



**САДОВОДСТВО, ОВОЩЕВОДСТВО, ВИНОГРАДАРСТВО И ЛЕКАРСТВЕННЫЕ
КУЛЬТУРЫ/HORTICULTURE, VEGETABLE GROWING, VITICULTURE AND MEDICINAL CROPS**

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AN IMPORTANT ELEMENT IN THE DEVELOPMENT OF HOP GROWING REGIONS

Research article

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Abstract

The article provides a comparative analysis of the development of nursery elements using modern biotechnological methods and traditional technology for obtaining planting material. According to the results of the analysis, it was found that in the first variant, the main part of the costs is spent on manual labor and on the cost of adapted cuttings obtained *in vitro*. In this regard, green cuttings obtained independently eliminate the cost of purchasing seedlings, which significantly reduces their cost. Reducing expenses increases net income and profitability of production. It is recommended to use adapted plants *in vitro* when laying a healthy queen cell, and the method of green cuttings in the future for the propagation of healthy plants.

Keywords: hops, *in vitro* culture, adaptation nursery farming, cultivation, seedlings.

ВАЖНЫЙ ЭЛЕМЕНТ В РАЗВИТИИ РЕГИОНОВ ВЫРАЩИВАНИЯ ХМЕЛЯ

Научная статья

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Аннотация

В статье представлен сравнительный анализ развития элементов питомниководства с использованием современных биотехнологических методов и традиционной технологии получения посадочного материала. По результатам анализа было установлено, что в первом варианте основная часть затрат приходится на ручной труд и на стоимость адаптированных черенков, полученных *in vitro*. В связи с этим зеленые черенки, полученные самостоятельно, исключают затраты на приобретение саженцев, что значительно снижает их себестоимость. Снижение затрат увеличивает чистый доход и рентабельность производства. Рекомендуется использовать адаптированные растения *in vitro* при закладке здорового маточника, а также метод зеленого черенкования в дальнейшем для размножения здоровых растений.

Ключевые слова: хмель, культивирование *in vitro*, адаптационное питомниководство, выращивание, саженцы.

Introduction

Hops belong to agricultural crops with a small volume of production — the global area of its plantations is more than 51 thousand hectares [1]. At the moment, most of the hop plantations available in the Russian Federation have degenerated or are severely depleted, affected by diseases and pests. The vast majority of hop farms produce hop yields below 15 c/ha. The acute shortage of high-quality hop planting material in the domestic market is caused by the inability to meet the needs of hop growers in planting material at existing production facilities, as methodological approaches to nursery farming have been lost [2].

Nursery farming is one of the most dynamically developing sub-sectors of agriculture. However, despite significant progress in increasing the volume of domestic planting stock, there remains a significant shortage of high-quality seedlings on the market, especially hops, which serves as a constraining factor in the development of the hop growing sub-sector [3].

At the current stage of hop farming development, in order to establish new plantations and repair them, it is necessary to increase the production of high-quality seedlings, especially for accelerated reproduction of the best and most promising varieties. The main task in this case is to improve the technology of growing healthy planting material [4].

Obtaining a healthy planting material can be solved using biotechnological and molecular genetic methods. In foreign and domestic agriculture, the methods of clonal micro-propagation of plants *in vitro* have become the most widespread, which make it possible to multiply and improve valuable genotypes in a short time, which can be used both directly in production and to accelerate the breeding process [5], [6]. Apical meristem culture, thermo-, cryo-, and chemotherapy, as well as various



combinations of these methods (combined therapy), are used to heal plants from viral diseases [7]. Such work is widely carried out with fruit, berry, ornamental plants, potatoes, and in recent years there have been studies on hop culture [8].

Modern trends in the development of nursery production are aimed at increasing integration into traditional technologies of growth stimulants, the principle of which is different. Some of them are aimed at improving the root formation process when using vegetative propagation methods, others are used during the growing season of seedlings and perform growth-stimulating functions and increase plant resistance to adverse factors and pathogenic objects [3].

The Chuvash Research Institute of Agricultural Sciences, a branch of the N.V. Rudnitsky Federal State Budgetary Scientific Institution of the FANZ of the North-East, conducted a study on the survival and development of adapted Flagship hop plants under various conditions using growth stimulants obtained *in vitro* from the Altai Center for Applied Biotechnology, Altai State University.

The purpose of the research is to develop an effective element of nursery management in the cultivation of standard hop seedlings at the stage of transfer and adaptation of the improved plant material obtained by the method of clonal micropropagation to field conditions.

