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Preliminary Study about Comparison of Potato Minitubers Production in Conventional Culture and Modern Culture – Aeroponic

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A R T I C L E I N F O

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A B S T R A C T

In 2024, within the Research Laboratory for Plant Tissue Cultures, of the National Institute of Research and Development for Potato and Sugar Beet Brașov, the minituberization process was evaluated for four potato varieties (Azaria, Brașovia, Cosiana and Cezarina) by applying two cultivation methods: aeroponic culture (wihout substrate) and classical culture (with a peat-perlite mixture as the cultivation substrate). The varieties studied behaved differently in minituberization, depending on the culture applied. The average number of minitubers (in the two cultivation methods) was between 16.50 (Azaria variety) and 5.17 (Cosiana variety). The statistical analysis (performed to establish the influence of the type of culture) shows the superiority in minituberization process of taeroponic culture (12 minitubers), compared to the classical culture on peat-perlite substrate (6.94).

1. Introduction

Improving the high-quality seed production and distribution of seed are key areas of research potential connected to crop management in potato growth since it depends on supportable potato production on a continuously refreshed supply of the planting material that is disease-free (FAO, 2016; Bentley et al., 2018, quoted by Buckseth et al., 2024). Several rapid multiplication methods, including stem cuttings, apical rooted cuttings, sprouts cutting, and minituber generation, have been developed in recent years for speedy potato multiplication (Buckseth et al., 2022a, quoted by Buckseth et al., 2024). Micropropagation helps to maintain local potato cultivars, produce clean plant material, treat seeds for infection, and maintain the physicochemical conditions of culture (Mohapatra and Batra, 2017, quoted by Buckseth et al., 2024).

The current conventional seed potato production includes the following phases: propagation of pathogen-free plant material (microplants, microtubers) under aseptic conditions in vitro, acclimation and cultivation of pathogen-free plant material on a substrate in insect-free greenhouses to produce minitubers (pre-basic seed potato), and field planting of the minitubers to increase the volume of seed material (basic seeds and other categories of seeds) (Broćić et al., 2021, quoted by Broćić et al., 2022).

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Minitubers are usually defined as the progeny tubers produced on in vitro derived plantlets or microtubers (Rykaczewska, 2016).

2. Literature review

In the past few years, the current problems in agriculture include the lack of arable land and limited water resources (MateoSagasta et al., 2017; Palm et al., 2018, quoted by Aleksić and Šušteršič, 2020), specifically in developing areas (Joyce, 2019, quoted by Aleksić and Šušteršič, 2020).

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, quoted by Khutinaev et al, 2021).

A promising direction in the achievement of required efficiency of minituber production is the use and development of aeroponics. Its significant advantage is ensured by growing plants in an air environment with aerosol delivery of nutrients to the roots and without the use of soil. Soil is a complex medium with a difficult-to-control microbiological composition and with a set of compounds that are often very aggressive toward plants (Tkachenko et al, 2021).

In the aeroponic cultivation system, the underground parts (roots and underground stems) of potato plants are situated in a dark chamber, called the module, suspended in the air, and supplied with water and nutrients through a nutrient solution dispersed in the form of fine fog particles, while the foliage is grown above the module under greenhouse conditions (Broćić et al., 2021, quoted by Broćić et al., 2022). Aeroponics optimizes root aeration, which is a major factor leading to a yield increase as compared to classical hydroponics (Softer and Burger, 1988 quoted by Farran and Mingo-Castel, 2006). It shows other advantages such as solution recirculation, a limited amount of water used, and good monitoring of nutrients and pH (Farran and Mingo-Castel, 2006).

3. Material and methods

In 2024, within the Research Laboratory for Plant Tissue Cultures, of the National Institute Research of for Potato and Sugar Beet (NIRDPSB) Brasov, the minituberization process was evaluated using two culture methods: aeroponic culture (without substrate) and classical culture, using perlite peat substrate. The experiment was a 2*4 bifactorial design, in which factor *a* was the type of culture, with two graduations: a_1 – aeroponic culture; a_2 – classical culture (considered control), and factor *b*: the variety, with four graduations: Azaria, Brașovia, Cosiana and Cezarina (control varieties). Materials used in aeroponic culture were: rock wool for acclimatization of microplants before transfer to aeroponic culture, aeroponic system under testing, equipped with sensors for maintaining pH and electroconductivity (EC) values, nutrient solution. Materials used in classical culture: 2 l pots required for classical culture, perlite peat mixture. During 09-26.05.2024 period, the microplants developed *in vitro*, on Murashige - Shoog (1962) culture medium were transferred to the greenhouse for acclimatization on a rock wool substrate, to be planted in aeroponic system. Periodically, a nutrient solution with an EC (electroconductivity) of 0.8 mS/cm was applied to the base of the root system. On 27.05.2024, the developed plants were transferred to aeroponic system, for its testing and to follow the evolution of varieties in this system. The images below show aspects of plant development (Figure 1), of the root system in the aeroponic system (Figure 2), the stolon's formation (Figure 3), the initiation of minitubers (Figure 4) and minitubers's in aeroponic system (Figure 5).

Figure 1. Developing potato plants in an aeroponic system

Source: original photo (A. Tican)

Figure 2. Root system development in an aeroponic system

Source: original photo (A. Tican)

Figure 3. Stolon's formation

Source: original photo (A. Tican)

Figure 4. Initiation of the minituberization process

Source: original photo (A. Tican)

Figure 5. Minitubers in an aeroponic system
Source: original photo (A. Tican)

For microplants to which the classical culture method was applied, were planted in protected space "insect-proof" in pots containing a mixture of perlite peat.

