

EFFECT OF THE VARIETY AND ORIGIN OF PLANTS ON THE PRODUCTION OF VIRUS-FREE POTATO MINITUBERS IN THE AEROPONIC GROWING SYSTEM

UTICAJ SORTE I POREKLA BILJAKA NA PROIZVODNJU BEZVIRUSNIH MINI KRTOLA KROMPIRA U AEROPONIK SISTEMU GAJENJA

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ABSTRACT

The effects of variety and origin of planting material were examined in the aeroponic growing system. The potato cultivars 'Cleopatra', 'Kennebec' and 'Agria' were used for the experimental purposes, originating both *in vitro* and from minitubers of the previous season's crops. Plants originating from minitubers were found to be simpler and cheaper to prepare for the aeroponic system of cultivation compared to plants obtained *in vitro*. The first harvest of the 'Cleopatra' minitubers began 43 days after planting in aeroponics, whereas the harvest of the 'Kennebec' and 'Agria' minitubers occurred 20 days later. The 'Cleopatra' cultivar yielded an average of 14.37 minitubers, followed by the 'Kennebec' cultivar and "Agria" cultivar with 16.91 and 19.43 minitubers on average, respectively. In the 'Cleopatra' and 'Kennebec' cultivars, the plant of the *in vitro* origin had a significantly larger number of tubers per plant than the plants originating from previous vegetation minitubers. In the 'Agria' cultivar, the *in vitro* created plants had a larger number of minitubers. The average mass of minitubers of all the cultivars under consideration was significantly higher in the plants originating from minitubers. A successive harvest of minitubers allows them to reach the desired size with dominant minitubers weighing over 8 g, which are considered large.

Key words: potatoes, *in vitro*, *ex vitro*, minitubers.

REZIME

Aeroponski sistem za proizvodnju predosnovnog sadnog materija krompira (bezvirusne mini krtole) počeo je da se primenjuje početkom 21. veka. Mini krtole su proizvedene *ex vitro* od aklimatizovanih biljaka dobijenih *in vitro* ili od umnoženih mikro krtola. Njihova veličinu je manja od konvencionalnih krtola semenskog krompira, ali je veća od *in vitro* krtola proizvedenih pod aseptičnim uslovima na veštačkim medijima. Veličina mini krtola se obično kreće od 5-25 mm.

U aeroponik sistemu gajenja, ispitivan je uticaj sorte i porekla sadnog materijala. Kao materijal u istraživanjima korišćene su tri sorte krompira Cleopatra, Kennebec i Agria sa dva porekla: *in vitro* i od mini krtola iz predhodne generacije. Biljke koje potiču iz mini krtola su jednostavnije i jeftinije za pripremu biljaka pogodnih za aeroponski sistem gajenja, u odnosu na biljke dobijene *in vitro*. Prvo branje mini krtola kod sorte Cleopatra počelo je 43 dana nakon sadnje u aeroponiku, dok je kod sorti Kennebec i Agria bilo 20 dana kasnije. Sorta Cleopatra formirala je u proseku 14,37 mini krtola, sorta Kennebec 16,91 u Agria 19,43 mini krtole. Kod sorti Cleopatra i Kennebec utvrđen je značajno veći broj krtola po biljci poreklom *in vitro*, u odnosu na broj krtola po biljci poreklom iz mini krtola iz predhodne vegetacije. Kod sorte Agria zabeležen je veći broj mini krtola poreklom iz sistema *in vitro*. Prosečna masa mini krtola bila je značajno veća kod biljaka poreklom iz mini krtola, u odnosu na biljke zasnovane iz mini krtola *in vitro*. Sukcesivno branje mini krtola omogućava da one dostignu željenu veličinu mase preko 8 g.

Ključne reči: krompir, *in vitro*, *ex vitro*, mini krtola.

INTRODUCTION

Minitubers are produced *ex vitro* from acclimatized plants obtained *in vitro* or from multiplied microtubers. Their size is smaller than conventional seed potatoes, but larger than *in vitro* tubers produced under aseptic conditions on artificial media (Struik, 2007). The size of the minituber usually ranges from 5 to 25 mm.

The aeroponic system for the production of pre-basic seed potatoes (virus-free potato minitubers) was introduced at the beginning of the 21st century (Ritter *et al.*, 2001, Nickols, 2005, Otazu, 2010.) The root of the plant is in a dark chamber (module), in the air, and water and nutrients are obtained through

a nutrient solution sprayed in the form of fine particles of fog of 50-60 microns. Access to the available oxygen in the air is 100 %, which promotes the growth rate of the roots and the plant. This environment also provides plants with a full access to carbon dioxide in the range of 450 to 780 ppm for photosynthesis, so that the plants in the aeroponics environment grow more rapidly and absorb more nutrients than conventional hydroponic plants (Ritter *et al.*, 2001).