Research methods and principles

The research was conducted in 2024 by the Chuvash Research Institute of Agricultural Sciences by laying a one-factor experiment on gray forest soil with a heavy loamy granulometric composition. In the course of the research, a comparative study of the survival rate, root system development and aboveground mass of hop plants obtained by green cuttings) and *in vitro* plants obtained in test tubes and adapted to daylight conditions at 56 °C. when transplanted into sterile soil in the laboratory of the Chuvash Research Institute of Agriculture, equipped with racks, for 1,5 months was carried out. The object of the study was the hop plants of the ordinary Flagship variety.

The experiment was repeated three times, with 25 plants per plot, and a total of 6 plots. The plot area is 1,8 m², the total area of the experiment is 10,8 m². The plants were planted manually according to the 30x10 cm scheme. The placement of plots is systematic.

The soil was pretreated with a soil cultivator with pointed paws and a rolling roller. Beds 1 m wide were sprinkled with river sand up to 16 kg per 1 m². After the sand was distributed with a rake, the bed for cuttings was abundantly watered to 100% of the maximum field moisture capacity. The cuttings were cut with a sharp knife on June 15 from green shoots that formed 3-5 or more pairs of leaves. The length of the stalk was 6–7 cm lower part of the leaf plate, 2-3 cm upper part. Then arcs of wire (5 mm in diameter) with a height of 40-50 cm were installed at a distance of 70-80 cm from each other and the green cuttings were covered with a reflective film that retains moisture better and creates a shading effect. The film was covered with earth from the edges so that there was no air circulation and so that the cuttings in the greenhouse had time to grow dormant buds and begin to form a root system. After 3 weeks, i.e. after rooting, the film and arcs were removed. No additional watering was subsequently carried out.

Adapted plants were planted from containers of the P9 brand along the root neck, then abundantly watered. During the growing season, no additional watering was carried out in order to study the development in natural conditions.

The development of the vegetative mass and its components (leaves and stems) and the root system were determined by the weight method on October 15. The quality of the root system was assessed according to GOST R 55758-2013 [9]. Planting material of common hops (stem cuttings and annual seedlings). The mathematical processing of the data was carried out by the method of variance analysis [10].

Main results

The winter of 2023-2024 was snowy, but the first stable snow cover appeared only in the 3rd decade of November. Up to this time, heavy rainfall actively moistened the soil, which allowed it to create a significant reserve of moisture before freezing. By the end of November, the snow height was 8-9 cm. Severe frosts were not observed until early December. The cooling to 25 °C led to a short-term freezing of the soil to -5,9 °C, but by mid-December, the warming was accompanied by heavy snowfalls, which created a snow cover 30 cm high, and led to a warming of the soil to -0,9 °C. By the end of January, the snow height reached 46 cm, and the soil cooled to -2,6 °C. In February – March, precipitation increased the height of the cover to 73 cm, due to which the soil temperature ranged from -2,3 to -0,2 °C.

April was warm. From the very first decade, warming led to rapid melting of snow and warming of the soil to positive temperatures. Almost the entire month had positive temperatures, and the last third of the month was characterized entirely by effective temperatures of 10 °C and above. 75 mm of precipitation fell in the second and third decades. Thus, optimal conditions have been created for overwintering plants. Prolonged autumn rains, as well as spring floods and precipitation, created a good supply of moisture in the root layer, which allowed open-ground crops to withstand the drought without critical damage. The first decade of May was almost 6 degrees colder than long-term indicators, with 2,5 times more precipitation. But the second and third decades were characterized by a sharp shortage of moisture. Further, until the end of July, dry weather was observed, when precipitation was unproductive or absent altogether, and was mainly accompanied by elevated temperatures. The exceptions were the first days of June and mid-July, when rains exceeding long-term data were recorded.

In general, plants experienced severe stress against the background of such climatic conditions. The picture changed at the end of the 2nd and beginning of the 3rd decade of August, when almost 125 mm of precipitation fell in 6 days, while the temperature was at the level of long-term indicators. During the whole of September, only 2 mm of precipitation fell.

September turned out to be warm and dry. For the entire month, only 1,5 mm of precipitation fell, while the average excess of long-term temperature values was 9,9 °C. The GTC for April-September was 1,26. However, during the period of basic plant growth and development, from mid-May to the end of the first decade of August, the GTC was only 0,6, which corresponded to arid conditions. Such conditions did not contribute to the full development of plants growing in the open ground.



