The cost of obtaining improved planting material of garlic (*Allium sativum* L.) using the *in vitro* method

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Abstract. The calculation of costs of obtaining planting material of winter garlic Gladiator variety using two methods developed in 2018 at the all-Russian Research Institute of Vegetable Production - the branch of the Federal Scientific Center of Vegetable Production, is made. The costs at different stages of growing winter garlic are shown. Thus, when growing winter garlic planting material from air bulbs in the Nonchernozem zone of the Russian Federation, the total cost is 370.24 thousand rubles, and for obtaining planting material using the *in vitro* method – 526.02 thousand rubles. The cost of one multi-clove bulb is 35.29 rubles and 52.6 rubles, respectively. The use of *in vitro* method allows obtaining planting material free of phytopathogens, which plays a very important role in reducing the pesticide load and greening the production of garlic for food and seed purposes.

1. Introduction

The Government of the Russian Federation has allocated about 2000 million rubles for the program of basic scientific research in the field of agricultural biotechnology in order to create new highly productive forms of cultivated plants that are resistant to adverse abiotic and biotic environmental factors. This indicates that the state is interested in using scientific achievements to ensure food security of the Russian Federation in conditions of economic isolation. Therefore, modern biotechnological methods are becoming popular not only in science, but also in the production of agricultural products.

According to the FAO, global garlic production in 2016 was 26.6 million tons. The main regions of garlic production are the countries of Asia, which account for more than 90% of the world’s total volume. In the Russian Federation in 2016, 262.2 thousand tons of garlic were obtained from the area of 27.6 thousand hectares. At the same time, 98% of all sown areas of garlic are in private households, 1.3% - agricultural organizations, 0.8% - belongs to PF and IE. The Moscow region takes the 5th place among the regions of the Russian Federation in terms of gross harvesting of 8.6 thousand tons [1].

Garlic occupies a significant place in the human diet and its role in using as a medicinal plant is increasing [2, 3]. Garlic, as an exclusively vegetative propagated plant, is subject to numerous viral, bacterial, fungal and other infections that are transmitted to offspring, which leads to decrease in yield, loss of quality, keeping capacity and often degeneration of varieties [4, 5]. In this regard, the problem of updating varieties and obtaining improved planting material is acute.

In Russia, a technology has been developed and widely implemented for obtaining potato planting material free of phytopathogens obtained using *in vitro* methods. The price of one microtubers of potatoes obtained in this way is 800 rubles, a tuber of super-elite material is 20 rubles [6, 7].
The technology for obtaining improved garlic planting material has not been developed in the Russian Federation. To develop it, it is necessary to conduct an economic analysis. The aim of our work was to analyze costs and calculate the net cost of obtaining winter garlic planting material using different methods as part of the future production technology of improved garlic planting material.

2. Materials and methods

The research material was the winter garlic variety Gladiator [8]. All-Russian Research Institute of Vegetable Production – the branch of FSCVP developed methodology for obtaining in vitro planting material of winter garlic (Allium sativum L.) [9,10], according to which technological maps of biotechnological stage of cultivation of garlic were calculated and compiled. To calculate the cost of plant production in culture in vitro, the following initial data were used: salary with specialist accruals of 40,000 rubles per month, the cost of 1 kW/hour – 4.66 rubles. [11] Growing plants in the field was carried out using the method “Obtaining planting material of winter garlic (Allium sativum L.) from air bulbs in the Nonchernozem zone of the Russian Federation” [12,13,14,15]. All work was carried out on the pilot site using manual labor. The estimated area is 300 sq. m.

3. Results

In this paper, we compare two new methods for obtaining winter garlic planting material through the air bulb and using culture in vitro, developed in the Department of Biotechnology of Innovative Projects of ARIVP – the branch of the FSCVP.

The method of obtaining winter garlic planting material from air bulbs includes a set of measures for cultivating winter garlic from obtaining air bulbs to multi-clove bulbs [16,17,18,19]. The process of obtaining a single-clove bulb from the air bulb is the most labor-intensive. Labor costs at this stage are 484 man-hours and 96.8 thousand rubles, and the total cost -125.28 thousand rubles.

In general, this method involves obtaining air bulbs, then obtaining single- and multi-clove bulbs. The total cost is 1,424 man-hours and 370.24 thousand rubles, while the cost of 1 multi-clove bulb is 35.29 rubles (table 1).

| Stage                  | Stage duration, months | Labour costs man/hour | Materials, thousand rubles | Electric power kW/hour | Other, thousand rubles | Total costs, thousand rubles | Net cost, rubles |
|------------------------|------------------------|-----------------------|---------------------------|------------------------|------------------------|-----------------------------|-----------------|
| Growing donor plants   | 9                      | 23.5                  | 4.7                       | 0.93                   | 0                      | 0                           | 6.13            |
| Biotechnological       | 10.5                   | 402                   | 90.4                      | 199.99                 | 22794                  | 10                          | 406.61          |
| Cultivation of the FFG | 9                      | 424                   | 84.8                      | 18.48                  | 0                      | 0                           | 113.28          |
| Total                  | 28.5                   | 1296                  | 179.9                     | 219.4                  | 20195                  | 20.5                        | 526.02          |
| Growing using air bulb |                        |                       |                           |                        |                        |                             |                 |
| Receiving air bulbs    | 9                      | 470                   | 94                        | 18.48                  | 0                      | 0                           | 122.48          |
| Receiving single-clove bulbs | 9      | 484                   | 96.8                      | 18.48                  | 0                      | 0                           | 125.28          |

Table 1. Costs of obtaining winter garlic planting material.
The method of obtaining winter garlic planting material using biotechnological methods also involves three stages: growing of donor plants, the biotechnological stage and growing of the first field generation (FFG) (table 1).

