Substrates and organic sources in the production of seedlings of *Physalis peruviana* L.

Sustratos y fuentes orgánicas en la producción de plántulas de *physalis peruviana* L.

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The objective was to determine the effect of commercial substrates and organic sources on the production of cape gooseberry seedlings (*Physalis peruviana* L.). The design was completely randomized, in a 2×3 factorial scheme, with two commercial substrates for the production of seedlings (Carolina®, Bioplant®) and three organic sources (control, vermicompost enriched with yoorin thermophosphate and poultry manure). Adding poultry manure to commercial substrates causes negative effects on precocity and emergence. Carolina® is a suitable substrate to produce cape gooseberry seedlings without needing supplementation with organic sources. Bioplant® behaves more like an emergence conditioner, requiring supplementation with organic sources (preferably vermicompost). Seedlings suitable for transplanting are obtainable at 47 days after sowing.
Additional key words: exotic fruit; plant propagation; Solanaceae; culture media; boron; C/N ratio.

RESUMEN
El objetivo fue determinar el efecto de los sustratos comerciales y las fuentes orgánicas en la producción de plántulas de uchuva (*Physalis peruviana* L.). El diseño fue completamente aleatorizado, en un esquema factorial de 2 x 3, con dos sustratos comerciales la producción de plántulas (Carolina®, Bioplan®) y tres fuentes orgánicas (control, vermicompost enriquecido con termofosfato yoorin y estiércol de aves de corral). Agregar estiércol de aves de corral a sustratos comerciales causa efectos negativos sobre la precocidad y la emergencia. Carolina® es un sustrato adecuado para producir plántulas de uchuva sin necesidad de suplementos con fuentes orgánicas. Bioplan® se comporta más como un acondicionador de emergencia, que requiere suplementos con fuentes orgánicas (preferiblemente vermicompost). Las plántulas adecuadas para el trasplante se pueden obtener a los 47 días después de la siembra.

Palabras clave adicionales: fruta exótica; propagación de plantas; Solanaceae; medio de cultivo; boro; relación C/N.

INTRODUCTION

*Physalis peruviana* (L.) fruit are considered exotic for their appearance, taste, medicinal properties and nutritional value (Rufato *et al*., 2008; Puente *et al*., 2011; Lima *et al*., 2013; Çakir *et al*., 2014; El-Beltagi *et al*., 2019). This fruit is commonly known as uchuva (Spanish), cape gooseberry, goldenberry or simply physalis (Muniz *et al*., 2011; Fischer *et al*., 2014).

The center of origin of *P. peruviana* is located between the Peruvian and Ecuadorian Andes (Morton and Russel, 1954). It is a perennial and semi-evergreen shrub of indeterminate growth (Fischer *et al*., 2014).

Cultivation in Colombia began in 1985 (Muniz *et al*., 2014), cape gooseberry is currently an important product in the country's export agenda, following banana (Fischer *et al*., 2014). Most of the cape gooseberry supply in Brazil is imported from Colombia, complementing production from small plantations in Santa Catarina, Rio Grande do Sul, Minas Gerais and São Paulo (Rufato *et al*., 2008; Lima *et al*., 2009; Muniz *et al*., 2011; Rodrigues *et al*., 2012; Betemps *et al*., 2014).
Cape gooseberry production in Brazil can be an excellent alternative for small and medium producers due to the high added value of the fresh fruit (98-150 R$/kg or 25.42-38.90 US$/kg) and ease of cultivation. This could transform the country from importer to exporter in a short period of time (Rufato et al., 2008).

Success in establishing new crop is comes primarily from propagation material. Cape gooseberry propagates mainly by seeds (Muniz et al., 2014; Fischer et al., 2014), which is a cheap and efficient method, since the seeds have a high and fast germination (72.50% - 7 days after sowing-DAS/82.50% - 21 DAS) (Melo et al., 2015). However, seedling obtention takes a long time, around 2 months (Miranda, 2005), factor which increases the cost of seedlings for producers and nurseries.

