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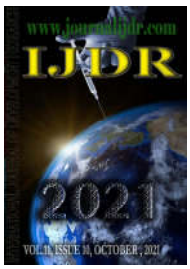

RESEARCH ARTICLE OPEN ACCESS

SEED SWEET POTATO PRODUCTION IN AEROPONICS

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ABSTRACT

The objective was to verify the possibility of the production of tuberous roots of sweet potatoes in an aeroponic systemin order to use these roots as seeds. The research was developed at the State University of Ponta Grossa (PR – Brazil). There were performed four attempts for the developing ofone aeroponic system in a greenhouse, involving experiments with structures and nutrient solutions for seven sweet potatoes genotypes. There were evaluated the percentage of alive seedlings in different periods of cultivation, average length of the roots, maximum number and measurements of length and width of the leaves. For the nutrient solutions there were evaluated the potential of hydrogen and electrical conductivity. It was concluded that the structure developed for the production of seed sweet potato in aeroponics responds to the needs of the culture and that the complete nutrient solution of Hoagland & Arnon (1950) is more efficient, with necessary adaptations to the conditions of local cultivars.

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INTRODUCTION

The increasing world population led to the significant raise of energetic demand. The renewable energies come as an alternative to the usage of fossil fuels. Renewable energies are characterized as those which sources can reestablish in a natural manner. Besides the environmental advantages, these renewable energies may be related to economic and social development of the locals where they are produced, generating incomes and employment (Acuña *et al*., 2017; Castro *et al*., 2019). The renewable energy originated from biomass is known as bioenergy. Biomass is material originated from organic matter that can be transformed into energy by its direct usage or by its transformation, such as biofuels (Bühring & Silveira, 2018; Creutzig *et al*., 2015). Among the crops with potential to generate biofuels is the sweet potato (*Ipomoea batatas*), for its productivity and the high quantity of starch that can be converted into bioenergy (Maino *et al*., 2019). The sweet potato is a dicotyledonous plant from the family Convolvulaceae, has an herbaceous stem and prostrate habit, branches with colors, sizes and hair very distinctive; wide leaves that vary in size and shape; hermaphrodite flowers which perform cross-fertilization, besides roots that can have different shapes and rough or smooth peel.

It is originally from America and records of its usage can be found over 10.000 years ago. Although it is perennial it is cultivated mainly as annual (Silveira *et al*., 2015). With all the qualities of the sweet potato crop, it is possible to highlight, as a challenge, the necessity of a large number of seedlings, up to 300 thousand per hectare, to propagate the culture (Nedunchezhiyan *et al*., 2012). Among the alternatives to the propagation of seedlings with better sanity has grown the cultivation in a controlled environment, hydroponics and aeroponics (Sharma *et al*., 2018; Wootton-Beard, 2019). In an aeroponic system the plants are cultivated without soil, the roots of the seedlings stay in the air and are evolved by a dark closed environment to receive directly a nutrient solution in the form of mist or droplets, with the reuse and recirculation of the solution. The plants show an ideal growth in the aeroponics systems due to the unimpeded supply of oxygen to the root system and the possibility to control important variables to the development of the culture, for example: nutrient solution concentration, frequency of application, potential of hydrogen (pH) and electrical conductivity (EC) of the nutrient solution. These factors made the usage of aeroponics interesting to the studies of development of roots and nutrient absorption (Oteng-Darko *et al*., 2017; Tessema *et al*., 2017). The production of potato (*Solanum tuberosum*) in aeroponics is consolidated as a technique (Buckseth *et al*., 2016). The authors highlight the higher

multiplication rate, sanity of the seedlings, easy inspection, utilization of nutrients that are not lost in groundwater, water saving, simplified harvest, uninterrupted production close to the consumer center. Cultivars adapted to the system, spacing between plants, the droplets size of water and nutrient supply to the roots, constant energy for the maintenance of the system, technical qualification of the ones involved in the process, concentration of the nutrient solution, potential of hydrogen (pH), electrical conductivity (EC) of the nutrient solution, increase of vegetative period of the plants and the economic viability are adversities to be supplanted by aeroponics.

