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Study Reffering to Potato Mini tubers Production Using Various Culture Systems

Andreea Tican*, Mihaela Cioloca, Monica Popa

National Institute of Research and Development for Potato and Sugar Beet Brașov, Brașov County, Romania
*Corresponding author. E-mail: tican_andreea@yahoo.com

ABSTRACT

Currently there are several culture systems that can provide disease-free mini tubers, and provide multiple yield of seed potato as compared to the conventional methods. The minituberization process was evaluated on different culture systems, in a bifactorial experience, type 4*4, where factor *a* was culture system, with four gradations: a_1 - system without automation on industrial substrate; a_2 - nutrient system film technique NFT; a_3 - Wilma system; a_4 - conventional system, without automation on peat-perlite substrate, and factor *b*: variety, with four graduations: Azaria, Brașovia, Cosiana and Cezarina. Culture system, variety and their interaction significantly influenced number and weight of potato mini tubers. The values of number and weight of mini tubers obtained in the system without automation on perlite substrate differ significantly, in a positive sense, from the other systems. The variety Azaria recorded the highest average number of mini tubers in the 4 culture systems, followed by the variety Cezarina. The NFT culture system contributed significantly to increasing minituberization capacity for Azaria variety, which led to the highest number of mini tubers recorded.

Keywords: potato, vitroplants, system culture, perlite, mini tubers.

INTRODUCTION

Potato quality seed variety is a key to increase the productivity of a potato crop. The genetic potential and other traits of a potato variety are determined or manifested using healthy or improved seed. Usual method of propagating potato throughout the world is using the vegetative seed tuber (Tessema et al., 2017). Seed potato programme consists of three stages: the production of prebasic seed, basic seed and certified seed (Van der Zaag, 1987). The seed is categorized as prebasic (grown under green house), Basic (S, SE, E) and certified seed (A, B, C), each category carrying its own threshold limit of diseases, pests and purity (Singh and Sharma, 2018).

In modern production, new technologies and methods of cultivation replace traditional schemes and are capable to significantly increase production efficiency and the final cost of production (Anikina et al., 2019). It is urgent to explore alternative production systems that allow an increase in global food security under the future climatic scenarios, by expanding areas for potato production, utilizing land with unsuitable or degraded soils. Hydroponics is a soilless cultivation method in which plants are grown using a nutrient solution. This production system removes the dependency on agricultural land and soil, reduces the presence of diseases and can mitigate the negative effects of extreme weather events utilizing precisely dosed nutrient solution (fertigation) (Woznicki et al., 2021). Compared to the conventional cultivation in soil, hydroponic cultivation ensures the faster growth and development of plants resulting in higher yields. Plants from such cultivations are of a high quality with good post-harvest durability. In addition, they are characterized by a higher health, due to the specificity of the cultivation, they are free from pests and soil borne diseases (Benton Jones, 2014). In most developing countries, practitioners traditionally used varying growth media such as perlite mixtures, peat moss, or bare soil to cultivate mini potato tubers (Rajendran, 2024). Market evidence of extensive use of perlite with soilless culture solutions suggests that perlite is a suitable growing medium with distinct properties. Perlite provides improved aeration and drainage and optimum moisture retention and

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nutrient availability when compared to other substrates (Grillas et al., 2001). Perlite quickly became a well-established substrate throughout Europe for hydroponic applications and is used, in particular, due to its low cost.

Soilless culture started as early as the 1930s as an artificial means of crop production with mineral nutrient solutions in the absence of soil (Mushtaq, 2021), and has been used on a commercial basis for about 40 years (Benke and Tomkins, 2017). It replaces and complements soil-based farming with hydroponics, aeroponics, aquaponics, urban farming, and vertical farming (Arumugam et al., 2021, quoted by Gebreegziher, 2023).

In hydroponics, plants' roots are immersed in water, and nutrients are supplemented to the solution. In aeroponics, plants are suspended in a closed, or semi-closed, container and the plant's roots sprayed with nutrient-rich water solution. Dryland regions in Australia, Canada, China, England, France, Holland, India, Israel, Italy, Japan, Jordan, the Netherlands, Pakistan, Saudi Arabia, Singapore, South Korea, the United Arab Emirates, the United Kingdom, and the USA are experimenting with soilless culture technology (Arumugam et al., 2021, quoted by Gebreegziher, 2023) for growing vegetables, and their production potential, demand, and market prices are projected to grow in terms of their market share (Fussy and Papenbrock, 2022, quoted by Gebreegziher, 2023).

