Block-container system for growing strawberry planting material in greenhouses

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Abstract. The study aims to develop an effective technological scheme for growing high quality strawberry planting material in a greenhouse, while minimizing the application of growth substrates. Mother plants of Darselect, Asia, Florence, Kimberly, Alba varieties were planted in peat-filled container blocks, which were placed on a special surface of technological tables on which trays with water were installed. The trays were previously covered with a thin water- and breathable synthetic material Agril (density of 17 g/m²), which prevented the stolons from immersing into water. The stolons grew from the mother plants, and rosettes rooted. The efficiency of the process depended on the number of stolons developing from the mother plants and the number of rosettes. Stolons with rosettes were isolated from the mother plants, while extracting the roots that penetrated into the synthetic material. Plants were planted in cassettes with peat and regularly watered using the finely-dispersed method. One week was enough for 100 % survival of plants. On 1 m² greenhouse area, during the first year, 124.0–139.5 daughter plants were grown.

1. Introduction

It is well known that the production of high-quality seedlings of strawberries requires a lot of manual labor and traditionally grown in field conditions with an open root system. To grow such seedlings, large land areas are required, especially if it is supposed to accelerate the production of a virus-free material. In this case, potted seedlings, which are grown in greenhouses are of considerable interest. Thus, it is possible to create optimal conditions for the development of plants and eliminate the complexity of the work depending on the weather.

It is known that potted plants quickly take root after planting and resume their growth thanks to a strong root system that is not disturbed by digging [1–3]. The use of inert and non-pathogenic substrates reduces the risk of infections and improves vegetative and generative plant productivity. Greenhouse seedlings can be used for planting much earlier than seedlings with open roots, since the latter should recover after wintering. Peat, coconut substrates, vermiculite, washed sand can be used. In greenhouses, seedlings can be produced for 3.5–5 weeks [4–7]. The success of rooting depends on various factors: the type of substrate, quality of rosettes, air humidity and humidity in the root zone. The effectiveness of rooting and quality of seedlings depend on the size of the rosette and its position on the stolon [8–10]. Very important parameters for assessing quality of seedlings are the appearance of plants, the size of the root system and the diameter of the horn. It is well known that quality of the root system determines the survival rate and its optimal development after planting in the field [11].

The aim of this study is to develop an effective technological scheme for producing quality planting material of strawberries in a greenhouse, while minimizing the use of growth substrates.
2. Materials and methods
The study was conducted in 2016–2018 in the greenhouse of the Agrobiotechnological Department of the Agrarian and Technological Institute of the Peoples' Friendship University of Russia (Moscow, Russia) and in the laboratory "Biotechnology of Agricultural Plants" of the Agrotechnological Institute of ChSU. We used an “intensive block aquatic source”. Containers were made from synthetic water- and breathable Agril material (density of 60 g/m²). They were filled with a substrate. Normalized peat Agrobalt (fraction 0-35 mm, pH H2O – 5.6) was used as a substrate for filling the containers. Adapted microplants were planted into the cassettes which were regularly automatically irrigated – one irrigation per day (3 min/day, approximately 2 l/block). The regime was maintained by the Garden drip irrigation timer from the central water supply system. Agril material (density of 17 g/m²) which prevented the roselettes from being immersed into water served as a support. Stolons with rooted rosettes were separated from the mother plants and replanted cassettes 0.52 x 0.31 m in size (35 cells of 125 ml) filled with peat. Planted cassettes were covered with Agril No. 17 synthetic material and regularly wetted using a fogging system over 16 hours during daylight hours with an interval of 20 minutes for 15 seconds.

The block was created in 2016 and studied for three years. The objects of research were Darselect, Asia, Florence, Alba, and Kimberly varieties. Five plants were planted in eight-liter blocks; in each variant, 24 blocks were placed on an area of 9.6 m, i.e. 120 plants were planted, a total of 600 mother plants were planted on the area of 48 m². Counts were performed on 10 plants in each variant. Complex fertilizers N: P: K (15:15:15) at a concentration of 5 g/l in a volume of 0.5 l block were applied monthly. During the stolon formation, all inflorescences growing from the mother plants were removed to facilitate the formation of rosettes. Stolons with rosettes were separated from the mother plants twice: at the end of July and August, the state of the root systems of daughter plants was evaluated. The root systems of ten plants from each variant were evaluated. Measurements of the root length were carried out with a ruler along the longest root, the diameter of the heart was measured using a caliper. From October to March, the greenhouse temperature was 7–12 degrees, from March to October – 15–35 degrees, additional lighting was not used. The significance of differences was evaluated using the LSD test at a 5 % significance level [12].

3. Results and discussion
The adapted microplants planted at the end of May 2016 had a height of 5–7 cm, became strong and developed powerful leaves. The active formation of stolons and rosettes began in mid-July. The irrigation regime was monitored. In the first year of observations, the stolon formation was very active. After the beginning of stolon growth and rosette formation, we studied the dynamics of development of daughter plants (Table 1, Fig. 1). First order daughter plants developed more actively, since they had an advantage in nutrition compared to subsequent order plants. For 6 weeks they formed a rather powerful leaf apparatus (especially Florence and Kimberly varieties), which affected the high average mass of plants. In some cases, the differences between varieties were significant. As a rule, the degree of development of the leaf apparatus whose weight fraction prevailed in the total mass of plants, correlated with the length of the root system, with the exception of Asia, in which such a pattern was not observed. The diameter of the horn also corresponded to the degree of plant development and was the largest in Florence variety, although differences in this indicator were not significant in other varieties except for Asia. Separated daughter plants were successfully replanted for growing in plastic cassettes filled with peat (Fig. 2, 3).

