Study of the effect of foliar top dressing with liquid polymer fertilizer Zelenit nitrogen micro on the growth and development of potato plants in vivo

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Abstract. This article contains the results of a study on the study of foliar feeding of potatoes with liquid polymer fertilizer Zelenit nitrogen micro at concentrations of 25, 30 and 35 mg/l. The provision of the plant with the main elements of nutrition contributes to good growth, accelerating its development, and also has a positive effect on the resistance of plants to negative influences. In the course of our research, it was found that it is effective to use foliar top dressing with Zelenit at a concentration of 30 to 35 mg / l, here the plants were better leafy and had the largest number of stems, which had a positive effect on the formation of the crop. The most productive of the studied varieties was the Belarusian variety Manifest, which ultimately had the maximum yield of seed material of the first field generation, which plays a paramount role for seed production. When studying the average coefficient of adaptability (Ka) in the conditions of the Pskov region, it was found that the most productive and promising varieties for growing in this region are Manifest and Lileya Belorussskaya with the highest coefficients of adaptability from 1.25-0.02 and with the use of liquid polymer fertilizer at a concentration of 25-30 mg / l.

1. Introduction

Potato is a crop that intensively uses nutrients from the arable layer of the soil and needs good nutrition throughout the growing season [5]. Nutrients must be available in an accessible form and in sufficient quantity, it often happens that in order to obtain a good harvest and high-quality tuber material, the amount of substances that is in the soil is not enough [1;6]. To overcome this, it is necessary to correctly develop the use of foliar fertilizing with mineral fertilizers for plants; they are more effective than root fertilization, which will allow obtaining consistently high yields. The use of trace elements increases not only the yield of tubers, but also their quality. The maximum positive effect of microelements is achieved only when the studied culture is fully provided with the main elements of mineral nutrition such as nitrogen, phosphorus, and potassium. With an increase in yield, an increase in the removal of nutrients by plants from the soil in connection with this increases the role of microelements in the fertilizer system [3-4;7].

That is why the production of a wide range of microfertilizers is significant for our region. They must contain a balanced ratio of nutrients to produce healthy seed potatoes. The advantage of microelements in plants is that they are contained in the composition of enzymes and it is they that act as catalysts for biochemical processes, increasing their activity [2;11].
2. Materials and methods
The studies were carried out in 2021 in the laboratory of plant clonal micropropagation of the Federal State Budgetary Educational Institution of Higher Education of the Velikolukskaya State Agricultural Academy and on an experimental plot using laboratory and field experiments. As an object of research, we used an in vitro collection of sterile healthy plants of potato varieties of the middle early ripeness group Lileya Belorussskaya, Manifesto, Real, Ryabinushka [10].

Aeroponic potato minitubers were planted under natural conditions in vivo. Soddy-podzolic medium loamy soil was noted on the experimental plot. Content: humus - 2.5%; pH 6.0-6.5; N - 60 mg/kg; P₂O₅ - 150 mg/kg; K₂O - 180 mg/kg. The arable layer was in the range of 20-25 cm. Organic fertilizers for autumn plowing were applied at the rate of 30 t/ha. Mineral fertilizers were applied N-90, P-180, K-180 kg/ha.

The repetition was four times, the accounting plot was 1.54 m², with a planting pattern of 70x25 cm. The tubers were planted in the first decade of May. For vegetative plants, foliar fertilizing was carried out with liquid fertilizer Zelenit nitrogen micro in concentrations of - 25, - 30 and - 35 mg/l 2 times in the budding and flowering phases.

In the first ten days of September, mini-tubers were dug out by hand. Two weeks before harvesting, the tops were mowed, the structure of the crop was determined by the day according to the requirements for the nursery for the production of mini-tubers. All research results were carried out in accordance with the method of research on potato culture [8].

To assess the productive and adaptive potential of varieties in terms of yield, the method of Zhivotkov L.A. [5] was used; in the analysis, the indicator was used - the average varietal yield of the year - this is the level of yield that is taken for one specific year and region. For the varieties that are compared, the general species adaptive response of the culture to specific growing conditions is taken, realized in the average yield value. When determining the species response, the summation of the yield of individual varieties is used, followed by dividing the indicator by their total number. The obtained value of a certain set of varieties to environmental factors in each particular year is an indicator of the reaction rate. To calculate the coefficient of adaptability (Ka), the following formula is used:

- \( Ka \cong \frac{X_{ij} \times 100}{X} \times 100. \)
- Where \( X_{ij} \) is the yield of the i-th variety in the j-th year of testing.
- \( X \) is the average varietal yield of the year, it is taken in the methodology as 100% [5,9]. And the conversion of the absolute values of the yield into percentages makes it possible to compare the behavior of varieties in different years. As a result, according to the obtained indicators, it is possible to evaluate the studied varieties for adaptability and their productive potential.

