

Substrates and organic sources for *Physalis peruviana* L. seedling production

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



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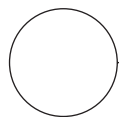
***Physalis peruviana* L. seedlings**

Photo: A.P.C. Melo

ABSTRACT

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 with a 2×3 factorial scheme using two commercial substrates (Carolina[®], Bioplant[®]) and three organic sources (control, vermicompost enriched with yoorin thermophosphate and poultry manure) for seedling production. Adding poultry manure to commercial substrates negatively affects precocity and emergence. Carolina[®] is a suitable substrate for cape gooseberry seedling production without supplements using organic sources. Bioplant[®] behaves more like an emergence conditioner, requiring supplementation with organic sources (preferably vermicompost). Seedlings that are suitable for transplant can be obtained at 47 days after sowing.

Additional key words: exotic fruit; plant propagation; Solanaceae; boron; C/N ratio.



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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 2×3, con dos sustratos comerciales la producción de plántulas (Carolina[®], Bioplant[®]) 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. Bioplant[®] 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; boro; relación C/N.

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Physalis peruviana (L.) fruits are exotic in terms of 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 called uchuva (Spanish), cape gooseberry, goldenberry or simply physalis (Muniz *et al.*, 2011; Fischer *et al.*, 2014).

The origin center for *P. peruviana* is located between the Peruvian and Ecuadorian Andes (Morton and Russel, 1954). It is a perennial and semi-evergreen shrub with indeterminate growth (Fischer and Melgarejo, 2020).

Cultivation in Colombia began in 1985 (Muniz *et al.*, 2014). The cape gooseberry currently plays an important role in the country's export market, following bananas (Fischer *et al.*, 2014). Most of the cape gooseberry supply in Brazil is imported from Colombia, complementing production on 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 presents an excellent alternative for small and medium producers because of the high added value of fresh fruits (98-150 R\$/kg or 25.42-38.90 US\$/kg) and ease of cultivation. Production could transform this country from importer to exporter in a short period of time (Rufato *et al.*, 2008).

Success in establishing new crops depends primarily from the propagation material. The cape gooseberry is propagated mainly with seeds (Muniz *et al.*, 2014; Fischer *et al.*, 2014), which is a cheap and efficient method because seeds have high, rapid germination (72.50% at 7 days after sowing (DAS); 82.50% at 21 DAS) (Melo *et al.*, 2015). However, obtaining seedlings takes a long time, around 2 months (Miranda, 2005), 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, and electrical conductivity), nutritional supplementation (macronutrients and micronutrients), containers (volume, shape, cost), irrigation (frequency, quantity and water quality) 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 several substrate recommendations for cape gooseberries: washed sand, charred rice husks, turbid, Brazilian coco peat and mycorrhizae are the more common ones (Miranda, 2005; Díaz *et al.*, 2010). Organic sources, such as manure and vermicompost, are excellent alternatives from the environmental and phytotechnical points of view (Inácio and Miller, 2009).

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

INTRODUCTION

MATERIALS AND METHODS

The cape gooseberry seeds came from plants 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 with a 2×3 factorial scheme using 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 is shown in table 1.

Table 1. Physical and chemical characterization of organic sources for substrates in the production of cape gooseberry seedlings.

Parameter	Poultry manure	Vermicompost
N (g kg ⁻¹)	28	8.2
P ₂ O ₅ (g kg ⁻¹)	65	76
K ₂ O (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)	8.01	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 with commercial and organic sources used a 9/1 ratio (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.

The seeds were sown in Styrofoam trays with 128 cells (40 cm³/cell) filled with different combinations of commercial substrate and organic sources. Two seeds were placed in each 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 above the greenhouse floor. Daily climatic data, namely temperature (minimum, maximum, average) and relative humidity (mean), were collected. The thermal amplitude and the accumulated degree-days (ADD) were calculated. The ADD values were calculated with an equation adapted from McMaster and Wilhelm (1997) (Eq. 1)

$$ADD = \sum_{i=1}^n (T_i - B_t) \quad (1)$$

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 was carried out during the emergence evaluation period, leaving only 1 seedling per cell.

A seedling growth analysis was performed 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 were sampled in each repetition. 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 subjected to the greenhouse method (60°C, 72 h) (Benincasa, 2003) to determine the dry weight of the shoots, roots and total dry weight.

