Improving the technological process for the mini-tubers production of the original seed of Jerusalem artichoke

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Abstract. The purpose of the research is the development and improvement of the technological process of production of mini-tubers of the original seed Jerusalem artichoke to increase the quantitative yield of the standard seed fraction "original seed Jerusalem artichoke" in accordance with the requirements of GOST R 55757-2013. The development of the technological process of production of the original seed Jerusalem artichoke was carried out with the introduction into the culture and reproduction through meristem; cuttings of plants from test tubes were carried out for their further reproduction; then, plants from test tubes were planted in propagatory specially made at the Institute installation for aerogydromassage the method of obtaining the minitubers. Introduced into the culture in vitro and propagated ten varieties (hybrids) of Jerusalem artichoke. In the production 1000 in vitro micro plants, the costs amounted to 76.5 thousand RUB. From one plant turned out more than 15 pieces of size more than 10 mm when growing minitubers in aerohydroplane propagator. The proposed methods can increase almost 2 times the volume of production of superelites of standard quality and increase profitability by 29%, for practical implementation with the greatest efficiency they can be implemented on the basis of modern well-equipped high-tech enterprises that are specialized in the original seed Jerusalem artichoke.

1. Introduction
Jerusalem artichoke is a tuberous perennial plant of the sunflower family, which originates from North America and is also known as wild sunflower or Jerusalem artichoke. This plant is characterized by good tolerance to frost, drought and poor soil, strong resistance to pests and plant diseases. For centuries, it has been cultivated due to the fact that it was an edible tuber and had healing properties [1, 2]. It is an important crop that is used as food, animal feed and energy culture. However, there was little basic research on its breeding, and the lack of elite varieties seriously limited its industrial use [3, 4, 5].

In the middle zone of the Russian Federation, biological seeds of Jerusalem artichoke, despite abundant flowering, ripen rarely, so this culture is propagated mainly by tubers.

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The analysis and mastering of the technological process for obtaining the starting material for the production of Jerusalem artichoke superelite are preliminarily carried out. For high yields, Jerusalem artichoke needs to use for planting only a new, benign regeneration material.

2. Materials and Methods
Experience shows that during the reproduction of Jerusalem artichoke in large volumes, the quality of the produced seeds may arise [3, 6, 7], therefore the development of the technological process of production of the original seed Jerusalem artichoke was carried out with the introduction into culture and reproduction through the meristem. According to the results of the assessment of clones, during the growing season in 2015, only healthy tubers were selected in the nursery and after germination, isolation, meristems were introduced into test tubes. In 2015-2016, grafting of plants from test tubes was carried out for their further reproduction. In 2016, plants from test tubes were planted in propogators - these are specially made installations at the institute for the aero-hydroponic method for obtaining mini-tubes.

The technological process of obtaining in vitro microtubes includes the cultivation of microplants according to the standard technology of clonal micropropagation with subsequent induction of tuberization. The most optimal for these purposes is Murashige-Skoog medium with a mineral base with the addition of growth regulators and a high concentration of sucrose for micro tuberization [6].

During the growing season, the air exchange and the maintenance of the optimum temperature were ensured by the combined coating with an anti-mosquito screen and ultrasil. Plant protection was carried out against Septoria and powdery mildew and was achieved by spraying of systemic and contact fungicides 3-5 times (Kurzat R, Shirlan, Skor, Infinito, Akrobat MTs).

3. Research Results
The process of clonal micropropagation consisted of four stages: 1 - introduction to the culture in vitro of plant material; 2 - micropropagation itself, due to which the maximum number of arylones (microshoots) is achieved; 3 - rooting of propagated shoots with their subsequent adaptation to soil conditions; 4 - growing plants in greenhouse conditions or in aero-hydroponic propagators and preparing them for planting in the field.

Ten varieties (hybrids) of Jerusalem artichoke introduced into culture in vitro and multiply. In the laboratory of bioengineering of the All-Russian Research Institute of Potato Farm, work on the introduction of Jerusalem artichoke into tissue culture was carried out. In the Russian Federation, such varieties of Jerusalem artichoke as Skorospelka, Diyetechieskiy, Podmoskovvnyy, Nakhodka, etc. were obtained in test tubes for the first time [8]. With the introduction of Jerusalem artichoke in culture in vitro, 4-6 cuttings can be obtained from a single plant. It is noticed that the upper cuttings root better [9, 10].