Virtanen and Tuomisto (2017) compared hydroponic method and conventional for mini tubers production. The non conventional method was beneficial in mini tubers formation. Also, Muro et al. (1997) studied the production of mini tubers by hydroponic and classical methods, using of the hydroponic systems increased yields.

MATERIAL AND METHODS

The minituberization process was evaluated on different culture systems, in a bifactorial experience, of the 4*4 type, in which the factor *a* was culture system: with four gradations: a_1 - system without automation on industrial substrate; a_2 - nutrient system film technique NFT; a_3 - Wilma system; a_4 - conventional system, without automation on peat-perlite substrate, and factor *b*: variety, with four graduations: Azaria, Brașovia, Cosiana and Cezarina.

The experiment was carried out under green-house conditions at Laboratory of Research for Plant Tissue Culture from National Institute of Research and Development for Potato and Sugar Beet Braşov. The biological material used consisted of virus-free *in vitro* plants, starting from the culture of meristems. In Figures 1 and 2 aspects of the evolution of potato plants on various types of culture systems are presented. Vitro plants of potato were planted in culture systems with the aim of producing the prebase seed class - mini tubers (Figure 3). The determinations made were for the number and weight of mini tubers/plant.

For systems with automation, timers were used to circulate the nutrient solution. In the Wilma system, the solution was distributed through nozzles in the upper part of the pots, and in the Nutrient Film Technique system, the nutrient solution was distributed at the base of the pots, through a nutrient film. The nutrient solution contains nitrogen, potassium, phosphorus, magnesium, sulfur, iron chelate, manganese, boron, copper, molybdenum, zinc, and the electroconductivity was maintained at 2 dS m^{-1}. In this study, the minituberization capacity of each variety was monitored, depending on the culture system used.

Figure 1. Plant growth and development in automated systems on perlite substrate

Figure 2. Plants development on perlite, in a system without automation

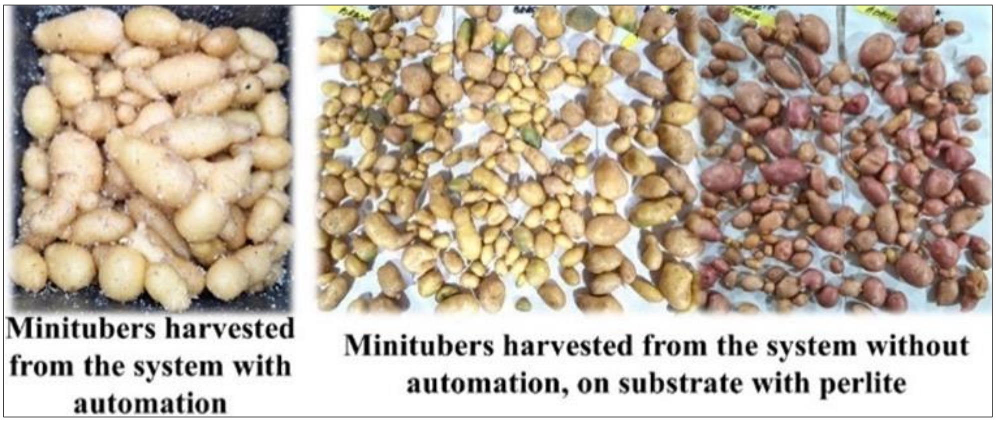

Figure 3. Mini tubers obtained from different systems

RESULTS AND DISCUSSION

In the conducted study, a significant influence of the culture system, the variety and their interaction on the analyzed parameters is observed (Table 1).

From the statistical analysis of the culture system influence on mini tubers number and on their weight, it can be seen that system without automation, with a static layer of nutrient solution, was the most effective both in terms of the average number of mini tubers obtained/plant and their weight /plant. On the industrial substrate, in the system without automation (with static nutrient solution) a mean number of mini tubers by 9.58 and an average weight of mini tubers by 86.08 g were obtained (with very significant positive differences, compared to the control system). When using the NFT system, positive differences are obtained compared to the peat-perlite substrate system (without nutrient solution), but insignificant for the two parameters (0.07 tubers; 3.79 g). The values of number and weight of mini tubers obtained in the system without automation on industrial perlite substrate differ significantly from the other systems (Table 2).

