Production of yellow passion fruit seedlings as a function of alternative growing media and controlled-release fertilizer[1]

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ABSTRACT

With the objective of evaluate the use of residues as growing media for the yellow passion fruit seedlings, a randomized block experiment was carried out with treatments distributed in a 2 × 21 factorial scheme corresponding to fertilizer management (presence and absence of controlled-release fertilizer), and combination of growing media from five local agro-industrial wastes (bark of cupuaçu fruit, almond shell of castanha-do-brasil, lumps of acerola fruit, lumps of cajá fruit, and lumps of açaí fruit) and a commercial growing media, which tested pure and was combined in a 1:1 ratio. The variables measured were the seedling height; stem diameter; height: stem diameter ratio; number of leaves; shoot, root, and total dry matter; and Dickson quality index. The dates were submitted to univariate and multivariate analyzes. The pairwise combination of growing medias produced from the bark of cupuaçu fruit, almond shell of castanha-do-brasil, lumps of acerola fruit, lumps of cajá fruit, lumps of açaí fruit, and commercial growing media in a proportion of 1:1 and with the use of controlled-release fertilizer constitute an alternative for other growing medias in the production of yellow passion fruit seedlings.

Keywords: Agro-industrial wastes; fertilization management; *Passiflora edulis* Sims.; seedling quality.

INTRODUCTION

Numerous studies have aimed to provide information on the potential of waste that can be utilized as a growing media in the production of seedlings (Silva *et al.*, 2018; Monaco *et al.*, 2020; Muniz *et al.*, 2020; Bustamante *et al.*, 2021), with the objective of minimizing the environmental impacts caused by the incorrect disposal (Krause *et al.*, 2017).

During the formation phase, the interaction between fertilization and growing media properties influences the morphophysiological characteristics of seedlings (Mariotti *et al.*, 2020). Although most growing medias conform to the standards established by legislation, the nutrient content of the material is insufficient to meet the requirements of seedlings for successful planting (Muniz *et al.*, 2020; Silva *et al.*, 2020).

Hence, nutritional supplementation is necessary during growing media formulation, either by fertigation (Madrid-Aispuro *et al.*, 2020) or conventional fertilizer application. Fertilization with conventional fertilizers can results in greater nutrient losses through leaching and volatilization (Vejan *et al.*, 2021), discomfort for nursery workers, and the creation of low-quality seedlings, all of which reflect the cost of production.

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As an alternative to conventional fertilizer application, controlled-release fertilizers represents a promising technology for the production of passion fruit seedlings (Muniz *et al.*, 2020; Silva *et al.*, 2020). This method presents the advantage that the fertilizer is applied to the growing media only during the preparation phase (Smiderle *et al.*, 2020). Although expensive, this technology decreases production costs, production time, labor required, and operational expenses; In addition, it optimizes space utilization, water use, and energy requirements (Gibson *et al.*, 2019).

The objective with study was to determine the influence of alternative growing medias and controlled-release fertilizer on the production of yellow passion fruit seedlings.

MATERIAL AND METHODS

From December 2017 to January 2018, the experiment was conducted at a nursery with 50% shading in the experimental field of Embrapa Acre in Rio Branco, Acre State, Brazilian Amazon (11°58'35″ S, 68°17'56″ W, altitude 159 m). Inside the nursery the maximum and minimum temperatures were 31.8 °C and 21.4 °C, respectively; and the relative humidity was 88.7%.

For the formulation of the growing medias, a commercial growing media based on pine bark (Com) and five agro-industrial residues, namely lumps of açaí fruit (Al); lumps of cajá fruit (Lcf); almond shell of castanha-do-brasil (Ascb); bark of cupuaçu fruit (Bcf); and lumps of acerola fruit (Laf) were used. After collection, the materials were dried in the sun for a week and then ground using a disintegrator (model B-611 and Maqtron®) with a 10 mm diameter sieve. Subsequently, they were combined in proportions of 1:1 (v/v ratio) using the combinatorial analysis of 'n' distinct elements, taken p = 2 to p = 2, yielding 15 combinations, plus the six pure growing media, resulting in 21 growing medias (T1: Bcf + Ascb; T2: Bcf + Laf; T3: Bcf + Lcf; T4: Bcf + Al; T5: Bcf + Com; T6: Ascb + Laf; T7: Ascb + Lcf; T8: Ascb + Al; T9: Ascb + Com; T10: Laf + Lcf; T11: Laf + Al; T12: Laf + Com; T3: Lcf + Al; T14: Lcf + Com; T15: Al + Com; T16: Bcf; T17: Ascb; T18: Laf; T19: Lcf; T20: Al and; T21: Com).

A randomized block design was used with three replicates and seven plants per plot, in a 21 × 2 factorial scheme, consisting of 21 growing medias, with and without controlled-release fertilizer. Table 1 lists the physical and chemical characteristics of the growing medias.