The production of minitubers (Prebase material) from potato microplants allows for rapid multiplication in the production of seed potatoes, reducing the number of generations in the field. Minitubers are free of pathogens, being obtained from virus-free vitroplants (according to the DAS-ELISA test), having as a starting point small meristematic explants (0.1-0.2 mm) for the success of viral eradication.

By approaching new research on the production of minitubers, we believe that unique scientific results can be obtained. New techniques in the production of seed potatoes are promoted worldwide, because potatoes have an essential food role, and these techniques offer major potential for production and quality. Because aeroponic culture is a relatively new technique that has not been extensively applied for the production of minitubers, practical studies on their production are needed.

4. Results and discussion

From Table 1, we can see the significant influence of crop type, variety and their interaction on the number of minitubers obtained.

Table 1. Analysis of variance for minitubers number

Source of variation	Sum of squares	DF	Square mean	F
Type of culture (a)	153.77340	1	153.77340	457.744 ** (18.51; 98.50)
Variety (b)	462.52870	3	154.17620	41.469 ** (3.49; 5.95)
Type of culture*Variety	424.52870	3	141.50960	38.062 * *(3.49; 5.95)

df, degrees of freedom.
** Significant at the 0.01 probability level.
Means found in the same columns, followed by the same letters, are not significant, according to Duncan's test (p≤0.05).
Source: elaborated by A. Tican, using ANOVA

From the statistical analysis of the influence of the type of culture on the number of minitubers obtained/plant, a distinctly significant, positive difference is observed for the aeroponic culture (Table 2).

Table 2. Influence of culture method on the number of minitubers

Type of culture (a)	Mean number of minitubers	Diff./Sign.
Aeroponic (a1)	12.00 A	5.06 **
Conventional (a2) (Ct)	6.94 B	-

LSD (p 5%) = 1.02; (p 1%) = 2.35; (p 0.1%) = 7.48

Means found in the same columns, followed by the same letters, are not significant, according to Duncan's test (p≤0.05).

Source: elaborated by A. Tican, using ANOVA

Evaluating the variety's ability to produce minitubers, the superiority of Azaria and Brașovia varieties (Table 3) is highlighted, which differ very significantly and significantly, in a positive sense, from the control variety. At the opposite pole is the Cosiana variety, which records the lowest number of minitubers (5.17).

Table 3. Influence of variety on the number of minitubers

Variety (b)	Mean number of minitubers	Diff./Sign.
Azaria (b_1)	16.50 A	10.04 ***
Brașovia (b_2)	9.75 B	3.29 *
Cosiana (b_3)	5.17 C	-1.29 ns
Cezarina (b_4) (Ct)	6.46 C	-

LSD (p 5%) = 2.43; (p 1%) = 3.41; (p 0.1%) = 4.81

Means found in the same columns, followed by the same letters, are not significant, according to Duncan's test (p≤0.05).

Source: elaborated by A. Tican, using ANOVA

By practicing unconventional culture, the highest values of the number of minitubers are obtained by the varieties Azaria (25.00) and Brașovia (14.00), which present positive, very significant differences compared to the control variety (Table 4). In conventional culture, Azaria (8 minitubers) and Brașovia varieties (5.50 minitubers) did not register significant differences compared to the control variety (8.92), but these were negative. Cosiana variety in classical culture produced the lowest number of minitubers (5.33) and a significant, negative difference compared to the Cezarina variety. From comparison of the results obtained between the types of culture, it is found that aeroponic culture influences very significantly, in a positive sense, Azaria and Brașovia varieties, compared to the classical culture. In contrast, for Cezarina variety, minituberisation was affected by applying of modern culture method, compared to classical method, determining a distinctly significant negative difference.

Table 4. Combined influence of culture type and cultivar on mean number of minitubers/plant

Culture type / Variety	Aeroponic (a_1)		Conventional (a_2)		a_1-a_2/Sign.
	Minitub. number	Diff./Sign.	Minitub. number	Diff./Sign.	
Azaria	25.00	21.00 ***	8.00	-0.92 ns	17.00 ***
Brașovia	14.00	10.00 ***	5.50	-3.42 ns	8.50 ***
Cosiana	5.00	1.00 ns	5.33	-3.58 o	-0.33 ns
Cezarina (Ct)	4.00	-	8.92	-	-4.92 oo

LSD 5% = 3.43; 1% = 4,82; 0.1% = 6.80.

LSD 5%= 3.10; 1% = 4.51; 0.1% = 7.08

Source: elaborated by A. Tican, using ANOVA

The extremely high temperatures of this year have strongly inhibited minitubers formation, with varieties starting to produce minitubers only in the second decade of August. In the future, efforts will be made to improve the method of obtaining minitubers in aeroponic system. According to the literature, the ideal temperature in the greenhouse to obtain minitubers in the aeroponic system is 18-25^{0}C during the day and 8-15^{0}C at night (Andrade-Piedra et al., 2019). Inside the aeroponic module, the ideal temperature for starting tuberization is between 16-19^{0}C. In July of this year, there were days when the temperature inside the aeroponic mode reached 25^{0}C.

5. Conclusions

The varieties studied behaved differently in minituberization, depending on the culture applied. The mean number of minitubers (in the two cultivation methods) was between 16.50 (Azaria variety) and 5.17 (Cosiana variety). The number of minitubers was between 25 - 4 in the aeroponic system (for the Azaria and Cezarina varieties) and 8.92 -5.33 in the classical cultivation system (Cezarina). The statistical analysis carried out to establish the influence of the type of culture shows the superiority in minituberisation process of the aeroponic culture (12 minitubers), compared to the classical culture on peat-perlite substrate (6.94).

The aeroponic cultivation system tested in 2024 constitutes a beginning of the production of minitubers through modern methodology, which through improvement can lead to an increase in the production of minitubers in the seed potato production system.

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