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The system of production of healthy planting material for potato under the conditions of the Chechen Republic

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Abstract

Relevance of the study: The relevance of this study is based on the need to obtain a large amount of planting material for potato in short time, the presence of systemic infection accumulating in tubers, which has to be eliminated, as well as, in connection with the solution of the above problems, the need to develop a technology for producing virus-free planting material in relation to the propagated genotypes of potato.

Purpose of the study: The purpose of this paper is to identify the patterns of growth and development of potato plants depending on the mineral nutrition ensuring optimal growth and maximum yield of minitubers, as well as developing a technology for obtaining healthy planting material for potato.

Methods of the study: The main method in this study is a scientific experiment, as well as the method of statistical processing of the data obtained. Primary propagation was carried out by the method of microclonal propagation using the apical meristems, ensuring the improvement of the planting material.

Results of the study: As a result of the study, a technology for the production of planting material for potato was developed, which included microclonal propagation of the initial forms, followed by adaptation of plants to non-sterile conditions in hydroponic systems and getting a crop of minitubers in aeroponic systems.

Significance of the study: The study showed the effectiveness of the developed technology of potato production. The study materials can be used by producers of potato planting material in order to increase production efficiency, as well as to improve the environmental situation in the region by reducing the treatment of planting developed from the sanitized material.

Keywords: aeroponics, minitubers, healthy planting material, potato, technology

INTRODUCTION

Favorable climatic conditions of the Chechen Republic and the availability of free areas make it possible to obtain high yields of potato. However, the gradual accumulation of a systemic infection by potato does not allow realizing the full potential of modern varieties of potato and makes it necessary to carry out the improvement of planting material.

At the laboratory of biotechnology of the Chechen State University, the technology for obtaining healthy planting material for potato that combines biotechnological techniques with the aeroponic potato growing system has been developed and is successfully applied.

The primary propagation of planting material was carried out at the laboratory of biotechnology of the Chechen State University in accordance with the generally accepted technology. In addition, during the process of microclonal propagation, experiments aimed at obtaining microtubers in a tubes culture were carried out; a nutrient medium providing 1-2 microtubers per tube plant was obtained.

Adaptation in vivo was carried out in hydroponicsystems, and minitubers were obtained in aeroponic systems at the Chechen State University. In the process of growth and development of plants, nutrient solutions were optimized according to the main macro- and microelements, based on the availability of existing complex water-soluble fertilizers.

In the process of work, the following goal was set and achieved: to identify the patterns of growth and development of potato plants depending on the mineral nutrition ensuring optimal growth and maximum yield of minitubers, as well as developing a technology for obtaining healthy planting material for potato.

LITERATURE REVIEW

It is well known that in the process of propagation potato gradually gets viral, bacteriological and fungal infection. A complex of diseases causes a decrease in the yield of potato. The only way to get high yields is the use of healthy seeds. The problem of potato health improvement began to be solved from the middle of the 20th century. Such a science as biotechnology made it possible to solve this problem in a cardinal way. The use of apical meristems with subsequent microclonal propagation made it possible to obtain and propagate improved potato varieties.

The use of the traditional technology of propagation of the potato seed material does not exclude the possibility of reinfecting the healthy planting material with fungal, bacterial and viral infections through the greenhouse soil, where minitubers are obtained directly. In order to prevent reinfection, it is necessary to exclude soil substrates, which is possible due to the use of hydro- and aeroponics in production.

Otazú [1] described the most detailed technology for the production of minitubers of potato under the aeroponic conditions abroad; however, the use of greenhouses and obtaining a single crop of minitubers in a year requires significant modification of his technology up to the year-round intensive production of potato planting material. The data given in his paper on aeroponic growing of potato were used to develop own formulations for tank mixtures at all stages of growing plants.

A similar technology for producing minitubers was used by Mardanshin (2014), but his technology was aimed at using laterals in aquatic culture, which, on the one hand, reduced the cost of production,and, on the other hand, reduced the processability in the production of minitubers. The use of plants after in vitro culture allows obtaining uniform growth and

development of potato and obtaining the highest possible yield of minitubers in aeroponic conditions.

