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Technology and mechanization of cultivation of Jerusalem artichoke healthier

Viktor I. Starovoitov[1*], Oksana A. Starovoitova[1], Nikolay Aldoshin[2], Aleksandra A. Manokhina[2]

[1]*All-Russian Research Institute of Potato Growing named after A.G. Lorkh, Kraskovo, Russian Federation*

[2]*Russian State Agrarian University – Moscow Agricultural Academy named after K.A. Timiryazev, Moscow, Russian Federation.*

**Corresponding author: agronir1@mail.ru*

Abstract

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Jerusalem artichoke (*Helianthus tuberosum* L.) is a promising bioenergy multi-purpose crop. The Jerusalem artichoke is a valuable culture that is a source of inulin, fructose and pectin. Green mass of the Jerusalem artichoke has a high content of complex carbohydrate (fructose, glucose, sucrose, etc.) in the dry weight of the plant contain up to 17% protein with a balanced amino acid composition. Biotechnological methods are firmly established in plant growing practice and are widely used for rapid multiplication and obtaining healthy planting material of many economically important crops. The technology of micro clonal propagation "*in vitro*" has great importance for the development of seed production of Jerusalem artichoke and obtain sufficient quantity of high quality planting material. Formed innovative scheme of sequential technological process of seed production of Jerusalem artichoke includes the production of original seed material "*in vitro*" Jerusalem artichoke, mass reproduction by aero hydroponic installations, and the rationale based on research of the technology of growing high-quality seed of Jerusalem artichoke. It was found that at cultivation of minitubers of micro plants in aero hydroponic installation compared to farming by traditional technology, the cost of one minituber decreased by 9.58 RUB.

Keywords: sequential technological process; seed production of Jerusalem artichoke; source of plants; minitubers

The Jerusalem artichoke (sunflower tuber) or, as it is called in Russia, 'artichoke' is a perennial tuber plant of the family Asteraceae (Starovoytov et. al. 2017). Topinambour (earthen pear), called Jerusalem artichoke, Sunchokes, is grown in France, and USA (McCarter et. al. 1984). Canada grows 13 mil. tons of Jerusalem artichoke, and in Russia, the area of planting artichoke is insignificant: about 3,000 ha of mechanized production and a number of gardens and orchards. Many countries grow Jerusalem artichoke as a vegetable crop (Italy, Spain, Germany). In small amounts as a vegetable crop it is imported in Russia (Mimiola 1988)

The Jerusalem artichoke is cultivated in the Russian Federation, primarily in Nizhny Novgorod, Lipetsk, Tver, Ryazan, Tula, Ulyanovsk, Kostroma, Volgograd, Omsk, Bryansk, Moscow, Saratov, Yaroslavl areas, the Chuvash Republic, Krasnodar and Stavropol territories. Veles Ltd. (Saratov region) grows a collection of varieties of Jerusalem arti-

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choke and the area of Jerusalem artichoke cultivating is 70 hectares. The purpose of it is a processing of feed, etc. Urukhskaya cannery OJSC (Kabardino-Balkaria) has a collection of varieties of Jerusalem artichoke and the area of Jerusalem artichoke cultivating is 400 ha, completed construction of a plant for the production of purees and syrups. Zavolzhsky CJSC (Kostroma oblast) has 100 ha for growing Jerusalem artichoke and processing it. Anushkevich N. Yu. KFKH (St. Petersburg's region) grows Jerusalem artichoke for the supply of fresh vacuum-packed tubers in the stores and has the area of 20 ha for it. The company practices complicated processing of Jerusalem artichoke. IstAgro Don Ltd. (Lipetsk region) organizes a commodity area, which consists of 4 farms and has a total area of 200 ha, also this company is building a factory for processing 50 th. t of Jerusalem artichoke to inulin, organophosphorus compounds and feed. Bioforma Ltd. (Kirov region) grows Jerusalem artichokes for the supply of fresh vacuum-packed tubers in stores, releases the powder of Jerusalem artichoke, builds the enterprise for manufacture of fructose sugar. The area of cultivation of Jerusalem artichoke is 100 hectares.

The analysis shows that the main problems of the implementation of the Jerusalem artichoke originated from the lack of technology for healthy seeds, it is cause of creation the seed production system of artichoke in Russia. Major seed companies for Jerusalem artichoke is OOO VIVA (Kostroma oblast), which is located in a clean phytosanitary area, grows new and perspective varieties of Jerusalem artichoke at the area of 100 ha, practices the original seed production of Jerusalem artichoke.

