The effectiveness of using mineral fertilizers with microelements «Nanosilicon», «Stimulin», and «Alfastim» drugs in the reproduction of sea buckthorn

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Abstract. The article is devoted to the study of the influence of new promising drugs «Nanosilicon», «Stimulin» and «Alfastim» on the rhizogenesis of green cuttings of sea buckthorn when growing planting material. The objects of the study were three promising varieties of sea buckthorn selected by the Research Institute of Horticulture of Siberia: Augustina, Essel and Etna. The purpose of the research is to search for drugs and optimal concentrations that stimulate root formation to increase the yield of high-quality planting material of valuable sea buckthorn varieties. As a result of the conducted research, the positive effect of the drug mineral fertilizer with microelements «Nanosilicon» on the rhizogenesis of green cuttings and the volume of the root system of sea buckthorn seedlings was established.

1. Introduction

It is possible to say without exaggeration that no wild plant of the domestic flora when introduced into the culture attracted such close attention and increased interest as sea buckthorn. Due to its good winter hardiness, regular fruiting and qualitative and quantitative content of biologically active substances, it has earned universal recognition and wide distribution in a short period of time [1].

Today, the priority direction in the reproduction of cultivated plants is green cuttings using root-forming stimulators [2, 3, 4]. Green cuttings ensure the production of root-bearing plants, which have genetic homogeneity, physiological and anatomical integrity of the body [5, 6]. When obtaining sea buckthorn planting material by the method of green cuttings, it was found that not all varieties regenerate well during reproduction and give a high percentage of rooted plants.

One of the most effective methods for growing sea buckthorn seedlings that stimulate the regeneration of adventitious roots is the treatment of basal parts with growth regulators [7, 8]. The effect of using growth stimulators on plant cells is that these substances affect the colloidal-chemical properties of protoplasm (permeability and viscosity) and increase the flow of water and dissolved substances into plant cells [9].

According to the literature, different varieties of sea buckthorn during reproduction by rooting green cuttings show different reactions to treatment with growth regulators. In ones, they can significantly stimulate the process of rhizogenesis, while in others they do not reveal a positive effect.
Therefore, the purpose of our research is to search for drugs and optimal concentrations that stimulate root formation to increase the yield of high-quality planting material of valuable varieties of sea buckthorn.

2. Materials and methods
The research was carried out in 2018-2019, in a large-sized film greenhouse, with partial cover with polyethylene film. The experimental site was located strictly in the middle of the greenhouse, as much as possible excluding the possible influence of microzones in the cultivation facilities. Irrigation system represents a small-droplet irrigation with automated regulation of intervals and duration of irrigation. In the first 20 days after planting, the watering mode was set according to the scheme: 10 seconds after 5 minutes, then the interval between watering was increased, while simultaneously increasing the duration of irrigation.

Substrate: the lower layer is 10-12 cm containing a mixture of sand and soil with a small amount of humus, the upper layer contains 8-10 cm of washed river sand.

The objects of the study were three promising varieties of sea buckthorn selected by the research Institute of Horticulture of Siberia: Augustina, Essel and Etna. The domestic mineral fertilizer drug with microelements «Nanosilicon» is created on the basis of biologically active silicon. The drug helps crops to absorb better macro-and microelements and be more resistant to stressful effects of external factors (drought, frost, damage by diseases and pests). According to a number of authors, the use of drugs containing microelements, including natural silicon, contributed to better adaptation of plants to ex vitro conditions [10], more intensive vegetative growth and increased yield on grape varieties [11] and grain crops [12, 13].

Stimulin is a new organic growth stimulant in agriculture. It protects plants from a complex of fungal and bacterial diseases and has an anti-stress effect on cultivated plants. Studies of the use of the drug Stimulin have shown its antifungicidal effect, improvement of the sowing qualities of seed material and increase in the productivity of grain crops [14].

Indolyl-3-butyric acid or IBA (1H-Indole-3-butanoic acid, IBA) is a solid crystalline substance from white to pale yellow in color with the molecular structure of a crystalline solid. For use as a plant growth stimulant, an alcohol solution is diluted in water to a concentration of 1-5%. IBA is the most powerful stimulator of rhizogenesis in comparison with other auxins [15]. When the regulator enters the cuttings, it is included in the metabolism, activates it and promotes the outflow of nutrients and other substances to the place of root formation [16, 17].

In 2019 a new plant growth regulator was added to the research – Alfastim, which activates the most important metabolic reactions of the plant, regulates the absorption and use of nutrients, stimulates the allocation of the root system and increases the permeability of the cell walls of the roots [18].