Also, the technology of obtaining microtubersin in vitro cultureis to be noted. The production of microtubers in the tube potato culture allows obtaining healthy planting material quickly and with minimum costs, and the need for culture chambers and labor costs are significantly reduced compared to the traditional production of planting material. A known method for growing potato microtubers [2] is that plants, cut into grafts, are placed for three weeks in the conditions of a ten-hour photoperiod at an illumination of 3.5-4.0 kcl, then the plants are transferred to the conditions of total darkness for 3-7 days. After this, to obtain microtubers, tube plants are grown for 1.5-2 months at 16-hour photoperiod and at a 3.0 kl. In addition, a method for accelerated production of microtubers is known [3], which is carried out by keeping the plants after cutting for 12 days at the usual 16-hour photoperiod and further transfer to a short-day 10-12 hours photoperiod for 30-45 days. It is also known that an increase in the concentration of sucrose and the addition of 6-benzylaminopurine and kinetin to the agar nutrient medium at a 1 g/l concentration often results in axillary tuber formation on cuttings without root and shoot growth. On the basis of these data, a nutrient medium was obtained and cultivation conditions were optimized to produce 1-2 microtubers from each microplant of potato in vitro. The effectiveness of using microtubers in the process of obtaining planting material was demonstrated by Koksharova [4].

Adaptation of plants in the hydroponic system of their own design after in vitro culture was carried out by Gordeev, *et al*. [5]. At the laboratory of biotechnology of the Chechen State University, biotechnological systems were mounted for growing tube plants up to the sizes suitable for transplantation into an aeroponic system, the design of whichwas in accordance with the description of Milekhin *et al*. [6].

In this connection, we have been conducting studies since 2014 on the development of scientific foundations for introducing a system of virus-free seed production in the Chechen Republic.

The developed system consists of the following stages:

- obtaining healthy tube plants with their subsequent microclonal propagation;
- adaptation of microplants to non-sterile conditions in conditions of hydroponics;
- growing plants using small aeroponic systems to obtain 4-5 true leaves;
- obtaining minitubers in an industrial aeroponic system.

In parallel, microtubers are produced in culture in vitro. The implementation of the proposed technology essentially eliminates the risk of reinfection.

Since the authors of technologies for the production of minitubers with improved health using theaeroponic method do not have consensus regarding the plant cultivation technology, our task has been to identify and develop a technology adapted to the conditions of the Chechen Republic.

Materials And Methods

The object of the study was the potato of the Gala and Red Scarlet varieties. Microclonal propagation was performed according to the methodology guidelines of Puzankov [7]. Samples of experiments on microclonal propagation of potatowere 30 tubes each in a four-fold replication. The developed tank mixtures were tested in a small aeroponic system, accommodating 72 plants.The experiment was repeated three times. The data obtained were checked for reliability using single-factor analysis of variance.

Results

Growing of microplants in vitro was carried out on the Murashige and Skoog nutrient medium, enriched with vitamins B1, B6, PP at a concentration of 0.5 mg/l, and also with meso-inositol at the concentration of 100 mg/l. Sucrose at the concentration of 30 g/l was added to the agar medium as a source of carbohydrate nutrition. For induction of tuber formation using the selection method, a nutrient medium with reduced content of NH_4NO_3, increased content of calcium, doubled concentration of iron chelate and addition of 80 g/l of sucrose was developed. Moreover, the concentration of sucrose in the nutrient solution directly influenced the number of microtubers. The effect of sucrose on the size of microtuberswas not reliable (Table 1).

Potato plants are grafted and placed on the usual Murashige and Skoog nutrient medium. When they reach height of 5-6 cm under the conditions of a laminar box, the nutrient medium of the above composition cooled up to 30 °C is added to the tubes with plants. The photoperiod is reduced to 10 hours for 3 days; then tubes with plants are placed in conditions of complete darkness for 45-60 days. At the end of this period, 98% of the plants form 1-2 microtubers per 1 shoot.

Growing of minitubers was carried out in the conditions of aeroponics. The specificity of growing in aeroponics is the complete regulation of all stages of plant growth and development. In this case, any error can lead to a decrease in yield, up to the total death of plants. The mineral composition of the tank mixture is essential. Based on the literature data and a series of experiments, we developed the compositions of tank mixtures for the stage of adaptation of microplants to ex vitro conditions, for the stage of growing plants in conditions of small aeroponic system, for the stage of growing the plant before the flowering phase and for the stage of tuber formation.

