SEEDLINGS OF *Acrocomia aculeata* IN DIFFERENT SUBSTRATES AND PROTECTED ENVIRONMENTS

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ABSTRACT: The seedling production stage is the key to achieve uniformity in tree breeding stage. This study evaluated "bocaiúva" (*Acrocomia aculeata*) seedling formation, with pre-germinated seeds in different substrates and protected environments, in the University of Mato Grosso do Sul State, Aquidauana, MS. As substrates, we used 100% cattle manure (M), 100% cassava branches (CB), 100% vermiculite (V), 50% cattle manure + 50% cassava branches, 50 % cattle manure + 50% vermiculite, 50% cassava branches + 50% vermiculite and ⅓ cattle manure + ⅓ cassava branches + ⅓ vermiculite. These substrates were tested in a greenhouse covered with 150 μm low density polyethylene (LDPE) film under thermo-reflective screen with 50% shading under film; black screen with 50% shading on the sides; black monofilament screen with 50% shading set on roof and sides; and aluminized thermo- reflective screen with 50% shading set on roof and sides. The completely randomized experimental design with 5 replications of 5 plants each was adopted. Initially, data were submitted to analysis of substrate individual variance in each growing environment, then performing the waste mean square evaluation and their environment joint analysis for comparison. The best growing environment is the thermo-reflective screen compared to LDPE greenhouse and black screen set. All substrates containing manure are recommended for bocaiúva seedlings formation. The pure cassava branch is not indicated for seedling, even using chemical fertilizer.

KEYWORDS: bocaiúva, cattle manure, cassava branches, vermiculite, protected cultivation.

MUDAS DE *Acrocomia aculeata* EM DIFERENTES AMBIENTES PROTEGIDOS E SUBSTRATOS

RESUMO: A etapa de produção de mudas é a fase fundamental para obtenção de uniformidade no plantel. Este trabalho avaliou a formação de mudas de bocaiúva (*Acrocomia aculeata*), com sementes pré-geminadas, em diferentes substratos e ambientes protegidos, na Universidade Estadual de Mato Grosso do Sul, Aquidauana-MS. Como substratos, foram utilizados 100% de esterco bovino, 100% de ramas de mandioca, 100% de vermiculita, 50% de esterco bovino + 50% de ramas de mandioca, 50% de esterco bovino + 50% de vermiculita, 50% de ramas de mandioca + 50% de vermiculita e ⅓ de esterco bovino + ⅓ de ramas de mandioca + ⅓ de vermiculita. Estes substratos foram testados na estufa agrícola coberta com filme de polietileno de baixa densidade (PEBD) de 150 μm, com tela termorrefletora de 50% de sombreamento sob o filme e tela preta de 50% de sombreamento nas laterais, no telado com tela preta de mono filamento de 50% de sombreamento na cobertura e nas laterais, e no telado com tela aluminizada termorrefletora de 50% de sombreamento na cobertura e nas laterais. Foi adotado o delineamento experimental inteiramente casualizado, com 5 repetições de 5 plantas cada. Inicialmente, os dados foram submetidos às análises de variâncias individuais dos substratos, em cada ambiente de cultivo, realizando em seguida a avaliação dos quadrados médios dos resíduos e a análise conjunta dos ambientes, para comparação destes. O melhor ambiente de cultivo é o de tela termorrefletora, comparado à estufa de PEBD e ao telado preto. Todos os substratos que contêm esterco bovino são indicados para a formação de mudas de bocaiúva. A rama de mandioca pura não é indicada para formação de mudas, mesmo utilizando adubação química.

PALAVRAS-CHAVE: bocaiúva**,** esterco bovino, ramas de mandioca, vermiculita, cultivo protegido.

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INTRODUCTION

Bocaiúva (*Acrocomia acuelata*), also known as "macaúba", is an important native species from Cerrado, a savannah-like ecosystem, belonging to Arecaceae family, is regarded as the largest dispersion palm with natural stand occurrence almost all over Brazil. They have deep roots that protect soil against erosion, leaves are used in animal feed and fruit is fully exploited (peel, pulp, nut and kernel) for various purposes. It is a promising species for oil production, food and biodiesel, being pest resistant, however its commercial cultivation is still very small.

The seed has dormancy and slow, irregular and often low germination, what makes seedling production a challenge to be overcome. Under natural conditions, germination process may take one to two years. In light of this problem, zygotic embryo in vitro cultivation is presented as a potential solution (SOARES et al., 2011; BORCIONI & NEGRELLE, 2012). Dormancy break researches have intensified, and currently, in vitro zygotic embryo culture makes pre-germinated seeds available in market for "macaúba" seedling development and growth. SOARES et al. (2011) studied germination of in vitro initial growth embryo of "macaúba" and found the highest germination percentage at 60 days.

Recently, non-fossil fuel use has received special attention by providing benefits to environment and a whole ecosystem (LOPES & STEIDLE NETO, 2011). In this sense, *Acrocomia aculeata* has aroused interest due to its potential use for biofuels. ABREU et al. (2012) reported that due to genetic structure, conservation strategies, and germplasm collection should be sampled from different groups of individuals. In studies with soaking and drying of fruits and seeds in bocaiúva germination RUBIO NETO et al. (2012) found that in nuts dried for nine days there is no vigor loss, however if dehydrated for 15 days seed viability loss was verified.