The effect of increased vegetative productivity in strawberry plants obtained in vitro is well known [13]. It is due to the fact that such plants violated the natural physiological rhythm of development and do not spend plastic substances on flowering and crop formation, since they do not have generative buds. Under natural conditions, this process proceeds under decreased daily temperatures and a decrease in the length of daylight in early autumn. In greenhouses, a decrease in the length of daylight hours and illumination decreases intensity of stolon development.
Table 1. Morphological indicators of rooted first order daughter plants six weeks after the beginning of crowning (2016)

| Variety of strawberry | weight (g) | Length of roots (cm) | Diameter of the crown (mm) |
|-----------------------|------------|----------------------|---------------------------|
| Darselect             | 11.1       | 7.7                  | 6.1                       |
| Asia                  | 9.5        | 11.4                 | 4.9                       |
| Florence              | 15.3       | 9.2                  | 6.8                       |
| Kimberly              | 13.2       | 8.2                  | 5.9                       |
| Alba                  | 11.4       | 10.1                 | 5.5                       |
| Average               | 9.7        | 9.3                  | 5.8                       |
| LSD<sub>0.05</sub>    | 3.3        | 3.9                  | 2.1                       |

Figure 1. Beginning of stolon development in the block container.

Table 2. Vegetative productivity of the block container in the greenhouse in 2016–2018

| Parameter                                      | Year    | Variety          | Average  |
|------------------------------------------------|---------|------------------|----------|
| The total number of rooted rosettes from the accounting area (9.6 m<sup>2</sup>), pcs. | 2016    | Darselect 2555   | 2836.2   |
|                                                 |         | Asia 2970        | 2332.8   |
|                                                 | 2017    | Florence 2530    | 1932.3   |
|                                                 |         | Kimberly 2777    | 1932.3   |
|                                                 | 2018    | Alba 3349        | 2238.7   |
| Average                                        |         | 2373.7           | 2643.7   |
| HCP<sub>0.05</sub>                             |         | 512              |          |
| Number of rosettes per 1 mother plant, pcs.   | 2016    | Darselect 21.3   | 22.0     |
|                                                 |         | Asia 24.8        |          |
|                                                 |         | Florence 21.1    |          |
|                                                 |         | Kimberly 23.1    |          |
|                                                 | 2017    | Alba 27.9        |          |
| Average                                        |         | 19.8             |          |
| HCP<sub>0.05</sub>                             |         | 4.3              |          |
| Number of rosettes per root development area, pcs/m<sup>2</sup> | 2016    | Darselect 204.5  | 115.9    |
|                                                 |         | Asia 238.1       |          |
|                                                 |         | Florence 202.6   |          |
|                                                 |         | Kimberly 221.8   |          |
|                                                 | 2017    | Alba 267.9       |          |
| Average                                        |         | 134.8            |          |
| HCP<sub>0.05</sub>                             |         | 41.3             |          |
| The area required for replanting rooted rosettes, m<sup>2</sup> | 2016    | Darselect 10.9   | 4.3      |
|                                                 |         | Asia 12.7        |          |
|                                                 |         | Florence 10.8    |          |
|                                                 |         | Kimberly 11.9    |          |
|                                                 | 2017    | Alba 14.4        |          |
| Average                                        |         | 11.2             |          |
| HCP<sub>0.05</sub>                             |         | 12.1             |          |
| Seedling yield, taking into account the growing area, pcs / m<sup>2</sup> | 2016    | Darselect 124.6  | 6.2      |
|                                                 |         | Asia 133.2       |          |
|                                                 |         | Florence 124.0   |          |
|                                                 |         | Kimberly 129.2   |          |
|                                                 | 2017    | Alba 139.5       |          |
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Table 2. Vegetative productivity of the block container in the greenhouse in 2016–2018
Table 2 shows that in the first year of the growing season all varieties showed high growing efficiency, but Alba variety was the most productive; by the number of rosettes per 1 mother plant, it significantly exceeded Darselect, Florence, and Kimberly varieties. The optimal water-air regime was ensured by the root system elevated by 15–20 cm above the water surface. In the planting year, cases of formation of peduncles were single and were not observed by the end of summer. When the temperature decreased and the water consumption reduced, watering began manual.

![Rooted daughter rosettes](image)

**Figure 2.** Rooted daughter rosettes

![Seedlings of strawberries after replanting into cassettes](image)

**Figure 3.** Seedlings of strawberries after replanting into cassettes

Despite the fact that in 2017, the vegetation began much earlier than in 2016, productivity of stolon development was lower. For a number of varieties, it was significant. Obviously, a certain negative effect was obtained due to active development of the generative organs. Rosette development was more effective in the second half of summer.

In 2018, the situation was similar to that in 2017 and the number of daughter rosettes decreased twice in comparison with the first year. Mass development of flower stalks was observed; by the second half of summer, on maternal plants, there were 5–12 small horns from which single stolons 1–2 mm in diameter grew.

4. **Conclusion**

This scheme can be an effective link in the production of healthy planting material for strawberries. The use of peat as a substrate makes it impossible to spread strawberry nematodes – potential intra-soil virus carriers. This is in favor of the fact that the propagation of strawberries is possible, since the probability of overgrowth is excluded. It is advisable to use adapted test-tube microplants obtained in the winter-spring period. The previously known increased tendency of such plants to develop vegetative organs can be used to increase the reproduction rate. These containers can be used for no more than two years. A reserve for increasing their productivity can be a mineral nutrition system.
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