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Research Article

Use of agro-industry residues as substrate for the production of *Euterpe precatoria* seedlings[1]

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ABSTRACT

The availability of single assai palm (*Euterpe precatoria*) seedlings with good quality is a fundamental requirement to expand the cultivation of the species. This study aimed to assess the use of fruit agro-industry residues as substrate for producing single assai seedlings. The experiment was carried out under nursery conditions, in a completely randomized design, with four replications and eight plants per plot. Fifteen treatments were evaluated: a commercial substrate, four dry and crushed agro-industrial residues (Brazil nut shell, acerola pit, assai pit and cupuassu peel) and ten combinations of these materials in the proportion of 1:1. The following variables were also measured: shoot height; stem diameter; number of leaves; shoot, root and total dry mass; and Dickson Quality Index score. The substrate formulated with Brazil nut shell + acerola pit stood out for promoting a higher growth and dry biomass, resulting in seedlings with a better quality. The pure assai pit residue was not efficient for producing seedlings, but it showed a good potential when mixed in equal proportion with other materials (e.g. Brazil nut shell and cupuassu peel).

KEYWORDS: Seedling quality, single assai palm, organic waste.

RESUMO

Uso de resíduos agroindustriais como substrato para a produção de mudas de *Euterpe precatoria*

A disponibilidade de mudas de açaizeiro solteiro (*Euterpe precatoria*) de boa qualidade é requisito fundamental para a expansão do cultivo da espécie. Objetivou-se avaliar a utilização de resíduos de agroindústrias frutíferas como substrato para a produção de mudas de açaizeiro solteiro. O experimento foi conduzido em condições de viveiro, em delineamento inteiramente casualizado, com quatro repetições e oito plantas por parcela. Quinze tratamentos foram avaliados: um substrato comercial, quatro resíduos agroindustriais secos e triturados (casca de amêndoa de castanha-do-Brasil, caroço de acerola, caroço de açaí e casca de cupuaçu) e dez combinações desses materiais na proporção 1:1. Também foram mensuradas as seguintes variáveis: altura da parte aérea; diâmetro do colo; número de folhas; massa seca da parte aérea, raiz e total; e Índice de Qualidade de Dickson. O substrato formulado com casca de amêndoa de castanha-do-Brasil + caroço de acerola destacou-se por promover maior crescimento e biomassa seca, resultando em mudas de melhor qualidade. O resíduo de caroço de açaí puro não foi eficiente para a produção de mudas, mas apresentou bom potencial quando em mistura de igual proporção com outros materiais (p. ex. casca de amêndoa de castanha-do-Brasil e casca de cupuaçu).

PALAVRAS-CHAVE: Qualidade de mudas, açaizeiro solteiro, resíduo orgânico.

INTRODUCTION

The single assai palm (*Euterpe precatoria* Mart.) is a single-stem palm tree widely distributed throughout central and northern South America. It mainly occurs in lowlands and "igapó" areas in Brazilian Amazonian states such as Acre, Amazonas, Rondônia and Pará (Henderson 1995). Its fruits are used by the pulp processing industry to obtain "assai wine", a drink rich in lipids, proteins, minerals, polyphenols and anthocyanins (Yayuma et al. 2011).

The Brazilian assai annual production is approximately 1.7 million tons of fruits, 12.8 % of which come from extractivism and 87.2 % from commercial crops, with Pará being the main producer (IBGE 2018a, IBGE 2018b). The rise in the national production is mainly due to the increased consumption and public investment policies in the

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forest and agricultural sectors, in addition to an increase in cultivated areas (Conab 2019). However, the production from commercial cultivation in the states of Acre, Amazonas and Rondônia is not expressive, being predominantly exploited by small and medium farmers, under low-tech monocultures (Vieira et al. 2018).