Table 1. Analysis of variance

Analysis of variance for number of mini tubers/plant				
Source of variation	Sum of squares	DF	Mean square	F
Culture system (a)	63	3	21.00	23.31 **(4.76; 9.78)
Variety (b)	298.71	3	99.57	33.37 **(3.01; 4.72)
Culture system (a)* Variety (b)	178.55	9	19.83	6.649 **(2.30; 3.26)
Analysis of variance for mini tubers weight/plant				
Culture system (a)	83590.59	3	27863.53	36.102 **(4.76; 9.78)
Variety (b)	64570.69	3	21523.56	18.511 **(3.01; 4.72)
Culture system (a)* Variety (b)	82549.36	9	9172.15	7.888 **(2.30; 3.26)

df, degrees of freedom.
** Significant at the 0.01 probability level.

Table 2. Influence of culture system on the number of mini tubers and on their weight (g)/plant

Culture system (a)	Number of mini tubers	Diff./Sign.	Weight of mini tubers (g)	Diff. (g)/Sign.
System without automation on industrial substrate (a_1)	9.58 A	2.64 ***	192.07 A	86.06 ***
NFT system (a_2)	7.01 B	0.07 ns	109.81 B	3.79 ns
Wilma system (a_3)	6.87 B	-0.07 ns	81.366 B	-24.66 ns
System without automation on peat-perlite substrate (a_4) (Ct)	6.94 B	-	106.02 B	-
LSD 5% = 0.95; 1% = 1.44; 0.1% = 2.31			LSD 5% = 27.79; 1% = 42.08; 0.1% = 67.60	

Means of each parameter designated by the same letter are not significantly different al 5% level using Duncan's Multiple Range Test

In a study made in Nepal (Dhital, 2014) the higher number and weight per m^2 was obtained in the hydroponic system compared to conventional system.

Tican (2018) at National Institute of Research and Development for Potato and Sugar Beet Braşov, analyzed the behavior of four potato varieties on different culture substrates, perlite and clay and two culture systems Wilma and NFT. When using perlite and the NFT system, the values of the number of mini tubers/plant were higher. Also, at this institute in 2016 were obtain mini tubers on perlite substrate were tested 2 types of culture: with circulating nutrient solution and with static layer of nutrient solution (Tican et al., 2018). System with circulating had a positive impact for mini tubers number.

Azaria variety recorded the highest average number of mini tubers (9.55) in the all four culture systems, followed by the variety Cezarina (9.50), without significant differences between the two varieties, but they differed significantly from Braşovia and Cosiana varieties (Table 3). Azaria and Braşovia varieties produced mini tubers with the highest average weight value (163.06 and 154.67 g), showing very significant positive differences compared to the control variety (78.24 and 69.85 g).

Table 3. Influence of cultivar on the number of mini tubers and their weight (g)/plant

Variety (b)	Number of mini tubers	Diff./Sign.	Weight of mini tubers (g)	Diff. (g)/Sign.
Azaria (b_1)	9.55 A	0.05 ns	163.06 A	78.24 ***
Braşovia (b_2)	7.91 B	-1.59 o	154.67 A	69.85 ***
Cosiana (b_3)	3.43 C	-6.07 ooo	86.70 B	1.88 ns
Cezarina (b_4) (Ct)	9.50 A	-	84.82 B	-

LSD 5% = 1.45; 1% = 1.97; 0.1% = 2.64 LSD 5% = 26.68; 1% = 38.98; 0.1% = 52.20

Means of each parameter designated by the same letter are not significantly different al 5% level using Duncan's Multiple Range Test

From combined influence analysis of culture system and variety on mean number of mini tubers/plant (Table 4), the beneficial effect of the NFT system is noted for Azaria variety, which led to highest number of mini tubers (11.50), significantly different in a positive sense compared to the Cezarina variety. In the system without automation, on perlite substrate, compared to the classic culture system on a peat-perlite substrate, Azaria, Cosiana and Brașovia varieties show significant positive differences (3.20; 3.06; 2.93). Wilma system registered significant positive differences for mini tubers number compared to classic system for the Azaria and Brașovia varieties (3.50 and 3.47). Brașovia variety registers a significant positive difference in the Wilma culture system, compared to the classic system (3.23 mini tubers). NFT and Wima systems did not have a positive influence on the Cosiana variety, it did not tuberize in automated systems.