Assessing the effects of the nutrient solutions in the production of tuberous roots of potatoes in the aeroponics system, Hassanpanah *et al*. (2014) highlight four proposals used in this system. The supplies of nutrients to the potato culture developed by Hoagland and Arnon (1950), Lommen and Struik (1992), Kang and Han (2005) and Otazu (2010). In aeroponics the ideal levels of pH are 6,5 to 6,8, not to exceed 7,3 when there is recycling of the solution. The great levels of EC in the nutrient solution are between 1,5 and 2,5 dS m^{-1}. The ideal is the replacement of the nutrient solution every four weeks (Tunio *et al*., 2020). Studying the electrical conductivity of the nutrient solution and the density of the plant in the aeroponics production of seed potatoes in tropical conditions, Calori *et al*. (2017) concluded that the electrical conductivity of 2,2 dS m^{-1} generated higher productivity of seed potatoes and higher yield was observed for the density of 100 plants m^{-2}. When performing experiments aiming to develop a low-tech system to the production of sweet potato seedlings in an aeroponic system, Villordon (2016) tested a strategic plan of structures and nutrient solutions in distinct phenological stages of the studied genotypes. The researcher concluded that the sweet potato plants are able to be manipulated along the alteration of nutrient solution, to form storage roots in an aeroponic system. In the face of scarcity of research about the theme, the objective was to verify the possibility of production of sweet potato storage roots in aeroponics aiming to use them as seeds.

MATERIAL AND METHODS

The experiments were performed from February of 2019 to February of 2020 in a greenhouse (covered by 150 μm plastic and a PAD-FAN™ cooling system) of the State University of Ponta Grossa (UEPG), in the state of Paraná. Ponta Grossa city (geographic coordinates 25° 5' 40" S and 50° 9' 48" W) is located at 956 m above sea level and the climate according to Köppen classification is temperate (IAPAR, 2019). The experiments used the unregistered genotypes BD-1, BD-9, BD-14, BD-15 and BD-16, as well as two registered genotypes, BRS-Cuia™ and Beauregard™. All the sweet potato genotypes used for the research were selected for being well cultivated in the region where the experiments were developed and for having easy propagation. The genotypes were obtained from the collection the Agricultural Mechanization Laboratory (LAMA) kept (Table 1). The prototype of the aeroponic system was built in a table with a wooden surface with 0,60 m x 0,40 m x 0,75 m dimensions. In the table surface two 0,05 m perforations were made to accommodate the seedlings of the selected genotypes. For this test were used the genotypes BD-1 and BD-16, chosen for the importance of their cultivation in the region. The seedlings were accommodated in plastic glasses (Cristalcopo™) of 0,18 L with substrate composed of soil, manure and limestone in a proportion of 2:2:1. At this stage, 50% of the roots of the seedlings were in the soil and 50% in the air to the aeroponics system calibration. A plastic container was placed below the seedlings to store the nutrient solution excess that was sprayed in the roots, with the disposal of the excess at this stage of the system adjustments (Figure 1). When being placed on the orifices of the table, the seedlings roots were kept in exposure in the interior of the structure, which was covered with a black polyethylene plastic (De Paiva™ of 0,10μm). This way the interior of the prototype was completely dark and the relative humidity was maintained between 50 and 70% (Calori *et al*., 2017; Sharma *et al*., 2018), measured by the Kestrel 3000™ device. At the roots the biofertilizer Supermagro™ was applied, prepared according to the specifications of the Ministry of Agriculture, Livestock and Supply (MAPA, 2016), in a concentration of 10% of the biofertilizer. For being a widely used nutrient solution in the region it was chosen for the calibration of the system at this first stage of the research. To prepare the Supermagro™ biofertilizer it was used water from the UEPG supply system and treated by the Sanitation Company of Paraná (SANEPAR™), which report can be found at Table 2. The applications of the biofertilizer at the roots were made manually with a Jacto™ sprayer, Supremo version, spray nozzle XR11002™, pressure 100kPa, medium droplet, flow rate of 0,46 L min^{-1} and capacity of 16 L. The application happened four times a day, with intervals of three hours during the applications, which started at 08:30 and ended at 17:30, during a period of fifteen days. From the prototype, through the advance steps about the knowledge circa the production of seed sweet potato in aeroponics, new structures for the cultivation of the genotypes were developed. The automation of the system was established as a goal to improve it. The variables analyzed for the improvement of the sweet potato production in aeroponics were: percentage of seedlings survival, average root length, maximum number of leaves, maximum leaf length, maximum leaf width, production of tuberous roots with potential to originate new plants, pH and ECof the nutrient solution.
The expansion of the structure to support a higher number of plants, has as premise to reach the prerequisite of 10 degrees of freedom, between the treatments and repetitions; known as minimum necessary to statistically validate a scientific experiment. This way it was possible to apply the Hartley tests, to verify the homoscedasticity of variances, and Shapiro-Wilk, to measure normality. It was intended that the treatment averages were submitted to the variance analysis by the Fisher-Snedecor test and compared by the Duncan test, with a confidence interval of 95% (Banzatto & Kronka, 2006).