The production of quality seedlings depends on several factors associated with the substrate composition (porosity, air and water retention, electrical conductivity), nutritional supplementation (macronutrients and micronutrients), containers (volume, shape, cost), irrigation (frequency, quantity and quality of water) and environment (temperature, humidity, photoperiod, radiation) (Villa et al., 2018; Reyes et al., 2019; Roveda-Hoyos and Moreno-Fonseca, 2019; Marchioretto et al., 2020). There are few substrate recommendations for cape gooseberry, with washed sand, charred rice husk, turbid, Brazilian coco peat and mycorrhizae being the most common (Miranda, 2005; Díaz et al., 2010). The use of organic sources, such as manures and vermicompost, are highlighted as excellent alternatives from the environmental and phytotechnical point of view (Inácio and Miller, 2009).

In view of the above, the objective of this study was to determine the effect of commercial substrates and organic sources on the production of cape gooseberry seedlings.

**MATERIALS AND METHODS**

The cape gooseberry seeds used were from plants present in the germplasm bank of UDESC (Universidade Estadual de Santa Catarina), at Lages, state of Santa Catarina (Brazil). The seeds were then kept in a cold chamber (5°C).

The design was completely randomized, in a 2×3 factorial scheme, with two commercial substrates (Carolina® - Carolina Soil Company, Santa Cruz do Sul/Rio Grande do Sul/Brazil; Bioplant® - Bioplant Agrícola Company, Nova Ponte – Minas Gerais/Brazil) and three organic
sources (none, vermicompost enriched with yoorin thermophosphate (Guimarães et al., 2017) and poultry manure).

The physical and chemical characterization of the organic compounds (Tab 1).

**Table 1.** Physical and chemical characterization of organic sources to prepare the substrates used in the production of cape gooseberry seedlings.

| Parameter                  | Poultry manure | Vermicompost |
|----------------------------|----------------|--------------|
| N (g kg⁻¹)                 | 28             | 8.2          |
| P₂O₅ (g kg⁻¹)              | 65             | 76           |
| K₂O (g kg⁻¹)               | 30             | 5.5          |
| Ca (g kg⁻¹)                | 105            | 82           |
| Mg (g kg⁻¹)                | 10             | 37           |
| Sulfur (g kg⁻¹)            | 4              | 2.2          |
| Copper (mg kg⁻¹)           | 90             | 310          |
| Iron (mg kg⁻¹)             | 13200          | 88500        |
| Manganese (mg kg⁻¹)        | 800            | 360          |
| Zinc (mg kg⁻¹)             | 500            | 2500         |
| Boron (mg kg⁻¹)            | 480            | 400          |
| Organic matter (g kg⁻¹)    | 415            | 120          |
| Humidity (g kg⁻¹)          | 95             | 280          |
| Mineral material (g kg⁻¹)  | 490            | 600          |
| pH                         | 8.6            | 6.87         |
| C/N Ratio                  | 9.5            | 11.8         |
| Organic matter (% Dry Matter) | 45.9        | 16.7         |
| Electrical conductivity (mS cm⁻¹) | 801        | 2.78         |
| Apparent density (g mL⁻¹)  | 0.54           | 1.29         |
| Real density (g mL⁻¹)      | 1.85           | 1.9          |
| Porosity (%)               | 70.8           | 32.1         |

The treatments using both commercial and organic sources used a 9/1 ratio combination (90% commercial substrate and 10% organic source). The commercial and composite substrates underwent a physicochemical analysis to determine N, P₂O₅ (colorimetry with molybdate), K₂O (flame photometry), Ca and Mg (atomic absorption), S (turbidimetry), Cu, Fe, Zn and Mn (atomic absorption), B (colorimetry with azomethine), organic matter, moisture, mineral matter and pH (potentiometry), C/N, organic matter (% dry matter), electrical conductivity, real density and apparent density.
Sowing took place in Styrofoam trays of 128 cells (40 cm³/cell), filled with the different combinations of commercial substrate and organic sources. Two seeds were distributed per cell. Six replicates of 36 seeds were used.

