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Effect of Substrates and Container Volume on the Initial Growth of Seedling of *Physalis peruviana* L

Jeniffer Ribeiro de Oliveira[1*], Weslley do Rosário Santana[1], Jalille Amim Altoé[1], Joabe Martins de Souza[1], André Caiô Cavalcante[1], Gleison Oliosi[1] and Gabriel Barbosa da Cruz[1]

[1]*Federal University of Espírito Santo, Campus São Mateus, Espírito Santo, Brasil.*

Authors' contributions

This work was carried out in collaboration among all authors. Author JRO prepared the practical and written work. Author WRS wrote the manuscript and reviewed the literature and counted on the collaboration of authors JAA and JMS to write the manuscript and review the literature. Authors ACC, GO and GBC collaborated in the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

The production of *Physalis peruviana* L. in semi-tropical and tropical regions is an alternative. for medium and small farmers. However technical information aspects like seedling adaption, cultivation and production need attention. Thus, the objective of this work was to evaluate the effect of different substrates and container volume in the initial growth of *Physalis peruviana* L. seedlings. The work was conducted from September to November, 2019, in a greenhouse located at Fazenda Experimental of the Federal University of Espírito Santo. The experiment was conducted in completely randomised design with 6 treatment combinations I.e. (R1 = container with volume of 50 cm^3; R2 = container with volume of 280 cm^3; and R3 = plastic cup with volume of 500 cm^3) and two substrates (S1 = Bioplant® and S2 = Provaso® + soil 1:1) and was replicated four times. After 60 days of experiment, the results demonstrated that the treatment composed by a container with volume of 500 cm^3 + substrate Provaso® + soil provided a better seedlings growth and quality.

**Corresponding author: E-mail: jeniffer.jr1994@gmail.com;*

Keywords: Containers; substrates; physalis; seedling quality; vegetative propagation.

1. INTRODUCTION

The genus Physalis contains several species of edible fruit with a sour and sweet taste [1]. Studies with populations of three different species (*P. acutifolia*, *P. chenopodifolia* and *P. pubescens*) indifferent that 78% of the species have agronomic potential, producing about 9.9 to 18.5 t ha^{-1}. This reveals the possibility that a wild resource with excellent nutritional properties can contribute to human nutrition [2].

Physalis peruviana L. is a fruit vegetable with high market added value, which stands out for its low production cost, making it accessible to small and medium producers, since cultivation in small areas allows high returns [3]. Having its center of origin in Andean countries, especially Colombia, Peru and Ecuador, its cultivation has expanded in tropical regions of America, emphasizing the commercialization of fresh and processed fruits [4].

The production of seedlings is one of the primordial steps for the adequate development of the crop, since physalis reproduce mainly in a protected environment [4]. However, to obtain quality seedlings, the size of the pool and the type of substrate are the first aspects required to be studied not only for volume available for root development but also for getting information regarding nutritional status of the plants [5]. The size of the pool is related to the quality of the seedlings, with larger containers favoring the development of the root system, but it increases the cost of production and the price of the seedlings, as it demands a greater amount of substrate and use of labor [6].

The physical characteristics and areas of the substrate offer optimal conditions for good seed germination and promote the development of seedlings with maximum potential [7]. The emergence and initial growth are favored by good aeration, structure and water retention capacity, nutritional status, absence of infestation of pests, diseases and pathogens of the substrate [8].

As it is a relatively recent crop in the country and highly innovative in the state of Espírito Santo, technical information on the cultivation of Physalis is scarce, with most of the management (seedling production, staking, fertilization, herbicides and irrigation) carried out according to the tomato culture, as they belong to the same family. However, this lack of information makes it difficult for producers to make the decision to implant the crop. Therefore, there is a need for research that will define the correct production management of Physalis. In this context, the objective of this work was to evaluate the effect of different container volumes combined with different substrates on the initial growth of *Physalis peruviana* L. seedlings.

2. MATERIALS AND METHODS

The work was carried out during the months of September of November 2019, in a greenhouse located at the Experimental Farm, at the Federal University of Espírito Santo, Campus of the Centro Universitário Norte do Espírito Santo (CEUNES).