RESULTS AND DISCUSSION

First test - aeroponic system suitability: At this stage only two genotypes were used, BD-9 and BD-16, with only one seedling each, because the tests were preliminary. The seedlings were planted in plastic glasses, accommodated in the aeroponic structure and received the Supermagro™ biofertilizer with applications using a manual sprayer. After 13 days, it was possible to recognize the darkening of the roots and chlorosis of the leaves, resulting in the seedlings' death. The authors attributed the death of the seedlings to the insufficiency of nutrients sprayed at the roots and to the insufficient water supply.

Second test - expansion of the aeroponic system, irrigation calibration and nutrient solution dosage: This stage started with the alteration of the aeroponic structure stand, aiming the expansion and automation of the process. The structure was built with iron (Fortte™), by the UEPG locksmith, measuring 1,70 m x 0,55 m x 0,80 m, with an iron net (Fenix™) measuring 0,04 m x 0,04 m as surface. The new structure was capable of accommodating 128 seedlings, with spacing between them of 0,08 m. One of the advantages of aeroponics is the possibility of reducing spacing between plants of sweet potato, which in the field is 0,25 to 0,40 m (EMBRAPA, 1995). Aiming to keep the roots in the dark and humidity in the interior of the structure, as required for an aeroponic system (Oteng-Darko *et al*., 2017; Tessema *et al*., 2017), this structure was covered with black plastic De Paiva™ of 0,10μm. This plastic was chosen for its high density, which provides the necessary darkness to the system. The second test also used plastic glasses of 0,18 L containing the same substrate as the first test. This procedure was necessary to develop the seedlings until the determination of the aeroponic system calibration to production of plants. The genotypes selected were the ones which were used at the first experiment (BD-9 and BD-16) as well as other five (BD-1, BD-14, BD-15, BRS- Cuia™ and Beauregard™). Nine repetitions of each one of the seven genotypes were made, totalizing 63 seedlings at this experiment. The manual applications of Supermagro™ were made at the roots, the same form as the first test of the experiment. However, the frequency of applications decreased because the biofertilizer was applied every two days possibiliting the observation of the seedlings with longer intervals of nutrient solution spray.

Table 1. Morphological characteristics of the genotypes of sweet potato (*Ipomoea batatas*) selected to the research of production of seed sweet potato in aeroponic system, State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019

Genotype	General leaf profile	Mature coler leaf	Leaf size[1]	Predominant color of periderm	Predominant color of pulp
BD-1	Lobulated	Green	Medium	Cream	Light yellow
BD-9	Lamost Split	Green	Medium	Brown-orange	Dark yellow
BD-14	Lobulated	Green	Medium	Yellow	Heavly pigmented with antthocyanins
BD-15	Triangular	Green	Medium	Cream	Dark cream
BD-16	Cordate	Green	Medium	Pinkish	Dark cream
BRS-Cuia™	Triangular	Green	Medium	White	Cream
Beauregard™	Lobulated	Green	Medium	Yellow	Dark orange

[1]Small = < 8 cm; medium: between 08 and 15 cm; big: between 16 and 25 cm; very big: > 25 cm.