The adaptation of plants under hydroponic conditions was carried out on a nutrient solution of the following composition: complex mineral fertilizer GREEN-GO 18-18-18 + 1.3 MgO manufactured by the Italian company Biolchim at the concentration of 1.11 g/l. Illumination for 18 hours. The duration of the period was 20 days.

Subsequently, the plants are transplanted to a small aeroponic system, where the plants are grown, as well as adaptation of plants to the aeroponicmethod of feeding nutrients to the plant roots is performed (Figure 1). The composition of nutrient solution per 100 liters is the following: Green crystalon 18-18-18 66.7 g + Pecacide 6.7 g + $MgNO_3$ 10.7 g + $CaNO_3$ 16. pH of the solution is adjusted up to 6.0-6.8. The duration of the period is 15 days.

At the end of this period, the plants are transplanted to an industrial aeroponic system, accommodating 680 plants (Figure 2). Before the flowering period, the plants are grown on a nutrient solution of the following composition: 1 g/l of Crystalon 18-18-18. At the beginning of the budding phase, the daylight hours are reduced up to 10 hours, 1 hour per day. After reaching the daylight hours of 10 hours, the nutrient solution in the tank is replaced with the following: complex mineral fertilizer FERTICARE 6-14-30 + 4.3 MgO manufactured by the YARA companyin the amount of 0.7 g/l + $MgNO_3$ 0.185 g/l.

After 10-15 days after the photoperiod is reduced to 10 hours, mass formation of minitubers begins (Figure 3). When the minitubers reach the standard size, the first collection begins.

Tubers are collected 3-4 times with a period between collections of 15-21 days. On average, 37 to 86 minitubers of standard size are obtained from one plant. At the end of vegetation, 7 to 19 tubers are obtained from 1 plant with a diameter of 0.4-0.8 cm, which corresponds to the size of microtubers, which are also successfully used to produce planting material.

Table 1 – Size and quantity of microtubers depending on the variety and concentration of sucrose

Variety	Index	Concentration of sucrose, g/l					
		50	**60**	**70**	**80**	**90**	**100**
Gala	Quantity, pcs	0.48	0.75	1.37	1.86	1.44	0.99
	$LSD_{0.5}$	0.24					
	Diameter, cm	0.39	0.57	0.77	0.81	0.80	0.68
	$LSD_{0.5}$	0.07					
Red Scarlet	Quantity, pcs	0.33	0.69	1.22	1.74	1.38	0.87
	$LSD_{0.5}$	0.29					
	Diameter, cm	0.41	-,62	0.80	0.84	0.82	0.74
	$LSD_{0.5}$	0.06					

Figure 1 – Growing of potato plants ina small aeroponicsystem

Figure 2 – Industrial aeroponic system

Figure 3 – Mass formation of minitubers

DISCUSSION

Thus, combining the microclonal propagation of potato and obtaining microtubers in vitro with the formulations developed for the production of minitubers in aeroponics of the Chechen State University, up to 40 thousand mini- and microtubers can be obtained for one cycle with the duration of 3.5-4 months.

Comparing the potato yields obtained in the conditions of the Chechen Republic, we came to the conclusion that our technology was not inferior, and sometimes exceeded the data of foreign authors. Farran, & Mingo-Castel [8] believed that the optimal weight of seed potato was 8 g and the yield of such tubers was 13.4 pcs. from 1 plant. Mateus-Rodríguez *et al*. [9] received the following yield of tubers from one plant depending on the variety: 71.7 pcs. from Chucmarina variety, 56.2 pcs. from Serranita and 30.6 pcs. from Yana Imilla varieties. Muthoni *et al*. [10], when studyingtwo potato varieties, obtained112 minitubers from Tigonivariety and 54 minitubers from the Asante variety.

Based on the foregoing, it is possible to recommend the developed technology for producing the potato planting material with improved health for industrial implementation.

