Studia Universitatis "Vasile Goldiş", Seria Ştiinţele Vieţii
Vol. 34, issue 1, 2024, pp. 5 - 11

STUDY REGARDING THE DEVELOPMENT OF POTATO PLANTS IN AN AEROPONIC SYSTEM

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Abstract. In 2024, the development of potato plants in an aeroponic system was tested at NIRDPSB Brașov. Determinations were made for 2 parameters: potato plant height and root length. The bifactorial experiment, 4 x 4 type, followed the effect of the combination of two experimental factors: the experimental factor a - planting density (with four graduations: d_1: 81 pl./m^2, d_2: 55 pl./m^2, d_3: 44 pl./m^2 and d_4: 30 pl./m^2) and the experimental factor b - variety (with four graduations: Azaria, Braşovia, Cosiana, Cezarina). The same behavior of the varieties in aeroponic system was observed for the height of the plants, both at 2 weeks and at four weeks. There were no significant differences between the Brasovia and Cosiana varieties, recording the highest plant height values, on the other hand, at the opposite pole is the Cezarina variety. Regarding root length, values significantly higher are obtained for planting densities d_4 and d_3, instead, the d_1 density strongly affected the development of the root system.

Keywords: potato, aeroponic system, density, variety, plants.

INTRODUCTION

The soil-less system uses a minimum input but facilitates a multiple-plant harvesting with a maximum output. The concept of the soil-less culture seeks to offer an innovative solution to ensure the environmental and soil-less economic sustainability of food supplies with high nutritional quality (Lakhiar et al., 2018). In soil-less culture, plants are raised without soil (Tessema. et al., 2017). The definition soil-less encompasses all the systems that provide plant management under soil-less conditions in which the supply of water and minerals is carried out by a nutrient solution, with or without a growing medium (e.g., rockwool, peat, perlite, pumice, coconut fibre, etc.) (Di Lorenzo et al., 2013)

The aeroponics system uses nutrient solution recirculation; hence, a limited amount of water is used (Tessema et al., 2017). In recent years, aeroponics has become widespread with an increased number of mini tubers per unit area and reduced production cost. It is based on soilless culture where roots are exposed to a mist environment where nutrients are circulating for a defined period in a closed chamber (Chiipanthenga et al. 2012).

Plant density significantly affects growth. Therefore, determining the most convenient planting density is also crucial for mini tuber production in aeroponics system. Farran and Mingo-Castel (2006) studied the effect of planting density (100 plants/m^2 and 60 plants/m2) on plant height, root length.

Aeroponics is a method of growing plants in a soil-free environment where the plant roots are suspended in air and are misted with a nutrient-rich water solution (Gurley, 2020). Aeroponic systems typically use pumps, timers, and spray nozzles to deliver a highly oxygenated mist of water and nutrients to the plant roots. The mist is delivered at timed intervals, allowing the roots to absorb nutrients and water.

Aeroponics offers several advantages over traditional soil-based agriculture, including faster growth rates, higher crop yields, and more efficient use of resources (Chaudhry and Mishra, 2019; Lakhiar et al., 2018). The soilfree environment also reduces the risk of soil-borne diseases and pests, allowing for a more sustainable and environmentally friendly approach to agriculture (Yang et al., 2022). On the other hand, its main challenges are high initial setup costs, maintenance requirements, and a high level of technical expertise requirements (Niu and Masabni, 2022).

This study has as objective: how density in aeroponic system and cultivar affected the following features: the height of the plant at 4 weeks after transferring biological material in aeroponic system; root length of plants at 4 weeks after transferring biological material in aeroponic system.

MATERIALS AND METHODS

In 2024, the development of potato plants in an aeroponic system was tested at National Institute of Research and Development for Potato and Sugar Beet Brașov (NIRDPSB). The experience included 4 planting densities: d1: 81 pl./m^2, d2: 55 pl./m^2, d3: 44 pl./m^2 and d4: 30 pl./m^2.

Experimental variants

To achieve the established objective, 16 experimental variants were studied. The bifactorial experiment, of the 4 x 4 type, included 3 repetitions and followed the effect of the combination of two experimental factors: the experimental factor a - planting density (with four graduations) and experimental factor b - variety (with four graduations).