A good quality fruit of the species were arranged, pulped and the extracted seeds were immediately packed on paper thereafter and kept in the laboratory, at room temperature for 24 hours, in order to eliminate the excess of moisture. Seeds were stored in the Kraft® paper bag upto the time of sowing. Sowing was carried out in a greenhouse with temperature and humidity controlled at 28°C ± 2°C and 75 ± 5%, respectively. A completely randomized design was used, in a factorial scheme with the combination of three containers (R1 = tube with a volume of 50 cm^3; R2 = tube with a volume of 280 cm^3 and R3 = plastic cups with a volume of 500 cm^3) and two substrates (S1 = Bioplant® and S2 = Provaso® + soil in a 1:1 ratio) totaling six treatments, four replications, six plants per experimental unit and 144 plants as a whole. The soil used was taken from the Experimental Farm of the Federal University of Espírito Santo. The Provaso® substrate is composed of sugarcane bagasse, peat, limestone, class A agroindustrial organic waste, manure and poultry beds, ash and vegetable cake. The Bioplant® substrate is formed by sphagnum peat, coconut fiber, rice husk in a pineapple seed, vermiculite and nutrients. Sowing was carried out on September 24, 2019, with two seeds sown per preparation at a depth of approximately 2 cm.

After germination, the plants were thinned, leaving only the most vigorous per pool. Manual weeding was performed daily. The irrigation system adopted in the experiment was the sprinkler, being carried out three times a day for six minutes each. No insect pest attack except white fly was observed during experimental time which were controlled by using insecticide LannateBR® + Agral in the dosage of 1 mL L-1 of water.

The variables analyzed includes number of leaves (NF), shoot length (CPA), stem diameter (DC), shoot dry matter (MSPA), root dry matter (MSR), total dry matter (MST) and Dickson's quality index (IQD) [9], through the equation MST(CPA/DC) + (MSPA/MSR). The variables number of leaves and height of aerial part were at the interval of 28, 35 and 42 days after sowing and the variable diameter of the collection evaluated 45 days after sowing.

The experiment was concluded in 60 days by removing seedling from the containers and separating aerial part from root and were kept in separate paper bags. Roots were washed thoroughly to remove any attached substrate. The moisture were removed by paper towel before placing it in Kraft® paper bags. The paper bags were finally kept in oven at 60 ± 5°C, for a period of 72 hours. After this period, the samples were removed from the greenhouse and weighed on an electronic analytical balance and the results expressed in grams [10].

The collected data were analysed by using software [11]. With the aid of the data package ExpDes.pt version 1.2 [12], the averages were compared using the Tukey test at the level of 1% probability.

3. RESULTS AND DISCUSSION

There was a significant interaction between the factors container volume and type of substrate for the variable number of leaves (Table 1), with no statistical difference only between substrates associated with the tube with a volume of 50 cm^3. The treatments with higher volume associate with Provaso® + soil performed relatively better than other. The performance of container were recorded in the order of 500 cm^3 > 280 cm^3 > 50 cm^3. This result is probably due to the greater space provided by the larger containers. The use of a larger container allows better root formation, allowing seedlings to better exploit the volume of substrate available and, consequently, greater absorption of water and nutrients [13]. In addition, the Bioplant® substrate has coconut fiber as its basic composition, which may have led to a loss of water, impairing the evaluated parameters, in addition to the low supply of nutrients. According to [14], the availability of water in the substrate is essential for survival and, consequently, the formation of seedlings from vegetative or seed propagation.

Table 1. Number of leaves of *Physalis peruviana* L. seedlings grown in different substrates and container volume

	Substrates	
Containers	Bioplant®	Provaso® + solo
50 cm^3	6,66 cA	7,08 cA
280 cm^3	8,45 bB	10,87 bA
500 cm^3	9,91 aB	12,12 aA
CV (%)	3,78	

Means followed by equal letters, uppercase in the lines and lowercase in the columns, do not differ from each other by Tukey test at 5% probability

There was also a significant difference between the factors for the variable length of the aerial part (Table 2). The treatments formed by the volume of 280 cm^3 + Provaso® + soil and volume of 500 cm^3 + Provaso® + soil were the best results for this analyzed characteristic.

Table 2. Aerial part length (cm) of *Physalis peruviana* L. seedlings grown in different substrates and container volumes

	Substrates	
Containers	Bioplant®	Provaso® + solo
50 cm^3	3,64 cB	5,22 cA
280 cm^3	6,62 bB	11,18 bA
500 cm^3	10,95 aB	15,16 aA
CV (%)	9,23	

Means followed by equal letters, uppercase in the lines and lowercase in the columns, do not differ from each other by Tukey test at 5% probability

In agreement with the present study, in an experiment carried out to produce *Physalis peruviana* L. seedlings in different substrates and containers, [15] found that the highest plant height occurred in the volume of the largest pool (400 cm^3). The lower height of plants grown in the 50 cm^3 pool is probably due to the lower volume of substrate, due to the limited space available, restricting the expansion of the root system, resulting in low availability of nutrients, hindering the development of the plant.