For fertilizer application, 10 kg m^{-3} of Basacote® Mini 3 M controlled-release fertilizer with an N-P-K formulation of 13-6-16, macro-and micronutrient profile of Mg: 1.4, S:10, Cu: 0.05, Fe: 0.26, Mn: 0.06, and Mo: 0.015, and a nutrient release duration of up to three months was used.

Polyethylene (disposable) pots with 300 mL capacity were utilized as growing media containers. Two seeds of the passion fruit 'BRS Gigante Amarelo' were used per container for sowing purposes. One day after emergence of the first pair of cotyledonary leaves, thinning was performed and one plant was left per container. Micro-sprinkler irrigation system was used to maintain the field capacity of the growing medias. The experimental area was covered with a transparent plastic canvas suited for greenhouses to prevent excess moisture from precipitation entering the area.

On day 54 after sowing, the following characteristics were measured: seedling height (H; cm), measured from the neck of the plant to the petiole of the youngest leaf with a graduated ruler; stem diameter (SD; mm), measured from the neck of the plant to 1 cm above the growing media with a digital caliper; height: stem diameter ratio (HSD); and number of leaves (NL). Subsequently, the seedlings were separated into shoots and roots, packed into raft paper bags, oven-dried at 65 °C until constant mass is achieved, and weighed on a digital scale to determine the following variables: shoot dry mass (SDM; g), root dry mass (RDM; g), and total dry mass (TDM; g).

The seedling quality was determined using the Dickson quality index (DQI) according to Equation (1) proposed by Dickson *et al.* (1960):

$$\mathrm{DQI} = \frac{\mathrm{TDM\ (g)}}{\left(\frac{\mathrm{H\ (cm)}}{\mathrm{SD\ (mm)}}\right) + \left(\frac{\mathrm{SDM\ (g)}}{\mathrm{RDM\ (g)}}\right)} \tag{1}$$

The analysis of variance was performed and the means of the growing medias were compared using the Scott–Knott test, and the fertilization means were compared using the Tukey test, both at a 5% probability.

The Pearson correlation coefficients were calculated among the biometric variables of the seedlings, the chemical and physical attributes of the substrates, and between these and those. These coefficients were visually represented by a correlation network, where closer and thicker nodes indicate a stronger correlation, with green representing positive correlations and red representing negative correlations. (Oliveira & Oliveira, 2021).

The data referring to the eight variables were submitted to multivariate analysis to obtain the dissimilarity matrix based on the Euclidean Mean Distance and, subsequently,

Table 1: physical and chemical attributes of the growing medias and mixtures obtained from agro-industrial waste

Growing medias	pH	EC[1]	N	P	K	Ca	Mg	S	OC[2]	C/N[3]
		dS m^{-1}	g kg^{-1}							-
Bcf+Ascb	5.1	0.4	9.9	0.9	7.9	2.4	1.5	1.2	334.4	34/1
Bcf+Laf	5.8	1.1	16.3	2	11.4	2.2	1.9	1.3	397.1	24/1
Bcf+Lcf	6.6	0.7	9.9	1.8	10.8	3.6	1.8	1.1	391.2	40/1
Bcf+Al	6.4	1.2	7.3	1	7.8	1.4	1.2	0.8	373.9	51/1
Bcf+Com	6.7	0.6	7.4	2.2	11	7.2	2.4	2.1	296.3	40/1
Ascb+Laf	5	0.3	17.3	1.3	4.4	4.3	1.6	1.4	304.7	18/1
Ascb+Lcf	5.4	0.1	11.2	1	4.6	3.6	1.2	1	281.2	25/1
Ascb+Al	4.9	0.5	10.7	0.5	3.4	2.3	1	0.8	323.3	30/1
Ascb+Com	4.5	0.6	7.2	1.5	3.1	6.5	2	1.9	218.6	30/1
Laf+Lcf	6.2	0.7	20.1	3.1	10.1	4.2	2	1.5	339.7	31/1
Laf+Al	4.8	1.2	13.8	1.7	6.3	1.8	1.3	1.1	388.9	28/1
Laf+Com	6.7	0.6	16	3.6	7.7	13.2	3.5	3.1	334.1	21/1
Lcf+Al	4.2	1.1	10.8	1.7	7.5	3.1	1.6	1.2	330.2	17/1
Lcf+Com	5.9	0.6	10	2.8	7.6	10.9	2.7	2.9	318.4	32/1
Al+Com	4.8	1.3	9.5	2.2	7	6.6	2.2	2.1	289.4	31/1
Bcf[a]	7.5	1.1	6.6	2.1	1.4	11.9	4.3	0.9	432.9	65/1
Ascb[b]	4.6	0.1	10.6	0.9	1.8	15.9	2.3	0.8	300.2	28/1
Laf[b]	6.5	0.5	22.1	1.7	9.1	12.8	1.8	0.9	374.3	17/1
Lcf	6.7	0.4	9.3	0.9	14.1	3.4	1.6	1	390.3	42/1
Al	5.7	1.2	8.2	2.4	7.3	13.6	2.3	1.6	401.6	49/1
Com[b]	5.6	1.1	3.3	2.1	2.7	8.8	1.9	2.1	154.3	47/1

