Innovative technologies for growing of mini-tubers in virus-free potato seed production

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Abstract. The article describes the method of growing of potatoes mini-tubers in three ways: aeroponic, hydroponic and aero-hydroponic. All three modules were installed at the experimental sites of the North Caucasus Research Institute of Mountain and Foothill Agriculture. Studies have shown that the installed aero-hydroponic modules in plastic foil houses significantly increased the percentage of economic efficiency, since the cultivation of mini-tubers can be carried out in two turns: the first from April to July; the second from August to November.

1. Introduction
In recent years mini-tubers of original seed material have become an extremely popular commodity group on the world market. This contributed to the need to develop various standardized methods in the technological process for the production of mini-tubers, for their further use in potato seed production.

2. Materials and methods
For a long time the development of basic technologies for growing of mini-tubers was carried out in heated greenhouse complexes. But, in the future, due to the high costs of heating, lighting and replacing the soil, this technology has become economically inefficient. Many producers have switched to more economical traditional technologies of growing of mini-tubers for seed material [1,3].

In practice, it was found that in the frame sheltered rooms of the tunnel type (greenhouses), where strict conditions of the controlled environment and measures of protection against pests in the spring and summer turnover are observed, it is possible to achieve optimal results in the cultivation of mini-tubers that will meet all the standards of the world market [2].

After harvesting samples in each batch of mini-tubers are taken for laboratory tests to identify phytopathogens. They are also sorted into fractions by size, since this is an important requirement of the technological process, both in production and in trade volume.

In accordance with international standards, mini-tubers with sizes from 9 to 60 mm in diameter are allowed for use. And this technological process has confirmed that the cultivation of mini-tubers in frame rooms is quite effective and allows to achieve high rates of quantitative yield of the standard fraction-75-85%.
There is also a hydroponic method of growing of mini-tubers. This method excludes land and peat soil, since all potato plants that will be placed in special compartments of the hydroponic module will be fed with a nutrient solution of various macro- and micro-salts specially derived for this technological procedure. The hydroponic method allows to grow mini-tubers all year round and eliminates the risk of viral infection from the outside at most.

Aeroponic cultivation technology. Aeroponics is a method of growing plants, in which the roots of the plant must constantly or periodically be in a nutrient medium in the form of fog or aerosol. Aeroponic installations should be maximally isolated from the external environment in order to maintain a high level of phyto-hygiene and protect from pests and diseases [4].

Experiments and studies have shown that the aeroponic technology allows to get, depending on the variety, from 40 to 100 mini-tubers from one bush. From aeroponic complexes collected on an area of 1000m² were obtained about 1 million mini-tubers within one year. Economic calculations also confirmed the effectiveness of this method of cultivation [5].

Aerohydroponics. In modern practice combined aero-hydroponic technologies have gained the greatest importance, aeration of the root system (aeroponics) is combined with either continuous or periodic immersion in a nutrient solution (hydroponics) [6].

The layout of plants on the module is 200×200 mm, total number of seats is 50, total area of the module for planting is 95×65 mm.

The experiment was based on planting test tube plants in each module.

**Research objective**
- Study the efficiency of new and promising potato varieties and hybrids mini-tubers growing using aeroponic, hydroponic and aero-hydroponic methods;
- Determine the quantitative and qualitative characteristics of the grown material under specified conditions on varieties with different maturation periods;
- Evaluate the productivity of mini-tubers grown in aeroponic, hydroponic and aero-hydroponic modules in natural light conditions;
- Give an economic assessment of the use of the aero-hydroponic method of mini-tubers growing in virus-free potato seed production.

3. Results and discussion
According to the results of previous studies, it is known that Murashige and Skoog nutrient solution most fully meets the requirements of the technological process for obtaining mini-tubers. During the entire growing season the nutrient solution was supplemented as it was exhausted.