The trays were kept in a protected environment (greenhouse). A thermo-hygrometer data logger (AK172) was installed one and a half meters from the height of the greenhouse floor. Daily climatic data, namely temperature (minimum, maximum, average) and relative humidity (mean), were collected. Thus, we calculated the thermal amplitude and the accumulated degree-days (ADD). ADD values were calculated following the equation adapted from McMaster and Wilhelm (1997) (1)

\[ ADD = \sum_{i=1}^{n} (T_i - B_t) \]  

where \( ADD \) is the accumulated degree-days or accumulated thermal sum in °C, \( T_i \) is the average daily temperature in °C, \( B_t \) is the base temperature (6.3 °C) (Salazar et al., 2008), \( n \) is the number of days and \( i \) is the day.

Seedling emergence was evaluated at 5, 8, 12, 16 and 21 DAS to calculate the emergence rate (Maguire, 1962). Seedling thinning occurred throughout the emergence evaluation period, leaving only 1 seedling per cell.

Seedling growth analysis took place at 47 DAS. The following variables were obtained: shoot height (cm), collecting diameter (mm), number of leaves, chlorophyll content (Falker Chlorophyll Index, FCI), total dry weight (g), shoot dry weight (g), root dry weight (g), shoot/height ratio and Dickson quality index (Dickson et al. 1960).

Three seedlings of each replicate were sampled. The shoot height and the hypocotyl diameter were determined using a graduated ruler and a pachymeter, respectively. The chlorophyll content was estimated using a CFL1030 meter (Falker). The seedlings were conditioned in paper bags and submitted to the greenhouse method (60°C, 72 h) (Benincasa, 2003) to determine the dry weight of the shoot, root and total dry weight.

The Test F was used to determine significance of the effects of the treatments, where the mean "organic sources" and the interactions between "organic sources" and "commercial substrates" were compared by the Tukey Test. A correlation analysis (Pearson) was carried out.
between the phytotechnical attributes (emergence and biometric) and the physicochemical composition of the substrates obtained.

RESULTS AND DISCUSSION

Emergence - The emergence of cape gooseberry seedlings began 8 DAS. This period is lower than the reported for most seedling production systems in Colombia, where onset of emergence occurs from 10 to 15 d. This precocity is associated with thermal conditions (Muniz et al., 2014). There were high diurnal temperatures (on average 28°C) and low nocturnal temperatures (on average 21.7°C), with the mean thermal amplitude up to the 8 day after sowing being 16.7°C.

The addition of poultry manure added to the commercial substrates caused deleterious effects on precocity and emergence viability (Fig. 1). Similar results have also been reported for other species, namely Cassia siamea, Dolonix regia, Leucaena leucocephala, Mimosa caesalpiniafolia, Enterolobium cotortosilicum (De Lucena et al., 2004), Solanum lycopersicon, Cucurbita pepo, Capsicum annum (Medina et al., 2009), Tamarindus indica (Queiróz et al., 2011), Passiflora edulis (Brugnara, 2014), Lepidium sativus (Rombola et al., 2015) and Zea mays (Vozhdayev et al., 2015).

![Emergence graph](image-url)
The substrates with poultry manure had four crucial characteristics that contributed to this low seedling-emergence: high nitrogen, potassium and sulfur levels, and high electrical conductivity (values above 2.0 mS cm\(^{-1}\)) (Tab. 2). These characteristics, along with the C/N ratio, were negatively correlated with percent emergence and speed of emergence (Tab. 3).