Table 2. Characterization of the water used as solvent in the nutrient solution applied in aeroponics for the cultivation of sweet potato (*Ipomoea batatas*), State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019

Parameter	Last 30 days average	Minimum/ Maximum allowed	Unit
Color	2,6	15,0	uH-n Cor^{-1}
Fluorides	0,8	0,6 a 1,1	Mg L F^{-1-1}
Turbidity	0,4	5,0	NTU^{-1}
pH	6,9	6,0 a 9,5	pH
Residual chlorine	0,8	0,2 a 5,0	mg L Cl^{-11}
Aluminium	0,1	0,2	mg L Al^{-1-1}
Total iron	0,0	0,3	mg L Fe^{-1}
Manganese	0,0	0,1	mg L Mn^{--1}
Microcystins	0,0	1,0	ug L^{-1-1}
Total coliforms	Absent	Absent	
Escherichia coli	Absent	Absent	

Source: SANEPAR (2019).

Table 3. Characteristics of the sweet potato (*Ipomoea batatas*) genotypes cultivated for 30 days in aeroponic system, with the Altech Crop Science™ nutrient solution, in concentration of 11,25 mL for 90 L^{-1} of water, State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019[1]

Genotype	Alive seedlings (%)	Average length of the roots (cm)	Maximum number of leaves	Maximum length of the leaves (cm)	Maximum width of the leaves (cm)
BD-1	67	2,3	08	7,5	10,0
BD-15	67	3,4	03	4,6	5,1
BD-16	67	1,8	05	5,5	5,7
BRS-Cuia™	33	1,6	03	3,5	3,6
Beauregard™	83	2,8	03	4,6	3,7

[1]There was no statistical analysis due to the fact some of the genotypes had few alive seedlings, reducing the degrees of freedom below the 10 that are acceptable (Banzatto & Kronka, 2006).

Table 4. Potential of hydrogen (pH) and electrical conductivity (EC) of the Altech Crop Science nutriente solution, in concentration of 11,25 mL for 90 L^{-1} of water, used in the cultivation of sweet potato (*Ipomoea batatas*) in na aeroponic system for 30 days, State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019 [1]

Parameter	Average of the samples	Ideal[1]
pH	7,5	5,0 a 7,3
EC	0,2	1,5 a 2,5 dS m^{-1}

1According to Tunio et al. (2020) for the prodcution of potatoes in aeroponics.

Table 5. Characteristics of the sweet potato (*Ipomoea batatas*) genotypes cultivated for 45 days in an aeroponic system, with the Hoagland & Arnon (1950) nutrient solution, in concentration of 0,5%, State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019[1]

Genotype	Alieve seedlings (%)	Average length of the roots (cm)	Maximum number of leaves	Maximum length of the leaves (cm)	Maximum width of the leaves (cm)
BD-1	67	8,2	08	7,3	8,0
BD-15	67	5,2	02	5,7	6,9
BD-16	08	7,8	04	4,2	5,0
BRS-Cuia™	42	3,0	03	4,0	5,5
Beauregard™	17	5,5	02	4,1	3,9

[1]There was no statistical analysis due to the fact some of the genotypes had few alive seedlings, reducing the degrees of freedom below the 10 that are acceptable (Banzatto & Kronka, 2006).

Table 6. Potential of hydrogen (pH) and electrical conductivity (EC) in the complete Hoagland & Arnon (1950) nutrient solution, in concentration of 0,5%, used for the cultivation of sweet potato (*Ipomoea batatas*) in aeroponic system for 45 days, State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019[1]

Parameter	Average of the samples	Ideal[1]
pH	7,1	5,0 a 7,3
CE	0,2	1,5 a 2,5 dS m^{-1}

1 According to Tunio et al. (2020) for the prodcution of potatoes in aeroponics.

Figure 1. Aeroponic system prototype with one seedling of genotype BD-9 and one seedling of genotype BD-16 of sweet potato (*Ipomoea batatas*), State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019

1 Iron structure;
2 Iron net on the surface of the system;
3 Nutrient solution reservatory and water pump;
4 PVC pipes responsible for the transportation of the nutrient solution to the sprinkler tips;
5 Sprinkler tips;
6 Plastic plates that helped the nutrient solution go back to the reservatory.

Figure 2. Schematic drawing of aeroponic system used for the production of seed sweet potato (*Ipomoea batatas*), State University of Ponta Grossa (UEPG), Paraná – Brazil, 2019.

