

Conference Paper

Influence of Growing Medium on the Parameters and Yield Capacity of the Mini Tuber Potato of the Charoite Variety

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Abstract

The creation of original seed grains of the Charoite variety, healed of pathogenic infections of various etiologies, was carried out through reproduction of the certified meristematic material of the microplants class. Mini tubers microplants were grown in 5.5 liter vessels on a “Agrobalt S” soil (control) mixed with peat and supplemented with 10% and 20% (of the volume) of the “ORVI” substrate. The use of the substrate “ORVI” mixed with peat and “Agrobalt S” soil positively influenced the growth, development and formation of tubers. The appliance of 10% of the “ORVI” substrate significantly increased the quantitative yield of mini tubers by 17% and the weight of tubers by 12.3%. The increase in the total number of mini tubers was due to the increase in tuber fraction from 10 to 30 mm. The appliance of a 20% “ORVI” substrate also led to an increase in the total number and mass of mini tubers. According to the EIA results, the mini tubers grown from microplants did not contain any latent viral infection. Tests on the seeds did not reveal symptoms of fungal diseases.

Keywords: breed, potatoes, mini tubers, mass of tubers, peat fertilizer, substrate

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Published: 5 April 2021

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Selection and Peer-review under
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Conference Committee.

1. Introduction

Modern agricultural production requires high-yielding, adaptive potato varieties that are responsive to high doses of mineral fertilizers, suitable for mechanized cultivation, and resistant to diseases and pests. The variety should have certain feeding, culinary and nutritional qualities, including a good tuber shape with shallow eyes and nondarkening pulp of good taste with a rich content of starch, protein and vitamins [1–3]. In this regard, the need for obtaining significant volumes of seeds of high reproduction for cost-effective farming appears.

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In obtaining a significant number of mini tubers, it becomes possible to reduce the potato seed production pattern, which is one of the longest among all crops. With this in mind, in recent years scientists have made many attempts to improve the technology for producing mini tubers, including the launch of industrial production of mini tubers in the form of a separate type of seed production. The production of mini-tubers is divided into two technological categories: nonsupport medium and support medium [4].

More than 20 years have passed since the introduction of nonsupport medium technologies, but their development is not widespread in Russia. This is due to the inflated value of the equipment and the failure to achieve the declared tuberization parameters in practice [5]. Other reasons are the need for continuous energy supply and the spread of infections through nutrient solutions.

Support mediums are based on natural materials and artificial substitutes for soils. The classic method of producing mini tubers takes place in greenhouses with various coatings or under mosquito shelters on natural soils or soil substrates. Soil and shelf greenhouses can be distinguished by the method of support medium placement [6].

The majority of large seed-growing companies in Russia currently grow mini tubers in glass or film soil greenhouses on natural organo-mineral substrates with extensive use of peat. This technology has the lowest cost of a mini tuber - not more than 0.15 dollars/pc. In most cases, one crop is grown per year [5].

Obtaining 4–5 tubers from one plant is considered cost-effective in European countries. The differentiated use of micronutrient fertilizers, biologically active substances and growth stimulants allows increasing the reproduction rate up to 8–10 tubers.

Large seed companies in Brazil, China, India, Pakistan, Australia have relied on the sale of mini tubers and operated based on this technology [6–8]. The original seeds are the most expensive production factor, amounting up to 25% of the final value in the potato cost of making in these regions. The high cost and low availability of quality seeds in these countries force producers to use non-standard material for seed reproduction, which leads to lower yields in the production of marketable potatoes.

Growing seed potatoes in a support medium is widespread among producers because it leads to a higher use of nutrients and an improvement in the quality of planting material [9]. The production of mini tubers on various substrates involves the use of different source material for reproduction. The use of substrates for growing mini tubers is frugal and cost-effective for countries with tropical and subtropical climates [10]. To obtain 100.000 mini tubers, you need to have up to 1000 m² of soil with one crop per year. Direct material costs for the production of in vitro plants with proven

quality by molecular diagnostics are at least 1 dollar/pc. In this regard, we should strive to obtain the maximum possible number of tubers from them.