Material costs for the production of 1000 in vitro microplants amounted to 76.5 thousand rubles, including: the source material – 57.5 thousand rubles (75%); remuneration of labor – 8.2 thousand rubles (11%); electricity costs – 3.5 thousand rubles (5%); equipment depreciation costs – 3.1 thousand rubles (4%); utility costs, consumables, phytotron depreciation, overhead – 4.2 thousand rubles (5%). The cost price of one micro plant was 76.54 rubles.

When grown in vitro culture, 1-2 tubers (average of 1.5 tubers) measuring 5–9 mm in diameter are usually formed from a single plant. With the aero-hydroponic method of growing mini-tubers, the plants are fed by supplying the nutrient solution to the roots in the form of an aerosol saturated with oxygen. The modified Knop solution is used as a nutrient medium. The concentration of salts in the medium may vary depending on the timing and phases of the growing season and must be maintained within 0.9-2.2 mg / l; pH of the medium is 5.9-6.3. Periodic feeding of the nutrient solution is carried out at certain intervals. The solution is regularly completely replaced and, if necessary, replenished with an adjustment of the content of macro- and microelements.
During the growing season of plants, the correct choice of the spectrum of light and photoperiod is of great importance [11, 12, 13, 14]. The most optimal mode of plant lighting is achieved through the use of DNAT400 lamps and LED 80 LED lamps (SYLVANIAGROLUX 400W) - 2 DNAT400 + 4LED80 and provides a 14-hour photoperiod.

Plant lighting and feeding of the nutrient solution are regulated using timers that are tuned to the necessary modes. Indoors, the relative humidity of the air must be maintained, which is 50-55%.

For the aerohydroponic production method of mini-tubes, various types of installations are used where plants are fed by feeding a nutrient solution to the roots in the form of an aerosol saturated with oxygen. When grown in propagators, collection is carried out manually, gradually, as the tubers mature and reach a standard size (mass of tubers is 7-10 g). The yield from one bush was more than 15 pieces with a size of more than 10 mm when growing minitubers in aero-hydroponic propagators. The storage of mini-tubers of Jerusalem artichoke is carried out at a temperature of -1°C / + 4°C and air humidity of 95-85% [15].

4. Results and Discussion

Of great importance for the development of Jerusalem artichoke seed production and obtaining high-quality planting material is the use of in vitro microclonal propagation technology.

With clonal micro propagation of Jerusalem artichoke, the following is achieved: the recovery of plants from fungal and bacterial pathogens, viral and mycoplasmal infections; obtaining genetically uniform planting material; getting a high breeding rate. 10-15 thousand plants can be obtained in six months. Work can be carried out throughout the year, since the development and growth of plants in vitro is practically independent of seasonal changes. Also, the need for large areas required for growing planting material is reduced [9], [11], [15].

The highest costs for the production of in vitro microplants are the production of the source material, which is 75% of all costs, wages – 11%, and energy costs – 5%.

With proper environmental management and using special methods of in vitro tuberization, there is the possibility of increasing a number of tubers of acceptable size (over 9 mm in diameter). Such microtubers are quite suitable for direct planting in the ground in spring-summer greenhouses or tunnels of covering synthetic material (ultrasil, lutrasil, spanbond, etc.) with the condition of strict adherence to phytosanitary and agrotechnical measures that exclude the possibility of new infections by pathogens from outside.

The best conditions for the planting of Jerusalem artichoke in spring-summer aero-hydroponic propagators are created from mid-April to mid-May.

The possibility of a more productive use of laboratory equipment and cultivation facilities by obtaining in vitro microtubers (during the autumn-winter season (September-January) and clonal propagation of microplants to the required volumes during the winter-spring season (January-May), with
subsequent cultivation of mini-tubers in a controlled environment under the protection of insect vectors of infections, including aerohydroponic structures and tunnels of light covering materials) allows for a 29% increase in profitability, as well as an increase in the production of standard-quality super-elites on almost 2 times.

5. Conclusion

The proposed techniques for practical implementation with the greatest efficiency can be implemented on the basis of modern, well-equipped high-tech enterprises that specialize in original Jerusalem artichoke seed production.