At this stage, the aeroponic system was put again at an area of automatic irrigation in the greenhouse, since the chlorosis of the leaves at the first stage was also assigned to the low water supply, because it was only being provided via roots. In parallel to the production of seedlings in glasses with substrate, seedlings from the same genotypes were put in water, so that after developing small roots they would be transferred to the aeroponic system. There were used plastic glasses (Cristalcopo) of 0,18L™ as the recipients with the water used for the seedling's development. After accommodating the seedlings without substrate at the aeroponic system, the concentration of Supermagro™ was decreased from 10% to 1%, due to the belief that this concentration was the cause of seedlings death on the first test. The applications of the biofertilizer were made the same form as in the first stage. This experiment came to its end after 12 days, when it was possible to verify that the seedlings without substrate did not survive the biofertilizer applications. The seedlings with substrate, even showing chlorosis on the leaves and roots darkening, survived. It became evident that the presence of soil was one of the reasons the seedlings were able to survive a longer time. It was not possible to do statistical analysis with the seedlings because many of them were dead by the end of the test, and the ones which survived did not show good characteristics of leaves and roots development.

Third test - structure alteration, aeroponic system automation and nutrient solution substitution: For this stage an iron structure (Fortte™) measuring 1,60 m x 0,50 m x 1,50 m and an iron net surface (Fenix™) of 0,04 m x 0,04 m x 0,04 m, was built by the UEPG locksmith. The iron structure was painted with synthetic enamel paint with white color, Suvinil™, to avoid rusting. The structure was covered with polypropylene, with one white side and one black side (De Paiva™). For presenting higher density than the previous one (200µm) this plastic elevated the maintenance of humidity and darkness in the aeroponic system, in comparison with the previous tests. Under the plastic were placed plastic plates which helped the return of the solution to the 90 L reservatory (Plasnew™). The reservatory was also covered with plastic to avoid the loss of solution to the external environment, as well as the entrance of organisms and light energy which could alternate the nutrient solution composition. The aeroponic system was automated by an Arduino Uno™ board, responsible for triggering a submerged Marcote ¾" water pump HB™. This water pump was placed in a plastic reservatory with a capacity of 90 L, with dark color to minimize the possibility of chemical reactions. A dark colored reservatory was used to avoid the entrance of clarity that could alternate the nutrient solution. The nutrient solution was transported through polyvinyl chloride pipes (PVC) Amanco™, to sprinkler tips in a wooden structure under the surface net, aiming the nebulization of solution directly at the seedling roots. The sprinkler tips are from Jacto™, JHC-8002, which have empty cone shaped nebulization, with pressure of 310kPa and flow rate of 0,8 L min^{-1}. A schematic drawing of the aeroponic system can be found at Figure 2.

At this stage a return path was developed in the aeroponic system which allowed the application of nutrient solution in an automatic form. The nebulization was programmed with intervals of 5 minutes off and 1 minute on, according to Villordon (2016), Oteng-Darko (2017) and Sharma (2018). For this test the nutrient solution Altech Crop Science™ was chosen, for being used in aeroponics and the researchers aimed to observe the results in the seedlings when using this nutrient solution in an aeroponic system close to the ideal. The concentration was 150 mL of the nutrient solution for $100L^{-1}$ of water. For the achievement of this stage of the 12 seedlings of the BD-16 genotype were produced, each were 12 centimeters long. It was selected the apex of the branches in the vases of sweet potato located at the greenhouse of UEPG for producing the seedlings. The cut in the parent plant, as well as the cut in the mature leaves, was made with scissors (Mundial™ 160/8N), remaining only the little leaves at the apex. After the seedlings were made, they were placed in an aeroponic system without the process of developing roots in water and soil. The support of seedlings on the table was made possible by the usage of plastic clip, brand Plastibrasil™, in a way where the roots were exposed to the air inside the aeroponic structure and the aerial part of the seedlings was exposed to the external environment. As the aeroponic system worked there was the wilting of the seedlings and the darkening of the roots. The researchers attributed these facts to the nutrient solution, which concentration was then adjusted to 90 mL to 100 L^{-1} of water. There were used 12 new seedlings of the genotype BD-16, since the ones from the previous experiment have died. After seven days the roots of the seedlings showed total darkening and were again discarded. Because the plants showed the same result as the previous stage, it was supposed that the answer obtained by the seedlings was due to the concentration of the nutrient solution. Therefore, it was decided to dilute the nutrient solution to the concentration of 45 mL to 90^{-1} of water. At this stage it was decided that the experiment should be expanded, then 12 seedlings from other four different genotypes were added: BD-1, BD-15, Beauregard™ and BRS Cuia™. Three days after the roots of the seedlings started receiving the nutrient solution in the planned concentration for this stage it was possible to notice their darkening, so that it was decided to interrupt the usage of this concentration and