Minitubers are successively harvested at intervals of 10 to 15 days, when they reach the desired size. This technique is successfully applied to the production of various horticultural species such as lettuce, tomato, cucumber and ornamental plants (Buckseth *et al.*, 2016). According to Farran and Mingo-Castel

(2006), the number and timing of the harvest is a key factor in optimizing the production of minitubers. The aeroponics technology is not potentially effective for all varieties of potatoes (Mateus-Rodriguez et al., 2012). In our previous research, the largest average number of minitubers was recorded in the 'Desiree' cultivar, whereas the smallest number was recorded in the 'Sinora' and 'Cleopatra' cultivars (Bročić et al., 2018b). Plants grown in the aeroponics system have shown increased growth and their vegetative cycle has extended by 12 to 36 % compared to plants that are cultivated in the substrate (Tierno et al., 2014). According to Abdullateef et al. (2012), a greater number and larger minitubers per plant were obtained with 25 plants per m², compared to 35 and 50 plants per m². In the production of minitubers, the most important parameter is their number, which (according to Tierno et al., (2014)) was 35-40 per plant on average depending on the variety. In aeroponics, an individual potato plant can produce more than 100 minitubers (Otazu, 2008).

MATERIAL AND METHOD

The experiment was conducted at the Potato Research Center and the RZ Plant in Guča during 2018. A total of three potato cultivars were included in the experiment: 'Cleopatra', 'Kennebec' and 'Agria'. Plants of both cultivars that were planted in aeroponic modules were obtained *in vitro* or from minitubers of the previous season's crops. The *in vitro* obtained plants were acclimated to the substrate of sand and perlite (1:1) 20 days before planting in aeroponics (June 5). The plants originating from the minitubers were pre-sprouting 35 days before planting (May 20th) in a substrate of sand and perlite (1:1). The acclimatized and rooted plants were transplanted in aeroponic on 25 June 2018. At the moment of planting in the aeroponic modules, the root of the plants was washed with water. The experiment was set as two-factorial including two cultivars of potatoes and two originating plants in 4 repetitions (the number of plants was 24 per 1 m²). The experiment was conducted in aeroponic modules using the methodology as described in our previous studies (Bročić et al., 2018a, 2018b). During the experiment, the temperature was recorded in the module (root zone), plastic greenhouses (zone halum and leaves) and outdoors. Temperatures were recorded at 7 am and 15 pm. During the experiment, the minitubers were collected at intervals of 7 to 20 days, starting from August 2 to November 23 (Chart 2). There were 10 reading times in total. Statistical analyses of the results were performed using the variance analysis and the Statistica 5.0 program.

RESULTS AND DISCUSSION

Temperature conditions. The root zone temperature is very important for the initiation, development and launch of root growth. (Chang et al., 2006). The best and most active root development takes place at temperatures approximating 20 °C. The optimal temperature for the initiation and initial growth of potato tubers is 16-19 °C, i.e. 18-22 °C in the formation and filling phase of the tuber. On the basis of Chart 1, it can be concluded that the daily maximum temperatures in the root zone (aeroponic) from the beginning of the experiment (June 25) to the end of August were dominant in the interval of 26-29 °C.

Such high temperatures reduced the number of initiated tubers and inhibited their filling (Figure 2). The temperature range from September to the second decade of November was optimal for the formation of tubers in the aeroponics chamber (12-20 °C).

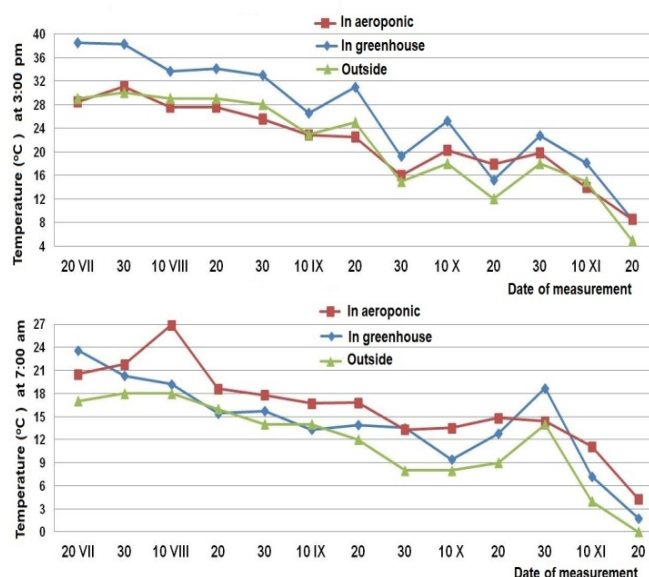


Fig. 1. Temperature conditions during the research

The number and mass of potato minitubers. The analysis of the average number of minitubers per plant and the average mass of a minituber showed very significant statistical differences under the influence of variety and origin of plants. The results of the measurements performed (Table 1) indicate that the cultivar 'Agria' had the largest number of minitubers (19.43), which is significantly higher than those of the 'Kennebec' (16.91) and 'Cleopatra' (14.37) cultivars. The influence of the plant origin was not statistically significant relative to the number of minitubers per plant. The average mass of the minitubers originating from minitubers in all three cultivars was significantly higher in relation to the plants originating *in vitro*. The 'Kennebec' cultivar had the largest mass of minitubers (12.08 g), followed by 'Cleopatra' (10.27 g) and the smallest cultivar 'Agria' (9.90 g). In all the treatments (except in 'Cleopatra' minitubers obtained *in vitro*), minitubers were over 8 g. This is the larger mass of minitubers compared to other authors (Chang et al., 2006, Struik, 2007), as well as in relation to our previous research (Bročić et al., 2018a, 2018b).