Growing medias	Fe	B	Cu	Mn	Zn	Hy[4]	Wd[5]	Dd[6]	WRC[7]	CEC[8]
	mg kg^{-1}					%	kg m^{-3}		%v/v	mmol$_c$ dm^{-3}
Bcf+Ascb	1900	11.5	13	108.1	28.2	8	415.1	381.9	57.4	232.3
Bcf+Laf	900	15	12.3	54.2	38.5	6	398.7	374.6	55.2	163.9
Bcf+Lcf	800	12.6	10.7	52.4	28.4	3.8	394.5	379.8	61.7	182
Bcf+Al	400	10.5	9	144	20.2	4.2	614.4	588.6	59.2	185.1
Bcf+Com	2400	10.6	10	86.9	25.9	16.3	315.8	264.5	43.6	162.9
Ascb+Laf	1600	12.8	15.2	107.1	31	8.8	326.3	297.5	48.2	225.2
Ascb+Lcf	1700	10.6	14.6	112.3	24.6	15.5	319.5	270.1	31.4	228.6
Ascb+Al	1100	7.9	10.2	144.7	21.2	9.8	516.3	465.7	47.7	269.1
Ascb+Com	3600	8.5	10.2	134.6	23.4	22.8	554.5	427.9	48.8	277.2
Laf+Lcf	400	17.5	13.5	47.3	37.6	11.7	262.1	231.3	62.8	141.1
Laf+Al	800	12.4	11.4	194.6	31	8.1	469.2	431.2	48.4	235.6
Laf+Com	3800	14.3	13.1	127.6	30.3	40.2	286.8	171.5	37.9	180.1
Lcf+Al	600	11	12.9	277.6	21.8	15.8	444.8	374.6	37.4	241.6
Lcf+Com	2900	11.9	11.1	84.6	21.1	29.9	238.2	167.1	34.8	123.2
Al+Com	3100	9.4	12.5	278.1	32.9	17.9	383.3	314.7	47.6	201.4
Bcf	6200	23.4	35.3	199.1	72.1	5.8	488.6	460.5	83.5	166.1
Ascb	11400	27.6	23.3	267	38.6	52	573.1	275	75.3	382.1
Laf	1600	10.7	10.6	40	18.9	9.2	265.8	241.5	73.6	129.1
Lcf	1100	5.8	8.3	46.3	21.2	11.3	232.1	205.8	81.9	105.9
Al	1300	14.1	20.9	68.9	56.8	12.8	568.1	495.5	66.3	93
Com	4500	7.7	6.7	84.5	15.7	25.2	508.9	380.8	44.4	319.3

[1] EC: electrical conductivity; [2] OC: organic carbon; [3] C/N: carbon/nitrogen ratio; [4] Hy: humidity; [5] Wd: wet density; [6] Dd: dry density; [7] WRC: water retention capacity; [8] CEC: cation exchange capability. Chemical and physical data obtained from Mendes *et al.* (2019) and Muniz *et al.* (2020).

the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) was applied in order to group the treatments that were similar. Univariate analyses, as well as the correlation network, were performed using the Rbio software (Bhering, 2017) and multivariate analyses were performed using Genes software (Cruz, 2013).

RESULTS AND DISCUSSION

There was a significant interaction between the G x F factors for all biometric variables of yellow passion fruit seedlings evaluated (Table 2).

The H, SD, HSD, and NL of the yellow passion fruit seedlings were higher in fertilized growing medias than those in the unfertilized growing medias (Figure 1A to 1D).

In fertilized growing medias, the combinations of Bcf + Laf, Bcf + Lcf, Bcf + Al, Bcf + Com, Laf + Lcf, Laf + Al, Lcf + Com and Al + Com caused the seedlings to attain greater H (Figure 1A). The heights of the seedlings produced in the treatments exceeded the values reported in the literature (Silva *et al.*, 2020; Cordeiro *et al.*, 2019). According to Junghans *et al.* (2017), yellow passion fruit seedlings are suitable for planting at 15–30 cm height, which would accredit the Laf + Com growing media with a potential use in the production of passion fruit seedlings without fertilization. This finding is pertinent for those nurseries where seedlings need to be produced at the lowest possible cost.

Higher mean values for SD were obtained for the Bcf + Laf, Bcf + Lcf, Bcf + Al, Bcf + Com, Ascb+Laf, Laf + Lcf, Laf + Al, Laf + Com, Lcf and Com (Figure 1B). The stem diameters of the seedlings produced on the best growing medias exceeded those specified by Silva *et al.* (2020).