Growing donor plants of winter garlic includes preparing the soil for planting, cutting ridges, preparing planting material, planting, caring for plants during the growing season, as well as preventive treatment against diseases and pests. The duration of the stage is 10 months. Labor costs amount to 470 man-hours and 94 thousand rubles. Donor plants are grown on ridges with a total area of 15 sq. m., the density of standing plants is 40 PCs. per sq. m., for simultaneous production of 350 garlic inflorescences suitable for introduction into culture.

The second stage is biotechnological, performed in laboratory conditions. It includes preparation of plant material for introduction into culture in vitro, cultivation in vitro, adaptation and growing of winter garlic plants in ex vitro conditions [20]. In general, the biotechnological stage lasts 10.5 months, including the period from introduction to culture to adaptation to ex vitro conditions on average takes 2.5 months, adaptation to ex vitro conditions and growing plants to a single-clove bulb, storage in the refrigerator – 7 months (table 2).

One of the important stages of in vitro cultivation is the introduction to the culture, on the effectiveness of which all subsequent work depends. In the cost structure of the biotechnological stage of growing winter garlic, it occupies only 3.62%, in monetary terms – 14.44 thousand rubles.

Micro-propagation, rooting and growing of plants in vitro for the duration and share in the cost structure are approximately the same. The duration of cultivation is about 1 month each stage. At the stage of micro-propagation, 30 well-formed plants obtained in vitro can be obtained from a single garlic inflorescence, i.e. from 350 inflorescences introduced into culture in vitro, 10.5 thousand plants can be obtained in vitro. The share in the cost structure is 16.5% or 43.47 thousand rubles.

Adaptation of regenerates to ex vitro conditions takes more than 7 months and is the most expensive, with 63.27% of the cost structure. At this stage, the plants obtained in vitro are grown to a single-clove bulb, followed by storage in cooling chambers until planting in the ground.

Electricity costs include payment for the electricity consumed by the light installation, laminar box, split system, drying cabinets, autoclaves, distillers and the refrigerator for vernalization of single-clove bulbs. The highest energy costs are incurred at the last stage of growing plants ex vitro and amount to 119.7 thousand rubles.

Table 2. The cost of obtaining 10,000 garlic plants in vitro.

| Indicators                        | Cultivation stages                      |
|-----------------------------------|-----------------------------------------|
|                                   | introduction to in vitro | micropropagation | rooting and growing plants in vitro | adaptation of plants in vitro to ex vitro conditions and their growth | Total        |
| Cultivation duration, months      | 0.5                                    | 1.5             | 1                                    | 7                        | 10.5         |
| Labour costs, thousand rubles     | 5.20                                   | 25.10           | 25.10                                | 49.20                    | 104.60       |
| Electric power, thousand rubles   | 1.22                                   | 4.86            | 4.75                                 | 83.28                    | 94.11        |
| Materials, thousand rubles        | 8.02                                   | 36.09           | 36.09                                | 119.70                   | 199.9        |
| Total, thousand rubles | 14.44 | 43.47 | 43.36 | 207.92 | 398.61 |
|-----------------------|-------|-------|-------|--------|--------|

The cost of materials includes the cost of tableware, chemical reagents, insulating materials, and disinfectants. To adapt regenerants, Jyffi 24 mm peat tablets were used, which increased the cost of materials by 119.7 thousand rubles.

The total cost of obtaining winter garlic plants in culture *in vitro* is 398.61 thousand rubles, and the cost of one plant is 39.86 rubles (table 2).

The final stage is the cultivation of the first field generation. Duration - 9 months, 10000 PCs of adapted plants are planted on beds with a total area of 300 sq. m., care for planting is carried out using the technology of growing winter garlic from a single-clove bulb. The cost of 1 bulb of the first field generation at this stage is 15.89 rubles.

In general, the cost of obtaining planting material using the *in vitro* method is 526.02 thousand rubles, and the cost of one bulb of the first field generation is 52.6 rubles.

4. Summary
As garlic is an exclusively vegetative-propagated plant, it is impossible to completely free the planting material from fungal, bacterial and viral infections using traditional methods. The planting material of winter garlic obtained using the *in vitro* method is cured from phytopathogens, and the cost of obtaining it is a long-term investment.

The total cost of obtaining 10,000 plants produced using the *in vitro* method is 526.02 thousand rubles, and the cost of one multi-clove bulb is 52.6 rubles. The share of expenses of the biotechnological stage is 77.3% (406.61 thousand rubles). From the bulbs of the first field generation, after 2 years of growing in the open ground, they can get planting material for 1 ha area.

5. References
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