Special zones of seed production in the territories of regional base enterprises (centres) will ensure the development of the original seed production of Jerusalem artichoke and improve the quality of industrial production of Jerusalem artichoke for processing, based on the use of the best domestic competitive varieties for the purpose of import substitution in the agro-food market of Russia.

Jerusalem artichoke has high resistance to diseases, however, there are some diseases, such as Sclerotinia (white mold) – occurs during growth on tubers (in extreme circumstances, the defeat is not more than 7% of crops); grey rot occurs during storage, transportation of the tubers on the places of mechanical damage; manifests in the form of gray-brown spots; soft rot – occurs on stems and leaves, which turn brown, and become watery. Usually appears on areas of mechanical damage; karmakamet artichoke. Young shoots of Jerusalem artichoke are sometimes damaged by the larvae of the chafer, mole crickets, and caterpillars of meadow moth. Roots and tubers can be damaged by wireworms, false wireworms, and larvae of the chafer.

In connection with the trend of increasing agricultural land for planting of Jerusalem artichoke, the question arises about the need to ensure quality seed material, ensuring max. realization of its genetic potential, thus providing high yield. For the effective cultivation of Jerusalem artichoke requires replacement of seed every 3–4 years, as from reproduction to reproduction, the accumulation of viruses and pathogens. You should also consider the zoning of varieties of Jerusalem artichoke by region for the most complete realization of biological potential. Industrial production of Jerusalem artichoke should be based on promising varieties, use of high quality seed material, cultivar changing and strain renovation of the seed.

Experience of large-scale cultivation of seed of Jerusalem artichoke shows that it is necessary to explore the possibilities of innovative technologies for the reproduction of original seeds, because there are new varieties, which are necessary to be quickly replicated.

One of the ways of reproduction of Jerusalem artichoke is cultivation of these seeds in the laboratory, for example, in Petri dishes. This is a time-consuming way, since the germination of these seeds of Jerusalem artichoke does not exceed 1–2%, and many varieties in the conditions of the Central Federal District do not produce seeds at all.

Currently, in practice of the original seed production of Jerusalem artichoke is the most widely distributed technology of clonal propagation in the field (Malko et al. 2011). For a long time, the development of traditional (baseline) technologies of cultivation of minitubers has been being focused on the use of ground glass winter greenhouses.

Another way: the production of elite seeds of Jerusalem artichoke, which includes the creation of a collection of improved varieties "*in vitro*" culture, is the "*in vitro*" propagation of the required quantity of plants and obtaining elite seed. To obtain mini-tubers the Lorch Potato Research Institute (FGBNU VNIIKH) developed and used aero hydroponic installation; it is possible to harvest throughout the year due to these installation. The produc-

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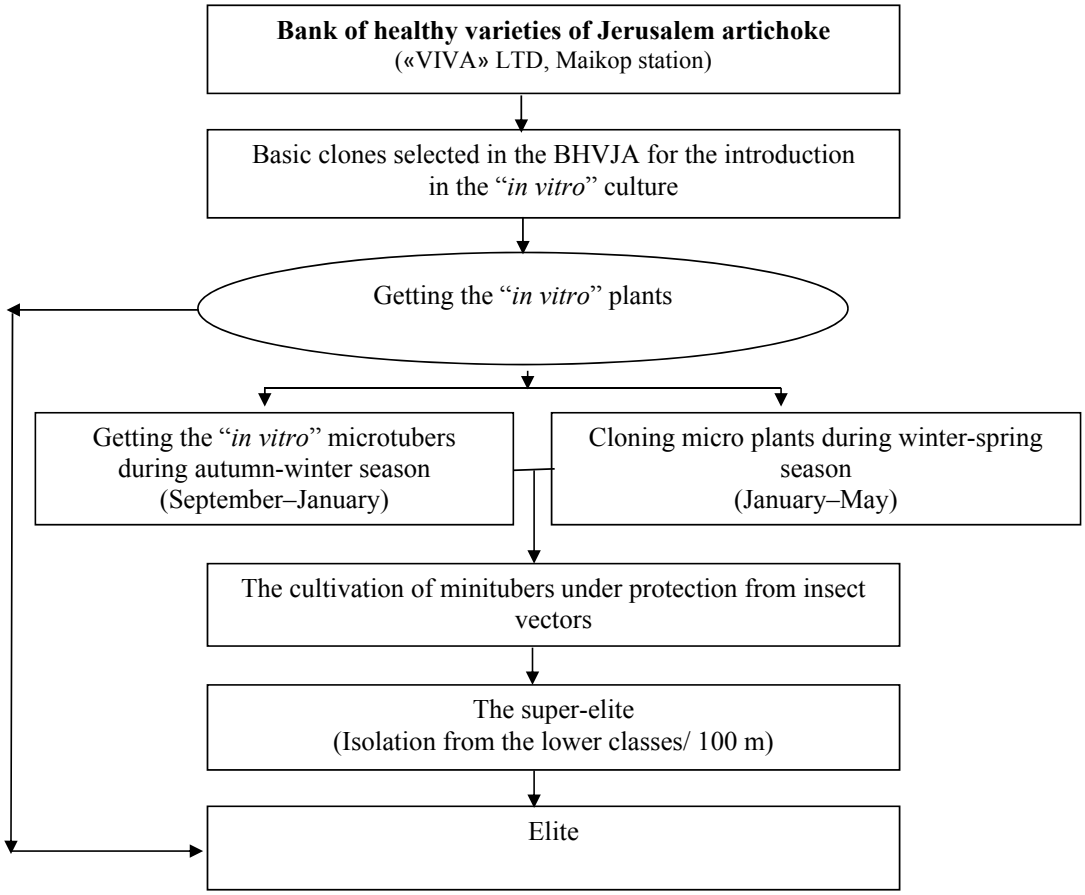