The growing medias Bcf + Laf, Bcf + Lcf, Bcf + Al, Bcf + Com, Ascb + Com, Laf + Lcf, Laf + Al, Lcf + Com, Al + Com, Bcf, Lcf and Com, all in the presence of fertilizer, caused the seedlings to attain greater HSD (Figures 1C). Passion fruit seedlings with HSD values between 13.60 and 17.42 at 54 days after sowing were suitable for field planting. However, as with forest species, HSD may vary depending on several factors such as growing media, fertilization, and seedling age (Faria *et al.*, 2019).

Higher mean values for NL were obtained for the Bcf + Ascb, Bcf + Laf, Bcf + Lcf, Bcf + Al, Bcf + Com, Ascb + Com, Laf + Lcf, Laf + Al, Laf + Com, Lcf + Com, Al + Com, Bcf, Al and Com (Figure 1D). Thus, the results of the study outweighed those reported by Silva *et al.* (2020).

In the presence of fertilizer, the seedlings had higher RDM, SDM, TDM and DQI than without fertilizer (Figures 2A to 2D).

Table 2: Summary of variance analysis of seedling height (H), stem diameter (SD), height: stem diameter ratio (HSD), number of leaves (NL), shoot dry mass (SDM; g), root dry mass (RDM; g), total dry mass (TDM) and Dickson quality index (DQI) of yellow passion fruit seedlings produced in growing medias, with and without controlled-release fertilizer

Sources of variation	g.l	Mean Square			
		H	SD	HSD	NL
Growing media (G)	20	204645.65*	4.77*	10865.44*	44.03*
Fertilization (F)	1	28961747.43*	580.36*	1707290.31*	6403.20*
G x F	20	212463.89*	4.97*	11736.82*	50.43*
Block	2	96028.22*	0.28ns	10055.04*	12.25*
Residual	687	5702.30	0.11	498.64	1.66
C.V (%)	-	29.24	13.73	25.12	17.39
Mean	-	28.24	2.37	8.91	7.41
Sources of variation	**g.l**	**SDM**	**RDM**	**TDM**	**DQI**
Growing media (G)	20	6.88*	0.37*	1.57*	0.033560*
Fertilization (F)	1	1352.15*	37.73*	350.67*	3.446883*
G x F	20	6.57*	0.37*	1.73*	0.037312*
Block	2	1.17*	0.007ns	0.21*	0.003633ns
Residual	687	0.16	0.008	0.02	0.000969
C.V (%)	-	25.57	28.98	10.94	27.91
Mean	-	1.57	0.32	1.12	0.111

g.l = degrees of freedom; C. V = coefficient of variation; * = significant effect by the F test at 5% of probability; ns = not significant effect according to the F test at 5%.