3. Results
According to the results of the work performed, it can be said that the use of foliar feeding of potatoes in the budding phase contributed to an increase in the assimilation surface of the leaves and the duration of the leaf apparatus. The periods of passage of phenological phases increased when plants were treated with Zelenit at a concentration of 30-35 mg/l in all early-ripening plant varieties studied by us by about 2-4 days.

The vegetation period of the studied varieties with the use of foliar treatment with microfertilizer was also longer in the variants with Zelenit spraying at a concentration of 30-35 mg/l. In comparison with the control variant, the growing season was distinguished by a longer period from 8 to 12 days.

The maximum vegetation period was recorded in the variant with Zelenit spraying - 35 mg / l, the maximum indicator was for the Real variety - 109 days, which is 8 days more than the control variant, for the Lileya Belorusskaya variety - 107 days more than the control 12 days.

To control when obtaining the maximum yield, biometric indicators of potatoes are very important (table 1).
When analyzing the table, it was found that the use of foliar dressings had a positive effect on the formation of both the number of stems and the height of plants. In all potato varieties studied by us, the maximum number of stems was noted in the variant when treated with Zelenit microfertilizer at a concentration of 35 mg/l; the increase to the control variants was on average one stalk. The largest number of stems was recorded in the variety Manifest - 5.2 pcs/plant, in the varieties Lileya Belorussskaya and Real this figure was 5.0 pcs/plant, fewer stems were noted in the variety Ryabinushka - 4.9 pcs/plant.

**Table 1.** Influence of foliar subcortex with the use of liquid polymer fertilizer Zelenit nitrogen micro on the biometric indicators of potatoes *in vivo*.

| Options          | Number of stems, pcs/plant | Plant height, cm | Number of stems, pcs/plant | Plant height, cm | Number of stems, pcs/plant | Plant height, cm | Number of stems, pcs/plant | Plant height, cm |
|------------------|-----------------------------|------------------|-----------------------------|------------------|-----------------------------|------------------|-----------------------------|------------------|
| Control (no spray) | 4.1                         | 54.1             | 4.2                         | 53.6             | 4.3                         | 41.7             | 4.2                         | 57.3             |
| Zelenit 25 mg/l  | 4.3                         | 54.5             | 4.8                         | 55.4             | 4.3                         | 42.1             | 4.3                         | 59.0             |
| Zelenit 30 mg/l  | 4.7                         | 60.7             | 5.0                         | 59.8             | 4.5                         | 43.8             | 4.7                         | 60.4             |
| Zelenit 35 mg/l  | 5.0                         | 64.4             | 5.2                         | 63.6             | 5.0                         | 44.5             | 4.9                         | 62.1             |

The minimum data on the formation of stems were in the control variant without treatment, their number ranged from 4.1-4.3 pieces/plant. In experiments with the use of Zelenit liquid polymer fertilizer, a positive trend was observed in all variants.

In terms of plant height, it can also be said that the use of foliar top dressings has a positive effect on the entire cycle of plant development, so the largest plant length was obtained in the Lileya Belorussskaya variety in the variant with Zelenit top dressing at a concentration of 35 mg/l - 64.4 cm. The height of the Manifest variety was 63.6 cm, and the plants of the Real variety were the shortest - 44.5 cm. In the control variant, the potato plants were the shortest.

From the obtained biometric indicators, it can be noted that the use of liquid polymer fertilizer Zelenit nitrogen micro has a positive effect on the development of the green mass of the plant. A well-formed ground part of potato plants should have a positive effect on the structure of the crop.

When studying the effect of foliar fertilizing with Zelenit nitrogen micro fertilizer on the structure of the potato crop under *in vivo* conditions (table 2), we found that the largest number of tubers per plant was obtained from the Manifest variety - 16.3 pcs/plant in the variant with spraying with Zelenit 35 mg/l, in second place is the variant with Zelenit 30 mg/l - 16.0 pcs/plant in the same variety.