The nursery phase is a crucial step in the commercial cultivation of a crop, which can enable farmers to obtain plants with a better field performance. Among the factors that contribute to the seedlings quality, the substrate has the role of supporting the seedling and providing the necessary nutrients that can ensure the development of a vigorous plant, in a short period of time (Camargo et al. 2011). It must meet its water and nutritional needs during its growth, as well as present a good texture, water retention and aeration, in addition to an adequate pH for the crop and a good cation exchange capacity (Terra et al. 2011, Martins et al. 2012).

The availability of commercial substrates in the Brazilian northern region is scarce, and the few existing options have a high cost, mainly due to transport to the planting site, what increases the seedling production cost. In addition, there is currently no recommendation for substrate directed to single assai, and the production of seedlings of this species is based on studies related to *Euterpe oleracea*, which, although belonging to the same genus, has distinct ecophysiological characteristics (Almeida et al. 2018, Araújo et al. 2019).

The use of organic materials that provide adequate supply of nutrients, aeration and water is an important alternative in producing quality seedlings (Andrade et al. 2015). Ferreira et al. (2015) suggest the use of agro-industrial residues in the composition of substrates for producing seedlings of forest species. This is aimed at reusing the nutrients contained in these materials and reducing the production cost, while also reusing these residues in order to minimize the impact caused by their disposal into the environment (Araújo et al. 2017, Krause et al. 2017).

Among the various residues from the Amazonian agro-industries, Brazil nut shell, acerola pit (Muniz 2017), assai pit (Erlacher et al. 2016) and cupuassu peel (Dias 2012) stand out for presenting a high availability in the region and a physicochemical potential to formulate seedling production substrates (Soares et al. 2014). Thus, this study aimed to evaluate the use of some agro-industrial residues as potential substrates for producing *E. precatoria* seedlings, in order to replace commercial products.

MATERIAL AND METHODS

The experiment was conducted at the Embrapa Acre experimental field nursery, in Rio Branco, Acre state, Brazil (10º1'30"S, 67º42'18"W and 160 m a.s.l.), from November 2017 to September 2018. The climate in the region is Am, according to the Köppen classification, with an average temperature of 26.2 ºC, rainfall of 1,935 mm year^{-1} and relative humidity of 84 %.

The experimental design was completely randomized, with fifteen treatments, four replications and eight plants per plot. The treatments consisted of a commercial substrate (Tropstrato V9 mix SLAB®), four substrates from Amazonian agro-industry residues (Brazil nut shell, acerola pit, assai pit and cupuassu peel) (Figure 1), plus ten pair combinations of these materials in the proportion of 1:1 (v/v ratio).

The employed materials presented different maturation stages. The Brazil nut residue was naturally decomposed for two years and cupuassu for six months, while the acerola and assai pit residues were fresh. These were ground in a B-611 disintegrator with an 8-mm diameter sieve, combined with each other to obtain the compounds, including the commercial substrate, and then subjected to physicochemical characterization (Table 1).

The seedlings were produced from single assai seeds obtained from the Embrapa Acre preservation area. These were sown in sand, and

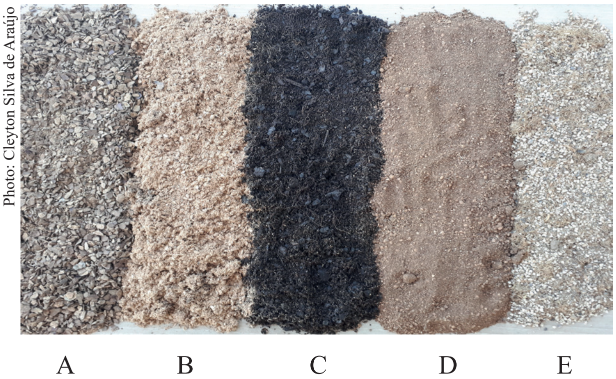

Figure 1. Brazil nut shell (A), acerola pit (B), Tropstrato V9 mix SLAB® (C), cupuassu peel (D) and assai pit (E) used as substrate for the production of *Euterpe precatoria* seedlings.

Table 1. Physicochemical composition of the substrates used in the experiment to produce *Euterpe precatoria* seedlings, without base fertilization.