The biological material used consisted of: plantlets obtained *in vitro* (within the Research Laboratory of Vegetal Tissue Cultures, of NIRDPSB Brasov) free of virus, starting from the culture of meristems, belonging to the varieties: Azaria, Braşovia, Cosiana, Cezarina**.**

Materials used in aeroponic culture: germination substrate; aeroponic system; the nutrient solution prepared in the laboratory composed of: tetra hydrated calcium nitrate; potassium phosphate, potassium nitrate, magnesium sulfate; iron chelate; boric acid; manganese

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chloride; zinc sulfate; copper sulfate; ammonium molybdate; pesticides and foliar fertilizer.

The methodology applied in the research carried out to test the aeroponic culture system Plant and nutrient handling

The aeroponic system is a system in which plant roots grow in a closed environment, without using soil or any other type of substrate. A precise amount of nutrients is supplied in the aeroponics unit, thus reducing wastage and minimizing fertilizer residues leaching into the groundwater. The room where the roots develop is covered with plastic covers with 45-50 mm holes and different planting densities.

The nutrient solution is pumped from the tank using a submersible pump. The pump is connected to the timer to accurately and timely deliver nutrients by spraying the roots of the plants inside the box through the nebulization system. Plantlets grown in culture containers under laboratory conditions can be easily affected by sudden changes in environmental conditions and therefore need an acclimatization period for better performance in aeroponic culture.

In the period 09-26.05.2024, the plantlets developed *in vitro* were transferred to the greenhouse for acclimatization on a stone wool substrate (Figure 1). This is a non-toxic and pathogen-free germination substrate. Grodan stone wool comes from volcanic rock: basalt. The cube is 100% inert after soaking in a pH 5.5 solution. Its fibrous structure allows good root proliferation. Periodically, a nutrient solution with an EC of 0.8 mS/cm was applied to the base of the root system.

Fig. 1. Acclimatization on a rockwool substrate.

Fig. 2. Transfering in aeroponic system.

On 27.05.2024, the developed plants were transferred for testing in the aeroponic system (Figure 2). In the first week (27-31.05), EC was maintained at 0.9 mS/cm, being gradually increased to 1.1, 1.3, 1.5, 1.8 mS/cm, and from 21.05.2024 it was maintained at the value of 2.0 mS/ cm, and pH in the range 6.3-6.5. The nutrient solution was dispensed at intervals of 3 minutes on and 20 seconds off.

Aspects of plant and root development can be seen in Figures 3 and 4.

a b c

Fig. 3. Evolution of plants (a: at 7 days after transfer in aeroponic system; b: at 13 days; c: at 32 days).

Fig. 4. Evolution of roots (a: at 7 days after transfer in aeroponic system; b: at 18 days; c: at 32 days).

RESULTS AND DISCUSSIONS

The experimental results obtained with four potato varieties, cultivated in a testing aeroponic system in the year 2024

The first parameter analyzed was plant height at the four planting densities of the aeroponic system and for the four varieties.

To determine the influence of each factor, as well as their interaction, on plant height, the analysis of variance for the bifactorial experience (4 × 4) was performed. At 4 weeks after transfer, planting density (factor a) has a significant influence, and variety (factor b) and the interaction between the factors have a distinctly significant influence (Table 1).

Table 1.

Analysis of variance (4 weeks after transfer) for plant height

Source of variation	Sum of squares	DF	Mean square	Sample F
Planting density (a)	308.9	3	102.9	4.6* (4.76;9.78)
Variety (b)	2629.7	3	876.6	54.4 ** (3.01;4.72)
Density* Variety	695.7	9	77.3	4.8**(2.30;3.26)

At 4 weeks after transfer, the average plant height varied between 43.9 cm for density d_2 and 36.8 cm for d_4, with significant differences between the two densities. It is observed that as the planting density is higher, the competition for light increases, resulting in stem elongation (Figure 5).

