# Application of Siliplant in the technology of growing potato minitubers in protected soil conditions

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**Abstract.** Under greenhouse conditions the effect of silicon-containing preparation with complex action, capable of simultaneously stimulating plant ontogenesis, photosynthetic processes and increasing the productivity and quality of plants was studied. The purpose of this study was to study the effect of the silicon-containing preparation Siliplant on the productivity and quality of minitubers of early maturity potato varieties Vineta in the system of virus-free (original) potato seed production. Results demonstrated that Siliplant causes an increase in biometric and physiological parameters such as plant height (by 5.7%), the number of stems in the bush (by 30%), weight of roots (by 16.7%), leaf area (by 23.7%), net photosynthetic productivity (by 37%) compared with the control variant.Root treatments with the preparation increased the yield by 19.3 % and the multiplication factor by 20.0 % compared to the control. Also, the use of Siliplant contributed to a slight increase in quality indicators (17.7 - 2.5 %), respectively, compared to the control. Thus, the use of Siliplant in the double root treatment of potato microplants in protected soil conditions is a promising agricultural technique in the conditions of Nizhny Novgorod region, allowing to increase the productivity of photosynthesis, yields and its quality.

## 1 Introduction

The most important aspect of the system of original seed production in the conditions of protected soil is obtaining a significant number of minitubers [1, 2]. In the technology of minituber production in modern conditions, other biologically active substances with complex action, called phytoregulators, are actively used.

According to the authors [3-5] phytoregulators can change the physiological and biochemical processes at the cellular level, due to the activation of the enzyme system involved in redox reactions, which leads to growth of vegetative and underground parts of

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plants. This allows potato plants in the course of ontogenesis to form resistance to pathogens of various kinds and adverse environmental conditions such as overheating, overcooling, and most often transplanting stress, which is especially relevant under greenhouse conditions. Such phytoregulators, or growth regulators include Siliplant, which contains silicon in its composition. Its peculiarity is that it contains silicon not only as an inorganic compound (ionic), which is assimilated by the plant as a nutrient element, but also in the form of silatrans (an organic substance). Silatrans are conductors of silicon in the most accessible form for plants, and also have the ability to exhibit a stimulating effect on the physiological and biochemical level of plant development.

There is an opinion [6, 7] that using Siliplant in the form of root and foliar feeding of plants can change the orientation of the enzymatic apparatus, and hence cellular metabolism, thereby affecting the growth and development of plants, which invariably leads to an increase in productivity and quality, i.e. there is an opportunity to control the process of yield formation. Therefore, this agronomic technique is quite effective because the silicon-containing fertilizer Siliplant most clearly shows its protective properties, especially under adverse greenhouse conditions, which are manifested when replanting microplants. The consequence is an increase in yield and quality of minitubers, which is the most important and necessary in the system of original potato seed production. Therefore, such research work has an applied aspect, as it is quite relevant not only for researchers, but also for potato producers, especially in the system of original seed production.

Within the framework of our study the effect of silicon-containing microfertilizer Siliplant on growth, photosynthetic parameters and as a result, on productivity (yields and some quality indicators) of potatoes under conditions of vegetative experience in the protected soil is considered.

The purpose of this research is to study the effect of silicon-containing microfertilizer Siliplant on the productivity of healthful early maturing potato varieties Vineta in an protected soil. In order to achieve this goal it is necessary to study the influence of the preparation Siliplant on:

1. the indicators of growth and development of potato microplants in an protected soil;
2. photosynthetic processes of potato microplants in greenhouses;
3. the yield, reproduction rate and some quality indicators of tubers in a protected soil.

## 2 Methods

Experimental and analytical work was carried out in the greenhouse of Elitkhoz LLC, Borsky District, Nizhny Novgorod Region, and in the laboratory of the Department of Biology, Chemistry, and Biology and Chemistry at the Minin Nizhny Novgorod State Pedagogical University in 2019-2021.

Vegetation experiments were laid in a greenhouse and treated according to the standard technique [8]. The total area of the plot - 28 m2, the accounting - 14 m2, repetition of experiments - three times, the arrangement of plots systematic. Planting scheme - 70x24 cm. Experimental scheme included 2 variants: variant 1 - control (without treatments); variant 2 - double root treatment with Siliplant at a dose of 1 l/ha. The first treatment was carried out a week after planting, the second - two weeks later.

The subject of the study is a health-improved potato variety Vineta, German selection, origin - Europlant Pflanzenzucht GmbH. Wineta variety belongs to the early group of ripeness. It has oval-round tubers in shape with yellow peel, flesh - light yellow, the eyes are small. It is resistant to a number of pathogens such as potato cancer, cyst nematode and the most common and harmful viruses. This variety has a high drought tolerance, which is important for growing in the greenhouse. Yield obtained in variety trials is 23.9 - 32.1 t/ha.