Substrate[1]	pH	N	P	K	Ca	Mg	S	Fe	B	Cu	Mn	Zn	OC[2]	H[2]	C/N	EC	WD	DD	WRC	CEC
		g kg^{-1}						mg kg^{-1}					g kg^{-1}	%		dS m^{-1}	kg m^{-3}		% m m	mmol$_c$ dm^{-3}
BNS	4.6	10.6	0.9	1.8	15.9	2.3	0.8	11,400	27.6	23.3	267.0	38.6	300.2	52.0	28:1	0.1	573.1	275.0	274.6	382.1
ACP	6.5	22.1	1.7	9.1	12.8	1.8	0.9	1,600	10.7	10.6	40.0	18.9	374.3	9.2	17:1	0.5	265.8	241.5	239.1	129.1
AP	5.7	8.2	2.4	7.3	13.6	2.3	1.6	1,300	14.1	20.9	68.9	56.8	401.6	12.8	49:1	1.2	568.1	495.5	152.8	93.0
CP	7.5	6.6	2.1	1.4	11.9	4.3	0.9	6,200	23.4	35.3	199.1	72.1	432.9	5.8	65:1	1.1	488.6	460.5	129.4	166.1
COM	5.6	3.3	2.1	2.7	8.8	1.9	2.1	4,500	7.7	6.7	84.5	15.7	154.3	25.2	47:1	1.1	508.9	380.8	262.3	319.3
BNS + ACP	5.0	17.3	1.3	4.4	4.3	1.6	1.4	1,600	12.8	15.2	107.1	31.0	304.7	8.8	18:1	0.3	326.3	297.5	154.6	225.2
BNS + AP	4.9	10.7	0.5	3.4	2.3	1.0	0.8	1,100	7.9	10.2	144.7	21.2	323.3	9.8	30:1	0.5	516.3	465.7	91.4	269.1
BNS + CP	5.1	9.9	0.9	7.9	2.4	1.5	1.2	1,900	11.5	13.0	108.1	28.2	334.4	8.0	34:1	0.4	415.1	381.9	119.7	232.3
BNS + COM	4.5	7.2	1.5	3.1	6.5	2.0	1.9	3,600	8.5	10.2	134.6	23.4	218.6	22.8	30:1	0.6	554.5	427.9	194.3	277.2
ACP + AP	4.8	13.8	1.7	6.3	1.8	1.3	1.1	800	12.4	11.4	194.6	31.0	388.9	8.1	28.1	1.2	469.2	431.2	98.4	235.6
ACP + CP	5.8	16.3	2.0	11.4	2.2	1.9	1.3	900	15.0	12.3	54.2	38.5	397.1	6.0	24:1	1.1	398.7	374.6	109.6	163.9
ACP + COM	6.7	16.0	3.6	7.7	13.2	3.5	3.1	3,800	14.3	13.1	127.6	30.3	334.1	40.2	21:1	0.6	286.8	171.5	250.8	180.1
AP + CP	6.4	7.3	1.0	7.8	1.4	1.2	0.8	400	10.5	9.0	144.0	20.2	373.9	4.2	51:1	1.2	614.4	588.6	81.7	185.1
AP + COM	4.8	9.5	2.2	7.0	6.6	2.2	2.1	3,100	9.4	12.5	278.1	32.9	289.4	17.9	31:1	1.3	383.3	314.7	186.8	201.4
CP + COM	6.7	7.4	2.2	11.0	7.2	2.4	2.1	2,400	10.6	10.0	86.9	25.9	296.3	16.3	40:1	0.6	315.8	264.5	179.4	162.9

[1] BNS: Brazil nut shell; ACP: acerola pit; AP: assai pit; CP: cupuassu peel; COM: Tropstrato V9 mix SLAB® (commercial substrate); and combinations (e.g. BNS + ACP) composed by 1:1 v/v ratio. [2] OC: organic carbon; H: humidity; C/N: carbon:nitrogen ratio; EC: electrical conductivity; WD: wet density; DD: dry density; WRC: water retention capacity; CEC: cation exchange capacity.

then the seedlings were selected in the "toothpick" stage, with approximately 3 cm long, and picked for 280 mL tubes. Next, 5 kg m^{-3} of Osmocote® slow release fertilizer (19-6-12) were previously added to the substrates (Almeida et al. 2018), with a nutrient release time of up to 12 months.