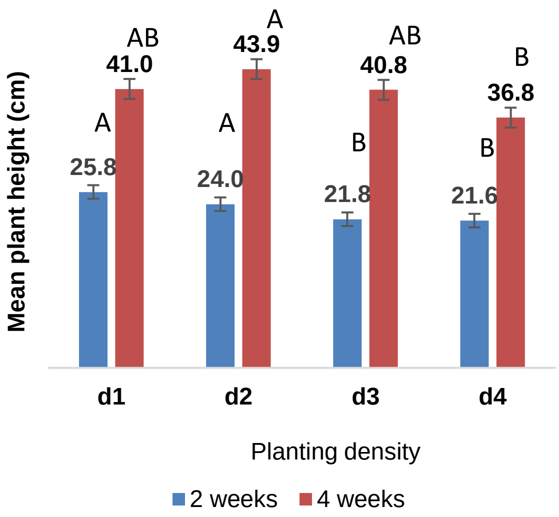

Fig. 5. The influence of the planting density in the aeroponic system, on the average height of the plants (cm) (at 2 weeks after transfer, respectively at 4 weeks after transfer)
Significance between densities was determined by Duncan's test. Values followed by the same letter 2 weeks after transfer are not significantly different (p < 0,05) (LSD $_{p\ 5\%}$ = 1.82); Values followed by the same letter 4 weeks after transfer are not significantly different (p < 0,05) (LSD $_{p\ 5\%}$ = 4.72)

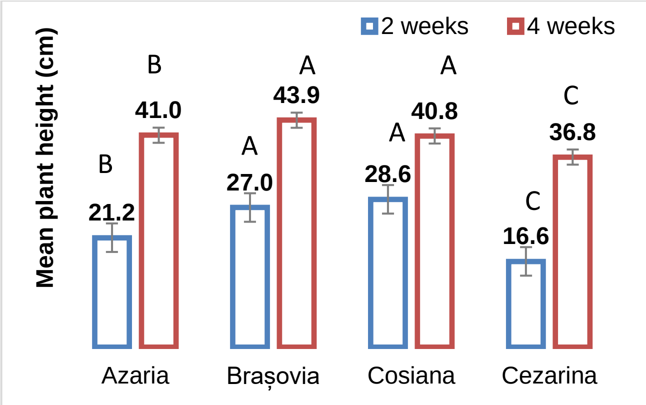

Fig. 6. The influence of the genotype cultivated in the aeroponic system, on the average height of plants (cm) (at 2 weeks after transfer, respectively at 4 weeks)
Significance between varieties was determined by Duncan's test. Values followed by the same letter 2 weeks after transfer are not significantly different ($p < 0,05$) (LSD $_{p\ 5\%}$ = 1.65); Values followed by the same letter 4 weeks after transfer are not significantly different ($p < 0,05$) (LSD $_{p\ 5\%}$ = 3.37)

The behavior of the varieties on the 4 planting densities is different (Table 2). Thus, for density 1, the Azaria variety reaches the highest value of plant height (48.67 cm), followed by Brașovia (with a close value of 48.50 cm). For planting densities 2 and 3, the Cosiana variety stands out (53.33 and 48.33 cm), followed by the Brașovia and Azaria varieties. For the lowest planting density of 30 pl./m^2, the Brașovia variety shows the highest value of plant height (47.00 cm), followed by the Cosiana and Azaria varieties, with very significant differences, compared to the control variety. At 4 weeks after transfering into aeroponic system, the ability of plants to grow is different for densities 1, 2 and 3 compared to density 4 (control). Thus, the varieties: Azaria, Cosiana and Cezarina register distinctly significant differences (13.17; 11.83; 12.33 cm).

Combined analysis of variance showed distinctly significant differences between cultivars and planting densities for root length, a significant difference in the cultivar*planting density interaction effect (Table 3).

Table 2.