**Table 2. Physical and chemical composition of the substrates composed of commercial products and organic sources to produce cape gooseberry seedlings.** Car. – Carolina\(^\circledR\); io. – Bioplant\(^\circledR\); Vermi. – Vermicompost; Poultry M. – Poultry Manure.

|                      | Car. | Bio. | Car. + Vermi. | Car. + Poultry M. | Bio. + Vermi. | Bio. + Poultry M. |
|----------------------|------|------|---------------|-------------------|---------------|-------------------|
| N (g kg\(^{-1}\))    | 9.2  | 9    | 8             | 14                | 8.2           | 15                |
| P\(_2\)O\(_5\) (g kg\(^{-1}\)) | 13.5 | 10.9 | 38            | 35                | 47            | 36                |
| K\(_2\)O (g kg\(^{-1}\)) | 4    | 4    | 6             | 14                | 6.5           | 12.5              |
| Ca (g kg\(^{-1}\))   | 12.7 | 8.6  | 38            | 55                | 36.5          | 35.4              |
| Mg (g kg\(^{-1}\))   | 61   | 11   | 40            | 42                | 16.3          | 11.4              |
| Sulfur (g kg\(^{-1}\)) | 2.6  | 2    | 2.8           | 3.5               | 1.7           | 3                 |
| Copper (mg kg\(^{-1}\)) | 10   | 20   | 160           | 30                | 120           | 240               |
| Iron (mg kg\(^{-1}\)) | 292  | 221  | 55000         | 23400             | 43200         | 22200             |
| Manganese (mg kg\(^{-1}\)) | 260  | 430  | 1800          | 380               | 1500          | 600               |
| Zinc (mg kg\(^{-1}\)) | 70   | 70   | 1500          | 200               | 900           | 250               |
| Boron (mg kg\(^{-1}\)) | 500  | 600  | 500           | 450               | 600           | 550               |
| Organic matter (g kg\(^{-1}\)) | 290  | 350  | 220           | 290               | 280           | 315               |
| Humidity (g Kg\(^{-1}\)) | 410  | 450  | 360           | 330               | 440           | 425               |
| Mineral material (g kg\(^{-1}\)) | 300  | 200  | 420           | 380               | 280           | 260               |
| pH                   | 5.6  | 6.02 | 6.19          | 7.01              | 6.76          | 6.91              |
| C/N ratio            | 31   | 41   | 24.9          | 17.9              | 35.4          | 21.2              |
| Organic matter (%Dry matter) | 49.2 | 63.6 | 34.4          | 43.3              | 50            | 54.8              |
| Electrical conductivity (mS cm\(^{-1}\)) | 1.72 | 1.09 | 1.78          | 2.67              | 1.81          | 2.91              |
| Apparent density (g mL\(^{-1}\)) | 0.18 | 0.37 | 0.33          | 0.25              | 0.49          | 0.4               |
| Real density (g mL\(^{-1}\)) | 0.57 | 1.1  | 1             | 0.73              | 1.35          | 1.3               |
| Porosity (%)         | 68.4 | 66.4 | 67            | 65.7              | 63.7          | 69.2              |
The high levels of nitrogen, potassium and sulfur caused an ionic imbalance culminating in saline and osmotic stress (Parida and Das, 2005; Chan et al., 2008; Libra et al., 2011) with consequent root toxicity. In addition, the water absorption must also have been altered due to osmotic potential change (Mokhle et al., 2012; Liu et al., 2014). Therefore, membrane functionality and enzymatic complexes became compromised causing deficiency and/or delay in root protrusion and consequent emission of aerial part.

Biometric attributes of cape gooseberry seedlings

An interaction between the factors "commercial substrates" and "organic sources" was observed for the variables index of emergence speed, number of leaves, total dry weight, root dry weight, shoot dry weight and Dickson quality index (Tab. 4). The other variables were considered relative to the means of each factor.

The commercial substrate Carolina® enabled the growth of cape gooseberry seedlings with biometric quality superior to the seedlings obtained with the substrate Bioplant® (Tab. 4 and 5). The differences recorded were 67% (height), 14% (hypocotyl diameter), 48% (height/diameter ratio), 37% (number of leaves), 17% (chlorophyll content), 385% (total dry weight), 700% (root dry weight), 400% (shoot dry weight) and 400% (Dickson quality index).
Table 4. Seedling emergence at 21 DAS (E21), emergence speed index (ESI), height (H) and hypocotyl diameter (HD), diameter/shoot height ratio (DHR), number of leaves (NL), total dry weight (TDW), root dry weight (RDW), shoot dry weight (SDW), chlorophyll content (CHLO) and Dickson quality index (DQI) of Cape gooseberry seedlings produced with different commercial substrates and organic sources.