Daily irrigations were performed using a misting system, as well as manual weed control whenever necessary. In addition, anthracnose (*Colletrotrichum gloesporioides*) control was conducted by spraying piraclostrobin + epoxiconazole and trifloxystrobin + tebuconazole (2.5 mL L^{-1}) fungicides (Nogueira et al. 2017), alternating fortnightly.

The following variables were evaluated at ten months after the subculture: shoot height (SH, cm), by measuring the plant stem until the emission of the youngest leaflet, with the aid of a graduated ruler; stem diameter (SD, mm), measured at the plant stem at 1.0 cm above the substrate, using a digital caliper; number of physiologically active and fully expanded leaves. The seedlings were subsequently divided into shoots and roots, stored in kraft paper bags and oven-dried at 65 ºC, until constant mass, and weighed on a digital scale, what enabled obtaining the variables of total dry mass (TDM, g), shoot dry mass (SDM, g) and root dry mass (RDM, g). Thus, the seedling quality was determined using the Dickson Quality Index (DQI), according to the formula proposed by Dickson et al. (1960): DQI = TDM/[(SH/SD) + (SDM/RDM)].

The data were submitted to the Shappiro-Wilk (Shappiro & Wilk 1965) and Bartlett (1937) tests to verify the normality of errors and homogeneity of variances, respectively. The data presented normality and homogeneity, except for those belonging to the variable number of leaves, for which the non-parametric Kruskal-Wallis test (Kruskal & Wallis 1952) was performed, followed by the Dunn's (1964) multiple comparisons test. Analysis of variance was performed for the other variables, and the means were subsequently grouped by the Scott-Knott method (Scott & Knott 1974). All tests were performed considering a significance level of 5 %.

RESULTS AND DISCUSSION

There was a significant effect ($p < 0.05$) of substrates on all assessed variables in *E. precatoria* seedlings at ten months after the subculture (Table 2).

A better performance of the substrate derived from Brazil nut shell (BNS) plus acerola pit (ACP) was observed over the others for shoot height and stem diameter (Table 3). The substrate of assai pit (AP) provided the lowest values for these variables. For the pure residues, seedlings grown on BNS and ACP substrates had a higher stem height and diameter, when compared to those grown on

Table 2. Summary of statistical analyzes for the Shappiro-Wilk (W), Bartlett (χ^2) and Kruskal-Wallis (H) tests, and analysis of variance (Anova) to different response variables[1] in the experiment to produce *Euterpe precatoria* seedlings, at ten months after the subculture.

Test	df	p-value						
		SH	SD	NL	SDM	RDM	TDM	DQI
W	14	0.655	0.868	0.970	0.207	0.168	0.625	0.422
χ^2	14	0.337	0.593	0.034/< 0.05	0.523	0.218	0.420	0.187
H	14	-	-	0.001**	-	-	-	-
Source of variation	df	Mean square (Anova)						
Substrates	14	108.78**	17.59**	-	8.75**	2.04**	18.74**	1.03**
Residual	45	2.78	0.22	-	0.15	0.07	0.32	0.04
CV (%)	-	8.19	4.95	5.71	10.26	13.49	9.93	13.66
Mean	-	20.34	9.46	4.44	3.73	1.99	5.72	1.41

[1] SH: shoot height (cm); SD: stem diameter (mm); NL: number of leaves; SDM: shoot dry mass (g); RDM: root dry mass (g); TDM: total dry mass (g); DQI: Dickson Quality Index; df: degree of freedom. ** Significant values at 1 % of probability.

commercial substrate, indicating that both the pure or mixed residues can be used as a good alternative for the seedling formation of this species under the studied conditions.

