Dependence of the number of potato minitubers on the method of planting micro-plants

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Abstract. Research is devoted to the study of the dependence of the number of mini-tubers of potatoes on the method of planting micro-plants. Four ways of placing micro-plants of seven Russian varieties were studied: in pots made of cassettes and test tubes and in beds made of cassettes and test tubes. The method of planting micro-plants had an impact on the safety of plants, it was higher when planted from test tubes in beds 93.3-100 %. For all the studied varieties, with the exception Of the Samba variety, the most preferable was planting micro-plants in pots for seeding, in which there was an increase in the yield of mini-tubers. To get the largest number of mini-tubers of potatoes of the optimal fraction, plants of the meteor, Courtney and Reggae varieties should be grown in seedling cassettes before planting in pots, and plants of the Zumba and Salsa varieties should be planted directly from tubes. Plants planted in pots from seedling cassettes formed the smallest leaf area. The dependence of the mini-tubers on the leaf area was established for potato varieties meteor, Samba and Gulliver. The conducted research indicates the need to study the method of planting micro plants for each variety in order to determine the most optimal one, which allows increasing the yield of mini tubers.

1. Introduction
Successful cultivation of agricultural crops depends on the quality of planting and sowing material. In potato seed production, it is of paramount importance to improve the planting material, which provides microclonal reproduction.

Recommendations on the technology of growing healthy material in protected ground are quite contradictory, as well as questions about the density of planting plants, how to place them [4]. However, it is the protected ground that allows you to provide high-quality planting material [3]. Growing mini tubers in the field under cover material is economically justified [1].

In experiments on the propagation of micro-plants when placing them with different schemes, it was found that a lower density of plantings contributed to the formation of mini-tubers of optimal size with fewer small tubers [2]. The influence of the growing environment on the yield of potato mini-tubers was revealed [5]. At the same time, there is evidence that the method of planting micro-plants flat and in ridges did not affect the yield of mini-tubers [6].

Each variety has its own characteristics, so there is a need to develop methods for growing them in relation to soil and climatic conditions and study methods of growing in order to obtain mini-tubers [7].

Thus, in order to improve potato seed production in the conditions of the Volga region of Russia, there is a need to carefully study the methods of planting micro-plants to increase the yield of mini-tubers of Russian potato varieties.

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2. Methods and materials
We studied the relationship between the number of mini-tubers of potatoes and the method of planting micro-plants. The experiment was conducted in the spring of 2020. The objects of research are promising potato varieties of Russian selection. We conducted a two-factor experiment. The first factor studied is the potato variety: Samba, Gulliver, Reggae, meteor, Salsa, Zumba, and Courtney. The second factor is the method of planting plants: in garden beds from seedling cassettes, in garden beds from test tubes, in pots from seedling cassettes, in pots from test tubes.

Each variant consisted of 200 pots of plants. The experiment was repeated four times. The plants were planted in greenhouses 22 m long and 6 m wide. The experiment was conducted in four greenhouses. The options in the greenhouse were placed randomly. For minituber growing, the medium was high-moor peat with low decomposition degree. This peat had standard pH of the growing medium (5.5). The substrate for growing mini – plants was riding peat of a low degree of decomposition. The peat substrate had the pH of 5.5 normalized by lime materials (dolomite and limestone flour).

The prepared peat was supplemented with a complex mineral fertilizer "Nitroammofoska" (NH4H2PO4 + NH4NO3 + KCL) produced by Uralchem. Fertilizers were well mixed with the medium. During planting, the pots were filled with peat 2/3 high of the total volume. Later, as potato plants grew, peat was added until planting pot was full.

Potato micro-plants were planted on 16 June. Before planting potato micro-plants, the soil in the pots was moistened with a drip irrigation system. When planted in pots, micro-plants were buried to the second internode. Greenhouse air temperature was maintained at +25 °C. To ensure automatic adjustment of the main parameters (temperature, humidity soil), a microclimate system is installed in greenhouses. Soil moisture was regulated by a drip irrigation system, and air humidity was maintained by a sprinkler system. Irrigation was carried out from a 10 m3 container. Water intake for irrigation was varied depending on the soil humidity, which was maintained at 65-70 %. During the growing season, potato plants were fed with YaraTera Kristalon special 18-18-18 +3MgO + micro fertilizers at the rate of 2 kg per 1 hectare. Fertilizers were applied together with drip irrigation.

As potato plants were growing and developing, leaf surface area was measured and recorded for control and experimental plants. The punching/cutting out method was used, where the weight of a leaf of the selected plants is measured, cutouts are made, weighted, and the leaf area of each plant is identified. An average sample of plants was taken, the leaves were quickly cut off, and their weight was calculated. Then, from the central part of the leaf blade of each leaf of the plants with a drill with a diameter of 1.1 cm, several punches were knocked out, combined and their weighing weight was set, with an accuracy of 0.01 g (in the experiment, a Sartorius Entris 423i-1SRU balance was used). The place where the cut is taken characterizes the average sheet density. The leaf area was determined by the formula:

\[ Sl = \frac{Ml \times Sv}{Mv} \]

Sl – area of plant leaves, cm²; Ml – mass of raw leaves, g; Mv – mass of raw die – cuts, g; Sv - area of die-cuts, cm².