Artificial support mediums are of two types: with nutrient saturation and ballast. The former includes fully synthetic Belarusian ion-exchange substrates “Biona” and “Triona” [4]. However, their current price (15 dollars/kg) makes it unreal to use it in the production of mini tubers. The use of cheap ballasts such as perlite, sand, vermiculite in combination with the frequent application of macro and micronutrients allows you to have a cost price of 0.25 dollar/pc. But the weight of the tuber with this technology is only 4-6 g. The studies carried out in various regions have shown that the productivity of potato mini tubers largely depends on the genotype [5,11]. In this regard, high-quality technology for producing mini tubers is required.

The introduction of new varieties into production directly depends on the availability of high-quality seed material free of pathogenic infection. The research and practice have established that changing of seed variety increases crop yields by 10-30%, and variety renewal by 30-50%, mainly due to the recovery of potatoes from a viral infection [12, 13].

At the Leningrad Scientific Research Institute of Agriculture «BELOGORKA» seed and potato breeding work has been carried out since the 30s of the last century. The Institute's potato varieties are regionalized in many regions of Russia.

Charoite variety has been included in 7 admission regions in the State Register of Breeding Achievements of the Russian Federation since 2014 [1, 2]. The variety is resistant to potato scab (patotype 1), to common favus, rhizoctonia blight, ultra-early ripening (1), highly plastic, tubers of elongated oval shape, when eyes are small, the tuber weight is 120-160 grams. The number of tubers in the nest is 8-12 pieces; quality - 94-98%; starch content - 15-21%; storability - 96%; productivity - max 55.0 t/hectare [2].

To increase the volume of the original seed potatoes of the Charoite variety, different methods of propagation of the source material were applied: through clonal nursery-gardens in the field and through vessels in protected ground. It was found that one plant of this variety forms an average of 10 tubers of the standard seed fraction in the field conditions, and from 4 to 5 pieces when using peat substrate “Agrobalt - S” in a 5 liter container [14].

Therefore, the aim of the study was to evaluate the effect of the substrate “ORVI” (Latvia) mixed with peat soil “Agrobalt-S” (Russia) on the growth, development and formation of the potato crop of the Charoite variety.

The objects of research were meristematic plants, the weight and number of mini tubers when grown on the peat fertilizer “Agrobalt S” mixed with the “ORVI” substrate in a closed greenhouse.

2. Methods and Equipment

The studies were performed using a protected ground. Microplants were grown in 5.5 liter vessels. Peat and soil “Agrobalt - S” were made on the basis of highmoor peat of low decomposition, extracted by carving or milling methods. To neutralize peat, calcitic materials are used (dolomite flour, limestone flour). Peat enrichment with nutrients is carried out by introducing the PG MIX complex of the micro-granulated fertilizer (Yara), which ensures a uniform distribution of nutrients throughout the volume and a high degree of assimilation and stability of the culture. It contained a standard peat fraction of 0-20 mm; pH_{KCl} - 5.4. Organic matter amounted to 80%, N – 150g per liter, P_2O_5 – 150g per liter, K_2O – 150g per liter. Ca – 120 g per liter, Mg – 30g per liter. This turfy substrate served as a control base variant for growing Charoite mini tubers.

In the second variant, 10% of the volume was substituted with the substrate “ORVI” and in the third – 20% of the same substrate. The support medium “ORVI” made in Latvia is an organomineral substance obtained on the basis of organic waste, sewage sludge and peat by fermentation at a certain temperature. This product has an EU phytosanitary passport for environmental safety. The content of the organic substance in the “ORVI” substrate is 95%, pHKCl – 5.8.