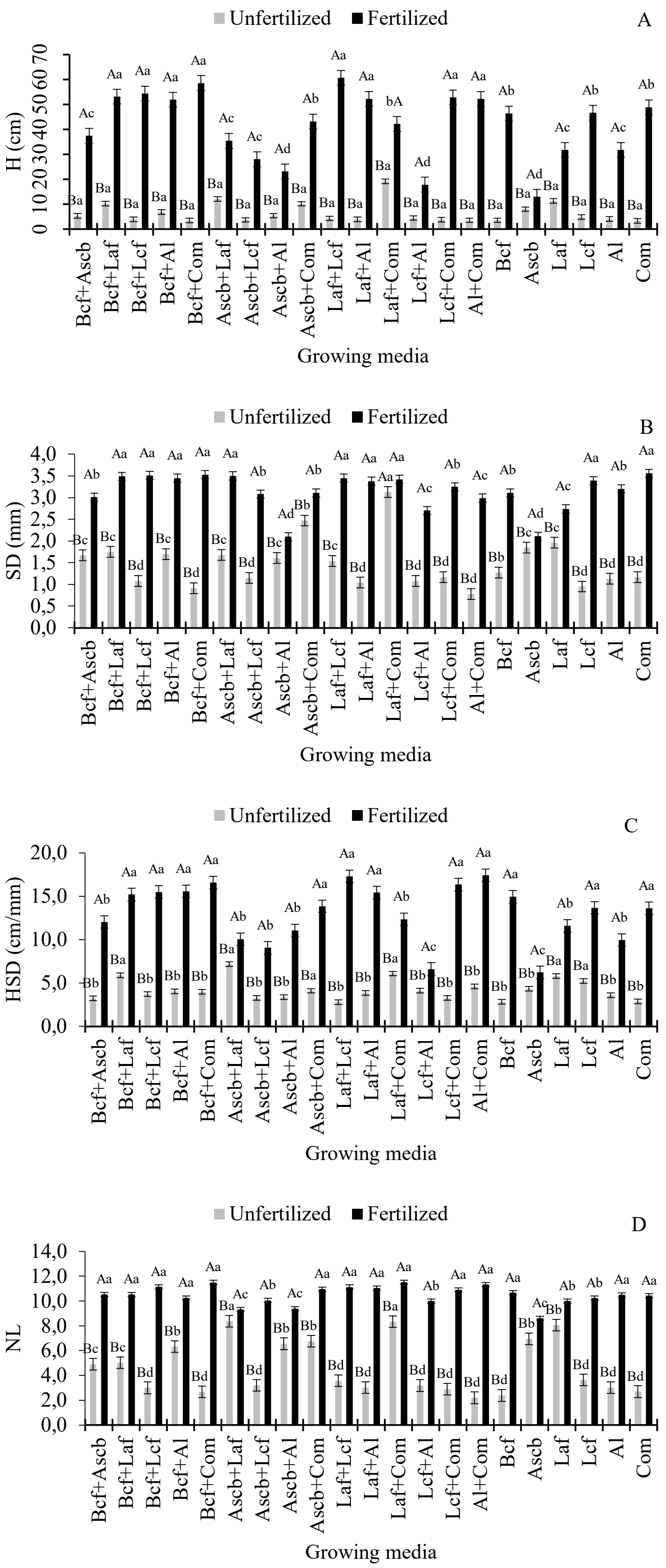

Figure 1: Mean values for seedling height – H (A), stem diameter - SD (B), height: stem diameter – HSD (C) and number of leaves – NL (D) of yellow passion fruit seedlings produced as a function of alternative growing media and controlled-release fertilizer. Notes: Bars with the same lowercase letters do not differ in substrate composition among themselves by Scott-Knott's test at $p < 0.05$ probability. Bars with the same capital letters do not differ in terms of presence and absence of fertilization, by Tukey's test with probability $p < 0.05$.