The most preferred size of potato mini-tubers is from 25 to 35 cm in diameter.

3. Results and discussion
Potato micro-plants planted from test tubes in the garden beds were the lowest (table 1). This is due to the longer formation of the root system of plants from test tubes, in comparison with plants planted from seedling cassettes. Micro-plants planted in seedling pots were higher than plants planted in garden beds. There were no differences between these variants in the Samba variety. Potato plants of the Gulliver variety planted in garden beds had the same height – 14.5 cm, regardless of whether they were planted from seedling cassettes or test tubes were planted.
Table 1. Height of potato plants in the budding phase, cm.

| Variety | Garden beds | Pots for seedlings |
|---------|-------------|--------------------|
|         | seedling cassettes | test tubes | seedling cassettes | test tubes |
| Meteor  | 23.9         | 25.5            | 26.0         | 25.3       |
| Courtney| 17.5         | 14.5            | 23.4         | 17.2       |
| Gulliver| 14.5         | 14.5            | 20.4         | 17.7       |
| Zumba   | 25.9         | 18.5            | 24.5         | 20.1       |
| Samba   | 32.1         | 25.5            | 33.2         | 25.6       |
| Reggae  | 22.5         | 12.7            | 16.7         | 16.8       |
| Salsa   | 23.9         | 17.6            | 25.1         | 20.4       |

Before harvesting, we calculated how many potato plants died and determined the percentage of preserved ones for each variant. It turned out that more plants were preserved when plants were planted from test tubes in garden beds. In this variant, 93.3 - 100% of micro-plants persisted (table 2).

Plants that were planted from seedling cassettes took root worse and not all were preserved until harvesting. The same is observed in plants planted in seedling pots. The exception was the Reggae variety – the safety of test tube plants in this variant was lower compared to micro-plants previously rooted in seedling cassettes and amounted to 93.3%. The Zumba potato Variety was distinguished by 100% survival rate in all variants of the experiment.

Table 2. The number of plants surviving to harvest, %.

| Variety | Garden beds | Pots for seedlings |
|---------|-------------|--------------------|
|         | seedling cassettes | test tubes | seedling cassettes | test tubes |
| Meteor  | 86.7         | 93.3            | 96.7         | 100        |
| Courtney| 93.3         | 100             | 96.7         | 100        |
| Gulliver| 90           | 100             | 96.7         | 100        |
| Zumba   | 100          | 100             | 100          | 100        |
| Samba   | 93.3         | 100             | 100          | 100        |
| Reggae  | 93.3         | 96.7            | 100          | 93.3       |
| Salsa   | 86.7         | 93.3            | 100          | 100        |

The method of planting micro-plants potato affected the mass of tubers from the one plant. So in the variant with planting plants in garden beds, the mass strongly depended on whether the test tube plants were grown before planting in seedling cassettes. In potato varieties Meteor, Samba and Salsa, when plants were planted directly from test tubes, the mass of tubers from one plant was higher (table 3). The Zumba and Reggae Varieties showed an inverse relationship. Potato varieties Courtney and Gulliver formed the largest mass of tubers from one plant in the variant with planting plants in pots for seedlings from seedling cassettes – 139.9 and 153.6 g, respectively.

Table 3. Mass of tubers per plant, g.

| Variety | Garden beds | Pots for seedlings |
|---------|-------------|--------------------|
|         | seedling cassettes | test tubes | seedling cassettes | test tubes |
| Meteor  | 114.1        | 195.9            | 133.2        | 125.9      |
| Courtney| 116.0        | 105.2            | 139.9        | 114.2      |
| Gulliver| 72.6         | 93.1             | 153.6        | 144.1      |
The main indicator in potato seed production is the number of tubers per plant. For all the studied varieties, with the exception of the Samba variety, planting micro-plants in seedling pots was the most preferable (table 4). Moreover, the meteor variety forms more tubers when planting micro-plants rooted in seedling cassettes, there was no significant difference between planting in garden beds and pots for seedling. For other varieties, it is most preferable to plant micro-plants from test tubes without pre-growing. Planting Samba plants from test tubes in the garden beds allows you to get the largest number of tubers from the plant – 8.5 pcs. Thus, pre-growing of potato micro-plants in seedling cassettes is advisable only for the Meteor variety.