it was opted to reduce the concentration to 22,5 mL to 90 L^{-1} of water. To avoid the discard of the seedlings it was made cuts of two centimeters at the end of them, this manner it was possible to continue using the same seedlings. It was unsuccessful one more time, then it was decided to change the concentration of the nutrient solution once more, now to 11,25 mL to 90^{-1} L of water. The seedlings were better adapted to this concentration for the first 15 days of the experiment, because they developed bigger and more complex roots, including adventitious roots, which in perfect conditions modified themselves into tuberous roots. However, from the 15th day the seedlings started to lose their leaves. Nevertheless, it was possible to evaluate characteristics of the sweet potato plants by the 30th day of the experiment. The evaluated variables were: percentage of alive seedlings, average length of the roots, maximum number of leaves, length and width of the leaves (Table 3). The evaluations were assisted by the digital pachymeter Digimess 100.174BL™ . It was not possible to do statistical analysis because some genotypes had few alive seedlings, reducing the degree-of-freedom below 10 (Banzatto & Kronka, 2006). The genotype Beauregard™ was the one with the better results related to percentage of alive seedlings by the end of this stage, while the genotype BRS Cuia™ was the one with lower percentage of surviving seedlings. According to the average length of the roots the BD-15 genotype was the one with the best results, and the BD-16 was the one with the worst. About leaves, the BD-1 genotype was the one with better results in number and dimensions. According to Huaman (1992) the leaves of all the genotypes used in this research are classified as medium size (8-15 cm), however this experiment showed inferior results. This may be a result of the densification of the culture (EMBRAPA, 1995). When it was found the best concentration of the nutrient solution tested, it was measured pH and EC of this solution, with samples of 0,1 L collected every three days (total of 10 samples) and taken to the Water Resources Laboratory of State University of Ponta Grossa (LPRH / UEPG). The results (Table 4) express that the pH is above the ideal and EC below the reference values established by Calori *et al* (2017) and Tunio *et al*. (2020) for the production of potatoes in aeroponics. Despite adventitious roots being observed, and knowing that in perfect conditions they would modify themselves into tuberous roots, it was not possible to see this process. This way, the researchers decided th*et al*terations in the nutrient solution should be done. Another important fact observed at this stage was that the seedlings were suffering from strangulation due to the usage of the plastic clips responsible for supporting the seedling in the aeroponic system, therefore the substitution by steel wire and plastic (Monaliza™) was decided for next experiments.

Fourth test - Nutrient solution replacement: At this stage the researchers decided to replace the nutrient solution by the one suggested by Hoagland & Arnon (1950). This decision happened because the Hoagland & Arnon nutrient solution is widely used in hydroponic and aeroponic studies with different cultures (Hassanpanah *et al*., 2014). The solution was prepared *et al*ma / UEPG. It was chosen to use the concentration of 0,5% according to studies of Villordon (2016). It used the same genotypes, repetitions and evaluations from the previous test. This stage was 45 days long, and then the variables were analyzed. Genotype BD-1 had better result in all the evaluated variables (Table 5). This genotype and BD-15 genotype had presented the same percentage of alive seedlings at the end of the third test, however there was a reduce of this percentage to the genotypes BD-16 and Beauregard™ with the usage of the complete nutrient solution of Hoagland & Arnon (1950). The only genotype with a higher percentage of surviving seedlings, when comparing third and fourth tests, was the BRS Cuia™. It is important to highlight th*et al*l the genotypes showed increasing in average length when using the complete nutrient solution of Hoagland & Arnon. Genotypes BD-16 and BD-1 had an increase of 6,0 and 5,9 centimeters, respectively, in their roots' average length when using the complete nutrient solution. In relation to the maximum number of leaves observed only genotype BD-1 did not show decline when compared to the results while using the commercial nutrient solution Altech Crop Science™, having the same results for both nutrient solutions. It is important to stress that even producing less leaves per seedling, these were alive for a longer time than when using the commercial nutrient solution. About the size of the leaves, the genotype BD-16 was the one with better results, making it possible to observe leaves with higher length and width when comparing with the ones developed while the seedling received commercial nutrient solution. Beauregard™ had a decrease in length, but an increase of width of the leaf. The same method from stage three for chemical analysis of the nutrient solution was repeated at this stage. The analysis of the nutrient solution evidenced that the pH was closer to the ideal. Although, the EC remained below the ideal values proposed by Calori *et al*. (2017) and Tunio *et al*. (2020) for the production of potatoes in aeroponics (Table 6). This was attributed to the fact the developed roots did not increase in diameter or changed its color, indicating the differentiation into storage roots. Thus, even surviving for a longer time and with longer roots, it was not possible to achieve storage roots with sweet potatoes, as it is consolidated in potatoes (Buckseth *et al*., 2016).