Combined influence of aeroponic planting density and variety on plant height (cm) 4 weeks after transfer

Density/ Variety	Density 1			Density 2			Density 3			Density 4 (Ct)			d1-d4	Sign.	d2-d4	Sign.	d3-d4	Sign.
	Pl. height (cm)	Diff.	Sign.	Pl. height (cm)	Diff.	Sign.	Pl. height (cm)	Diff.	Sign.	Pl. height (cm)	Diff.	Sign.						
Azaria	48.67	22.33	***	42.50	13.50	***	37.33	2.00	ns	35.50	12.50	***	13.17	**	7.00	ns	1.83	ns
Brașovia	48.50	22.17	***	50.67	21.67	***	42.33	7.00	*	47.00	24.00	***	1.50	ns	3.67	ns	-4.67	ns
Cosiana	40.39	14.06	***	53.33	24.33	***	48.33	13.00	***	41.50	18.50	***	-1.11	ns	11.83	**	6.83	ns
Cezarina (Ct)	26.33	-	-	29.00	-		35.33	-		23.00	-	-	3.33	ns	6.00	ns	12.33	**

DL 5% = 6.75; 1% = 9,17; 0,1% = 12.29.　　DL 5%= 7.49; 1% = 10.49; 0.1% = 15.26.

Table 3.

Analysis of variance (4 weeks after transfer) for root length

Source of variation	Sum of squares	DF	Mean square	Sample F
Planting density (a)	2364.12	3	788.04	55.65 ** (4.76; 9.78)
Variety (b)	12206.96	3	4068.99	35.44** (3.01; 4.72)
Density* Variety	1914.49	9	212.72	1.85* (2.30; 3.26)

The plants height values belonging to the studied varieties (Figure 6) do not differ significantly for the Brașovia (27 and 43.9 cm) and Cosiana (28.6 and 40.8 cm) varieties (2 and 4 weeks after transfer). On the last place, regarding this parameter, is the Cezarina variety, the values being significantly different compared to the other varieties (both 2 weeks and 4 weeks after the transfer.

Regarding root length, values significantly higher are obtained for planting densities d_3 and d_4 than the other 2 densities. Although for planting density d_1 plants height was not affected, it led to a reduction in root length (41.03 cm) (Figure 7).

Between Azaria, Brașovia and Cosiana varieties there were no significant differences for this analyzed parameter (Figure 8). The root length for the Cezarina variety (24.88 cm) differs significantly from the other varieties in a negative sense, and at the opposite pole is the Brașovia variety (with the highest value of the root length: 64.33 cm).

For planting densities d_2, d_3 and d_4, the varieties Azaria, Brașovia and Cosina record higher values of root length, compared to the control variety, with very significant positive differences. Between planting densities d_3 and d_4 there were no significant differences in root length, instead the highest planting density (d_1: 81 pl/m^2) strongly affected root length, leading to a highly significant negative difference (-36.89 cm) for the Cosiana variety and significant, negative differences for the Azaria (-23.33) and Brașovia (-16.17 cm) varieties (Table 4).

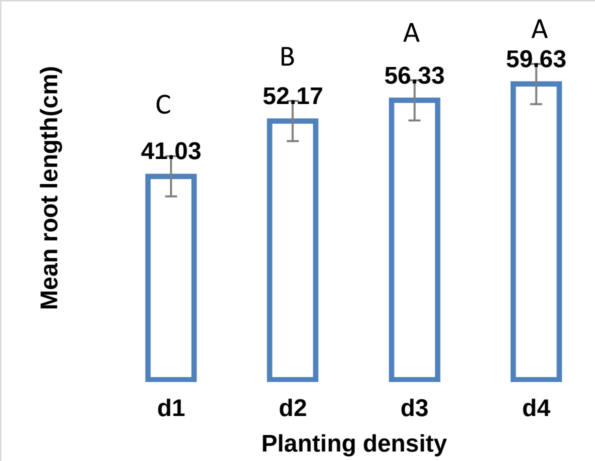

Fig. 7. The influence of the planting density in the aeroponic system, on the average roots (cm) (4 weeks after transfer)
Significance between densities was determined by Duncan's test. Values followed by the same letter are not significantly different (p < 0,05) (LSD $_{p\ 5\%}$ = 3.76)