**Table 4. Number of tubers per plant, pcs.**

| Variety | Garden beds | | | | Pots for seedlings | | | |
|---------|-------------|---|---|---|-------------|---|---|---|
|         | seedling cassettes | test tubes | seedling cassettes | test tubes |
| Meteor  | 5.7          | 4.3          | 5.8          | 5.1          |
| Courtney| 4.4          | 3.3          | 5.9          | 6.9          |
| Gulliver| 4.2          | 5.1          | 8.1          | 9.3          |
| Zumba   | 5.5          | 4.9          | 5.4          | 7.0          |
| Samba   | 3.5          | 8.5          | 4.8          | 7.6          |
| Reggae  | 4.3          | 3.7          | 5.3          | 6.5          |
| Salsa   | 4.6          | 5.2          | 4.9          | 7.9          |

To obtain the largest number of mini-tubers of the optimal fraction (Ø 25-35 mm), the Gulliver potato variety should be grown in seedling pots, and there are no differences between test tube plants and pre-grown ones (table 5). Plants of Meteor, Courtney and Reggae varieties should be grown in seedling cassettes before planting in seedling pots. While plants of Zumba and Salsa varieties are better planted directly from test tubes. To get the largest number of tubers of the optimal fraction, micro-plants of the Samba variety should be planted from test tubes into garden beds.

**Table 5. Quantitative distribution of tubers by fractions (per plant), pcs.**

| Variety | Fraction Ø | Ø 25-28 | Ø 28-30 | Ø 30-35 | Ø >35 |
|---------|------------|---------|---------|---------|-------|
|         | garden beds / seedling cassettes | | | | |
| Meteor  | 2.5        | 0.5     | 0.4     | 0.8     | 1.5   |
| Courtney| 1.5        | 0.4     | 0.4     | 0.8     | 1.3   |
| Gulliver| 1.6        | 0.7     | 0.3     | 0.9     | 0.8   |
| Zumba   | 1.0        | 0.3     | 1.0     | 0.9     | 2.3   |
| Samba   | 1.7        | 0.1     | 0.5     | 0.6     | 0.6   |
| Reggae  | 1.0        | 0.4     | 0.3     | 0.3     | 2.3   |
| Salsa   | 2.3        | 0.5     | 0.7     | 0.5     | 0.6   |

|         | garden beds / test tubes | | | | |
| Meteor  | 0.2        | 0.7     | 0.7     | 2.7     |
| Courtney| 0.8        | 0.1     | 0.3     | 0.6     | 1.5   |
| Gulliver| 2.1        | 0.5     | 0.2     | 1.1     | 1.2   |
| Zumba   | 0.6        | 0.3     | 0.6     | 0.7     | 2.7   |
| Samba   | 2.6        | 0.8     | 0.8     | 1.9     | 2.3   |
| Reggae  | 1.3        | 0.8     | 0.8     | 0.5     | 0.5   |
| Salsa   | 0.1        | 0.1     | 1.0     | 1.2     | 2.6   |

|         | pots for seedlings / seedling cassettes | | | | |
| Meteor  | 1.3        | 0.9     | 0.5     | 1.4     | 1.7   |
Plants planted in pots from seedling cassettes formed the smallest leaf area - from 284 to 760 cm² (table 6). The exception was the Reggae variety – the smallest area of leaves in the budding phase was recorded in the variant with planting plants from test tubes in garden beds. The larger the leaf area of the meteor, Samba, and Gulliver potato varieties, the more mini-tubers the plants form. The remaining potato varieties formed the maximum number of mini-tubers with an average leaf area.

Table 6. Average leaf area of one plant in the budding phase, cm².

| Variety | Garden beds | Pots for seedlings |
|---------|-------------|--------------------|
|         | seedling cassettes | test tubes | seedling cassettes | test tubes |
| Meteor  | 790         | 689               | 553             | 669        |
| Courtney| 826         | 1697              | 463             | 880        |
| Gulliver| 842         | 1196              | 760             | 1306       |
| Zumba   | 1890        | 1483              | 738             | 761        |
| Samba   | 894         | 963               | 284             | 906        |
| Reggae  | 1615        | 718               | 838             | 735        |
| Salsa   | 2643        | 1127              | 559             | 1219       |

4. Conclusion

In most potato varieties, plants planted from seedling cassettes were higher, with the exception of the Gulliver variety, in which the method of planting did not affect the height of the plants. In the Zumba variety, all the plants were preserved at the time of harvesting. In General, the number of plants during harvesting was higher when plants were planted from test tubes and amounted to 93.3-100%.

It should be noted that to increase the yield of mini-tubers, plants of the meteor, Courtney and Reggae varieties must be grown in seedling cassettes before planting in pots, plants of the Zumba, Salsa and Samba varieties should be planted directly from test tubes, which allows you to get the largest number of mini-tubers of the optimal fraction (Ø 25-35 mm).

The dependence of the number of mini-tubers obtained from the plant on the leaf area was revealed. For example, potato varieties meteor, Samba and Gulliver have more mini-tubers at the maximum leaf area. However, in other varieties of potato plants, the maximum number of mini-tubers was formed with an average leaf area. All of the above points to the need to plant micro-plants from test tubes directly into the garden beds.

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