Influence of methods of planting micro-plants of potatoes on the number of minitubers

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Abstract. The paper presents the results of research on the comparative evaluation of methods for obtaining minitubers of potatoes of promising varieties of Russian selection. In the course of research, the most preferred methods for growing micro-plants for each variety were identified, which allow to achieve the maximum yield of minitubers from one plant. Of all the varieties studied in the course of the study, the most balanced by fractional composition was the early variety Udacha. To get the maximum number of mini-tubers of potatoes from one plant of the Gusa and Bellarosa varieties, micro-plants that are previously rooted in seedling cassettes should be planted in the beds. For Charoit, Samba, Courtney, Irbitsky and St. Petersburg varieties, rooted plants should be potted. Potato plants of Pennant, Nevsky and Reggae varieties produced top yields of mini tubers when they were bedded directly from test tubes. Luck variety produced the highest tuber yield when its plants were planted in 5L plastic pots. The Lux variety turned out to be more plastic – the plants formed the same number of tubers in three variants at once. A less preferred method for obtaining minitubers for this variety is to plant pre-rooted plants in the beds.

1. Introduction

Potato is the world’s first non-grain food [1]. In Europe and North America, it is considered the main source of carbohydrates [2]. Throughout the history of potato production, breeders have bred an enormous number of varieties [3].

The main criteria that agricultural producers are concerned about when choosing a potato variety for planting is its demand or, in other words, commercial value [4].

Science does not stand still. Every year, breeders produce galore of promising new potato varieties [5]. Russian breeders have bred a sufficient number of varieties with valuable competitive characteristics, but their share in the seed potato market is still insignificant.

Studying new domestically-bred potato varieties allows for identification of best suited varieties for the Volga-Vyatka region, Russia. Further, an in-depth study of the influence of planting methods on the yield of mini tubers of each variety might help formulate their cultivation guidelines. Field testing of new varieties in the region will promote the market of promising potato varieties of domestic selection, which will reduce the dependence of potato growers on imported seed material. Thus, many potato producers will be able to purchase affordable seed potato of high quality.

For potato growers to have enough high-quality planting stock, potato seed breeding requires special focus, namely, improving seed yield at each stage of propagation [6]. More emphasis should be put on...
promising potato varieties which, for some reason, have not yet become widely popular although being of quality and yielding capacity as good as popular varieties [7].

In their research, Feleke A., Regasa G. and Muche M. noted the need to introduce new promising varieties, since this, in their opinion, will allow agricultural producers to achieve stability. In addition, researchers note the importance of introducing new knowledge and achievements of breeders into production in ensuring food security of any state [8]. Some researchers report that different potato varieties respond differently to stress factors. Stress can lead to a decrease in the gross yield of products, to a decrease in the number of tubers per plant, which in turn is a negative factor in potato seed production, including the production of minitubers [9]. Kleinwechter U, Gastelo M, Ritchie J, Nelson G, Asseng S believe that introducing very flexible varieties will help to raise yields in potato cultivation. To this effect, sowing seed production shall be boosted and ways to increase the seed stock of promising varieties shall be found [10]. The aim of the study is to study how the method of planting micro-plants affects the number of minitubers of potatoes of various varieties.

2. Methods and materials
The work on this subject is carried out in the research laboratory on the propagation of potato varieties of the Federal State Budgetary Educational Institution of Higher Education Chuvash State Agricultural Academy. The Academy owns a trial field where over 10 domestic potato varieties are tested every year, as well as how various factors affect the quantity and product quality potato.

Micro-plants were planted in greenhouses between 3 and 6 June 2019. There were four schemes of planting.
- Scheme 1 – micro-plants were planted in 5 L pots.
- Scheme 2 – planting micro-plants in the beds.
- Scheme 3 – pre-rooted micro-plants were potted.
- Scheme 4 – pre-rooted micro-plants were planted in the beds.
To allow the micro-plants to adapt to soil conditions, they were placed in seedling containers a month prior to growing seedling cassettes.