In evaluating the use of agro-industrial residues as alternative substrates, Muniz (2017) found that acerola pit provided a greater stem height and diameter in *Passiflora edulis* seedlings, when compared to Brazil nut shell and commercial substrate. Moreover, according to Oliveira et al. (2019), different proportions of decomposed babassu residue do not influence the growth of *E. oleracea* seedlings.

Table 3. Mean values of shoot height (SH), stem diameter (SD) and number of leaves (NL) for *Euterpe precatoria* seedlings produced on substrates composed with Amazonian agro-industry residues.

Substrates[1]	SH (cm)	SD (mm)	NL
BNS	23.30 b	11.01 b	4.57 ab
ACP	20.24 c	10.47 c	4.60 ab
AP	6.19 e	3.74 f	1.67 b
CP	15.81 d	7.48 e	4.38 ab
COM	17.67 d	7.72 e	4.28 ab
BNS + ACP	29.45 a	12.84 a	4.75 ab
BNS + AP	20.87 c	9.99 c	5.19 a
BNS + CP	24.03 b	10.12 c	4.88 a
BNS + COM	22.90 b	9.43 d	4.32 ab
ACP + AP	18.57 d	8.85 d	4.47 ab
ACP + CP	18.87 d	9.45 d	4.75 ab
ACP + COM	25.21 b	11.59 b	4.57 ab
AP + CP	18.17 d	8.99 d	4.88 a
AP + COM	22.84 b	10.49 c	4.63 ab
CP + COM	21.04 c	9.81 c	4.66 ab

[1] BNS: Brazil nut shell; ACP: acerola pit; AP: assai pit; CP: cupuassu peel; COM: Tropstrato V9 mix SLAB® (commercial substrate); and combinations (e.g. BNS + ACP) composed by 1:1 v/v ratio. Mean values followed by the same letter in each column do not differ by the Scott-Knot method (Scott & Knott 1974), for the SH and SD variables, or by the Dunn's (1964) test for the NL variable (both tests at 5 % of probability).

The shoot height, together with the stem diameter, provides a good estimate for predicting the initial growth in the field and is technically accepted as a good measure of the seedling performance potential (Rossa et al. 2010, Heberle et al. 2014). A larger stem diameter provides to plants a greater capacity for translocating nutrients and water to the shoots used in the vegetative growth, dry mass gain, and metabolic and photosynthetic processes (Oliveira et al. 2013). According to Dutra et al. (2015), the larger the stem diameter, the better is the growth balance with the shoot, especially when seedling hardening is required.

The number of leaves was analyzed by the non-parametric Kruskal-Wallis test (Kruskal & Wallis 1952), in which a significant influence of the substrates under study was observed ($H = 37.191$; $p < 0.01$). The comparisons in pairs (*post hoc*) showed the smallest number of physiologically active leaves in seedlings grown in the substrate formed by assai pit residue. The other means did not differ from each other (Table 3).

Silva et al. (2011) and Araújo et al. (2017) verified that substrates with organic constituents contributed to increase the number of leaves in *Hancornia speciosa* and *Schizolobium amazonicum* seedlings, respectively. Unlike the results presented herein, Erlacher et al. (2016) found that the number of leaves of *Eruca vesicaria* and *Brassica oleracea* was higher with the use of ground assai pit, if compared to commercial substrate. According to Lima et al. (2008), seedlings with a higher leaf production at the time of being taken to the field present a faster initial growth due to a higher production of photoassimilates and later allocation to other parts of the plant.

The negative effect of the assai pit substrate for growth variables may be related to its cation exchange capacity - CEC (Table 1), considered lower than the minimum 120.0 mmol$_c$ dm^{-3} recommended by Verdonck et al. (1981). This attribute is directly related to the availability of cations and the reduction in leaching losses, since the higher the CEC of a substrate, the higher is its retention of adsorbed cations. The highest CEC in the Brazil nut shell substrate stands out, what possibly favored a greater availability of nutrients to the seedlings.

