It includes the natural loss of mass and the absolute waste, represented by
various types of rot and sprouts. There is no technical defect due to the initially high quality of tubers for storage.

Table 1. The structure of quantitative losses of potatoes by variant of the experiment.

| Variant of treatment | Natural weight loss, % | Absolute waste (rot and sprouts), % | Total quantitative losses, % |
|----------------------|------------------------|-------------------------------------|----------------------------|
| Gala variety         |                        |                                     |                            |
| Control              | 8.8±0.24               | 5.6                                 | 14.4                       |
| Ekorost              | 8.5±0.23               | 6.0                                 | 14.5                       |
| Strada N             | 8.1±0.28               | 5.3                                 | 13.4                       |
| Strada P             | 7.6±0.30               | 5.1                                 | 12.7                       |
| Latona variety       |                        |                                     |                            |
| Control              | 7.8±0.19               | 4.6                                 | 12.4                       |
| Ekorost              | 7.6±0.18               | 4.9                                 | 12.5                       |
| Strada N             | 7.2±0.32               | 4.2                                 | 11.4                       |
| Strada P             | 6.4±0.20               | 4.0                                 | 10.4                       |

As studies have shown, all types of foliage spraying used led to a decrease relative to the control in the natural loss of the mass of tubers of varieties Gala and Latona for eight months of storage by 0.2-1.4 %. The smallest natural weight loss of tubers of both varieties was noted in the variant with the use of the complex fertilizer Strada R. One should note the lower natural weight loss in all variants of Latona, which is explained by the longer period of natural dormancy in this variety compared to Gala variety.

From the data in Table 1, it follows that the treatment with Ekorost humate does not lead to any improvement in preservation of tubers of both potato varieties in relation to the control due to an increase in the absolute waste by 0.3-0.4 %. There was a decrease in the total quantitative losses in the rest of experimental variants. The best result in reducing the loss of tubers was shown by the treatment of plants with complex micronutrient Strada R: the total quantitative losses decreased by 1.7 % in Gala potato variety and by 2.0 % in Latona variety as compared with the control.

4. Discussion
The studies have shown the effectiveness of foliage spraying of growing potato plants with complex micronutrients to increase the storage of tubers. The greatest effect on reducing losses was noted when using micronutrient Strada R with dominating phosphorus. This result is quite obvious, because phosphorus nutrition plays a leading role in improving carbohydrate and protein metabolism in potato plants, actively participates in starch accumulation, which ultimately ensures ripening and the formation of high-quality tubers with good keeping quality.

The use of humate Ekorost does not have a pronounced effect on increasing the storage capacity of tubers, although it leads to a slight decrease in natural loss. Probably, the effect of humates is to the greatest extent associated with the activation of soil bacteria and improvement of the soil structure, and to a lesser extent affects internal biochemical processes in plants, providing an increase in the storage capacity of tubers.

5. Conclusion
As a result of the research, a decrease of the natural loss of the tuber mass of varieties Gala and Latona was revealed when using all studied variants for foliage spraying, which amounted to 0.2-1.4 % for eight months of storage. The use of multicomponent complex micronutrients Strada N and Strada P also led to 0.3-0.6% decrease of the total waste in relation to the control, that ultimately reduced the total quantitative loss of tubers by 1.0-2.0 %. The greatest effect on the reduction of total quantitative losses was caused by the treatment of plants with complex micronutrient Strada R with dominating...
phosphorus. The use of humate Ekorost did not have a pronounced effect on increasing the preservation of tubers.

Thus, an efficiently organized plant nutrition system makes it possible to smooth out the effect of unfavorable soil and climatic factors on the preservation of tubers and reduce the quantitative loss of tubers during long-term storage of potatoes.

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