The object of the study is silicon-containing microfertilizer "Siliplant". The manufacturer of this microfertilizer is NNPP "NEST M". It is a liquid chelate microfertilizer, which has in its composition bioactive silicon and complex trace elements in the chelate form, the most accessible to plants. Siliplant is designed for seed and vegetative plant treatment. During vegetation the following types of treatments are possible - root and foliar, i.e. by vegetative mass. Silicon causes growth of the root and vegetative mass of plants, especially the leaf area, increases resistance to adverse environmental factors (drought, hypothermia, transplanting stress), and all this changes cellular metabolism, and leads to increased photosynthesis, resulting in increased yields and more tubers per bush.

Transplanting of microplants from test tubes to greenhouse conditions was carried out from May 1 to 15. During the growing season, we determined the indicators of plant growth and development (length and number of stems in the bush, mass of the root system per bush), yield and number of tubers per bush, photosynthetic indicators (the size of the assimilation surface of leaves, net photosynthetic productivity), some qualitative indicators of yield (dry matter, starch) according to conventional methods [9].

Harvesting of mini-tubers of potatoes was carried out by digging the tubers on the experimental plots in August - early September, respectively, according to the years of the experiment. The assimilative surface of leaves was determined by weight method using notches, photosynthesis productivity by A.A. Nichiporovich method, starch content in tubers - by specific weight, dry matter - by weight method [9].

Experimental data were statistically processed by common methods using Microsoft Excel computer programs [8].

## 3 Resuts

The positive effect of silica-containing preparation Siliplant on growth indicators (din and height of stems in the bush, weight of roots per bush) of potato plants was obtained in the course of vegetation experiment. Growth indicators of the experimental variant were significantly higher compared to the control variant (Table 1).

**Table 1.** Influence of Siliplant on the biometric indicators of potato Vineta microplants in protected soil conditions (average for 2019 - 2021).

| Variant | Number of stems, pcs/plant | Stem height, cm | Root weight, g |
|---|---|---|---|
| Control | 5.0 | 49.1 | 28.7 |
| Siliplant | 6.5 | 51.9 | 33.5 |
| $LSD_{05}$* | 1.1 | 0.9 | 1.7 |

* $LSD_{05}$ - Least Significant Difference at 5% level of significance.

Applying a double root feeding of early maturity varieties Vineta microplants in the greenhouse by silicon-containing microfertilizer Siliplant increased the number of stems (by 30.0%), stem length (by 5,7%) and root weight (by 16.7%), compared with the control variant.

The application of silicon-containing microfertilizer Siliplant to Vineta potatoes under the protected soil conditions resulted in 23.7% increase of leaf surface, and the net photosynthesis productivity in the flowering phase increased by 37.0% compared to the control variants. Before harvesting, there was a significant decrease in photosynthesis productivity in the experimental variant by 2.5 times and in the control by 1.4 times during the same time interval. This indicates a greater accumulation of organic matter in tubers of the experimental version.

**Table 2.** Effect of Siliplant on photosynthetic processes of Vineta potato microplants under greenhouse conditions (average for 2019-2021).

| **Variant** | **Assimilative leaf surface** | | **Net photosynthetic productivity (mg/m² per day)** | | |
|---|---|---|---|---|---|
| | **m²/busk** | **thousand m²/ha** | **budding** | **flowering** | **before harvesting** |
| Control | 0.59 | 35.4 | 4.6 | 5.4 | 3.8 |
| Siliplant | 0.73 | 43.8 | 5.3 | 7.4 | 3.0 |
| $LSD_{05}$ | 0.1 | - | 0.3 | 1.1 | 0.3 |

**Table 3.** Influence of Siliplant on the yield of Vineta potatoes under protected soil conditions (average for 2019-2021).

| **Variant** | **Yield of tubers** | | **Number of tubers, pcs/plant** |
|---|---|---|---|
| | g/plant | kg/m² | |
| Control | 328.1 | 1.9 | 7.5 |
| Siliplant | 391.2 | 2.3 | 9.0 |
| $LSD_{05}$ | 12.3 | - | 0.9 |

The application of silicon-containing microfertilizer Siliplant in the form of root treatments during the cultivation of microplants in a nursery method in protected soil conditions increased the yield by 19.3%, the coefficient of multiplication increased by 20,0%, compared with the control variants according to the indicators. This trend persisted through the years of research.