The pH is another chemical characteristic of a substrate that is related to nutrient solubility. This characterization of the substrates showed a great variation (Table 1), with values associated to the substrates BNS + COM (pH = 4.5) and CP (pH = 7.5) outside the range of 5.0 to 6.5 recommended by Cadahía & Eymar (1992) as being ideal for a good vegetative growth of seedlings. This probably influenced the development of seedlings, because there may be a low availability of N, K, Ca, Mg and B in substrates with a pH below 5.0, while at a pH above 6.5 there might be a deficiency in P, Fe, Mn, Zn and Cu (Valeri & Corradini 2000).

Araújo et al. (2016) indicate N, P, K, Ca and Mg as the nutrients which most limit the growth of *E. oleracea* seedlings, possibly because they affect metabolic functions, with N and K being indicated as the most required macronutrients by seedlings of this species. In turn, Viégas et al. (2008) highlight B as a fundamental micronutrient for assai, and its omission is responsible for a decrease in the seedling stem height and diameter. It is noteworthy that the substrate with only acerola pit (ACP) contained high levels of N and K, while the B content was higher in that with Brazil nut shell - BNS (Table 1), what may partly explain the better growth of plants produced on the BNS + ACP substrate, from a mixture of both.

Regarding the biomass accumulation, a similar effect was observed for the shoot, root and total dry mass, in which the BNS + ACP substrate also provided to plants the greatest accumulation of dry matter; while the assai pit (AP) substrate resulted in plants with lower shoot, root and total biomass gain (Table 4).

The dry matter accumulation reflects the net photosynthesis rate which occurred during the whole formation of the seedling, being extremely influenced by the cellular concentrations of nutrients such as N, P, K, Mg and S, which actively participate in the metabolic processes of photoassimilate generation (Santos et al. 2016). The shoot is responsible for providing phytohormones and carbohydrates to the roots, which, in turn, provide water and other nutrients, making this an essential relationship for seedling development (Lima et al. 2018).

Table 4. Mean values of shoot dry mass (SDM), root dry mass (RDM), total dry mass (TDM) and Dickson Quality Index (DQI) of *Euterpe precatoria* seedlings produced on substrates composed with Amazonian agro-industry residues.

Substrates[1]	SDM (g)	RDM (g)	TDM (g)	DQI
BNS	4.41 c	2.62 b	7.03 c	1.85 b
ACP	4.77 c	2.32 c	7.08 c	1.77 c
AP	0.33 f	0.15 e	0.48 f	0.12 f
CP	2.32 e	1.30 d	3.61 e	0.93 e
COM	2.48 e	1.57 d	4.05 e	1.05 e
BNS + ACP	6.64 a	3.17 a	9.81 a	2.24 a
BNS + AP	3.77 d	1.55 d	5.32 d	1.17 d
BNS + CP	4.08 c	2.4 c	6.48 c	1.59 c
BNS + COM	3.21 d	2.06 c	5.28 d	1.33 d
ACP + AP	3.27 d	1.6 d	4.87 d	1.18 d
ACP + CP	3.46 d	2.20 c	5.65 d	1.59 c
ACP + COM	5.71 b	2.73 b	8.45 b	2.00 b
AP + CP	3.25 d	1.85 c	5.09 d	1.34 d
AP + COM	4.56 c	2.23 c	6.78 c	1.61 c
CP + COM	3.70 d	2.08 c	5.79 d	1.48 c

[1] BNS: Brazil nut shell; ACP: acerola pit; AP: assai pit; CP: cupuassu peel; COM: Tropstrato V9 mix SLAB® (commercial substrate); and combinations (e.g. BNS + ACP) composed by 1:1 v/v ratio. Mean values followed by the same letter in each column do not differ by the Scott-Knot method (Scott & Knott 1974) at 5 % of probability.