The planting mixture was thoroughly mixed. The vessels were filled and seeped through a day before planting the microplants. Fertilizing was not carried out during the growing season. Watering was carried out as needed. In total, 162 plants of 54 in each variant participated in the experiment.

Protection from carrying agent aphids, late blight and early blight was carried out by spraying plants early in the morning or late in the evening. Two treatments with the insecticides “CIPI”, “KS” (1.6 ml / per liter of water) and “Sharpei” (2 ml/l) in a mixture with fungicide Kurzat (5 g/l) and “Ordan” (5 g/l) were carried out.

Latent virus infection was determined by enzyme multiplied immunoassay using recommendations [6, 15]. Biometric indicators (plant height, number of stems) were taken into account by measuring and counting. The determination of the fractional composition, sowing indicators of the quality of the mini tubers was carried out using the current standards [16]. Data on productivity and the elements of its components are processed statistically by analysis of variance and correlation analysis.

3. Results

Microplants of the Charoite variety were rooted in all variants on the 7th day. They grew and developed equally intensively, did not bud and did not bloom. Differences between the variants were noted at the onset of the aging and dying phases of the tops.

Plants on “Agrobalt S” peat soil had signs of top aging by 07.24. The dieback of the tops occurred on July 30. In the variant with the addition of 10% of the “ORVI” substrate to standard fertilizer, signs of aging of tops in plants and its dying were noted five days later. However, the most extended period of plant vegetation was noted when 20% of the ORVI substrate was added to the peat soil “Agrobalt - C”. Regarding the control variant, the aging of the tops and its dieback occurred after 13 days.

Metering biometric data showed that the plants had one stem in all the variants of the experiment. The average height of which was 60 cm in the control version; with the addition of 10% of the substrate “ORVI” - 65 cm; with adding 20% of the “ORVI” substrate – 70 cm. The elements of the productivity of microplants grown in vessels on a peat soil “Agrobalt S” and the addition of an ORVI substrate to it (10 and 20% of the volume) are presented in Table 1.

TABLE 1: Elements of the productivity of microplants when grown in vessels on the peat soil fertilizer “Agrobalt S” and the substrate “ORVI”, 2019.

Variant	Quantity of recorded plants, pcs.	Mass of tubers, g		Quantity of tubers, pcs.		Number of tubers in % to control
		Total	Of one plant	Total	Of one plant	
1. Peat soil “Agro- balt S” (control)	54	9280	171.8	284	5.3	100
2. Peat soil “Agro- balt S” 90%+10% of ORVI substrate	54	10418	192.9	337	6.2	117
3. Peat soil “Agro- balt S” 80%+20% of ORVI substrate	54	9330	172.8	290	5.4	102
Least average experience error ₀₅		77.24		77.83		

The use of the “ORVI” substrate in addition to the peat soil “Agrobalt S” positively influenced the formation of the crop. Relatively significant differences in the total mass of tubers and the total number of tubers were obtained with a ratio of 90% to the “Agrobalt S” peat soil and 10% to the “ORVI” substrate (Table 1). One microplant in this variant formed a crop with a total mass of tubers of 192.9 g and an average number of mini tubers of 6.2 pieces, which is 17% more than that with the standard peat soil.

To check the statistically significant differences in the experimental variants, we performed an analysis of variance between the experimental variants in terms of the quantitative indicators obtained by the mini tubers of the Charoite variety. The data obtained allow us to confirm a statistically significant change in the number of tubers and their mass indices by fractions in the variants using the “ORVI” substrate (Table 2).

TABLE 2: The ANOVA analysis of statistical differences according to the options of the experiment for indicators of mini tubers of Charoite variety.

Productivity elements	Effective Fisher's ratio criterion F_{fact}	Abstract Fisher's ratio criterion $F_{table}, p=5\%$	The probability of accepting the null hypothesis
Mass of tubers, grams	23.84	6.95	0.006
The number of tubers, pieces	118.87	6.95	0.0003

The analysis of the quantitative yield of different mini tuber fractions (Table 3) showed that the increase in the number of tubers in this variant is due to an increase in the number of mini tuber fractions from 10 to 30 mm. In relation to the control variant, it amounted to +13% in the variant with 20% of the “ORVI” substrate +15%. Supposedly, this happens due to the prolongation of the vegetation period of plants when using the substrate “ORVI”.