Discussion

The propagation of hop seedlings is one of the main issues in the development of hop farming. With the traditional technology of propagation by stem cuttings, where the reproduction coefficient is extremely low (1 to 4) and depends on the number of mother plants, green cuttings and microclonal propagation methods have a number of advantages.

Green cuttings are one of the most promising methods of vegetative propagation, which allows increasing the yield of cuttings from one mother plant by 4-5 times. The bottlenecks of this method are: a long period of root formation, low rooting (no more than 30-50%) and poor development of the root system [11].

The advantages of clonal plant micropropagation in comparison with traditional methods are:

- a significantly higher reproduction rate, estimated to reach 105-106 mericlones per year, with 5-50 ordinary plants from one, usually obtained over the same period [12];
- miniaturization of the process, leading to savings in the areas occupied by mother and propagated plants;
- improvement of planting material from diseases and pests.

In order to identify differences between hop plants obtained *in vitro* (adapted to non-sterile soil conditions) and the green cuttings method, seedlings were dug at the end of the growing season on October 15. During the autumn digging and measurements, it was found that the root system of seedlings obtained *in vitro* was more developed than that of seedlings obtained by green cuttings. This is reflected both in longer main roots (an increase of 24,2%) and in a larger number of them (37,8%). The diameter of the main roots did not differ significantly between the variants.

The aboveground part of the plants also differed in variants. In terms of the number of stems, a 2-fold increase was observed in plants obtained in the laboratory, but most of the stems were thin, puny and matted. In terms of above-ground weight, these seedlings exceeded the control by 36%. At the same time, there was no significant difference in the number of internodes and the length of the stem between seedlings obtained both by green cuttings and *in vitro*.

Due to the fact that the plants obtained *in vitro* already had a certain amount of root system by the time they were planted in the open ground, they were able to adapt to the new conditions faster.

The survival rate and survival rate of adapted cuttings significantly exceeded those of green cuttings. This made it possible to increase the yield of seedlings by 4,3% compared with green cuttings; while exceeding the control for survival by 3% (HCP05 = 1,1%) and survival by 6,4% (HCP05 = 3,5%).

Economic efficiency was determined by technological maps and the cost of funds. Economic efficiency indicators (net profit, the level of profitability of planting material production) were determined according to a generally accepted methodology. The calculations were based on the selling price of a seedling — 120 rubles/piece for *in vitro* improved material, 100 rubles/piece for green cuttings. The price of the resulting healthy plant in a P9 container with peat soil and perlite is 60 rubles/piece. The calculation of the seedling yield was carried out based on an area coefficient of 0,7, taking into account the passages between the beds and the place for the tractor to pass when caring for pests and diseases, as well as when digging with a digger. The labor cost for the production of 1000 seedlings is 8 people/day. In addition to the wages of the workers, the direct costs included the following items: for the production of seedlings from green cuttings, a white matte film of 200 microns was used — 160 rubles/m² and greenhouse garden arcs of 2 m — 95 rubles/ piece. 200 m² of film is required per 100 m² — 32,000 rubles, 143 arcs with placement every 70 cm — 13585 rubles. Spraying to protect plants from pests and diseases was carried out with the preparations Acardo — 6162 rubles / l at a dose of 0,5 l / ha, Metaxil — 1200 rubles / kg at a dose of 2 kg / ha, Ordan — 1200 rubles / kg at a dose of 2 kg / ha, sirocco — 900 rubles / l at a dose of 2,8 l/ha. Fuel costs and salaries of workers and tractor drivers were also taken into account. With the yield of green cuttings of 66,4%, and adapted cuttings of 70,7% per 1 ha, the following profitability is obtained.

Conclusion

Based on the results of research conducted in 2024, experimental data were obtained for the development of nursery elements.:

- adapted plants *in vitro*, when laying a breeding nursery, increase the percentage of seedling yield by 4,3% compared to using the green cuttings method, but it is more expensive and significantly inferior in profitability;
- adapted plants *in vitro* are recommended to be used when laying a healthy queen cell, and the method of green cuttings in the future for the propagation of healthy plants;

Most of the costs are spent on manual labor and on the cost of adapted cuttings obtained *in vitro*. In this regard, green cuttings obtained independently eliminate the cost of purchasing seedlings, which significantly reduces their cost. Reducing expenses increases net income and profitability of production submission.

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Не указан.

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Conflict of Interest

None declared.

Review

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