Toledo et al. (2015) verified that the substrate composition from organic residues promoted an increase in root, shoot and total dry mass of *Eucaliptus grandis* seedlings. On the other hand, after evaluating the use of organic substrates on the dry matter accumulation in *Calophyllum brasiliense* seedlings, Vieira et al. (2014) found that it did not influence the shoot dry mass, regardless of the employed mixture.

It is important to highlight that growth variables should not be considered in isolation for choosing the best quality seedlings. Thus, Eloy et al. (2013) propose the Dickson Quality Index as a good indicator of their quality, as several important morphological characteristics are considered in its calculation, such as the robustness and equilibrium of the biomass distribution.

In this research, the maximum quality index was found in seedlings grown on the substrate composed with Brazil nut shell and acerola pit (BNS + ACP); in contrast, the minimum index was observed with the use of substrate composed only with assai pit - AP (Table 4). Except for the AP, all obtained values are higher than those proposed by Hunt (1990) as a minimum value (DQI = 0.2) for quality seedlings. However, the reported study considered *Pseudotsuga menziesii* and *Picea glauca*, and the DQI model itself had *Picea glauca* and *Pinus monficola* (Dickson et al. 1960).

The literature shows that the quality index is a variable characteristic, even among *Euterpe* spp. seedlings (Silva et al. 2015, Almeida et al. 2018, Araújo et al. 2018), and it may vary according to the species, seedling age and treatment to which it was submitted (Gomes et al. 2013). It is noteworthy that there is not yet a determined average index for *E. precatoria*, what reinforces the idea that more studies are needed to classify good quality seedlings. However, the higher index values indicate higher vigor seedlings and, consequently, better quality (Costa et al. 2011).

In evaluating the effect of different organic substrates composed of soil, coffee straw and cattle manure on the production of *Archontophoenix alexandrae* and *Bactris gasipaes* palm tree seedlings, Martins Filho et al. (2007) found that coffee straw proved to be unsuitable for the seedling formation of these species, possibly because the material is still decomposing. In the present study, the same response may have occurred with the AP (assai pit) and CP (cupuassu peel) substrates, which have a low relative N content and, consequently, a high C/N ratio (Table 1). A high C/N ratio above 30:1 may lead to N deficiency, due to a temporary immobilization by microbial biomass and excess of C, making the decomposition process slow, while losses of N may occur at levels below 10:1 by volatilization in the form of NH_3 (Kiehl 2004, Kumar et al. 2010, Klein 2015).

The inferior development observed in seedlings grown on the substrates coded as AP, CP and COM (Tables 3 and 4) may also have occurred due to their high dry densities, what may have resulted in mechanical impedance reducing the root growth and, consequently, a nutrient absorption decrease. The dry density values found for AP, CP, BNS + AP, BNS + COM, ACP + AP and AP + CP (Table 1) are all above 250-400 kg m^{-3}, the range considered as ideal by Fermino (2002). Silva et al. (2011) point out that, with the increase of this physical characteristic, there is also a reduction in the total porosity, with a consequent decrease of airspace, resulting in a change in the air/water ratio of the substrate and detrimental effects on the plant development.

The electrical conductivity observed for the substrates (Table 1) may also have influenced the results. Cavins et al. (2000) suggest that levels from 0.76 dS m^{-1} to 1.25 dS m^{-1} have an adequate salinity for developing most crops; however, in the present research, it was observed that better results were obtained with the use of substrates with levels considered as very low (0-0.25 dS m^{-1}) or low (0.26-0.75 dS m^{-1}). The effect of salinization is related to the reduction of the substrate osmotic potential, decreasing the water availability for seedlings (Oliveira et al. 2015).

CONCLUSION

Substrates produced from agro-industry residues can replace commercial substrate without compromising the quality of *Euterpe precatoria* seedlings. The substrate containing Brazil nut shell and acerola pit mixed in the same proportion provides growth and quality to the seedlings, therefore constituting the most promising option among the evaluated substrates for producing this species in the nursery phase.

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