The F Test was used to determine significance in the effects of the treatments, with the mean “organic sources” and the interactions between the “organic sources” and “commercial substrates” compared with the Tukey test. A correlation analysis (Pearson) was carried out between the phytotechnical attributes (emergence and biometric) and the physicochemical composition of the substrates.

RESULTS AND DISCUSSION

Emergence - The cape gooseberry seedling emergence began 8 DAS. This period was shorter than most seedling production systems in Colombia, where emergence onset occurs from 10 to 15 d. 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 a mean thermal amplitude of 16.7°C up to 8 DAS.

Adding poultry manure to the commercial substrates had deleterious effects on the precocity and emergence viability (Fig. 1). Similar results have also been

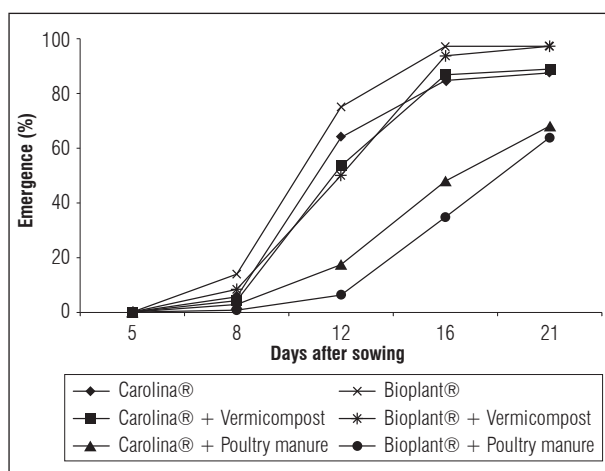


Figure 1. Evolution of cape gooseberry seedling emergence with different commercial substrates and organic sources.

reported for other species, namely *Cassia siamea*, *Dolox regia*, *Leucaena leucocephala*, *Mimosa caesalpiniaefolia*, *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).

The substrates with poultry manure had four crucial characteristics that contributed to a 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 the emergence percentage and emergence rate (Tab. 3).

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, water absorption must have been altered because of the osmotic potential change (Mokhele *et al.*, 2012; Liu *et al.*, 2014). Therefore, membrane functionality and enzymatic complexes were compromised, causing deficient and/or delayed root protrusion and aerial emission.

Biometric attributes of cape gooseberry seedlings

An interaction was observed between the factors “commercial substrates” and “organic sources” for the variables emergence speed index, 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 cape gooseberry seedling growth with higher seedling biometric quality than with the substrate Bioplant® (Tab. 4 and 5). The differences 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).

The superiority of the Carolina® substrate was attributed to its higher nutritional content (nitrogen, phosphorus, calcium, magnesium and sulfur) and balance of physical characteristics (apparent density and

Table 2. Physical and chemical composition of the substrates composed of commercial products and organic sources used in cape gooseberry seedling production. Car. – Carolina®; Bio. – Bioplant®; 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)	29,290	22,100	55,000	23,400	43,200	22,200
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

Table 3. Correlation matrix between emergence attributes and physicochemical composition of substrates used to produce cape gooseberry seedlings.

	8E	12E	16E	21E	ESI	N	K ₂ O	S	C/N	EC
8E	1									
12E	0.804	1								
16E	0.836	0.967	1							
21E	0.777	0.968	0.983	1						
ESI	0.860	0.993	0.964	0.954	1					
N	-0.650	-0.972*	-0.916*	-0.933*	-0.939*	1				
K ₂ O	-0.717	-0.921*	-0.844*	-0.813*	-0.929*	0.906*	1			
S	-0.790	-0.790	-0.883*	-0.785	-0.800	0.726	0.736	1		
C/N	0.935*	0.840*	0.883*	0.793	0.884*	-0.724	-0.833	-0.924	1	
EC	-0.893*	-0.951*	-0.892*	-0.872*	-0.976*	0.878	0.930	0.738	-0.887	1

8E - 8E - Emergence 8 days after sowing (DAS); 12E - 12 DAS; 16E - 16 DAS; 21E - 21 DAS; ESI - Emergence speed index; N - Nitrogen (g kg⁻¹); K₂O - Potassium (g kg⁻¹); S - Sulfur (g kg⁻¹); C/N - C/N ratio; EC - Electrical conductivity (mS cm⁻¹). * - significant ($P < 0.05$).