[16], when analysed the effect of the mixture of various substrates on the emergence and initial development of açaí seedlings, they found that the soil + Provaso® mixture was the one that provided the best shoot length result,

corroborating with the results found in this experiment.

As shown in Table 3, there was also a significant interaction between the factors of container volume and type of substrate for the aerial part dry matter variable. Significant difference was observed in both substrate and container, with the exception of treatments with a volume of 50 cm^3, which showed no difference between substrate, as well as between the volumes of 50 and 280 cm^3 for the Bioplant® substrate. The best results demonstrated were observed in the treatments containing the largest volumes and both substrates (volume of 500 cm^3 + Bioplant® and 500 cm^3 + Provaso® + soil).

Table 3. Aerial part dry matter of *Physalis peruviana* L. seedlings grown in different substrates and container volume

	Substrates	
Containers	Bioplant®	Provaso® + solo
50 cm^3	0,08 bA	0,13 cA
280 cm^3	0,19 bB	0,40 bA
500 cm^3	0,44 aB	0,78 aA
CV (%)	3,78	

Means followed by equal letters, uppercase in the lines and lowercase in the columns, do not differ from each other by Tukey test at 5% probability

The highest dry matter values of aerial part were found in the largest seedlings produced in the largest container. As with the other variables, the lowest values were shown by the seedlings produced in the smallest volume container, with the Provaso® substrate standing out again in relation to Bioplant®. These results may be related to the greater availability of nutrients in this substrate, associated with the greater space provided by the container. The availability of nutrients and organic matter from the substrate to the plant is considered essential to its development, as it is linked to the formation of carbon skeletons, enabling the accumulation of plant biomass [17].

The lower accumulation of phytomass or plant material can be explained by the fact that very small containers posses only small amounts of substrates, limiting the supply of nutrients and, consequently, causes the depletion of plant reserves in a short time [18]. Our results were also in line with these findings for most of the variable analysed. These results demonstrate that the substrate and the container exert great influence both in the formation of the root system and in the architecture of the aerial part.

Similarly in case of castor seedling while using different containers of 50, 120 and 180 cm^3 and plastic bags of 500 cm^3, the highest weight of shoot dry matter was observed in the 500 cm^3 container [19]. The larger capacity container provided a greater volume of soil to be explored by the root system, increasing the absorption of water and nutrients, the rate of photosynthesis, providing greater production of photoassimilates, resulting in greater development of the aerial part.

There was no significant interaction between the factors of container volume and type of substrate for the variables stem diameter, root dry matter, total dry matter and Dickson's quality index (Table 4), however, there is a significant difference in these variables when one container is compared to another, agreeing with previous results that demonstrate that the larger the container, the better the seedling response.

The seedling grown in 50 cm^3 witnesses smaller diameter, height and lesser number of leaves. It hinders the root system, and results in shortage of availability of water and nutrients and, consequently, causes reductions in plant growth. Containers with greater volume, on the other hand, can accelerate development, in addition to allowing these plants to remain in the nursery for longer. Similar behavior was observed by [20], studying the effect of substrates and containers on the growth of passion fruit seedlings.

Work carried out by [21], evaluating the quality of organic cucumber seedlings by combining different substrates and containers, found that the dry matter values of root, aerial part and total had an increase proportional to the volume of the container, the larger the container, the higher the values of the variables.

The best seedling quality indexes were obtained in the largest volume container, as shown in the previous table and in the Provaso® + soil substrate, and attested in Table 5. The superior quality of seedlings produced with the Provaso® substrate may be related to the fact that the benefits provided by its components, which favor soil drainage and aeration, increase nutrient levels and attenuate soil compaction and erosion [16].