Fig. 1. Innovative shame of sequential technological process of the original seed production of Jerusalem artichoke

tion of improved seed mini-tubers is the basis for high-quality seed of Jerusalem artichoke.

Current innovations and our experience in the micro-propagation of artichoke "*in vitro*" can be vastly used in the production of Jerusalem artichoke. New technological solutions allowed to considerably improving methods of "*in vitro*" material for growing minitubers in the conditions of the vegetative structures of various types and designs.

Experience of cultivation and especially standard technology of large-scale production of original seeds of Jerusalem artichoke to the present time did not exist. Like the potato, the Jerusalem artichoke belongs to the tuber crops. For the production of original seed potatoes in the FGBNU VNIIKH developed a scheme of sequential technological process, which has justified itself and is widely used in seed production. It was decided to take that as a basis (Fig. 1).

Biotechnological methods gained a foothold in plant growing practice and are widely used for rapid multiplication and obtaining healthy planting material of many economically important crops. The technology of micropropagation "*in vitro*" is of great importance for the development of seed production of Jerusalem artichoke and obtaining sufficient quantity of high quality planting material.

The advantages of micro-propagation of artichoke compared to traditional methods of obtaining genetically uniform planting material are: recovery of plants from viral diseases; the production of plants free from fungal and bacterial pathogens, mycoplasma and nematode infections; high rate of reproduction. In the clonal micro-propagation of artichoke in six months you can get 10–15 thousands plants; the possibility of work during the year, as the growth and development of plants "*in vitro*" do not depend on seasonal changes, and saving space required for cultivation of a landing material .

Sterilization of initial plant material is a required condition for the introduction of aseptic culture. We used a standard method applied before on potatoes (Starovoitova et al. 2017).

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Fig. 2. "*In vitro*" culture of Jerusalem artichoke variety Skorospelka

Fig. 3. Universal aerohydroplane module (propagator) with active backlight

MATERIAL AND METHODS

In the FGBNU VNIIKH varieties of Jerusalem artichoke – 'Diet', a 'Canadian', 'Nahodka', 'Pasko 1', 'Podmoscownie', 'Skorospelka', 'solar Pasko', 'Tajik', 'Purple', and 'PBB' (Fig. 2) have been entered in "*in vitro*" culture and propagated .

Minitubers are usually grown in the spring and summer greenhouses. The average one turnover in greenhouses of 500 m^2 you can maximally get up 50,000 tubers (average of 7 tubers on 1 plant). Previously imported soil should be thoroughly checked for the absence of quarantine objects.

Aero hydroponic method of reproduction of the original artichoke. A module is a sufficient system of cultivation of plants, with the possibility of operating in natural or artificial environments. The module is mobile and can be equipped with several other modules in a single complex node. Nutrition of plants is differentiated and delivered to the plant roots by aeroponic and hydroponic methods (Hutinel et al. 2012)

The roots of the plants grow isolated from the environment, allowing their full service aerohydroponic system and monitoring of development of roots and minitubers. The module provides a fixative device that will keep the plants in the process of growth and development.

The main advantages of the module is its mobility and possibility of operation in spring and autumn, in open areas or in greenhouses, eliminates the significant costs of expensive lighting ,which is required indoors. The only condition for the sustenance of plants is supply of water and electricity for pump work (Hutinel et al. 2012).