In other potato varieties, the use of foliar feeding at a micronutrient concentration of 35 mg/l also had a positive effect, in the Lileya Belorussskaya and Real varieties, 15.9 tubers per plant were formed, and in the Ryabinushka variety this figure was 15.8 pieces.

The smallest number of tubers per plant was collected in the control variant from the Ryabinushka variety - 12.1 pcs/plant.

In terms of the mass of tubers, the experience with the use of microfertilizer Zelenit at a concentration of 35 mg/l in all the studied varieties, the maximum mass of tubers was noted in the Manifest variety - 1205 g/plant, the Real variety is in second place - 1078 g/plant.

Good results were obtained in the treatment with Zelenit 30 mg/l. The smallest mass of tubers was formed in plants in experiments without the use of top dressings.

Studies of the fractional composition of potatoes showed that a positive effect on the formation of seed material with a size of 30-60 mm had a Zelenit microfertilizer at a concentration of 35 mg/l, and good performance was also noted in the variant using Zelenit 30 mg/l. The largest amount of seed fraction was noted in the Real variety - 12.9 pieces, the Manifest - 12.6 pieces, the smallest number of tubers of this fraction was noted in the Ryabinushka variety.
Table 2. Influence of foliar top dressing with microfertilizer Zelenit nitrogen micro on the structure of potato yield \textit{in vivo}.

| Variety      | Experience | Variant          | Number of tubers pcs/plant | Weight of tubers g/plant | Number of tubers by fractions, pcs. | Productivity, t/ha | Increase, t/ha |
|--------------|------------|------------------|-----------------------------|--------------------------|-------------------------------------|-------------------|---------------|
|              |            |                  |                             |                          | >60 mm                               | 30-60 mm          | <30 mm        |
| Lileya Belorusskaya | Control (no spray) | 13.6              | 818                         | 0.6                      | 8.7                                 | 4.3               | 18.6          | -             |
|              |            | Zelenit 25 mg/l   | 14.0                        | 906                      | 0.7                                 | 9.2               | 4.1           | 19.1          | 0.5           |
|              |            | Zelenit 30 mg/l   | 15.5                        | 957                      | 0.9                                 | 10.8              | 3.8           | 24.5          | 5.9           |
|              |            | Zelenit 35 mg/l   | 15.9                        | 1037                     | 1.1                                 | 12.4              | 2.4           | 26.6          | 8.0           |
| Manifest     | Control (no spray) | 14.4              | 915                         | 0.8                      | 7.5                                 | 6.1               | 22.2          | -             |
|              |            | Zelenit 25 mg/l   | 15.1                        | 978                      | 0.6                                 | 8.6               | 5.9           | 24.7          | 2.5           |
|              |            | Zelenit 30 mg/l   | 16.0                        | 1129                     | 0.9                                 | 11.5              | 3.6           | 29.6          | 7.4           |
|              |            | Zelenit 35 mg/l   | 16.3                        | 1205                     | 1.0                                 | 12.6              | 2.7           | 31.5          | 9.3           |
| Real         | Control (no spray) | 14.5              | 857                         | 1.2                      | 8.0                                 | 5.3               | 15.2          | -             |
|              |            | Zelenit 25 mg/l   | 14.8                        | 954                      | 1.1                                 | 9.8               | 3.9           | 17.4          | 2.2           |
|              |            | Zelenit 30 mg/l   | 15.6                        | 1006                     | 0.8                                 | 12.3              | 2.5           | 19.5          | 4.3           |
|              |            | Zelenit 35 mg/l   | 15.9                        | 1078                     | 0.9                                 | 12.9              | 2.1           | 21.6          | 6.4           |
| Ryabinushka  | Control (no spray) | 12.1              | 865                         | 0.7                      | 8.7                                 | 2.7               | 17.3          | -             |
|              |            | Zelenit 25 mg/l   | 13.6                        | 908                      | 0.7                                 | 9.1               | 3.8           | 17.9          | 0.6           |
|              |            | Zelenit 30 mg/l   | 14.7                        | 1025                     | 1.1                                 | 10.2              | 3.4           | 22.4          | 5.1           |
|              |            | Zelenit 35 mg/l   | 15.8                        | 1036                     | 1.0                                 | 11.6              | 3.2           | 25.7          | 8.4           |

Despite the fact that the conditions of the 2021 growing season were marked by a dry summer period, the favorable effect of spraying with microfertilizer had a positive effect on the development of potato plants in general. Spraying the vegetative plants of this crop in the phase of the beginning of flowering under conditions of insufficient water supply in 2021 with liquid polymer fertilizer Zelenit nitrogen micro performed a protective and anti-stress function. As a result, this contributed to a significant increase in yield from 6.4 to 9.3 t/ha, compared with the control variant.