Table 4. Stem diameter (DC), root dry matter (MSR), total dry matter (MST) and Dickson quality index (IQD*)*

Containers	DC	MSR	MST	IQD
50 cm^3	1,94 c	0,06 c	0,16 c	0,04 c
280 cm^3	2,88 b	0,21 b	0,50 b	0,11 b
500 cm^3	3,61 a	0,38 a	0,98 a	0,19 a
CV (%)	12,41	37,21	27,87	21,89

Means followed by equal letter in the columns do not differ from each other by Tukey test at 5% probability

Table 5. Stem diameter (DC), root dry matter (MSR), total dry matter (MST) and Dickson quality index (IQD) of *Physalis peruviana* L. seedlings according to the type of substrate

Substrates	DC	MSR	MST	IQD
Bioplant®	2,41 b	0,17 b	0,41 b	0,09 b
Provaso® + solo	2,88 a	0,21 a	0,50 a	0,11 a
CV (%)	12,41	37,21	27,87	21,89

Means followed by equal letter in the columns do not differ from each other by Tukey test at 5% probability

[22] reported that the chicken litter, a component present in Provaso®, proved to be a chemically active organic source, composing a good substrate whenever associated with a material that provides good physical characteristics, such as vegetable cake (castor, cotton, etc.), a compound obtained from the natural decomposition of organic matter sources and which is also present in the Provaso® substrate.

[23] explain that Dickson's quality index is an indicator of seedling quality, which integrates the vigor and balance of the phytomass distribution. The inferior quality of the seedlings in the smaller volume container associated with Bioplant substrate, can be explained as a result of the moment in which the substrate is placed in a limited space, influencing the development of the seedlings, root system architecture and biological associations seedlings with the medium, being related to the translocation of water in the plant-soil-atmosphere system [17].

As observed in this work, [15] in his experiment with physalis, evaluating different substrates and containers, found that the highest seedling quality index was in the largest volume container, associated with manure-based substrates, which are components that promote an increase in organic matter and nutrients, effects similar to that provided by the substrate Provaso® + soil, which promoted the highest quality index of Dickson in the present work.

The variables stem diameter, root dry matter and total dry matter also showed the highest averages for the substrate Provaso® + soil. A result similar to that found by [24] who, when analyzing the initial development of *Physalis peruviana* L. seedlings in different substrates (Solo, Provaso® and Bioplant®), observed the best averages for the Provaso® substrate.

In the present study, it was evident that for all the variables studied, the Provaso® + soil substrate and the container with a volume of 500 cm^3 stood out among the others, both associated and analyzed separately. The results of current study indicates that not only selection of substrate is important for successful cultivation of this crop but selection of suitable size of container is also equally important as it will helps in seedling development and facilitates its management.

4. CONCLUSION

The treatment consisting of a volume of 500 cm^3 + Provaso® + soil was what provided the best growth and quality of seedlings.