Table 4. Combined influence of culture system and cultivar on mean number of mini tubers/plant

Culture system/ Variety	System without automation on industrial substrate (a_1)		NFT system (a_2)		Wilma system (a_3)		System without automation on peat-perlite substrate (a_4) (Ct)		a_1-a_4 Sign.		a_2-a_4 Sign.		a_3-a_4 Sign.	
	Mini tubers number	Diff./ Sign.	Mini tubers number	Diff./ Sign.	Mini tubers number	Diff./ Sign.	Mini tubers number	Diff./ Sign.						
Azaria	11.20	0.90 ns	11.50	3.94 *	7.50	-3.73 o	8.00	-0.92 ns	3.20	*	3.50	*	-0.50	ns
Brașovia	8.43	-1.86 ns	8.978	1.41 ns	8.76	-2.50 ns	5.50	-3.42 o	2.93	*	3.47	*	3.23	*
Cosiana	8.39	-1.91 ns	0.00	-7.56 ooo	0.00	-11.23 ooo	5.33	-3.58 o	3.06	*	-5.33	ooo	-5.33	ooo
Cezarina (Ct)	10.30	-	7.56		11.23	-	8.92	-	1.39	ns	-1.36	ns	2.32	ns

LSD 5% = 2.91; 1% = 3.95; 0.1% = 5.29 LSD 5% = 2.69; 1% = 3.69; 0.1% = 5.06

From the combined influence of culture system and variety (Table 5) on mean weight (g) of mini tubers/plant it is observed: a negative, but insignificant difference in the Wilma culture system, compared to the classic culture system for the Azaria variety (-30.73 g); and very significant negative differences for the Cosiana variety, which did not form tubers in automated systems. The highest value of the average weight of mini tubers/plant was recorded in the Azaria variety, on perlite substrate, in the system without automation (241.93 g), followed by the same variety, by growing in the NFT system (203.32 g).

Table 5. Combined influence of culture system and cultivar on mean weight of mini tubers/plant

Culture system/ Variety	System without automation on industrial substrate (a_1)		NFT system (a_2)		Wilma system (a_3)		System without automation on peat-perlite substrate (a_4) (Ct)		a_1-a_4 (g) Sign.		a_2-a_4 (g) Sign.		a_3-a_4 (g) Sign.	
	Weight (g)	Diff. (g)/ Sign.	Weight (g)	Diff. (g)/ Sign.	Weight (g)	Diff. (g)/ Sign.	Weight (g)	Diff. (g)/ Sign.						
Azaria	241.93	97.14 ***	203.32	119.75 ***	88.13	19.55 ns	118.57	76.52 *	123.06	***	84.45	**	-30.73	ns
Brașovia	188.99	44.20 ns	152.35	68.78 *	168.71	100.13 **	108.63	66.28 *	80.36	**	43.72	ns	60.09	*
Cosiana	192.59	47.81 ns	0.00	-83.57 oo	0.000	-68.58 o	154.23	111.88 ***	38.37	ns	-154.23	ooo	-154.23	ooo
Cezarina (Ct)	144.79	-	83.57	-	68.58	-	42.35	-	102.44	**	41.22	ns	26.23	ns

LSD 5% = 57.35; 1% = 77.96; 0.1% = 104.41 LSD 5% = 56.77; 1% = 79.00; 0.1% = 110.59

In a study conducted by Correa et al. (2008), the researchers compared the potato seed tuber production of Monalisa and Agata cultivars in NFT with traditional beds and pots methods and in terms of tubers/plant number in single and staggered harvest, the NFT system performed better statistically.

CONCLUSIONS

Cultivation system, variety and their interaction significantly influenced the number and weight of mini tubers.

The values of number and weight of mini tubers obtained in the system without automation on industrial substrate with perlite differ significantly, in a positive sense, from the other systems.

The Azaria variety recorded the highest average number of mini tubers in the 4 culture systems, followed by the Cezarina variety, without significant differences between the two varieties, but they differed significantly of the Brașovia and Cosiana varieties. The varieties Azaria and Brașovia produced mini tubers with the highest average weight value, showing very significant positive differences compared to the control variety Cezarina.