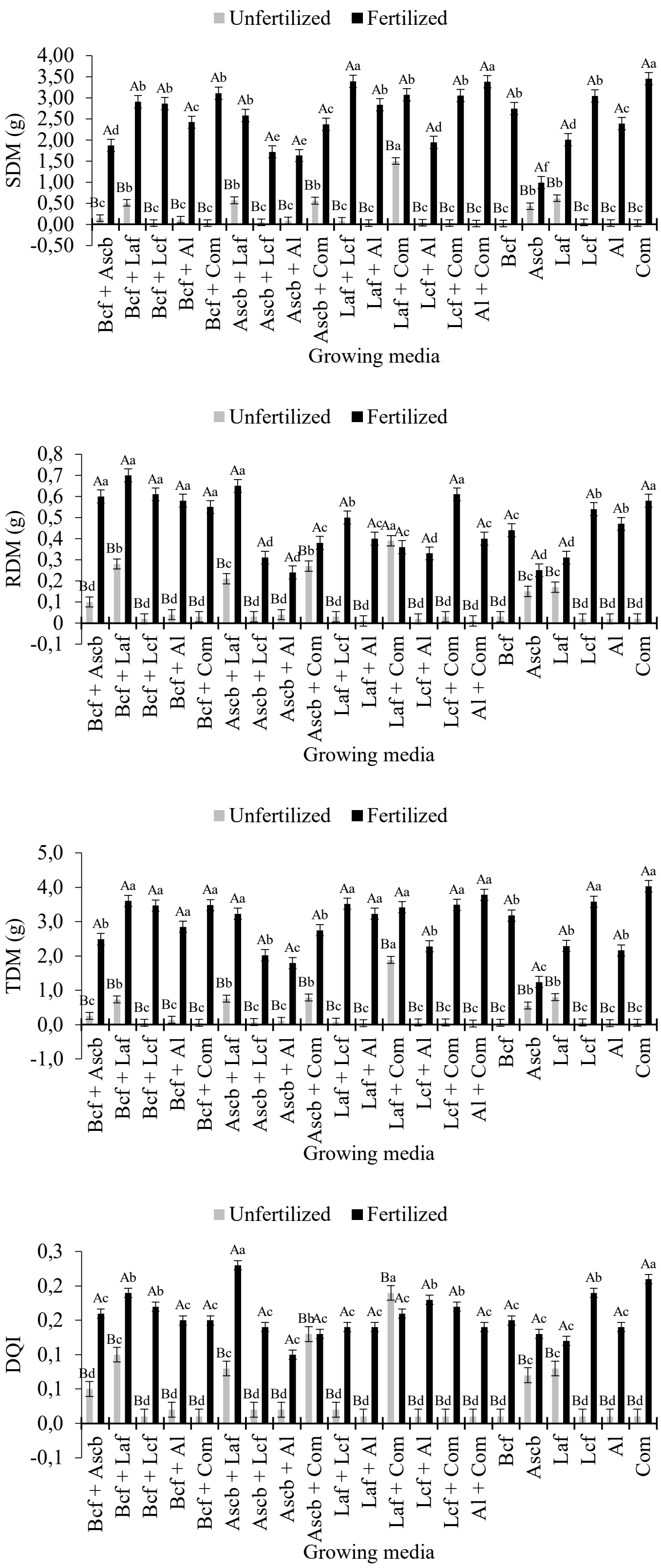

Figure 2: Mean values for shoot dry mass – SDM (A), root dry mass – RDM (B), total dry mass – TDM (C) and Dickson quality index – DQI (D) of yellow passion fruit seedlings produced as a function of alternative growing media and controlled-release fertilizer. Notes: Bars with the same lowercase letters do not differ in substrate composition among themselves by Scott-Knott's test at $p < 0.05$ probability. Bars with the same capital letters do not differ in terms of presence and absence of fertilization, by Tukey's test with probability $p < 0.05$.

The seedlings showed increased SDM in the Laf + Lcf, Al + Com and Com growing medias (Figure 2A). RDM of passion fruit seedlings were higher in the growing medias Bcf + Ascb, Bcf + Laf, Bcf + Lcf, Bcf + Al, Ascb + Laf Lcf + Com and Com (Figure 2B). Concerning to TDM, Bcf + Laf, Bcf + Lcf, Bcf + Al, Bcf + Com, Ascb + Laf, Laf + Lcf, Laf + Al, Laf + Com, Lcf + Com, Al + Com and Lcf caused the seedlings to attain greater values (Figure 2C). Seedlings produced on the Ascb + Laf and Com growing medias acquired the greatest DQI values (Figure 2D).

The values of dry biomass of the seedlings produced on the growing medias that stood out in this study were comparable to or exceeded those described in the literature (Muniz *et al.*, 2020; Cordeiro *et al.*, 2019). However, in certain cases, they were lower which could be attributed to the differences in the cultivars and management practices adopted during seedling production (Mendonça *et al.*, 2021).

The lowest values may have resulted from the RDM that contributed the least to TDM, since the high availability of nutrients from growing medias and fertilizer reduced the need of plants to further expand their root systems (Wang *et al.*, 2018).

The DQI values are variable for yellow passion fruit seedlings in research because they depend on seedling production management practices and factors, such as the environment, growing media, mineral nutrition, irrigation technique, quality of water used in irrigation, seedling age, cultivar, sowing depth, containers, plant health, and the interaction of environmental factors and genotype. Mendonça *et al.* (2021) obtained a DQI of 0.33 when using soil and carnauba bagasse (1:1) as growing media; Silva *et al.* (2018) reported a DQI value of 0.20 in growing media whose composition included carbonized rice husk and decomposed stem of *Ceiba pentandra* L.; Muniz *et al.* (2020) discovered maximum DQI values of 0.25, 0.20 and 0.24 in growing media composed of acerola lumps, growing media made of almond shell of castanha-do-brasil, and commercial growing media, respectively, all the three were supplemented with 12 kg m^{-3} of controlled-release fertilizer.

There was no correlation observed between the biometric characteristics of fertilized and non-fertilized seedlings (Figure 3). However, overall, both the seedlings grown in the substrate with controlled-release fertilizer and those without it exhibited strong, significant, and positive correlations. In general, the chemical and physical attributes of the substrates did not show significant correlations with the biometric characteristics of passion fruit seedlings, except for phosphorus (P), which showed a moderate and positive correlation with SDM and NL. Therefore, the results of this study reinforce that the highest-rated substrates can be used regardless of their specific attributes, since as they receive proper nutritional management, as this leads to the seedlings exhibiting desirable characteristics for planting.

Considering that only the growing medias that received the controlled release fertilizer led the seedlings to reach minimum standards to be taken to the field, it was applied cluster analysis. From the dendrogram obtained by the UPGMA method, it was verified the formation of four groups of growing medias (Figure 4).

The first group was formed by Ascb + Al and Ascb growing medias; the second by Lcf + Al, Ascb + Lcf, Laf, Bcf + Ascb and by Al; the third by the growing media Ascb + Laf; and the fourth, with 61.9% of similar growing medias, by Al + Com, Laf + Com, Ascb + Com, Laf + Al, Bcf, Lcf, Com, Bcf + Al, Bcf + Com, Laf + Lcf, Bcf + Laf, Bcf + Lcf and Lcf + Com. The cophenetic correlation coefficient was 0.73, indicating an adequate adjustment of the UPGMA clustering method to verify the similarity between treatments (Streck *et al.*, 2017).

Therefore, more than half of the evaluated growing medias are like the commercial one, thus constituting viable alternatives to produce yellow passion fruit seedlings. Silva *et al.* (2022) verified that the cluster analysis was efficient to select alternative growing medias, with a reduction of up to 60% of the commercial one in their mixtures, to produce *E. edulis* seedlings.