The substrate for the cultivation of minitubers was high-moor peat with a low degree of decomposition Agrobalt C. This peat is pH-normalized lime materials (dolomite flour, limestone flour) - the acidity of the soil substrate was 5.5. In addition, peat is initially enriched with basic nutrients - N: 150 MG / L; P2O5 - 150 MG / L; K2O - 250 MG / L; Mg - 30 mg / L; Ca - 120 mg / L + trace elements. The organic matter content is about 80%. The substrate has a highly porous structure, which allows the root system of potato micro-plants to grow freely and grow minitubers. Peat does not contain pathogens, weed seeds.

In each variant, 500 micro-plants of potatoes were planted. The experiment was repeated four times. The plants were planted in polycarbonate greenhouses measuring 6 m * 22 m. The placement of options in the greenhouse is random. 4 greenhouses were planted with experimental options. Potato micro-plants were planted in 5.6 L plastic pots 200x200x250 mm in size.

A complex mineral fertilizer "Nitroammofoska" (NH4H2PO4+NH4NO3+KCL) produced by Uralkem was added to the prepared peat. It contains three main components that are necessary for normal growth and development of the plant at different stages – nitrogen, phosphorus and potassium (NPK). Nitrogen, phosphates (digestible) and potassium are equal here, 16 % each. 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.

On hot days, the plants were watered daily, on cloudy days - every other day. The air temperature in the greenhouse was maintained at +25 °C. To ensure automatic adjustment of the main parameters (temperature, air and soil humidity), a microclimate system was installed. Soil moisture was controlled using a drip irrigation system, air humidity was maintained using a sprinkler system. Watering was carried out from a 10 m³ tank. Water intake for irrigation was carried out from the well. The soil irrigation rate varied depending on the environment, which was maintained at the level of 65-70%.
In order to protect potato plants from pests and diseases, every 10 days the greenhouses were treated with Revus top (Syngenta, consumption rate of 0.6 l/ha), Konfidor-ekstra (Bayer, consumption rate of the drug - 0.125 kg/ha, working fluid consumption - 300 l/ha), Metaxil (Avgust, consumption rate of the drug - 2.5 kg/ha, working fluid consumption - 400 l/ha).

The study used promising domestically-bred cultivars of various maturity groups. Each maturity group had a standard variety recommended for the conditions of the Volga-Vyatka region of the Russian Federation. Very early varieties – Charoite, Hussar, Bellarosa (st). Early varieties – Luxe, Reggae, Luck (st). Middle-early varieties – Samba, Courtney, Nevsky (st). Mid-season varieties – Irbitsky, Pennant, St. Petersburg (st).

In the Volga-Vyatka region of the Russian Federation, unfavorable weather conditions are developing (lack of moisture, significant temperature fluctuations over a short period of time). High yields of potatoes of late varieties are possible only in individual separate years. Such varieties are not suitable for the industrial production of Ware potatoes, since there is a risk of not getting a crop that would cover the costs.

Minitubers were unearthed between 16 and 20 September 2019 105-107 days after potato planting. Records were made during unearthing. Yield of tubers per plant, tuber grade range, and tuber weight were assessed for each scheme. 100 plants of each scheme were randomly selected. All potato tubers were divided into 3 fractions: Ø25+ mm; Ø9-25 mm; Ø <9 mm. Statistical data processing was carried out according to the method of B. Dospekhov (2012).

3. Results and discussion

In original potato seed production, yield of tubers per plant is of the utmost importance. Figure 1 shows yield of minitubers of potato varieties of very early and early maturity groups, while figure 2 shows yield of minitubers of middle-early and mid-season varieties.

Among the studied very early varieties, Hussar variety produced the highest number of tubers per plant in the schemes with pre-rooted plants planted out to pots and pre-rooted plants bedded out – 6.3 and 6.2 pcs, respectively. Charoite plants yielded the largest number of tubers when pre-rooted in seedling containers and then planted out to pots – 5.9 pcs. Although, in this case, the yield of standard-grade tubers is lower (figure 1).

Figure 1. Yield of potato minitubers of very early and early varieties by schemes: 1 – micro-plants are planted in 5 L pots; 2 – micro-plants are bedded; 3 – pre-rooted micro-plants are potted; 4 – pre-rooted micro-plants are bedded.
Bellarosa, the standard variety from the group of very early varieties, had the lowest number of tubers per plant. It gave the highest yield in the scheme with pre-rooted plants bedded out.