Table 1. The two-factor experiment was based on the following scheme:

| Factor A-variety                  | Factor B-concentration of the root-forming stimulator: |
|----------------------------------|--------------------------------------------------------|
| - Augustine (large-fruited, early-maturing, with a slight effort of separation), | - water (0 mg/l) control,                                      |
| - Essel (large-fruited, sweet-fruited), | - IBA 0.005% (50 mg/l),                                   |
| - Etna (early-maturing, red-fruited) | - Stimulin (1 mg/l),                                      |
| | - Stimulin (10 mg/l),                                           |
| | - Stimulin (100 mg/l),                                         |
| | - Nanosilicon (1 mg/l),                                       |
| | - Nanosilicon (5 mg/l),                                       |
| | - Nanosilicon (10 mg/l),                                      |
| | - Alvastin (10 mg/l)                                          |

The experience bookmark date in 2018 is July 21 and in 2019 is July 17. Options are placed on the principle of organized repetitions and is randomized within repetitions. In total, 72 plots were laid in
2018, and 81 plots of 30 plants each were laid in 2019. The number of plants is 30. The length of the cuttings when planting is 36 cm. The digging of seedlings was carried out in the first decade of October.

During the research period the following accounts were made:
- percentage of rooted green sea buckthorn cuttings;
- determination of the volume of the root system (installed after digging seedlings, using a measuring cylinder, by the volume of displaced water);
- the height of the seedlings (from the root neck to the apical bud) was determined with a measuring tape after digging;

In all experiments, statistical data processing was performed using the methods described by B. A. Dospekhov [19].

3. Results and Discussion
The rhizogenic capacity of sea buckthorn cuttings varied from 35.5 to 95.6% in 2018 and from 53.3 to 100% in 2019 (table 2).

The rootability of Augustine, Essel and Etna varieties without the use of root-forming stimulants averaged 73.7% in 2018 and 18.6% higher in 2019 (92.3%). The best rootability in 2019 is indicated by the average data on factor A. Regardless of the growth stimulator, cuttings of the Augustine and Essel varieties in 2019 had the best rooting in 1.4-1.5 times compared to the previous year. The Etna variety was characterized by the best rooting in both years.

The use of IBA contributed to an increase in the yield of rooted cuttings with the exception of the Etna variety in 2019. It is important to note that the difference in the Augustine variety was significant.

The use of the drug Stimulin in concentrations of 1 and 10 mg/l on Augustine and Essel varieties was characterized by rootability at the control level. Increasing the concentration to 100 mg/l had a negative effect, reducing the rootability in relation to the control by 1.3-1.8 times. On the Etna variety, the use of all three concentrations of this drug was at the level of the control variant.

| Table 2. Rootability of annual sea buckthorn seedlings, % |
|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| **Factor B – stimulator** | **Factor A – variety** | **Average of the factor B** | **2018 LSD for factor A – 6.2; B – 10.0; AB – Ff<Ft** |
| **Years** | **Augustine** | **Essel** | **Etna** | **Average** | **2018** | **2019** |
| Control | 65.6 | 81.1 | 65.6 | 87.0 | 90.0 | 100.0 | 73.7 | 89.4 |
| IBA (50 mg/l) | 75.6 | 90.0 | 74.4 | 91.5 | 95.6 | 100.0 | 81.9 | 93.8 |
| Stimulin (1 mg/l) | 57.8 | 82.2 | 71.1 | 96.7 | 87.8 | 100.0 | 72.2 | 93.0 |
| Stimulin (10 mg/l) | 57.8 | 86.7 | 53.3 | 91.1 | 90.0 | 100.0 | 67.0 | 92.6 |
| Stimulin (100 mg/l) | 35.5 | 61.1 | 45.6 | 53.3 | 88.9 | 95.6 | 56.7 | 70.0 |
| Nanosilicon (1 mg/l) | 56.7 | 91.8 | 56.7 | 96.7 | 88.9 | 100.0 | 67.4 | 96.2 |
| Nanosilicon (5 mg/l) | 56.7 | 93.4 | 67.8 | 91.1 | 93.3 | 100.0 | 72.6 | 94.8 |
| Nanosilicon (10 mg/l) | 54.5 | 94.6 | 56.7 | 97.8 | 92.2 | 100.0 | 67.8 | 97.5 |
| Alvastin (10 mg/l) | 82.2 | 85.6 | 94.5 | 87.4 |
| Average for factor A | 57.5 | 84.8 | 61.4 | 87.9 | 90.8 | 98.9 |

*(LSD – the Least Significant Difference)*

The drug of Nanosilicon was characterized by various effects on the rootability of green cuttings in the years of research. In 2018 the stimulator in concentrations of 1, 5 and 10 mg/l did not have a positive effect on the percentage of rooted cuttings, having an indicator at or below the control variant. In 2019...
on the contrary, the overestimated concentration of this drug allowed 94.6 and 97.8% of cuttings of Augustine and Essel varieties to take root, exceeding the variant without growth stimulants by 10.0-13.5%. On the Etna variety the use of the drug was not significant.

Added to the study in 2019, the drug Alfastim at a concentration of 10 mg/l was ineffective, showing action at the control level.

The results of the dispersion analysis showed that the influence of the variety on rootability in 2018 was at the level of 54.8% and decreased to 21.8% in 2019, on the contrary, the force of the influence of the drug concentration increased from 11.3% to 40.9%. The interaction of factors in 2018 and 2019 was 5.4 and 17.6%, respectively.