| Treatments | E21 (%) | ESI | H (cm/plant) | HD (mm/plant) | DHR | NL (leaves/plant) | CHLO (FCI) | TDW (mg/plant) | RDW (mg/plant) | SDW (mg/plant) | DQI |
|------------|--------|-----|--------------|--------------|-----|------------------|------------|----------------|----------------|----------------|-----|
| Substrate (Subs) | | | | | | | | | | | |
| Carolina®  | 92.12  | 7.57 | 7.38 | 2.24 | 3.27 | 7.52 | 29.77 | 0.26 | 0.05 | 0.20 | 0.03 |
| Bioplant®  | 92.59  | 7.84 | 4.41 | 1.96 | 2.20 | 6.68 | 25.38 | 0.16 | 0.03 | 0.13 | 0.02 |
| Test F     | 0.04 ns| 1.53 ns| 56.09**| 14.14**| 74.60**| 9.93**| 15.54**| 23.27**| 12.78**| 15.61**| 4.20 |
| Organic Source (OS) | | | | | | | | | | | |
| Control    | 95.83 a| 9.07 a| 4.66 b| 1.93 b| 2.34 b| 6.38 b| 25.82 b| 0.17 b| 0.04 b| 0.12 b| 0.03 |
| Vermicompost | 97.22 a| 8.58 a| 6.15 a| 2.25 a| 2.70 b| 7.33 a| 27.00 ab| 0.20 ab| 0.06 a| 0.14 b| 0.04 |
| Poultry manure | 84.02 b| 5.47 b| 6.86 a| 2.13 ab| 3.16 a| 7.59 a| 29.90 a| 0.27 a| 0.03 b| 0.23 a| 0.02 |
| Test F     | 15.28**| 100.33**| 10.69**| 6.57**| 14.48**| 6.92**| 4.72*| 7.02**| 11.12**| 12.82**| 6.15 |
| Test F (Subs×OS) | 3.13 ns| 7.30**| 1.04 ns| 1.92 ns| 3.18 ns| 4.44*| 2.15 ns| 9.08**| 7.76**| 10.41**| 7.77 |

* significant ($P<0.05$); ** significant ($P<0.01$); ns – non significant; Means followed by the same letter do not differ by Tukey’s test ($P>0.05$).
Table 5. Emergence speed index (ESI), number of leaves (NL), total dry weight (TDW), dry matter mass (RDW), shoot dry weight (SDW) and Dickson quality index (DQI) of cape gooseberry seedlings produced with different commercial substrates and organic sources.

|                  | Control       | Vermicompost  | Poultry manure |
|------------------|---------------|---------------|----------------|
| ESI              | 8.51 bA       | 8.26 aA       | 5.92 aB        |
| Carolina®        | 9.62 aA       | 8.89 aA       | 5.02 bB        |
| NL               | 7.38 aA       | 7.56 aA       | 7.63 aA        |
| Bioplant®        | 5.38 bB       | 7.11 aA       | 7.55 aA        |
| TDW              | 0.27 aAB      | 0.20 aB       | 0.32 aA        |
| Bioplant®        | 0.07 bB       | 0.21 aA       | 0.21 bA        |
| RDW              | 0.07 aA       | 0.07 aA       | 0.03 aB        |
| Bioplant®        | 0.01 bB       | 0.06 aA       | 0.03 aB        |
| SDW              | 0.20 aA       | 0.12 aB       | 0.29 aA        |
| Bioplant®        | 0.05 bB       | 0.17 aA       | 0.17 bA        |
| DQI              | 0.04 aA       | 0.04 aA       | 0.02 aB        |
| Bioplant®        | 0.01 bB       | 0.04 aA       | 0.02 aAB       |

Means followed by the same lowercase letter in the column and upper case letter in the row do not differ by Tukey’s test ($P > 0.05$).