CONCLUSION

It was concluded that the structure developed for the production of sweet potatoes in aeroponics corresponds to the needs of the culture. The complete nutrient solution of Hoagland & Arnon (1950) was more efficient, with necessary adjustments to the local conditions and cultivars.

REFERENCES

ACUÑA, E., CANCINO, J., RUBILAR, R; PARRA, C. Bioethanol potential from high density short rotation woody crops on marginal lands in central chile. Cerne, 23(1), 133-145, 2017, https://doi.org/10.1590/01047760201723012278.

BANZATTO, D.A., KRONKA, S.N. Experimentação Agrícola. Jaboticabal: FUNEP, 2006. 237p.

BUCKSETH, T., SHARMA, A.K., PANDEY, K.K., SINGH, B.P., MUTHURAJ, R. Methods of pre-basic seed potato production with special reference to aeroponics — A review. Scientia Horticulturae, 204(1), 79-87, 2016, https://doi.org/10.1016/j.scienta.2016.03.041.

BÜHRING, G.M.B., SILVEIRA, V.C.P. Biogas originated from residual biomass in ecosystem services. Revista Ambiente & Água, 13(4), e2214, 2018, http://dx.doi.org/10.4136/ambi-agua.2214.

CALORI, A.H., FACTOR, T.L., FELTRAN, J.C., WATANABE, E.Y., MORAES, C.C., PURQUERIO, L.F.V. Electrical conductivity of the nutrient solution and plant density in aeroponic production of seed potato under tropical conditions (winter/spring). Bragantia, 76(1), 23-32, 2017, https://doi.org/10.1590/1678-4499.022

CASTRO, M.T., SOUZA, M.G., CASTRO, A.O. Renewable energy: wind energy, its effects and environmental gains. Journal of Engineering and Technology for Industrial Applications, 5(19), 103-108, 2019,https://dx.doi.org/10.5935/2447-0228.20190056.

CREUTZIG, F., RAVINDRANATH, N.H., BERNDE, G., BOLWIG, S., BRIGHT, R., CHERUBINI, F., CHUM, H., CORBERA, E., DELUCCHI, M., FAAIJ, A., FARGIONE, J., HABERL, H., HEATH, G., LUCON, O., PLEVIN, R., POPP, A., ROBLEDO-ABAD, C., ROSE, S., SMITH, P., STROMMAN, A., SUH, S., MASERA, O. Bionergy and climate change mitigation: an assessment. Global Change Biology Bionergy, 7(1), 916-944, 2015, https://doi.org/10.1111/gcbb.12205.

EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária. A cultura da batata-doce.Centro Nacional Pesquisa de Hortaliças. Brasília: EMBRAPA-SPI, 1995, 94 p.

HASSANPANAH, D.S., HOSSEINZADEH, A.A., SOHELI, B., ALLAHYARI, N., MOHAMMADI, R. Evaluation of the nutrient solutions effects on minitubers production of potato promising clones under Aeroponic system. Roma: FAO, 2014, 64p.