The module consists of box, inside of which aerohydroponic and hydroponic systems flow nutrient solution are mounted. Hydroponic part is comprised of hydro reservoir where of the lower part of the roots of plants are constantly wetted and, at the same time serves as a storage device for the working fluid, supplied through the aeroponic system box (Figs 3 and 4). Flow of the nutrient solution is a wa-

Fig. 4. Development of mini tubers of Jerusalem artichoke in propagator

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Table 1. Test of growing minitubers on aerohydroplane install, grade Skorospelka, 2016

Method of growing	Plants (pcs·m^{-2})	Obtained tubers	Area (m^2)	Yield of the tubers (pcs·m^{-2})	Average No. of tubers (pcs·m^{-2})
Aerohydroponic	40	604	1.0	604	15.1

ter pump equipped with a filtration system on the inlet and outlet.

Aeroponic system consists of finely disperse sprayer mounted in the pipe, which is connected to the water pump through the fine filter and provides efficient aeration and oxygenation of the nutrient solution. Further, the liquid after wetting the roots, flows back into hydro reservoirs, mixed with the rest of the liquid, and is preparing for further recycling.

Tests to determine the qualitative and quantitative characteristics of the minitubers obtained in the conditions of aerohydroplane were conducted. The experiment was placed on the territory of Vniikh in an isolated environment facility (Fig. 4).

RESULTS AND DISCUSSION

During the research it was found that when growing minitubers in terms of aerohydroponic yield per plant was more than 15 pieces of minitubers (Table 1) larger than 10 mm (the size adopted for minitubers of Jerusalem artichokes, which are freely planted by planters), for example, one, which was developed by us (GOST 32790 2014; GOST R 55757 2013).

The test results showed that aerohydroponic method of growing with natural lighting conditions is very effective and promising way of producing minitubers. The cost of 1st certified micro plants was 76.54 RUB, one miniclube grown in pot culture, was 23.91 RUB. The cost of one miniclube grown in aerohydroponic installation was 14.33 RUB.

The resulting plants were transferred to the seed farms for production of original seeds of Jerusalem artichoke Viva, Ltd. (Kostroma region) for further research. In FGBNU VNIIKH a machine was developed to improve skill of the technology of planting and mechanization. The scheme machine is shown in Fig. 5.

Specifications of planters: type of machine is mounted, four-row, working width – 3,0 m, driven from the supporting wheels of the planters, working speed is 1.5–2 km·h^{-1}, productivity is 0.42– 0.56 ha in an hour of pure time, 0.21–0.28 ha/h in the change, row spacing is 0.75 m, proportions are 2,610 × 3,310 × 1,450 mm, weight is 800 kg. Machine can plant mode minitubers of Jerusalem artichoke in automatic and semi-automatic mode, in the bio containers, and without the bio containers.

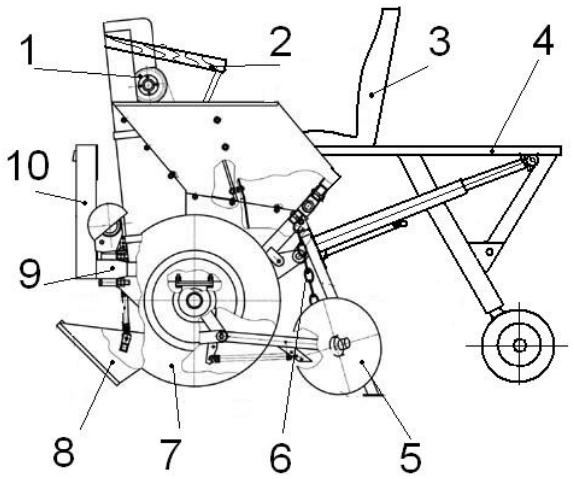

Fig. 5. Schematic diagram of the planters for minitubers of Jerusalem artichoke

1 – apparatus of disembarkation; 2 – platform; 3 – seat; 4 – ground; 5 – covering knife; 6 – limiter; 7 – supporting-driving wheel; 8 – opener; 9 – frame; 10 – coupling

CONCLUSION

Technology of cultivation of Jerusalem artichoke seed is an important component in the industrial development of the cultivation of Jerusalem artichoke.

For the production of minitubers of Jerusalem artichoke source plants were obtained from the nursery and placed into "*in vitro*" culture. For the practical implementation of technological scheme of obtaining minitubers based on aerohydroponic method is recommended. It can be the most effectively implemented on the basis of modern, well-equipped high-tech enterprises, specialized in original seed-growing of Jerusalem artichoke.

As a result of our researches it is figured out that the cost of one miniclube decreased by 9.58 rubles

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due to using cultivation of minitubers of micro plants in aerohydroponic installations compared to farming by traditional technology.

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