The volume of the root system of annual sea buckthorn seedlings, without the use of root formation stimulants, was in 2018 of 0.2-0.4 cm$^3$. In 2019 this indicator was 1.7-2.5 times higher (table 3). The average for factor A in 2019 is 1.3-1.7 times higher than the average in 2018.

When using the IBA, the volume of the root system in both 2018 and 2019, for all studied varieties, significantly exceeded the control variant by 0.2-0.9 cm$^3$. The greatest effect was observed on the Etna variety in the year with the worst rootability of the crop (2018).

Table 3. Volume of the root system of annual sea buckthorn seedlings, cm$^3$

| Factor B – stimulator | Augustine 2018 | Augustine 2019 | Essel 2018 | Essel 2019 | Etna 2018 | Etna 2019 | Average of the factor B |
|-----------------------|----------------|----------------|------------|------------|------------|------------|------------------------|
| Control               | 0.3            | 0.5            | 0.2        | 0.2        | 0.4        | 0.9        | 0.3                    | 0.6                    |
| IBA (50 mg/l)         | 0.6            | 0.7            | 0.6        | 0.8        | 1.3        | 1.4        | 0.8                    | 1.0                    |
| Stimulin (1 mg/l)     | 0.3            | 0.5            | 0.3        | 0.6        | 0.7        | 1.5        | 0.4                    | 0.9                    |
| Stimulin (10 mg/l)    | 0.4            | 0.5            | 0.3        | 0.6        | 0.4        | 1.3        | 0.4                    | 0.8                    |
| Stimulin (100 mg/l)   | 0.2            | 0.3            | 0.2        | 0.2        | 0.4        | 0.6        | 0.3                    | 0.4                    |
| Nanosilicon (1 mg/l)  | 0.4            | 0.6            | 0.3        | 0.6        | 0.6        | 1.4        | 0.4                    | 0.9                    |
| Nanosilicon (5 mg/l)  | 0.4            | 0.6            | 0.3        | 0.6        | 0.9        | 1.5        | 0.5                    | 0.9                    |
| Nanosilicon (10 mg/l) | 0.4            | 0.6            | 0.4        | 0.6        | 0.7        | 1.2        | 0.5                    | 0.8                    |
| Alvastin (10 mg/l)    | 0.4            | 0.4            | 0.4        | 1.0        | 1.0        | 0.6        | 0.4                    | 0.8                    |
| Average for factor A  | 0.4            | 0.5            | 0.3        | 0.5        | 0.7        | 1.2        | 0.4                    | 0.8                    |

2018 LSD$_{0.05}$ for factors A – 0.1; B – 0.1; AB – $F_{0.05}$

2019 LSD$_{0.05}$ for factors A – 0.1; B – 0.1; AB – 0.2

*(LSD – the Least Significant Difference)

The effect of the drug Stimulin on green cuttings of the Augustine variety at a concentration of 1 mg/l was at the control level and the Essel and Etna varieties was effective (the control variant was exceeded by 0.1 cm$^3$ and 0.3-0.6 cm$^3$, respectively). When the concentration of this drug increased, the root system volume index decreased, yielding to control.

Treatment of cuttings with Nanosilicon positively affected the volume of roots of annual sea buckthorn seedlings. On all varieties and in all concentrations of the drug, an increase of 0.1-0.6 cm$^3$ was observed. In the variety of Etna in the year 2019 marked the largest volume of 1.5 cm$^3$.

The use of the drug Alfastim on Augustine and Essel varieties in 2019 was less effective in relation to the control variant.

Dispersive analysis of the data showed that in 2018 and 2019 the volume of the root system of sea buckthorn seedlings was determined by varietal affiliation, the share of influence of which was 38.4% and 61.6%, respectively. The effect of the drug concentration was less pronounced – from 19.9% to 28.7%. The interaction of factors was insignificant (6.6-8.9%).
4. Conclusion
The Etna variety was characterized by the best rhizogenic ability during the research years. Regardless of growth stimulants, cuttings of the Augustine and Essel varieties had better rooting in 2019 by 1.4-1.5 times compared to the previous year.

In 2018 the highest rootability of green cuttings was observed with the use of the IBA drug in all the studied varieties. In 2019 the use of Nanosilicon in a concentration of 10 mg/l contributed to better rooting of green cuttings of the Augustine and Essel varieties.

The use of the IBA root-forming stimulator and mineral fertilizer with microelements «Nanosilicon» positively affected the volume of the root system, exceeding the control version by 0.2-0.9 cm$^3$ and 0.1-0.6 cm$^3$, respectively.

For 2 years of research, it was noted that with an increase in the concentration of the drug Stimulin from 1 to 100 mg/l, there was a significant decrease in the rootability of green cuttings on all the studied varieties.

As a result of the conducted research, no reliable effect of the drug Alfastim on the rootability and volume of the root system of annual sea buckthorn seedlings have been established.

Dispersion analysis of data for 2018-2019 studies showed that in a more favorable year of sea buckthorn cuttings rooting, the effect of variety specificity on the percentage of rooting decreases and the effect of the drug concentration increases.

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