Early Luck potato variety is poor in tubers. All our tested schemes for this variety on average produced 3.5 tubers. This is the lowest figure among all early varieties. The highest yield of minitubers was produced where micro-plants were planted out directly to pots – 4.1 pcs per plant.

Luxe plants produced equal number of tubers in all three schemes – 6.5 pcs. Notably, micro-plants of Luxe variety planted out directly to pots produced tubers of <9 mm diameter. Pre-rooted plants planted out to beds yielded 17% less of tubers – 5.4 pcs per plant.

The highest yield of standard-grade tubers per plant for Reggae variety was observed in the scheme where micro-plants were bedded out – 6.6 pcs, the lowest – where’re-rooted plants were planted out to pots.

![Figure 2. Yield of minitubers of middle-early and mid-season varieties.](image)

Balanced distribution of tuber grades is one of the most important parameters of the sowing potato seed quality.

Table 1 shows grade distribution of mini-tubers of very early potato varieties which are crucial for early harvest. The most well-balanced tubers were produced by Hussar plants planted out to pots and beds without pre-rooting. Pre-rooted Charoite and Bellarosa plants planted out to pots produced off-standard tubers that are unsuitable as sowing seeds and their quantity was 1.2 pcs and 1.1 pcs, respectively.

| Variety  | Scheme | Grade Ø25+ mm | Grade Ø9-25 mm | Grade Ø <9 mm |
|----------|--------|--------------|---------------|--------------|
|          |        | g            | g             | g            |
|          |        | pcs          | pcs           | pcs          |
| Charoite | 1      | 43.9         | 15.4          | 0            |
|          |        | 2.1          | 3.1           | 0            |
|          |        |              |               |              |

**Table 1.** Grade distribution of mini-tubers of very early potato varieties.
Among early varieties, Luck variety had the most well-balanced distribution of tuber grades (table 2). This variety produced tubers of 9 to 25 mm diameter in all micro-plant planting schemes. Luxe variety was characterized by a greater weight of tubers of Ø25+ mm grade – 26.4-77.1 g. However, in terms of quantity, mid-grade tubers prevailed.

Table 2. Grade distribution of minitubers of early potato varieties.

| Variety | Scheme | Grade Ø25+ mm g pcs | Grade Ø9-25 mm g pcs | Grade Ø <9 mm g pcs |
|---------|--------|----------------------|----------------------|---------------------|
| Luxe    | 1      | 26.4 1.1             | 25.1 4.1             | 0.41 1.3            |
|         | 2      | 56.1 2.2             | 23.1 4.3             | 0 0                 |
|         | 3      | 77.1 3.5             | 15.5 3.0             | 0 0                 |
|         | 4      | 32.6 1.2             | 15.1 3.2             | 0.26 1.0            |
|         | 1      | 0 0                  | 25.3 4.4             | 0 0                 |
| Reggae  | 2      | 37.3 1.4             | 32.2 5.2             | 0 0                 |
|         | 3      | 0 0                  | 19.8 3.3             | 0 0                 |
|         | 4      | 34.7 1.3             | 23.8 4.4             | 0 0                 |
|         | 1      | 0 0                  | 23.4 4.1             | 0 0                 |
|         | 2      | 0 0                  | 17.9 3.2             | 0 0                 |
|         | 3      | 0 0                  | 15.5 3.4             | 0 0                 |
|         | 4      | 0 0                  | 16.7 3.3             | 0 0                 |

Potted Reggae plants also had well-balanced tuber grade distribution. Ø9-25 mm grade prevailed: from 3.3 pcs – in the scheme where plants were pre-rooted in pots, to 5.2 pcs – in the scheme where micro-plants were bedded.

All tubers of Luck and Reggae varieties complied with the standards.

Samba and Courtney plants produced standard-grade tubers in all schemes (table 3). Nevsky standard variety had off-standard tubers – 1.2 pcs – in the scheme where micro-plants were bedded.

