



## Initial Growth of *Physalis peruviana* L. Seedlings on Different Substrates

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### Authors' contributions

This work was carried out in collaboration with all authors. All authors read and approved the final manuscript.

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### ABSTRACT

The substrate is one of the most important factors in the formation of the seedling and must present conditions suitable for germination and development of the seedling root system. The objective of this work was to evaluate the effect of different substrates on the initial growth of *Physalis peruviana* L. seedlings. The experiment was conducted at the Experimental Farm, of the Federal University of Espírito Santo– São Mateus (Brazil). The experimental design used was completely randomized, with three treatments (Soil, Provaso® and Bioplant®), seven replications and seven plants per plot, using seeds with 427 days of storage. At 56 days after sowing, the 10 most vigorous seedlings were selected for evaluation. The following characteristics were evaluated: percentage of emergence, emergence speed index (ESI), mean time of emergence (MET), number of leaves (NL), stem diameter (SD), aerial part length (APL), aerial part fresh matter (APFM), aerial part dry matter (APDM), root fresh matter (RFM), root dry matter (RDM) and Dickson quality index (DQI). The Provaso® substrate showed the best performance in all studied variables, being recommended for the production of *Physalis* seedlings.

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## 1. INTRODUCTION

The *Physalis peruviana* L. species is a plant of the Solanaceae family, whose region of origin comprises the Amazon and Andes, having varieties grown in America, Europe and Asia [1]. It is a perennial shrub, with an indeterminate growth habit and 40-70 cm in height, reaching 2 meters, in case of staking. It is characterized by having fruit wrapped in a balloon-shaped cup, which protects it from attack by insects, birds, pathogens and weather conditions [2]. It is a plant adapted to a wide range of altitudinal climate, with base temperatures (minimum) for the stems (6.3°C) and fruit growth (1.9°C) being relatively low and that can be classified as a light-demanding light, requiring from 1500 to 2000 h direct sunlight year<sup>-1</sup> [3].

Currently, Colombia has the largest worldwide production of *Physalis*, exporting fruits at high prices, to several countries in the Americas, including Brazil, since Brazilian production is unable to supply the national market. This fruit is consumed in Brazil as a very expensive exotic, with a price between 20 to 90 reais per kilogram [4].

In Brazil, *Physalis* is very popular in the North and Northeast regions, however, production is still small. The high added value of the fruits, combined with the good adaptation and rusticity of the plant, makes its cultivation an excellent alternative for the small and medium Brazilian producer [2]. In Rio Grande do Sul, the introduction of the culture made it possible to increase the families' budget, since the entire plant is used, where roots and leaves are destined for medicinal use, fruits for fresh or processed consumption and the seeds used in the species propagation [2].

The propagation of *P. peruviana* L. occurs mostly through the sexual route, since they have a high percentage of germination (85-90%) [2], germinating around the 10<sup>th</sup> to the 15<sup>th</sup> day [5].

In the context of seedling production, an important issue to be considered is the substrate [6]. According to [7], the use of appropriate substrates becomes essential when it is intended to optimize the cost: benefit of production systems. According to [4], this alternative provides greater yield compared to traditional methods, as it induces precocity, less possibility

of contamination by phytopathogens, less seed expenditure, in addition to providing favorable conditions for the development of the seedling root system.

According to Lima et al. [8], one of the points of importance to be defined in the search to obtain good seedlings quality is the definition of a more suitable substrate, as this is one of the important factors in the formation of fruit species, especially *Physalis*. According to [9], the appropriate substrate must have good aeration and drainage capacity, balanced chemical and physical composition.

Thiel et al. [10] evaluated the initial development of *Physalis* seedlings submitted to different substrates and observed that the percentage of emergence, shoot length, shoot dry mass and root dry mass were higher in Plantmax® substrate, which is the best performance compared to other tested substrates. [11], when evaluating the effect of the substrate on the production of tomato seedlings, found that the mixture of Soil + sand + bovine manure and Plantmax® provided a significant increase in the rooting and development of the seedlings when compared to the use of sand.

As it is a relatively recent crop in the country and highly innovative in the state of Espírito Santo, technical information on cultivation is scarce, with this, most of the management (seedling production, staking, fertilization, herbicides and irrigation) is carried out according to the tomato culture, as they belong to the same family [12]. Therefore, the need for research to define the correct production management of *Physalis peruviana* is visible, starting with the evaluation of the best substrates for seedling production.

In this context, the objective of this work was to evaluate the effect of different substrates on the initial growth of *Physalis peruviana* L. seedlings, grown in a greenhouse in São Mateus, northern region of the state of Espírito Santo.