The nutrient system film technique contributed to the increase of the minituberization capacity for the Azaria variety, which led to the recording of the highest number of mini tubers.

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REFERENCES

Anikina, I.N., Hutinaev, O.S., Rakhmetov, A., 2019. *Prospects for hydroponic technologies in Kazakhstan Science, production, business: current state and ways of innovative development of the agricultural sector using the example of Bayserke-Agro Agricultural Holding*. Proc. of the Int. Sci. and Techn. Conf., vol. 2, Almaty.

Benke, K., and Tomkins, B., 2017. *Future food-production systems: Vertical farming and controlled environment agriculture*. Sustainability: Science, Practice & Policy, 13(1): 13-26.

Benton Jones, J.Jr., 2014. *Complete Guide for Growing Plants Hydroponically*. 1st ed., CRC Press, Anderson, SC, USA.

Correa, R.M., Pinto, J.E.B.P., Pinto, C.A.B.P., Faquin, V., Reis, E.S., Monteiro, A.B., Dyer, W.E., 2008. *A comparison of potato seed tuber yields in beds, pots and hydroponic systems*. Sci. Hortic., 116: 17-20.

Dhital, S.P., 2014. *Growth and Minituber Yield of Potato Cultivars Grown in Hydroponic and Conventional Cultivation System*. Nepal Agric. Res. J., 14: 26-33.

Gebreegziher, W.G., 2023. *Soilless culture technology to transform vegetable farming, reduce land pressure and degradation in drylands*. Soil & Crop Sciences, Review Article, Cogent Food & Agriculture, 9: 2265106.

Grillas, S., Lucas, M., Bardopoulous, E., Sarafopoulos, S., 2001. *Perlite based soilless culture systems: Current commercial application and prospects.* Acta Hortic., 548: 105-113.
DOI: 10.17660/ActaHortic.2001.548.10, https://doi.org/10.17660/ActaHortic.2001.548.10

Muro, J., Diaz, V., Goni, J.L., Lamsfus, C., 1997. *Comparison of hydroponic culture and culture in a peat/sand mixture and the influence of nutrient solution and plant density on seed potato yields*. Potato Research, 40: 431-438.

Mushtaq, S., 2021. *Hydroponics-plant without soil*. Just Agriculture Multidisciplinary Newsletter, 2(2): 1-6.

Rajendran, S., Domalachenpa, T., Arora, H., Li, P., Sharma, A., Rajauria, G., 2024. *Hydroponics: Exploring innovative sustainable technologies and applications across crop production, with Emphasis on potato mini-tuber cultivation*. Heliyon, 10(5), e26823. https://www.sciencedirect.com/science/article/pii/S2405844024028548

Singh, B.P., and Sharma, S., 2018. *Potato seed production systems - Then and now*. Potato J., 45(1): 1-16.

Tessema, L., Chindi, A., Giorgis, G., Solomon, A., Shunka, E., Seid, E., 2017. *Determination of Nutrient Solutions for Potato (Solanum tuberosum L.) Seed Production under Aeroponics Production System*. Open Agriculture, 2: 155-159. DOI: 10.1515/opag-2017-0015

Tican, A., 2018. *Experimenting hydroponic culture systems on different substrates to obtain potato minitubers*. Rom. Agric. Res., 35: 147-153. https://doi.org/10.59665/rar3519

Tican, A., Chiru, N., Cioloca, M., Bădărău, C.L., 2018. *Obtaining minitubers by applying hydroponic culture*. Rom. Agric. Res., 35: 141-146. https://doi.org/10.59665/rar3518

Virtanen, E., and Tuomisto, J., 2017. *Hydroponic Minituber Production in Growth Room Conditions and Carry-Over Effects of the Technique on Produced Minitubers*. Journal of Agricultural Science, 9(1): 41-48.

Woznicki, T., Møllerhagen, P.J., Heltoft, P., Kusnierek, K., 2021. *Growing Potatoes (Solanum tuberosum L.) Hydroponically in Wood Fiber - A Preliminary Case-Study Report*. Agronomy, 11, 1369. https://doi.org/10.3390/agronomy1107136

Zaag, D.E. van der, 1987. *Yield reduction in relation to virus infection*. In: De Bokx, Van der Want (eds.), Virus of potatoes and seed potato production. Pudoc, Wageningen: 146-150.