Table 3. Grade distribution of minitubers of middle-early potato varieties.

| Variety | Scheme | Grade Ø25+ mm g pcs | Grade Ø9-25 mm g pcs | Grade Ø <9 mm g pcs |
|---------|--------|----------------------|----------------------|---------------------|
| Samba   | 1      | 57.5 2.5             | 17.2 3.2             | 0 0                 |
|         | 2      | 0 0                  | 24.1 4.6             | 0 0                 |
|         | 3      | 63.9 2.2             | 24.6 4.3             | 0 0                 |
|         | 4      | 34.4 1.4             | 20.2 4.3             | 0 0                 |
|         | 1      | 31.7 1.2             | 18.6 3.1             | 0 0                 |
| Courtney| 2      | 50.9 2.0             | 17.3 3.3             | 0 0                 |
|         | 3      | 105 3.2              | 19.1 3.6             | 0 0                 |
|         | 4      | 92.3 4.2             | 12.0 2.1             | 0 0                 |
| Nevsky (st) | 1    | 0 0                  | 24.8 5.3             | 0 0                 |
Samba variety had the most well-balanced grade distribution in the scheme where plants were bedded. Bedded Nevsky plants had 18.8% of off-standard tubers. Pre-rooted in seedling containers, they produced bigger tubers.

Pre-rooted bedded plants of all mid-season varieties produced off-standard tubers (table 4). Irbitsky variety had 23.9% of off-standard tubers, Pennant variety – 16.9%, St. Petersburg variety – 20.9%.

Table 4. Grade distribution of minitubers of mid-season potato varieties.

| Variety         | Scheme | Grade Ø25+ mm | Grade Ø9-25 mm | Grade Ø <9 mm |
|-----------------|--------|---------------|----------------|--------------|
|                 | g      | pcs           | g              | pcs          |
| Irbitsky        | 1      | 21.1          | 1.3            | 9.9          | 2.1          | 0             | 0             |
|                 | 2      | 0             | 0              | 8.6          | 2.2          | 0             | 0             |
|                 | 3      | 18.7          | 1.3            | 11.7         | 2.2          | 0.31          | 1.1           |
|                 | 4      | 24            | 1.2            | 16.1         | 3.3          | 0             | 0             |
| Pennant         | 1      | 0             | 0              | 25.5         | 5.2          | 0.72          | 2.2           |
|                 | 2      | 0             | 0              | 38.6         | 7.1          | 0.38          | 1.1           |
|                 | 3      | 25.3          | 1.5            | 23.5         | 4.4          | 0.3           | 1.2           |
|                 | 4      | 0             | 0              | 36.1         | 7.2          | 0             | 0             |
|                 | 1      | 0             | 0              | 28.9         | 5.6          | 0             | 0             |
|                 | 2      | 0             | 0              | 35.0         | 6.1          | 0             | 0             |
|                 | 3      | 23.8          | 1.1            | 21.7         | 4.2          | 0.41          | 1.4           |
|                 | 4      | 19.9          | 1.0            | 15.9         | 3.3          | 0             | 0             |

Among middle-early varieties, Courtney variety produced the highest yield of tubers per plant where're-rooted plants were planted out to pots – 6.8 pcs. Nevsky variety had the least tubers where pre-rooted plants were planted out to pots – 4 pcs.

Samba variety had on average 5.6 tubers per plant in all schemes. Herewith, the maximum yield of tubers was produced by pre-rooted plants planted out to pots – 6.5 pcs. Schemes 1 and 4 performed equally in tuber yield per plant producing 5.7 pcs.

In all schemes, Irbitsky plants produced on average twice less tubers than Pennant and 1.5 times less than St. Petersburg varieties. With that, the lowest tuber yield per plant was produced by bedded plants – 2.2 pcs, the highest – 4.6 pcs – where pre-rooted plants were planted out to pots.

Pennant variety yielded the best where plants were bedded – 8.2 pcs.

4. Conclusion

Among all varieties studied, Luck, an early variety, had the most well-balanced grade distribution. Hussar and Bellarosa varieties give the best potato minituber yield per plant where micro-plants are pre-rooted in seedling containers and then bedded out. For Charoit, Samba, Courtney, Irbitsky and St. Petersburg varieties, pre-rooted plants should be planted out to pots. Pennant, Nevsky and Reggae potatoes yielded the largest amount of minitubers when bedded directly from test tubes. Luck variety yielded the best when plants were planted in 5 L plastic pots. Luxe variety was the most flexible – it yielded equally in three schemes. A less preferred minituber growing method for this variety is bedding out pre-rooted plants.

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