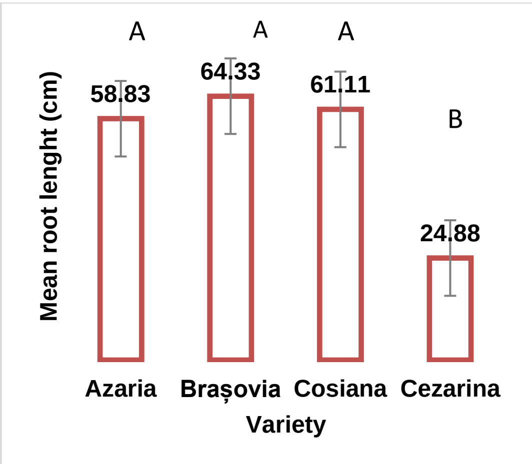

Fig. 8. The influence of genotype in aeroponic system, on average roots of plants(cm) (4 weeks after transfer)
Significance between varieties was determined by Duncan's test. Values followed by the same letter are not significantly different (p < 0,05) (LSD $_{p\ 5\%}$ = 9.01)

Table 4.

Combined influence of aeroponic planting density and variety on root length (cm) 4 weeks after transfer

Density/ Variety	Density 1			Density 2			Density 3			Density 4 (Ct)			d1-d4	Sign.	d2-d4	Sign.	d3-d4	Sign.
	Root length (cm)	Diff.	Sign.	Root length (cm)	Diff.	Sign.	Root length (cm)	Diff.	Sign.	Root length (cm)	Diff.	Sign.						
Azaria	43.17	15.83	ns	67.00	45.00	***	61.67	39.00	***	63.50	36.00	***	-20.33	o	3.50	ns	-1.83	ns
Brașovia	55.50	28.17	**	56.33	34.33	***	73.00	50.33	***	72.50	45.00	***	-17.00	o	-16.17	o	0.50	ns
Cosiana	38.11	10.78	ns	63.33	41.33	***	68.00	45.33	***	75.00	47.50	***	-36.89	ooo	-11.67	ns	-7.00	ns
Cezarina (Ct)	27.33	-	-	22.00	-	-	22.67	-	-	27.50	-	-	-0.17	ns	-5.50	ns	-4.83	ns

DL 5% = 18.02; 1% = 24.50; 0,1% = 32.81. DL 5% =16.05; 1% = 21.93; 0,1% = 29.67.

CONCLUSIONS

At 4 weeks after transferring plants in aeroponic system, planting density had a significant influence on plants height; variety and interaction between the factors had a distinctly significant influence on first studied parameter.

The combined analysis of variance revealed significant distinct differences between cultivars and planting densities for root length, a significant difference in the effect of cultivar–planting density interaction for root length.

For planting densities d_2, d_1 and d_3 there were no significant differences in plant height, obtaining the highest values. At high planting densities the competition of plants for light caused stem elongation.

For the planting densities of 30 pl./m^2 (d_4) and 30 pl./m2 (d_3), the root length reached the highest values (59.63 cm and 56.33), without significant differences between these 2 densities. As the planting density increased (55 and 81 pl./m^2), the average root length was strongly affected (52.17 cm; 41.03 cm).

Regarding the influence of the variety on the height of the plants in the aeroponic system, tBrașovia and Cosiana varieties stand out with high values, while the Cezarina variety is at the opposite pole. About the influence of variety on the root of the plants in the aeroponic system, we can observe that Brașovia, Cosiana and Azaria varieties showed higher values, without significant differences between them (64.33, 61.11 and 58.83 cm). In the aeroponic culture, the Cezarina variety also suffered in terms of root length, registering the lowest value (24.88), which is significantly different from the other varieties.

AUTHOR CONTRIBUTION

Conceptualization, A.T.; methodology, A.T., C.C.; data collection, A.T.; data validation, A.T.; data processing, A.T.; writing - original draft preparation A.T.; writing - review and editing, A.T., M.C., M.P., M.S.

FUNDING

This research work was carried out with the support of National Institute of Research and Development for Potato and Sugar Beet Brasov and also was financed from PN 23 19 01 01 Project “Research on increasing the performance process of the potato minitubers production using an intelligent aeroponic system”, period 2023-2026, and represents a part of researches from this project**.**

CONFLICT OF INTEREST

The author declares no conflict of interest.

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