**Table 1.** Quantitative yield of different size fractions of mini-tubers of various potato varieties in the aero-hydroponic module

| Varieties | Fraction, mm | Number of tubers, pcs | Average weight of 1 tuber, g |
|-----------|--------------|------------------------|-----------------------------|
| Romano    | 10-15        | 241                    | 1,5-2,7                     |
|           | 15-20        | 329                    | 3,1-7,2                     |
|           | 20-25        | 1523                   | 7,3-12,1                    |
|           | 25-30        | 724                    | 12-14,3                     |
|           | 30-35        | 186                    | 27                          |
|           | >35          | 53                     | 33                          |
| Udacha    | 10-15        | 263                    | 2-3,1                       |
|           | 15-20        | 398                    | 3,3-9,8                     |
|           | 20-25        | 1782                   | 10-15,2                     |
|           | 25-30        | 761                    | 15,7-23                     |
|           | 30-35        | 143                    | 25-32                       |
|           | >35          | 85                     | >32                         |
| Hybrid    | 10-15        | 245                    | 1-3                         |
Tubers were removed after the diameter fraction reached 20-30 mm every 7 days. After harvesting the collected mini-tubers were treated with 0.1% sodium hypochlorite solution followed by rinsing in water to avoid bacterial contamination. The collected mini-tubers were dried at high relative humidity for a week, after which they were kept at a temperature of 20-25°C for 5 days. Then the mini-tubers were stored at a temperature of 3-4 °C.

In Table 1 one observes the average quantitative yield of mini-tubers obtained from each module. Based on these data, high results for the number of mini-tubers were obtained in the size of the fraction with a diameter of 20-25 mm.

Table 2. Productivity and quantitative yield of seed material depending on the fractions of mini-tubers planted in the foothill zone

| Fractions of planted tubers | Weight of tubers, g/plant | Number of tubers, pcs/plant | Tubers yield, ths. pcs/ha | Weight of tubers, g/plant | Number of tubers, pcs/plant | Tubers yield, ths. pcs/ha | Weight of tubers, g/plant | Number of tubers, pcs/plant | Tubers yield, ths. pcs/ha |
|-----------------------------|----------------------------|------------------------------|----------------------------|----------------------------|------------------------------|----------------------------|----------------------------|------------------------------|----------------------------|
| 10-15                       | 103                        | 3,5                          | 193                        | 111                        | 2,1                          | 233                        | 95                         | 2,5                          | 223                        |
| 15-20                       | 147                        | 4,5                          | 267                        | 153                        | 4,6                          | 292                        | 138                        | 4,1                          | 296                        |
| 20-25                       | 233                        | 6,2                          | 311                        | 197                        | 5,7                          | 371                        | 209                        | 6,4                          | 357                        |
| 25-30                       | 257                        | 7,1                          | 353                        | 321                        | 9,1                          | 423                        | 286                        | 8,6                          | 398                        |
| 30-35                       | 295                        | 7,3                          | 537                        | 359                        | 10,2                         | 751                        | 322                        | 9,3                          | 653                        |
| >35                         | 327                        | 7,9                          | 611                        | 448                        | 12,3                         | 854                        | 387                        | 11,4                         | 792                        |

The planting of mini-tubers was carried out in the foothill zone of North Ossetia in the village of Mikhailovskoye at the experimental sites of the SKNIIGPSKH. Table 2 shows the average productivity of the Romano, Udacha and Hybrid 10.2/5 varieties. These varieties showed excellent productivity results, and Udacha variety completely exceeded expectations in terms of the number of tubers yield of seed material.

Table 3. Efficiency of using the aero-hydroponic module per potato variety

| Source data | Costs | Tubers grown | Actual costs |
|-------------|-------|--------------|--------------|
| Total plants, pcs | 60    | 90-110       | 13.7, 2750   | 3.578, 65     | 200-245, 3.3-3.9             |

The energy consumption for obtaining one tuber when grown under artificial conditions with the use of sodium and LED lamps approximately amounted to 1150-1650 W per 1 mini-tuber. The cost of the aero-hydroponic module was about 3.5 W and this is a significantly profitable indicator when growing mini-tubers in virus-free potato seed production.
4. Conclusions
This method is more practical, because it provides feeding of plants in two ways at the same time. The main one is the aeroponic feeding circuit, which is completely dependent on the energy supply. The second one is hydroponic, which constantly feeds the roots of the plant and is completely independent of electricity.

On one aero-hydroponic installation can be planted up to 60 plants. It gives from 20 to 50 pieces of mini-tubers with a fraction of 20 to 35 mm, which make up more than 75% of the entire crop of one bush.

Studies have shown that the installed aero-hydroponic modules in plastic foil houses significantly increased the percentage of economic efficiency, since the cultivation of mini-tubers can be carried out in two turns: the first from April to July; the second from August to November. The cost-effectiveness of this technology lies in the fact that by the beginning of the first turn, there is no shortage of light, and by the end of the second turn the temperature drop is not critical for plants. Thus, the costs of heating and lighting were reduced maximally.

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