However, to find the ideal volume for the growth of physalis seedling, additional research is needed where containers with volumes greater than 500 cm^3 can be tested in order to standardize the size of container.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Vargas-Ponce O, Martinez JS, Tavares MPZ, Mares LEV. Traditional management of a small-scale crop of *Physalis angulata* in Western Mexico. Genetic Resources and Crop Evolution. 2018;63(8):1383-1395.
Available:https://doi.org/10.1007/s10722-015-0326-3
2. Mares LEV, Zagaroza FAR, Gonzáles JJSV, Vargas-ponce O. Phenology, agronomic and nutritional potential of three wild husktomato species (Physalis, Solanaceae) from Mexico. Scientia Horticulturae. 2016;20:83-94.
Available:https://doi.org/10.1016/j.scienta.2016.01.005
3. Lima CSM, Gonçalves MA, Tomaz ZFO, Rufato AR, Fachinello JC. Staking systems and Physalis transplant times. Ciência Rural. 2010;40(12):2472-2479.
Available:http://dx.doi.org/10.1590/S0103-84782010001200006
4. Mezzalira EJ, Villa F, Piva AL, Santin A, Melgarejo MA. Initial development of physalis species under growing environments. Revista de Ciências Agroveterinárias. 2017;16(3):293-301.
Available:https://pdfs.semanticscholar.org/8feb/3d175f90fe95f7a18172f3872177d47f83c4.pdf
5. Barbosa CKR, Valadares SV, Bomfim FPG, Honório ICG, Martins ER. Influence of substrate and cell size of expanded polystyrene trays on seedling development and marigold production (*Calendula officinallis* L.). Revista Brasileira de Plantas Medicinais. 2010;12(1):18-22.
Available:http://dx.doi.org/10.1590/S1516-05722010000100004
6. Zaccheo PVC, Aguiar RS, Stenzel NMC, Neves CSVJ. Container size and seedling formation time in the development and production of yellow passion fruit. Revista Brasileira de Fruticultura. 2013;35(2):603-607.
Available:http://dx.doi.org/10.1590/S0100-29452013000201032
7. Minami K, Salvador D. Substrato para mudas. Piracicaba: USP/ESALQ. 2010; 209.
8. Kuhn PR, Kulczynski SM, Bellé C, Koch F, Werner CJ. Production of fisalis seedlings (*Physalis peruviana* L.) from seeds of green and ripe fruits submitted to different substrates. Enciclopédia Biosfera. 2012; 8(15):1378-1385.
Available:http://www.conhecer.org.br/enciclop/2012b/ciencias%20agrarias/producao%20de%20mudas.pdf
9. Dickson A, Leaf AL, Hosner, JF. Quality appraisal of white spruce and white pine seedling stock in nurseries. Forest Chronicle. 1960;36:10-13.
Available:https://doi.org/10.5558/tfc36010-1
10. Carvalho NM, Nacagawa J. Seeds: science, technology and production. Jaboticabal: FUNEP. 2012;590.
11. The R Development Core Team. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing; 2018.
12. Ferreira EB, Cavalcanti PP, Nogueira DA. ExpDes. pt: Experimental Designs package. R package version 1.2.0; 2018. Retrieved Sept, 11.
13. Malta AO, Oliveira, VEA, Almeida DJ, Santos AS. Growth of melon on different substrates. Revista Sítio Novo. 2017;1: 238-246.
Available:http://sitionovo.ifto.edu.br/index.php/sitionovo/article/view/82/52
14. Carvalho RP, Cruz MCM, Martins LM. Frequência de irrigação utilizando polímero hidroabsorvente na produção de mudas de maracujazeiro amarelo. Revista Brasileira de Fruticultura. 2013;35(2):67-70.
Available:http://dx.doi.org/10.1590/S0100-29452013000200022
15. Santos AS. Seed germination and seedling production of *Physalis peruviana* L. under salt stress. Thesis (Master in Tropical Horticulture) - Federal University of Campina Grande, Centro de Ciências e Tecnologia Agroalimentar, Pombal, Campina Grande; 2019.
16. Paixão MVS, Júnior HP, Hoffay ACN, Mônico AF, Oliveira EM, Grobério RBC. Povaso® fertilizer mixed with the substrate in the emergence and initial development of açaí palm seedlings. Brazilian Journal of

Animal and Environmental Research. 2019;2(3):975-981. Available:http://www.brazilianjournals.com/index.php/BJAER/article/view/1903/1917
17. Cecco RM, Klosowski ES, Silva DF, Villa F. Germination and initial growth of seedlings of unconventional physalis species in different substrates and environments. Revista de Ciências Agroveterinárias. 2018;17(1):45-53. Available:https://doi.org/10.5965/223811711712018045
18. Bandiviesso EM, Costa EB, Barcelos MN, Bandiviesso DM, Murakami LF. Growth of green eggplant on different substrates. Revista de Agricultura Neotropical. 2014; 1:15-25. Available:https://doi.org/10.32404/rean.v1i1.217
19. Andrade FR, Petter FA, Marimom JÚNIOR BH, Zuffo AM, Souza TRS, Gonçalves LGV. Formation of castor seedlings in different containers. Revista Brasileira de Ciências Agrárias. 2012;7(2):274-279. Available:https://www.redalyc.org/pdf/1190/119023684012
20. Silva WL, Brito AS, Brito CFB, Mesquita NLS, Silva YCP. Development of passion fruit in containers and substrates based on vermiculite residue. Revista Agrotecnologia. 2016;7:53-60.
21. Ferreira RLF, Araújo S, Neto SEA, Santos DCF. Quality of cucumber seedling changed by the combination of substrates and containers. Scientia Naturalis. 2019;1: 13-22. Available:https://periodicos.ufac.br/index.php/SciNat/article/view/2896
22. Lima RLS, Severino LS, Silva MIL, Vale LS, Beltrão NEM. Volume of containers and composition of substrates for the production of castor seedlings. Ciência e Agrotecnologia. 2006;30:480-486. Available:http://dx.doi.org/10.1590/S1413-70542006000300014
23. Eloy E, Caron BO, Schmidt D, Behling A, Schwers L, Elli EF. Quality evaluation of *Eucalyptus grandis* seedlings using morphological parameters. Revista Floresta. 2013;43(3):373-384. Available:http://dx.doi.org/10.5380/rf.v43i3.26809
24. Martins WP. Initial development of *Physalis peruviana* L. seedlings on different substrates. Dissertation. Northern University Center of the State of Espírito Santo, Federal University of Espírito Santo, São Mateus; 2018.

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