The dynamics of the minituber formation. The first harvest of minitubers of the 'Cleopatra' and 'Kennebec' cultivars began on August 2, 43 days after planting in the aeroponics. For the 'Agria' cultivar, the first harvest of minitubers was 20 days later, on August 22. Similar results were obtained by other researchers (Farran et al., 2006, Mateus-Rodriguez et al., 2012, Abdullateef et al., 2012).

The number of minitubers of the 'Kennebec' and 'Agria' cultivars in the first, second and third harvest periods was the smallest, whereas the average mass of these tubers was the largest and ranged from 10 to 20 g (Graph 2.). The mass of the 'Cleopatra' minitubers decreased after the second harvest. The number of minitubers of the plants obtained *in vitro* was initially larger than that of the plants originating from the previous crop's minitubers but with a non-significant statistical difference. The successive harvesting of potato minitubers allows them to reach the desired mass of over 8 g, as confirmed by the results of other authors (Ritter et al., 2001, Struik 2007, Rykaczewska 2016) minitubers of the previous season's crops. Plants originating from minitubers were found to be simpler and cheaper to prepare for the aeroponic system of cultivation compared to plants obtained *in vitro*.

Table 1. The influence of the cultivar and origin of planting material on the number and mass of potato minitubers

Cultivars (A)	Origin of plants (B)	Average number of minitubers per plant	Average mass of a minituber (g)
Cleopatra	MT	13.21	13.88
	<i>In vitro</i>	15.53	6.66
	Average	14.37	10.27
Kennebec	MT	14.67	14.86
	<i>In vitro</i>	19.15	9.30
	Average	16.91	12.08
Agria	MT	19.92	10.72
	<i>In vitro</i>	18.95	9.08
	Average	19.43	9.90
Average	MT	15.93	13.15
	<i>In vitro</i>	17.87	8.34
LSD _{0,05}	(A)	2.13	1.21
	(B)	2.95	2.41
	(A x B)	4.56	3.16
LSD _{0,01}	(A)	2.62	2.03
	(B)	3.15	2.35
	(A x B)	5.34	4.18

Legend: MT-from minituber

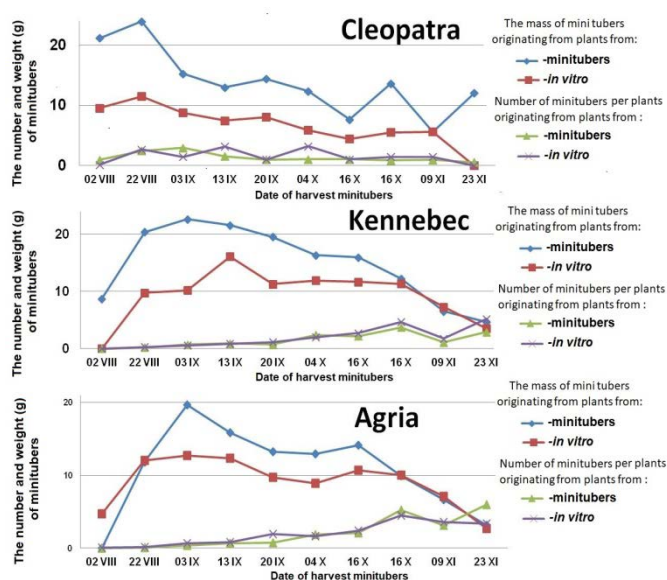


Fig. 2. The dynamics of the formation of minipotato tubers of different origin in the aeroponic system

CONCLUSION

The effects of the variety and origin of planting material were examined in the aeroponic growing system. The potato cultivars 'Cleopatra', 'Kennebec' and 'Agria' were used for the experimental purposes, originating both *in vitro* and from The first harvest of the 'Cleopatra' minitubers began 43 days after planting in aeroponics, whereas the harvest of the 'Kennebec' and 'Agria' minitubers occurred 20 days later. The 'Cleopatra' cultivar yielded an average of 14.37 minitubers, followed by the 'Kennebec' cultivar and "Agria" cultivar with 16.91 and 19.43 minitubers on average, respectively. In the 'Cleopatra' and 'Kennebec' cultivars, the plant of the *in vitro* origin had a significantly larger number of tubers per plant than the plants originating from previous vegetation minitubers. In the 'Agria'

cultivar, the *in vitro* created plants had a larger number of minitubers. The average mass of minitubers of all the cultivars under consideration was significantly higher in the plants originating from minitubers. A successive harvest of minitubers allows them to reach the desired size with dominant minitubers weighing over 8 g, which are considered large.

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