Table 4. Seedling emergence at 21 days after sowing (E21), emergence speed index (ESI), height (H), 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 (CHL) and Dickson quality index (DQI) of cape gooseberry seedlings produced with different commercial substrates and organic sources.

Treatment	E21 (%)	ESI	H (cm/plant)	HD (mm/plant)	DHR	NL (leaves/plant)	CHL (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 ab
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 a
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 b
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 according to 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			
Carolina®	8.51 bA	8.26 aA	5.92 aB
Bioplant®	9.62 aA	8.89 aA	5.02 bB
NL			
Carolina®	7.38 aA	7.56 aA	7.63 aA
Bioplant®	5.38 bB	7.11 aA	7.55 aA
TDW			
Carolina®	0.27 aAB	0.20 aB	0.32 aA
Bioplant®	0.07 bB	0.21 aA	0.21 bA
RDW			
Carolina®	0.07 aA	0.07 aA	0.03 aB
Bioplant®	0.01 bB	0.06 aA	0.03 aB
SDW			
Carolina®	0.20 aA	0.12 aB	0.29 aA
Bioplant®	0.05 bB	0.17 aA	0.17 bA
DQI			
Carolina®	0.04 aA	0.04 aA	0.02 aB
Bioplant®	0.01 bB	0.04 aA	0.02 aB

Means followed by the same lowercase letter in a column and the same uppercase letter in a row do not differ according to Tukey's test ($P > 0.05$).

actual density) (Tab. 2). Cape gooseberry seeds are very small and quickly deplete their reserves, so the substrate must provide necessary nutrients and satisfactory aeration conditions for seedling growth and development (Melo *et al.*, 2015). The ideal substrate provides the conditions needed rapid and uniform emergence and vigorous, proportional development (Ferreira *et al.*, 2009). The Bioplant® substrate acts more like an emergence conditioner. Other studies have reported a lack of adequate physical and chemical conditions for seedling production in other species when fertilization supplementation is primordial (Almeida *et al.*, 2014). Dutra *et al.* (2012) reported that Bioplant® led to the formation of copaiba seedlings (*Copaifera langsdorffii*) that were deficit in the accumulation of leaf and total dry weight. Ferreira *et al.* (2009) described this substrate as causing asymmetry between the shoot and root dry weights in cupuaçu 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 contents (Tab. 6). Only these attributes presented a correlation with the biometric attributes.

The boron content and humidity were negatively correlated with the shoot height, height-diameter ratio, and chlorophyll content (Tab. 6). Cape gooseberry seedlings may not tolerant inadequate boron levels in substrates. This tolerance depends on the transport speed from the roots to the shoot (Salvador *et al.*, 2003). No symptoms of boron toxicity were observed in the cape gooseberry seedlings. Other studies should be conducted to determine the nutritional requirements for boron and other nutrients in the seedling production phase.

The C/N ratio had the opposite effect on the height, diameter/height ratio, number of leaves and chlorophyll content (Tab. 6). A substrate with a high C/N ratio has low degradability, low nutrient availability and, depending on the seedling production period, deficient nitrogen (Maeda *et al.*, 2007). Nitrogen is a key component of several molecules that are essential

Table 6. Correlation between emergence speed and biometric attributes and the physical and chemical composition of composite substrates in cape gooseberry seedling production.

	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	
OM (%)	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.

for the primary and secondary metabolism of plants (proteins, nucleic acids, hormones, chlorophyll and vitamins). Therefore, an 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 ADD was 1,054°C. In Colombia, the average period for obtaining transplanted seedlings is 60 d (Angulo, 2005). In addition to the delayed early emergence (10-15 DAS), seeds are sown in trays, and seedlings are transplanted to 1 L plastic bags 15 days after emergence, where they stay for another 30 d (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 of 5.38 leaves at 47 DAS (Tab. 5) but they were not suitable for transplant because of a low height, minimum accumulation of dry weight and low quality, as indicated by the Dickson index (Tab. 4). Seedlings may not have to reach a height of 15 to 20 cm because several other Solanaceae (tomato, eggplant, pepper) species are successfully transplanted with lower heights. Therefore, the transplanting criteria need to be better established, based on a combination of attributes related to climatic conditions (degree-days), biometric attributes and local productive systems. The production of cape gooseberry seedlings with the Carolina® substrate did not require supplementation with organic sources. An alternative for supplementation in 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 because of deleterious effects on emergence.

CONCLUSION

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

Seedlings that are suitable for transplant can be obtained at 47 DAS.

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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