4. Discussion

The results obtained for the cultivation of mini tubers of the Charoite potato variety show different indicators for tuber fractions depending on the substrate used.

The analysis using the Kendall correlation coefficient (Rk) described the general nature of the nonlinear dependence on the fractional composition of the mini tubers of their number and weight by size categories for the Charoite variety. Regardless of the growing variant, a functional dependence $Rk = 0.93-0.99$ is actually observed for tuber mass indices at a statistically significant 5% level. For the number of tubers, this dependence increases from $Rk = 0.29$ in the basic control variant to $Rk = 0.33$ (10%) and $Rk = 0.64$ (20%) in the variants using the “ORVI” substrate.

The Charoite variety is ultra-early ripening and can produce marketable yield in the field on the 60th day after planting. Harvesting in the early stages gives a high percentage of marketability. Under the conditions of the protected ground, when growing microplants at mini tubers in vessels on the “Agrobalt S” peat soil, the marketable yield is formed on the 55th day, when applying 10% of the “ORVI” substrate by 60 and 20% - by 68. The yield of standard tubers (9 - 60 mm) in accordance with GOST 33996-2016

TABLE 3: Mass and quantitative yield of different mini tuber fractions when growing microplants in vessels on the peat soil “Agrobalt C” and the substrate “ORVI”, 2019.

Variant	Fraction, mm	Tuber average mass, g	Mass of tubers, g	The number of tubers,	
				pieces	%
1. Peat soil “Agro-balt S” (control)	<10	-	-	-	-
	11-20	1	10	8	3
	21-30	5	60	13	4
	31-40	11	550	48	17
	41-50	22	1490	69	24
	51-60	35	2165	62	22
	61-70	49	2465	50	18
	>71	75	2540	34	12
	Total mini tubers		32	9280	284
2. Peat soil “Agro-balt S” 90%+10% of substrate ORVI	<10	1	3	4	1
	11-20	1	50	36	11
	21-30	4	105	27	8
	31-40	11	725	69	20
	41-50	22	1225	56	17
	51-60	37	1830	49	14
	61-70	54	2700	50	15
	> 71	82	3780	46	14
	Total mini tubers		31	10418	337
3. Peat soil “Agro-balt S” 80%+20% of substrate ORVI	<10	1	5	6	2
	11-20	2	40	26	9
	21-30	5	150	31	11
	31-40	10	395	38	13
	41-50	23	1095	48	17
	51-60	36	2310	64	22
	61-70	57	1880	33	11
	>71	80	3515	44	15
	Total mini tubers		32	9330	290

amounted to 70% when using the “Agrobalt S” peat soil; 10% of “ORVI” substrate - 71%; 20% “ORVI” substrates - 74%.

The latent infection of the meristematic plants and the mini tubers grown from them was evaluated by the EIA method (Sandwich variant) in July and February and did not reveal any latent infection in any of the variants [6, 15].

The sowing indicators were determined a month later after harvesting and showed that the mini tubers did not show signs of fungal diseases in all cases (late blight, *Rhizoctonia* blight, common scab, etc.).

5. Conclusion

The use of the “ORVI” substrate mixed with the peat soil “Agrobalt S” for growing mini tubers in vessels positively affected the growth, development and formation of the crops. The application of 10% of the “ORVI” substrate to the peat soil “Agrobalt S” significantly increased the quantitative yield of mini tubers by 17% and the total weight of tubers – by 12.3%. The increase in the number of mini tubers is due to the increase in the tuber fraction from 10 to 30 mm.

Conflict of Interest

The authors have no conflict of interest to declare.

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