The process of clonal micropropagation with the introduction into culture in vitro of plant material; Namely, micropropagation, rooting of propagated shoots with their subsequent adaptation to soil conditions, growing plants in greenhouse conditions or in aerohydroponic propagators and preparing them for planting in the field, allows more productive use of cultivation rooms and laboratory equipment. This is done by obtaining in vitro plants of Jerusalem artichoke during the autumn-winter season (September-January) and clonal propagation of micro-plants to the required volumes during the entire winter-spring season (January-May), followed by cultivation of mini-tubers in a controlled environment under protection from insect vectors infections (including aerohydroponic structures). This makes it possible to ensure an increase in profitability by 29%, and also to increase the production volume of standard-quality super-elites in almost 2 times.

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References

[1] Szewczyk A, Zagaja M, Bryda J, Winiarczyk S, and Andres-Mach M 2019 Topinambur – New possibilities for use in a supplementation diet Annals of Agricultural and Environmental Medicine: AAEM 26(1), pp 24-28
[2] Starovoitov V, Starovoitova O, Aldoshin N, and Manohina A 2017 Jerusalem artichoke as a means of fields conservation Acta Technologica Agriculturae 20(1) pp 7-10
[3] Dunin M S 1935 Diseases and pests of Jerusalem artichoke Proceedings of the VNII of Grain Crops VI(1)
[4] Lv S, Wang R, Xiao Y, Zeng J, and Zhao C 2019 Growth, yield formation, and inulin performance of a non-food energy crop, Jerusalem artichoke (Helianthus tuberosus L.), in a semi-arid area of China Industrial Crops and Products 134 pp 71-79
[5] Fukano Y, Guo W, Noshita K, Hashida S, and Kamikawa S 2019 Genotype-aggregated planting improves yield in Jerusalem artichoke (Helianthus tuberosus) due to self/non-self-discrimination Evolutionary Applications 12(3) pp 508-518
[6] Starovoitov V I, Starovoitova O A, Khutinaev O S, Biryukova V A, Shmyglya I V, Manokhina, A A, ... Baranov V V 2016 Guidelines for the Typical technology of large-scale production of original seeds of Jerusalem artichoke (Moscow, Russia)
[7] Kays Stanley J, and Nottingham Stephen F 2007 Biology and chemistry of Jerusalem artichoke: helianthus tuberosus L. (Boca Raton, FL: CRC Press)
[8] Starovoitov V I, Starovoitova O A, Aldoshin N V, and Manokhina, A A 2018 Technology and mechanization of cultivation of jerusalem artichoke healthier Research in Agricultural Engineering 64(3) pp 151-156
[9] Somda Z C, McLaurin W J, and Kays S J 1999 Jerusalem artichoke growth, development, and field storage. II. Carbon and nutrient element allocation and redistribution Plant Nutr. 22 pp 1315-1334
[10] Starovoitov V I, Starovoitova O A, Chernikov D V, Manokhina A A, Shmyglya I V, Boyko Yu P, Boyko V V, and Feoktistov A N 2012 The method of growing plants of Jerusalem artichoke patent for invention RUS 2534350 (Moscow, Russia)
[11] Martirosyan Yu Ts 2014 Aeroponic technology in the primary potato seed production - advantages and prospects In Materials of the International Scientific-Practical Conference on Potato Farming: Biotechnology Methods in Potato Breeding and Seed Production (pp 175-179) (Moscow, Russia)
[12] Zubr J 1991 Performance of different Jerusalem artichoke cultivars in Denmark (1982-1984) In G Gosse
and G Grassi Eds., *Topinambour (Jerusalem Artichoke)* (pp 43-51) (Luxembourg, LUX: Commission of the European Communities)

[13] Mordashin, I S, and Lobastova E Yu 2014 An effective method for accelerated reproduction of healthy potatoes *Potatoes and Vegetables* 5 pp 23-24

[14] Khutinaev O S, Yurlova S M, and Anisimov B V 2012 Features of hydroponic cultivation of mini- and microtubers on installations KD-10 and “Minivit” in *Potato Growing* (pp 125-131) (Moscow, Russia: All-Russian Research Institute of Potato Farming)

[15] Sobrado M A, and Turner N C 1986 Photosynthesis, dry matter accumulation and distribution in the wild sunflower *Helianthus petiolaris* and the cultivated sunflower *Helianthus annuus* as influenced by water deficits *Oecologia* 69 pp 181-187