Owing to their physicochemical properties (Table 1) and the application of fertilizer, the Bcf + Laf, Bcf + Lcf, Bcf + Al, Bcf + Com, Ascb + Laf, Laf + Al, Laf + Com, Lcf + Com, Lcf, and Com growing media combinations were responsible for the seedlings attaining better biometric characteristics (Figures 1, 2 and 4).

As established by Ingram (2014), Bcf + Laf, Bcf + Al, and Lcf + Com possessed pH in the optimal range (5.7–6.5); Ascb + Laf and Com in the acceptable range (5.0–5.6); Bcf + Lcf, Bcf + Com, Laf + Com, and Laf in the higher range (6.6–7.0); while Laf + Al possessed pH in the lower range (< 5.0). However, in the case of Laf + Al, the levels of macro nutrients were not compromised. The high pH of growing media can be adjusted by applying sulfuric acid (Massa *et al.*, 2018) or by using other low-pH components. Similarly, the low pH of growing medias can be corrected

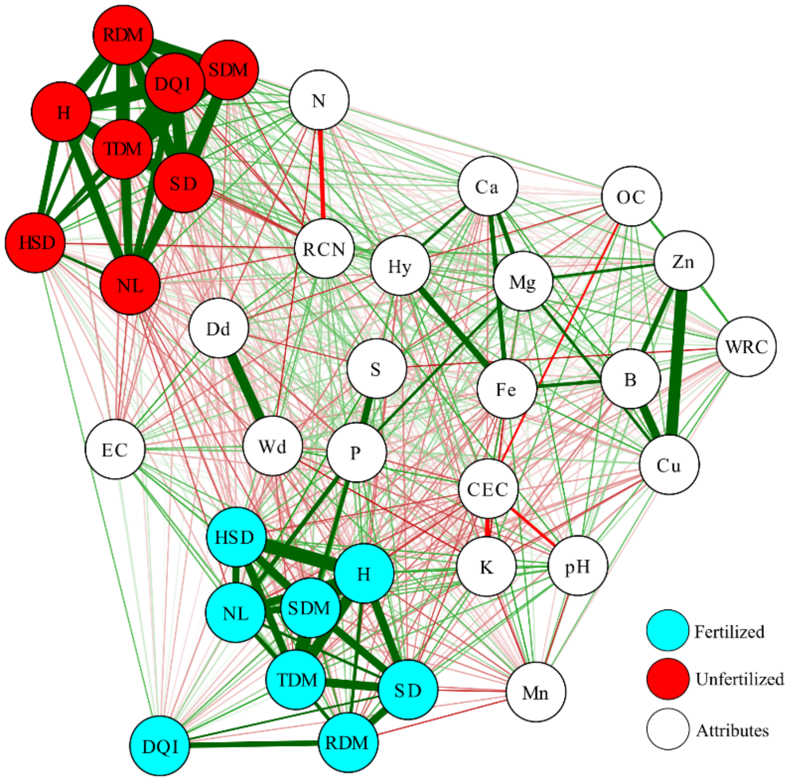

Figure 3: Correlation networks between the biometric characteristics of fertilized and non-fertilized passion fruit seedlings, between the chemical and physical attributes of the substrates, and between the chemical and physical attributes of the substrates and the biometric characteristics of the seedlings.

with limestone application (Muniz *et al.*, 2020) or with higher pH mixtures. Passion fruit is sensitive to electrical conductivity; seeds do not germinate and plants do not grow or produce properly in locations where the electrical conductivity of the soil saturation extract is greater than 1.3 dS m^{-1} (Cavalcante *et al.*, 2009). Therefore, the growing medias that present electrical conductivity between 0.3 and 1.2 dS m^{-1} are considered possessing an acceptable range (Abad *et al.*, 2001).

The macro and micronutrient content of the growing medias in the current study exceeded the optimal values proposed by Ingram (2014). The contents of N, P, K, and Mg were higher than those determined by Cordeiro *et al.* (2019), in the growing media formulated with 80% decomposed babassu stem + 20% soil and sand (1:1) as well as in the commercial growing media, both of which are recommended for the production of yellow passion fruit seedlings. The cation exchange capacity values of the growing medias used in our study were superior to that determined by Costa *et al.* (2018) and lower than the values established by Méndez *et al.* (2015). This was probably because of the particle size of the growing medias, (Altland *et al.*, 2014) which did not impair the performance of the growing medias due to the fertilization carried out or other chemical and physical characteristics presented.