The superiority of the Carolina® substrate is attributed to its higher nutritional content (nitrogen, phosphorus, calcium, magnesium and sulfur) and balance of physical characteristics (apparent density and actual density) (Tab. 2). The cape gooseberry seeds are very small and quickly deplete their reserves, being essential that the substrate provide the necessary nutrients and satisfactory aeration conditions for seedling growth and development (Melo et al., 2015). The ideal substrate provides conditions for rapid and uniform emergence as well as a vigorous and proportional development (Ferreira et al., 2009). Thus, Bioplant® substrate acts more like an emergence conditioner. Other studies report a lack of adequate physical and chemical conditions to produce seedlings of other species, when the supplementation with fertilization becomes primordial (Almeida et al., 2014). Dutra et al. (2012) report that Bioplant® led to the formation of copaiba seedlings (Copaifera langsdorffii) with deficit in the accumulation of leaf and total dry
weight. Ferreira et al. (2009) describe this substrate as a factor causing asymmetry between shoot and root dry weight for cupuassu seedlings (*Theobroma grandiflorum*).

The fundamental physical and chemical attributes for the growth of cape gooseberry seedlings are: moisture, mineral matter, C/N ratio, organic matter and boron and sulfur content (Tab. 6). Only these attributes presented a correlation with biometric attributes.

Boron content and humidity were negatively correlated with shoot height, height-diameter ratio, and chlorophyll content (Tab. 6). Cape gooseberry seedlings are possibly not tolerant to inadequate boron levels in the substrate. This tolerance depends on the transport speed from the roots to the shoot (Salvador et al., 2003). It is noteworthy that no symptoms of boron toxicity were observed in cape gooseberry seedlings. Thus, other studies should be conducted to determine the nutritional need of boron and other nutrients in the seedling production phase.

The C/N ratio provided the opposite effect on height, diameter/height ratio, number of leaves and chlorophyll content (Tab. 6). A substrate with high C/N ratio has low degradability, low nutrient availability and, depending on the period of seedlings production, nitrogen deficiency may occur (Maeda et al., 2007). Nitrogen is a key constituent of several molecules essential for the primary and secondary metabolism of plants (proteins, nucleic acids, hormones, chlorophyll and vitamins). Therefore, the unbalanced supply of this nutrient impacts several biosynthetic pathways and consequently the growth and allocation of dry weight (Xu et al., 2012).

The seedlings were ready for transplant at 47 DAS, when over four true leaves had fully expanded (Tab. 5). The accumulation of degree-days was 1054°C. In Colombia, the average period for obtaining transplanted seedlings is 60 d (Angulo, 2005). In addition to the greater delay at early emergence (10-15 DAS), sowing takes place in trays and the seedlings are transplanted to plastic bags of 1 L fifteen days after emergence, where they stay for another 30 days (Miranda, 2005). Transplant suitability encompasses criteria related to shoot height (15-20 cm), hypocotyl diameter (0.5 cm) and number of leaves (3-4) (Miranda, 2005; Angulo, 2005). The seedlings produced only with the Bioplant® substrate had on average 5.38 leaves at 47 DAS (Tab. 5), but were not suitable for transplant due to low height, minimum accumulation of dry weight and to the low quality represented by the Dickson Index (Tab. 4). The possibility that there is no need for the seedling to reach a height of 15 to 20 cm should be highlighted, since several other Solanaceae (tomato, eggplant, pepper) are successfully transplanted at lower
altitudes. Therefore, the transplanting criteria need to be better established based on the combination of attributes related to climatic conditions (degree-days), biometric attributes and the local productive system. The production of cape gooseberry seedlings with the Carolina® substrate does not require supplementation with organic sources. An alternative supplementation for the Bioplant® substrate is vermicompost enriched with yoorin thermophosphate, a material with excellent chemical and physical attributes (Tab. 1). The use of poultry manure must be carefully mediated due to deleterious effects on emergence.
Table 6. Correlation between emergence speed and biometric attributes, and physical and chemical composition of composite substrates to produce cape gooseberry seedlings.