The highest yield was obtained in the variety Manifest treated with Zelenit at a concentration of 35 mg/l - 31.5 t/ha, in the variety Lileya Belorusskaya - 26.6 t/ha, in the variety Ryabinushka - 25.7 t/ha and the lowest yield was variety Real – 21.6 t/ha.

The most important indicator that characterizes a variety is considered to be the stability of its yields over the years, and when cultivated in various production conditions. When growing potatoes in unfavorable soil and climatic conditions, not only the potential productivity of varieties, but also their environmental sustainability is of no small importance - this is relevant for regions with risky farming.

To solve such problems, it is necessary to grow highly plastic varieties that should give high yields even when exposed to adverse factors.

To increase the level of potato production, the choice of variety is of primary importance. The potential of the studied variety, and indeed of all varieties, is determined by a complex of features and properties, but yields come first.

From our studies, the following results were obtained in terms of the average coefficient of adaptability (Ka), which can be used to judge the productive capabilities of the potato varieties we studied (table 3).

The growing season of 2021 was characterized by a dry, unfavorable period for the development of potato plants in June and July. As a result, the coefficient of adaptability ranged from 1.25 to 0.81. The highest coefficient of adaptability among the varieties was noted in the variety Manifest in all studied...
variants. The maximum indicator was noted in the variant with the use of liquid polymer fertilizer Zelenit nitrogen micro at a concentration of 25 mg/l - 1.25.

**Table 3.** Productivity of potato varieties and their coefficient of adaptability depending on the use of liquid polymer fertilizer Zelenit nitrogen micro.

| Options                      | Lileya Belorussian | Manifest    | Real       | Ryabinushka |
|------------------------------|--------------------|-------------|------------|-------------|
| Yield, t/ha                  | 18.6               | 22.2        | 15.2       | 17.3        |
| Adaptability coefficient (Kₐ)| 1.01               | 1.21        | 0.83       | 0.95        |
| Yield, t/ha                  |                  | 24.7        | 17.4       | 17.9        |
| Adaptability coefficient (Kₐ)|                  | 1.25        | 0.88       | 0.90        |
| Yield, t/ha                  |                  | 29.6        | 19.5       | 22.4        |
| Adaptability coefficient (Kₐ)|                  | 1.23        | 0.81       | 0.93        |
| Yield, t/ha                  |                  | 31.5        | 21.6       | 25.7        |
| Adaptability coefficient (Kₐ)|                  | 1.19        | 0.82       | 0.97        |
| Medium-varietal yield, t/ha  |                  |             |            |             |
| Zelenit 25 mg/l              | 19.1               | 24.5        | 26.6       |             |
| Zelenit 30 mg/l              | 24.5               | 26.6        | 26.6       |             |
| Zelenit 35 mg/l              | 26.6               | 31.5        | 31.5       |             |

In the Lileya Belorusskaya variety, the highest coefficient of adaptability was obtained in the Zelenit 30 mg/l variant - 1.02. The lowest rates were noted in the varieties Real from 0.81-0.88 and in Ryabinushka from 0.90-0.97.

4. **Discussion**

There is no soil that is one hundred percent enriched with nutrients from nature. In this regard, we must use organic, mineral and complex fertilizers, since they are the sources of macro- and microelements when growing potato seed material.

The use of foliar fertilizing with microfertilizers has a positive effect both on the development of this crop and increases their resistance to the negative effects of the environment.

5. **Conclusion**

From our studies on the effect of microfertilizer Zelenit on the development of potatoes, as well as on the most important thing is the yield and obtaining the maximum amount of the seed fraction of the first field generation, it was found that it is effective to use foliar top dressing with Zelenit at a concentration of 30 to 35 mg/l. In this variant, the plants were better leafy and had the largest number of stems, which had a positive effect on the formation of the crop. The most productive of the studied varieties was the Belarusian variety Manifest, which ultimately had the maximum yield of seed material of the first field generation.

Under the conditions of the Pskov region, according to the obtained average coefficient of adaptability (Kₐ), it can be said that the most productive and promising varieties for growing in this region are Manifest and Lileya Belorusskaya with the highest coefficients of adaptability from 1.25-0.02 and with the use of liquid polymer fertilizer in concentrations from 25-30 mg/l.

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