## 2. MATERIALS AND METHODS

The present work was conducted during the months from March to May 2018, in a greenhouse located at the Experimental Farm, at the Federal University of Espírito Santo, Campus of the North University Center of Espírito Santo (CEUNES), São Mateus, Brazil.

The greenhouse had temperature and relative humidity controlled at  $30^{\circ}\text{C} \pm 2^{\circ}\text{C}$  and  $70 \pm 5\%$ , using a Completely Randomized Design with three treatments, seven replications and seven plants per experimental unit, totaling 147 plants. The seeds were obtained from fruits of the local market. The seeds were stored for 427 days in Kraft paper and kept on a shelf at ambient temperature. Then, the seeds were sown on different substrates having  $23.0 \times 7.0$  cm polystyrene bags as containers. Two seeds were sown per bag, at a depth of 1 cm. The treatments were defined with the following substrates: Soil, constituted mainly by sand, taken from the Experimental Farm of the Federal University of Espírito Santo; Provaso substrate, produced by the company Grupo Genfertil, composed of sugarcane bagasse, peat, limestone, agro-industrial class A organic waste, manure and bedding poultry, ash and vegetable pie; and Bioplant® substrate, produced by the company Bioplant Agrícola Ltda., formed by sphagnum peat, coconut fiber, rice husks, pine husks, vermiculite and nutrients. Manual weeding was performed daily. The irrigation system adopted in the experiment was the sprinkler, being carried out three times a day for two minutes each. After germination, the plants were thinned, leaving only the most vigorous per bag. Due to the unevenness in the emergence and development of seedlings, a selection was made, at 56 days after sowing, of the 10 most vigorous seedlings of each treatment for seedling growth assessments.

The following variables were analyzed: germination percentage; emergence speed index (ESI); mean emergence time (MET); number of leaves (NL); stem diameter (SD), measured at the base of the stem, using a digital caliper; aerial part length (APL), expressed in cm, measured with a millimeter ruler, from the collection to the apical bud; aerial part fresh matter (APFM); aerial part dry matter (APDM); root fresh matter (RFM), root dry matter (RDM) and Dickson quality index (DQI).

To determine the root dry matter, the root was removed from the substrate and washed carefully, then weighed on an electronic analytical balance. To obtain the dry mass, the parts of the seedlings were placed in paper bags, of the Kraft type, properly identified and taken to dry in an oven with forced air circulation set at  $60 \pm 5^{\circ}\text{C}$ , for a period of 72 hours. After this period the samples were removed from the oven and weighed on an electronic analytical balance and

the results expressed in grams [13]. For the calculation of Dickson quality index (DQI), the [14] methodology was used, considering the height, stem diameter, aerial part dry matter, root and total dry matter (obtained by adding the aerial part dry matter with root dry matter) indicators, according to the equation:  $\text{DQI} = \text{TDM}/(\text{APL}/\text{SD}) + (\text{APDM}/\text{RDM})$ , where: TDM = total dry matter (g), APL = aerial part length (cm), DC = stem diameter (mm), MSPA = aerial part dry matter (g), and RDM = root dry matter (g).

The data obtained were submitted to analysis of variance (ANOVA), using the program SISVAR version 5.3 [15] and when the F value presented significance at the level of 5% of probability, the Tukey test was applied.

### 3. RESULTS AND DISCUSSION

Table 1 shows the results obtained by the germination test. It is noticed that there was a statistical difference between the substrates for the analyzed variables, and Provaso® conferred superior results in all of them. Provaso® and Bioplant® substrates did not differ from each other, however, Soil and Bioplant® substrate were statistically equal for the variable MET. [16] identified higher germination index values for Bioplant® treatments in the production of 'Biquinho' pepper seedlings.

In work on germination and development of cherry tomato seedlings on different substrates, [17] found no significant differences for germination percentage and MET between the substrates tested for tomato. The same was reported by [18] in *Physalis peruviana* L. in which seeds of ripe fruits had maximum emergence in substrate type peat + vermiculite (33.0%) but it was not statistically different from other studies. However, the result found by this author, was much lower, when compared to the best treatment of the present study.

Different results were found by [19] when studying the seedling production of *Solanum betaceum* cav. and *Physalis angulata* L. in different substrates, where they identified that the best percentages of physalis seed germination were in the substrates composed of Soil + pine acicule, Soil + Mecplant® commercial substrate + Carolina® commercial substrate + pine acicule and seeds of tamaril the best was Soil + Carolina® commercial substrate.