|     | ESI  | SH   | HD   | DHR  | NL   | CHLO | TDW  | SDW  | DQI   | S    | B    | OM   | Hum  | MM   | C/N  | OM (%) |
|-----|------|------|------|------|------|------|------|------|-------|------|------|------|------|------|------|---------|
| ESI | 1    |      |      |      |      |      |      |      |       |      |      |      |      |      |        |         |
| SH  | -0.511 | 1    |      |      |      |      |      |      |       |      |      |      |      |      |        |         |
| HD  | -0.311 | 0.856* | 1    |      |      |      |      |      |       |      |      |      |      |      |        |         |
| DHR | -0.553 | 0.983* | 0.758 | 1    |      |      |      |      |       |      |      |      |      |      |        |         |
| NL  | -0.634 | 0.871* | 0.857* | 0.852* | 1    |      |      |      |       |      |      |      |      |      |        |         |
| CHLO| -0.674 | 0.875* | 0.746 | 0.844* | 0.745 | 1    |      |      |       |      |      |      |      |      |        |         |
| TDW | -0.554 | 0.873* | 0.620 | 0.932* | 0.858* | 0.643 | 1    |      |       |      |      |      |      |      |        |         |
| SDW | -0.616 | 0.761 | 0.421 | 0.852* | 0.740 | 0.536 | 0.960* | 1    |       |      |      |      |      |      |        |         |
| DQI | 0.264 | 0.425 | 0.689 | 0.353 | 0.558 | 0.119 | 0.400 | 0.181 | 1      |      |      |      |      |      |        |         |
| S   | -0.800 | 0.781 | 0.493 | 0.806 | 0.621 | 0.930* | 0.652 | 0.642 | -0.182 | 1    |      |      |      |      |        |         |
| B   | 0.484 | -0.925* | -0.648 | -0.943* | -0.670 | -0.891* | -0.792 | -0.714 | -0.166* | -0.875 | 1    |      |      |      |        |         |
| OM  | -0.007 | -0.701 | -0.940* | -0.575 | -0.667 | -0.521 | -0.428 | -0.214 | -0.785 | -0.219 | 0.468 | 1    |      |      |        |         |
| Hum | 0.434 | -0.908* | -0.700 | -0.885* | -0.618 | -0.841* | -0.689 | -0.633 | -0.135 | -0.810 | 0.921* | 0.589 | 1    |      |        |         |
| MM  | -0.252 | 0.908* | 0.913* | 0.828* | 0.719 | 0.773 | 0.633 | 0.487 | 0.497 | 0.593 | -0.792 | -0.880* | -0.903* | 1    |        |         |
| C/N | 0.884* | -0.837* | -0.664 | -0.836* | -0.822* | -0.908* | -0.737 | -0.712 | -0.021 | -0.924* | 0.784 | 0.396 | 0.777 | -0.669 | 1      |         |
| M.O (%) | 0.176 | -0.868* | -0.958* | -0.772 | -0.747 | -0.700 | -0.603 | -0.426 | -0.644 | -0.469 | 0.696 | 0.953* | 0.804 | -0.981* | 0.595 | 1      |

* - significant (P<0.05). ESI - Emergence speed index; SH – Shoot height; HD - Hypocotyl diameter; DHR – Diameter/height ratio; NL – Number of leaves; CHLO - Chlorophyll; TDW – Total dry weight; SDW – Shoot dry weight; DQI – Dickson quality index; S - Sulfur; B - Boron; OM – Organic matter; Hum - Humidity; MM – Mineral matter; C/N - C/N ratio; OM (%) – Organic matter.
CONCLUSION

Carolina® is a substrate suitable for the production of cape gooseberry seedlings without the need for organic-source supplementation. Bioplant® acts more like an emergence conditioner, being the supplementation with organic source (preferably with vermicompost) essential.

It is possible to obtain seedlings suitable for transplanting at 47 days after sowing.

Conflict of interests: The manuscript was prepared and reviewed with the participation of the authors, who declare that there exists no conflict of interest that puts at risk the validity of the presented results.

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