Bcf + Laf, Ascb + Laf, Laf + Al, and Laf + Com growing media usages achieved adequate C/N ratios (Gavilanes-Terán *et al.*, 2017), probably due to the presence of LAF. The C/N ratio of the other growing medias may have been offset by the addition of the controlled-release fertilizer that contained 13% N, which was high enough to prevent competition between seedlings and microorganisms (González-Orozco *et al.*, 2018). The commercial growing media, which is generally recommended for growing yellow passion fruit species, has a higher C/N ratio than most alternative growing medias; however, the growing media has been found suitable for the production of passion fruit seedlings. In this regard, it is perceived that this characteristic cannot be applied universally, because growing medias with higher C/N ratios than the recommended value do not always affect the production of vegetable seedlings (Nieto *et al.*, 2016).

Growing medias that present favorable physical characteristics such as bulk, volumetric, and particle densities, porosity, water holding capacity, and total porosity typically result in better seedling formation (Zorzeto *et al.*, 2014).

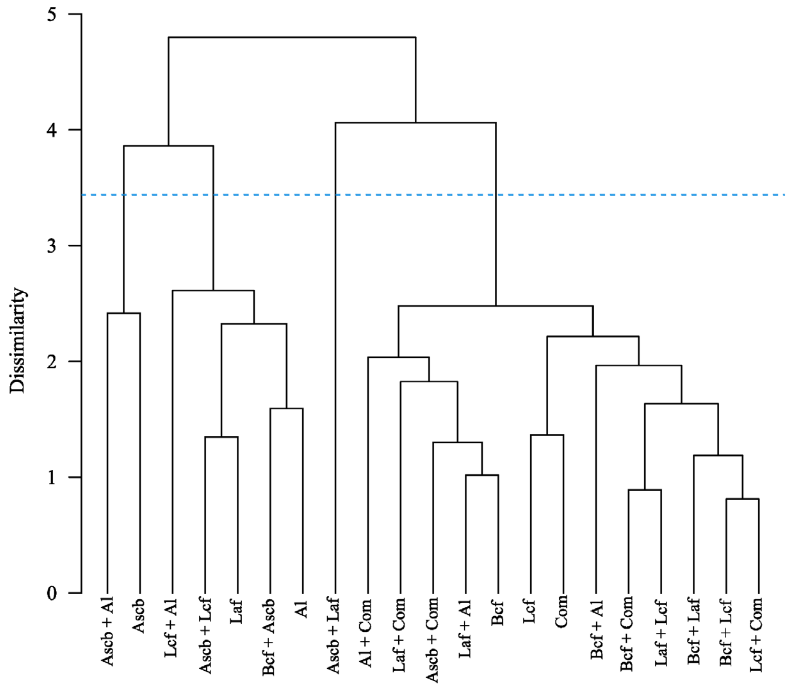

Figure 4: Dendrogram generated by UPGMA method from the dissimilarities through the Euclidean Mean Distance among 21 growing media containing controlled-release fertilizer, based in eight features of seedlings passion fruit.

Suitable growing medias must have a density of less than 400 kg m^{-3} (Abad *et al.* 2001). Bcf + Al and Laf + Al possessed higher values; however, other desirable characteristics and resultant positive effects on seedling production overrode this limitation. Hence, it can be suggested that dry density is not a limiting factor and should be defined according to species (Muniz *et al.*, 2020). The values reported in the literature vary widely depending on the species and growing media, without compromising seedling quality (Mota *et al.*, 2018; Neres *et al.*, 2019).

Bcf + Laf, Bcf + Lcf, Bcf + Al, and Lcf showed water retention capacities in the indicated ranges (Méndez *et al.*, 2015; Noguera *et al.*, 2003). Nevertheless, growing medias with lower water retention capacities can be used if a strategy is adopted to ensure water availability for plants throughout the day.

Therefore, it can be perceived that renewable growing medias associated with fertilization provide a viable alternative to commercial growing medias for the production of yellow passion fruit seedlings from a technical point of view.

Several studies have shown the growth and development of yellow passion fruit seedlings as a function of growing medias associated with fertilization (Muniz *et al.*, 2020). Therefore, it is clear that the growing medias presenting considerable physicochemical characteristics also need nutritional supplementation, including commercial ones.

It is important to note that the fertilizer used had a release duration of three months. However, as the seedlings were evaluated by day 54, it is possible to reduce the amount of fertilizer in the first cover fertilization, hence, amortizing the initial cost of implantation. The fact that these growing medias can be used in larger containers associated with a longer stay in the nursery to produce a taller seedling ("mudão"-type, where the seedlings are above 90 cm tall) as a cultural strategy to mitigate the effect of diseases in the field is also worthy of mention.

CONCLUSIONS

The pairwise combination of growing medias produced from the bark of cupuaçu fruit, almond shell of castanha-do-brasil, lumps of acerola fruit, lumps of cajá fruit, lumps of açaí fruit, and commercial growing media in a proportion of 1:1 and with the use of controlled-release fertilizer constitute an alternative for other growing medias in the production of yellow passion fruit seedlings.

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