In the present study, it was observed that the maximum emergence occurred in the Provaso®

substrate and the MET in this treatment was the largest (10.65 days) of all the others evaluated (Table 1). According to [13], seeds with high MET, are more exposed to biotic and abiotic factors that can compromise their development. This exposure, in excess, to temperature and humidity can cause deterioration of the seeds due to the loss of membrane integrity, thus becoming a gateway to pathogens. Therefore, it is understood that although the Provaso® substrate provided better germination, it caused a delay in germination stabilization, exposing the seeds to adverse conditions.

By analysis of variance, a significant effect of the substrates on the production of *Physalis* seedlings was observed for all the analyzed characteristics (Tables 2 and 3). Generally speaking, it is observed that the best results of stem diameter, aerial part length, aerial part fresh matter, root fresh matter and aerial part dry matter were obtained by the substrate Provaso®. The composition of this substrate was probably adequate for the development of the seedlings, since most of the analyzed growth parameters were favorable. The average number of leaves and the APDM/ RDM ratio were numerically higher in the Provaso® substrate, however statistically equal to the Bioplant® substrate. For root dry matter variable, the highest average was obtained on the Provaso® substrate, however it was statistically equal to the Soil substrate.

These results contradict those found by [20] when they evaluated the Bioplant® substrates, black Soil + humus; black Soil + humus + coconut fiber and black Soil + filter cake + humus, in the production of lettuce seedlings, in which the best results of aerial part length, fresh and dry matter of aerial part and root were obtained from cultivation in Bioplant® substrate.

For number of leaves, the general average was 13.87, with the Provaso® and Bioplant® substrates, resulting in higher averages for the

variable, 23.60 and 10.10 leaves respectively, differing statistically from the substrate Soil with an average of 7.90 leaves (Table 2).

The effect of Soil-based substrate on the number of leaves has been reported by other authors. [21] observed lesser leaf development in the Soilsubstrate (2.0), while the Soil + organic compost and Soil + cattle manure + organic compost + earthworm humus substrates resulted in higher performance in cherry tomato seedlings.

There was a significant difference between all evaluated substrates, for the variable stem diameter (Table 2). The Provaso® substrate was superior, with an average of 5.24 mm, while the substrate Soil, provided seedlings with smaller diameters of the collection (1.96 mm). In work regarding the production of tomato seedlings cv. Santa Cruz on different substrates, [22] obtained a lower result, 1.89 mm, for the stem diameter variable, and this result occurred on the substrate with organic compost after 31 DAS.

In the aerial part length assessment, the best performance was observed for the Provaso® substrate (29.19 cm). The Soil and Bioplant® substrates did not differ statistically from each other, however, the average of Bioplant® substrate (15.89 cm) was higher than that of Soilsubstrate (12.62 cm) (Table 2). This fact was also confirmed by [18] when they evaluated *Physalis peruviana* seedlings, grown on different substrates, at 45 days after sowing, and observed the influence of the substrate on the aerial part length, with the highest value of the variable (2.31 cm) being observed in seedlings from the peat substrate, a fact similar to what occurred in the present work, since the Provaso substrate has peat in its composition. [23], studying different substrates to the germination, emergence and obtention of cape gooseberry (*Physalis peruviana* L.) seedlings, found the highest seedling height using the Brazilian coco peat substrate, with plant height of 79.14 mm.

**Table 1. Final emergence percentage, emergence speed index (ESI) and mean emergence time (MET) of *Physalis peruviana* L. seeds in different substrates**

Substrates	Emergency (%)	ESI	MET (days)
Soil	18.98a	0.44b	7.65b
Provaso®	34.79b	0.66a	10.65a
Bioplant®	31.01b	0.61a	8.48ab
CV (%)	24.76	20.05	38.96

Means followed by the same lowercase letter do not differ statistically from each other by the Tukey test at the level of 5% probability

**Table 2. Number of leaves (NL), stem diameter (SD) and aerial part length (APL) of *Physalis peruviana* L. seedlings grown on different substrates**

Substrates	NL	SD (mm)	APL (cm)
Soil	7.90 b	1.96 c	12.62 b
Provaso®	23.60 a	5.24 a	29.19 a
Bioplant®	10.10 a	3.14 b	15.89 b
CV (%)	36.09	25.16	19.87

Means followed by the same lowercase letter do not differ statistically from each other by the Tukey test at the level of 5% probability

Thiel et al. [10] evaluated the initial development of *Physalis* seedlings submitted to different substrates and reported that the average aerial part length of the plants that grew on the Plantmax® substrate was the largest among the tested substrates, while the plants that grew on fine sand presented the lowest average. According to [24] organic products provide the addition of nutrients, mainly macronutrients, which can alter the nutritional supply of the substrate, and consequently the growth and nutrition of seedlings.