CONCLUSION

High yields of potato are closely connected with the use of healthy planting material, which cannot be obtained without the use of modern biotechnological methods. The prevention of reinfection with fungal, bacterial and viral infections is possible when producing minitubers using the aeroponic method. The optimization of all vital processes of plant cultivation (nutrition, humidity, illumination) allows obtaining a high yield of minitubers from 1 plant – from 37 to 86 pieces, which allows making the production of the improved seed material highly profitable.

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REFERENCES

[1] Otazú, V. (2010).*Manual on Quality Seed Potato Production Using Aeroponics*. Lima, Peru: International Potato Center (CIP). (p. 44).

[2] Esipova, Z.I. (1987). Klubne obrazovanie in vitro kak sposob polucheniya posadochnogo materiala v pervichnom semenovodstve kartofelya [Tuber Formation in Vitro as a Way of Obtaining Planting Material in Primary Seed Growing of Potato]. *Selektsiyai semenovodstvo*, *3*, 51-53.

[3] Trofimets, L.N., Ostapenko, D.P. and Boyko, V.V. *et al*.(1985).*Ozdorovlenie i uskorennoe razmnozhenie semennogo kartofelya. Metodicheskiere komendatsii* [Health Improvement and Accelerated Propagation of Seed Potato. Methodical Recommendations]. Moscow, pp. 36.

[4] Koksharova, M.K. (2004). *Sposoby ozdorovleniya I uskorennogo razmnozheniya semennogo kartofelya*. *Avtoref. dis. kand. s.-kh. nauk* [Methods of Health Improvement and Accelerated Propagation of Seed Potato (Ph.D. ThesisAbstract)]. Tyumen: State University Ural Scientific Research Institute of Agriculture, pp. 16.

[5] Gordeev, O.V., Sokolova, A.V. and Gordeev, V.O. (2016). Gidroponnaya ustanovka dlya proizvodstva mini klubnei kartofelya [Hydroponic System for the Production of Potato Minitubers]. In T.V. Lebedeva,O.V. Gordeev,&A.A. Vasiliev (Comps.), *Selektsiya, semenovodstvoi tekhnologiya plodovo-yagodnykh kultur I kartofelya: sbornik nauchnykh trudov* [Selection, Seed Production and Technology of Fruit and Berry Crops and Potato: Collection of Research Papers] (Vol. 18). Chelyabinsk: FGBNU "South Ural Scientific Research Institute of Horticulture and Potato", pp. 360-364

[6] Milekhin, A.V., Rubtsov, S.L.,Bakunov, A.L., Dmitrieva, N.N., &Vovchuk, O.A. (2014). Perspektivy I spolzovaniya biotekhnologicheskikh ustanovok v bezvirusnom semenovodstve kartofelya v srednem Povolzhe [Prospects of

Using Biotechnological Plants in the Virus-Free Potato Seed Farming in the Middle of the Volga Region]. *Izvestiya Samarskogo nauchnogo tsentra Rossiiskoi akademii nauk, 16*(5(3)), 1184-1191.

[7] Puzankov, O.P. et al. (1988). *Metodicheskie ukazaniya po ozdorovleniy u semennog okartofelya* [Methodology Guidelines for the Improvement of Seed Potato]. Minsk: Urozhai, p. 28.

[8] Farran, I., & Mingo-Castel, A.M. (2006). Potato Minituber Production Using Aeroponics: Effect of Plant Density and Harvesting Intervals. *American Journal of Potato Research, 83*(1), 47-53.

[9] Mateus-Rodriguez, J.R., de Haan, S., Andrade-Piedra, J.L., Maldonado, L., Hareau, G., Barker, I., Chuquillanqui, C., Otazú, V., Frisancho, R., Bastos, C., Pereira, A.S., Medeiros, C.A., Montesdeoca, F., and Benítez, J. (2013). Technical and Economic Analysis of Aeroponics and other Systems for Potato Mini-Tuber Production in Latin America. *American Journal of Potato Research, 90*(4), 357-368.

[10] Muthoni, J., Mbiyu, M. ad Kabira, J.N. (2011). Up-Scaling Production of Certified Potato Seed Tubers in Kenya: Potential of Aeroponics Technology. *Journal of Horticulture and Forestry, 3*(8), 238-243.