**Table 4.** Influence of Siliplant on biochemical indicators of potato varieties Vineta under protected soil conditions (average for 2019-2021).

| **Variant** | **Biochemical parameters** | |
|---|---|---|
| | **dry matter, %** | **starch, %** |
| Control | 20.3 | 12.0 |
| Siliplant | 23.9 | 12.3 |
| $LSD_{05}$ | 0.2 | 0.1 |

The application of silicon-containing microfertilizer Siliplant in the form of root treatments during the growth of microplants by seedling method in protected soil conditions increased the content of dry matter - by 17.7 % and starch - by 2.5 % in minitubers, compared with the control variant without treatments. There were no significant deviations in the content of dry matter and starch in tubers by years of research, since the external conditions in the greenhouse are most often similar.

## 4 Discussion

During the experiment it was found that plants treated with Siliplant had a greater number of stems (by 30.0%) and their length (by 5.7%). Along with the increase in vegetative part of plants in the experiment, an increase in the underground part of microplants (by 16.7 %) was also noted. The increase in parameters of above-ground and underground parts of potato plants can be explained by the fact that double root treatment of plants promotes the development of a more powerful root system at the beginning of ontogenesis, which can more effectively use nutrients and water from the soil layer and cause active growth of potatoes. Thus, it provides greater resistance to adverse environmental factors (overheating, overcooling and stress from transplanting to the greenhouse). As a result, silicon-containing preparation Siliplant, having a high biological effectiveness, thanks to its content of bioactive silicon and a complex of trace elements in an accessible chelate form, reveals more fully the genetic potential of potato plants, which is reflected in the growth and development indicators, which further provide increased yields and quality of potatoes.

Physiological and biochemical processes occurring in plants are of great importance for the formation of the highest and highest quality potato crop. According to some researchers [10], 90-98% of the yield is created by photosynthesis, the main working body of which is the leaf surface, which was clearly demonstrated in our experience. Siliplant application increased the assimilative surface of potato leaves (Table 2). At the flowering phase there was an increase of leaf surface by 23.7 %, compared with the control variant. The tendency to increase the assimilative surface of leaves, as a rule, leads to an increase in productivity of photosynthesis, which is a qualitative characteristic of the leaf area.

In the experiment it was found that the maximum photosynthetic productivity was recorded in the variant with Siliplant in the phase of full flowering. The excess in this indicator was 37.0% compared to the control. Before harvesting, there was a reliable reduction of photosynthesis productivity in the experimental variant by 2.5 times, in the control by 1.4 times for the same time interval. This indicates a greater accumulation of organic matter in the tubers of the experimental variant. This process leads to an increase in the yield of potatoes. This is evidenced by the research data of A.A. Nichiporovich [11], who believes that 90-95% of organic matter is created in the leaf during photosynthesis, and up to 80% of these organic substances are able to enter the tubers in 70-day-old plants.

As follows from the data in Table 3, the work of photosynthetic apparatus had an impact on the formation of tuber yield. The application of Silyplant in the microgrowing of seedlings in the conditions of protected soil increased the yield by 19.3 % compared to the control variant. This increase in yield is reliable. Multiplication coefficient increased in the experimental variant by 20.0 % compared to the control. This trend of increasing the number of tubers per bush is the most important in the system of original seed production, as it allows us to obtain a sufficient number of mini-tubers for further multiplication in nurseries of super-elite.

Apparently, silica-containing Siliplant promotes the growth and development of plants in protected soil conditions, as it increases the activity of enzymes involved in redox processes, which increases photosynthetic activity, and as a consequence, increases the yield, and, consequently, increases the number of tubers in the bush. The stimulating effect of silica-containing preparations on photosynthetic processes and yield was noted earlier in the works of other researchers [12-14].

Analysis of quality indicators of potatoes showed a tendency to increase the content of dry matter and starch in 3 years of research when Siliplant was used (Table 4). In comparison with the control application of Siliplant contributed to increase in the content of dry matter (by 17.7 %) and starch (by 2.5 %) in minitubers. These data show insignificant differences in the content of qualitative indicators by years of research, since the external conditions in the greenhouse are excluded, as evidenced by the data of our previous studies.

## 5 Conclusion

The application of silicon-containing microfertilizer Siliplant causes an increase of growth indices, such as plant height (by 5.7%), the number of stems in the bush (by 30.0%) and root weight (by 16.7%), as compared to the control variant.

Leaf area was found to increase by 23.7 % and net photosynthetic productivity by 37.0% for the variant with Siliplant microfertilizer compared to the control variant.

Root treatments with Siliplant increased the yield by 19.3 % and the reproduction rate by 20.0 % compared to the control. Also, the use of Siliplant contributed to a slight increase in quality indicators (17.7 - 2.5 %), respectively, compared with control.

Thus, the use of silicon-containing microfertilizer Siliplant in the double root treatment of potato microplants in the conditions of protected soil is a promising agricultural technique in the conditions of the Nizhny Novgorod region, which can increase the productivity of photosynthesis, crop yield and its quality.

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