According to Table 3, higher values for aerial part fresh matter and aerial part dry matter were observed in the Provaso® substrate with 15.82 and 1.61 g plant<sup>-1</sup>, respectively, differing statistically from the others. The superior result of the Provaso® substrate, possibly due to its composition, which contains poultry manure, one of the richest components in nutrients, with high levels of total nitrogen, N-ammonium and phosphorus, in addition to Ca, Mg, Mn and Zn, allowing better nutritional support for the seedlings.

The variable RDM, presented a different behavior, since the Provaso® substrate differed statistically from Bioplant® substrate, however it was similar to Soil substrate, since the Soil and Bioplant® substrate did not differ, with only difference between Provaso® and Bioplant® substrate (Table 3). According to [25] variables

such as root dry matter are likely to be positively altered by the chemical properties of the substrate. Probably, the best performance of the Provaso® substrate, verified in the present work, is related to its chemical and physical properties favorable to the initial development of plants.

For the APDM/RDM ratio, it is observed that seedlings grown on Provaso® substrate showed a higher APDM/RDM ratio (3.06), but it was statistically equal to Bioplant® substrate (2.35), differing only from the Soil substrate (0.68) (Table 3). [26] studied the influence of different substrates (Bioplant®, carbonized rice husks and coconut fiber) in the production of *Delonix regia* flamboyant seedlings (Bojer ex Hook.) Raf. and found that the treatments did not differ from each other. Results similar to that found in the present study were found by [16] when substrates with higher proportions of organic matter proved to be more efficient for the APDM/RDM ratio, in *Croton floribundus* Spreng seedlings.

By the Dickson quality index (DQI), it can be said that the seedlings formed in the Provaso® substrate present a better quality standard, considering that the average obtained in this treatment was higher and significantly different from those obtained in the other studied substrates (0.26), because the higher the DQI, the better the quality of the seedling produced [27]. The Soil (0.07) and Bioplant® (0.07)

**Table 3. Aerial part fresh matter (APFM), root fresh matter (RFM), aerial part dry matter (APDM), root dry matter (RDM), aerial part dry matter and root dry matter ratio (APDM/RDM) and dickson quality index (DQI) of *Physalis peruviana* L. seedlings grown on different substrates**

Substrates	APFM	RFM	APDM	RDM	APDM/RDM	DQI
		----- (g planta <sup>-1</sup> ) -----				
Soil	1.34 b	1.28 b	0.34 b	0.32 ab	0.68 b	0.07 b
Provaso®	15.82 a	8.09 a	1.61 a	0.57 a	3.06 a	0.26 a
Bioplant®	4.00 b	1.94 b	0.37 b	0.14 b	2.35 a	0.07 b
CV (%)	39.4	63.65	65.87	75.74	39.67	71.67

Means followed by the same lowercase letter do not differ statistically from each other by the Tukey test at the level of 5% probability

substrates did not differ from each other, however a higher average was observed in Bioplant® substrate (Table 3). [22] also showed different results due to the different substrates used in the production of tomato seedlings. The DQI values ranged from 0.0037 to 0.0073 and the substrate that showed the best DQI for tomato seedlings was organic and the treatments carbonized rice husk and carbonized rice husk + earthworm humus presented the worst, when compared other treatments.

Dickson quality index is a good indicator of seedling quality as it considers the vigor and balance of the biomass distribution in the seedling [28]. However, DQI results for the production of *Physalis* seedlings were not observed in the literature. According to [29], for seedlings to exhibit an acceptable quality standard, they must present DQI greater than 0.20.

As seen, the seeds and later the seedlings, had different behaviors in each substrate, making it possible to identify Provaso® substrate as the best among those evaluated. This result is very valuable, for producers who are interested in starting the production of the crop in the northern region of Espírito Santo, since this substrate is from the region, being easily found in agricultural products stores. Furthermore, it demonstrates the real need for studies that evaluate not only the substrate, but all the factors involved in the production of crop seedlings.

#### 4. CONCLUSION

Under the conditions studied, the Provaso® substrate is recommended for the initial growth of *Physalis peruviana* L. seedlings, as it has better performance compared to the other tested substrates. While the Soil substrate is not suitable for the production of seedlings.

#### 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.

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