HOAGLAND, D. R., ARNON, D.I. The water culture method for growing plants without soils. Berkeley: California Agricultural Experimental Station, 1950, 347p.

HUAMAN, Z. Systematic Botany and Morphology of the Sweetpotato Plant. Lima: International Potato Center, 1992, 22p.

IAPAR - Instituto Agronômico do Paraná. Atlas climático do Paraná. Available in: http://www.iapar.br/modules/conteudo/conteudo.php?conteudo=677. Accessed on: March 15, 2019.

KANG, B., HAN, S. Production of speed potato *(Solanum tuberosum* L.) under the recycling capillary culture system using controlled release fertilizers. Journal of the Japanese Society for Horticultural Science, 74(1), 295-299, 2005, https://doi.org/10.2503/jjshs.74.295.

LOMMEN, W.J.M; STRUIK, P.C. Production of potato minitubers by repeated harvesting: effects of crop husbandry on yield parameters. Potato Research, 35(1), 419-432, 1992.

MAINO, S.C., SEABRA JÚNIOR, E., DAL POZZO, D.M., SANTOS, R.F., SIQUEIRA, J.A.C. Batata-doce (*Ipomoea batatas*) dentro do contexto de culturas energéticas, uma revisão. Revista Brasileira de Energias Renováveis, 8(4), 629-638, 2019, http://dx.doi.org/10.5380/rber.v8i4.65754.

MAPA - Ministério da Agricultura, Pecuária e Abastecimento. Preparo do biofertilizante Supermagro™.MAPA: Brasília, 2016. 2p.

NEDUNCHEZHIYAN, M., BYJU, G., JATA, S.K. Sweet Potato Agronomy. Fruit, Vegetable and Cereal Science and Biotechnology, 6(1), 1-10, 2012.

ONTENG-DARKO, P. KYEI-BAFFOUR, N., OTOO, E., AGYARE, W. Growing seed yams in the air: the agronomic performance of two aeroponics systems developed in Ghana. Sustainable Agriculture Research, 6(3), 106-116, 2017, http://dx.doi.org/10.5539/sar.v6n3p106.

OTAZU, V. Manual on quality seed potato production using aeroponics. Lima: International Potato Center, 2010. 45p.

SANEPAR - Companhia de Saneamento do Paraná. Análise da qualidade da água.Available in: http://site.sanepar.com.br/agua/analise-da-qualidade-da-agua. Accessed on: 25 November 2019.

SHARMA, U., BARUPAL, M., SHEKHAWAT, N.S., KATARIA, V. Aeroponics for propagation of horticultural plants: an approach for vertical farming. Horticulture International Journal, 2(6), 443-444, 2018,http://dx.doi.org/10.15406/hij.2018.02.00093.

SILVEIRA, M.A., SOUZA, F.R., ALVIM, T.C., DIAS, L.E., SANTANA, W.R., VITA, M.K.G., GOUVÊA, G.R.S.R., COSTA, D.M. A cultura da batata – doce como fonte de matéria prima para produção de etanol.Boletim Técnico. Palmas: UFT, 2015, 44p.

TESSEMA, L., CHINDI, A., GEBREMEDHIN, W.G., SOLOMON, A., SHUNKA, E., SEID, E. Determination of nutrient solutions for potato (*Solanum tuberosum* L.) seed production under aeroponics production system. Open Agriculture, 2(1), 155-159, 2017. https://doi.org/10.1515/opag-2017-0015.

TUNIO, M.H., GAO, J., SHAIKH, S.A., LAKHIAR, I.A., QURESHI, W.A., SOLANGI, K.A., CHANDIO, F.A. Potato production in aeroponics: an emerging food growing system in sustainable agriculture for food security. Chilean Journal of Agricultural Research, 80(1), 118-132, 2020, https://dx.doi.org/10.4067/S0718-58392020000100118.

WOOTTON-BEARD, P. Producing fodder crops using hydroponics. Aberystwyth: Farming Connect, 2019, 9p.

VILLORDON, A. Revealing the hidden half: development of a low-cost aeroponics growth system as a tool for sweet potato root research. Baton Rouge: LSU College of Agriculture, 2016. Available in: https://www.lsuagcenter.com/profiles/ lbenedict/articles/ page1469558759243. Accessed on: July 8, 2020.

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