Studies with fruit seedlings, testing cultivation environments and substrates (COSTA et al., 2010a; COSTA et al., 2011a, b; SANTOS et al., 2011), show that interaction and joint action of these two factors provide the best conditions for plant growth. Thus, seedling strength and robustness will provide cash crops with potential for fruit production. The Mato Grosso do Sul State has great potential for commercial development of bocaiúva orchards, and research throughout the production chain is needed, starting with high quality seedling formation.

Given the above, this study aimed to evaluate the production of bocaiúva seedlings using different substrates in different environments in the Upper Pantanal region of Mato Grosso do Sul State.

MATERIAL AND METHODS

The bocaiúva (*Acrocomia aculeata*) seedling development experiments on different substrates and cultivation environments were conducted from October 25th 2010 to February 22nd 2011 (120 days) at the University of Mato Grosso do Sul State, Aquidauna College Unit (altitude: 174 m, longitude: 55°40' W and latitude: 20º27' S). The climate, according to Köeppen is Aw (tropical humid climate with average annual temperature of 29 ºC).

As containers for seedling formation, perforated black polyethylene plastic bags of 15.0 x 25.0 cm (1.8 L) filled with the following substrates were used: (S1) 100% cattle manure, (S2) 100% crude cassava, (S3) 100% vermiculite (S4) 50% cattle manure + 50% cassava branches, (S5) 50% cattle manure + 50% vermiculite (S6) 50% crude cassava + 50% vermiculite and (S7) 1/3 cattle manure + 1/3 + cassava branches + 1/3 vermiculite (Table 1).

TABLE 1. Chemical analysis of organic materials used in the bocaiúva experiment. Aquidauna, MS, 2010-2011.

Material	$g\ kg^{-1}$							
	N	P	K	Ca	Mg	S	C	OM
EB	9.30	1.82	1.00	4.95	0.90	1.07	112.00	192.00
RM	26.70	6.62	29.00	27.45	7.70	3.25	483.00	830.00
	-	-	-	$mg\ kg^{-1}$				
	pH	U	C/N	Cu	Zn	Fe	Mn	B
EB	7.10	14.12	12.04	14.00	103.00	6000.00	239.50	12.19
RM	8.80	65.04	18.09	16.50	170.00	910.00	223.00	28.75

* Laboratory of Soil analysis, Solanalise, Dourados, MS. OM = organic matter, U =% humidity at 65°C, M = cattle manure, CS = cassava branches.

Treatments consisted of tested substrates in three protected environments: (A1) an arch greenhouse (6.40 m x 18.00 m x 4.00 m) with zenith opening in the ridge, covered with 150 μm low density polyethylene (LDPE) film, light diffuser and containing a thermo-reflective screen with 50% shading below this, with side and front monofilament screen with 50% shading; (A2) flat roof farming nursery (6.40 m x 18.00 m x 3.50 m), with cover and black monofilament screen sides under 50% shading, placed at 45º degrees, and (A3) flat roofing agricultural nursery (6.40 m x 18.00 m x 3.50 m), with cover and aluminized thermo-reflective screen side, under 50% shading, positioned at 45º degrees. A2 and A3 environments were considered black and aluminized screened environments, respectively, and A1 environment LDPE greenhouse.

To evaluate substrates inside protected environments, a completely randomized design with five replications of five plants each was adopted. Initially, data were submitted to individual substrates variance analysis (for each growing environment), then performing the mean-square residual evaluation and joint environments analysis (groups of experiments). Sisvar 5.3 statistical software was used, and the means were compared by Tukey test at 5% probability.

Pre-germinated seeds from Acrotech® with 30 days were sowed on October 25^{th}, 2010. Measurements of seedling height (PH) at 30; 60; 90 and 120 days after sowing (DAS) were made. At 120 DAS, neck diameter (ND), shoot dry phytomass (SDP), and root dry phytomass (RDP) were also measured. Phytomass drying was performed in an oven with forced air circulation at 65 °C for 72 hours. SDP and RDP were added to obtain the total dry phytomass (TDP). The ratios: shoot and root dry phytomass ($SRDP_r$), height and diameter (HD_r), height and shoot dry phytomass ($HSDP_r$), and Dickson quality index (DQI) were also determined:

$$DQI = \frac{TDP(g)}{\frac{PH(cm)}{ND(mm)} + \frac{SDP(g)}{RDP(g)}} \quad (1)$$

Dry and wet bulb temperatures were daily measured at 09 am, 12 and 03 pm in each growing environment throughout the experimentation period. Subsequently, relative humidity was determined with the aid of Psychrometrics Function Demo software (Table 2).

TABLE 2. Air Temperature (°C) and average relative humidity (%) at 09 am, 12 and 03 pm, in growing and external environments. Aquidauna - MS, 2010-2011.

	T_{air}			RH_{air}		
	09am	12	03pm	09am	12	03pm
LDPE Greenhouse	27.69	31.74	32.28	73.04	61.51	62.31
Black screen	28.02	32.31	33.32	76.32	61.58	61.51
Aluminized screen	28.13	32.25	33.42	77.34	64.16	63.52
External	27.76	32.01	32.87	77.93	64.66	62.93

* T_{air} - air temperature (ºC); RH_{air} - relative humidity (%).

Manure was composted for 30 days, wet and upturned to decrease in temperature and change colors. Branches were crushed in hammer mill screen type 12 (Table 3) and composted for 30 days. Medium texture vermiculite was used. Irrigation was performed manually with sprinkler once or twice a day until substrate saturated, which was observed in the beginning of superficial water runoff. Substrates were fertilized as recommended by RIBEIRO et al. (1999), with 2.5 kg single superphosphate (P_2O_5), 0.3 kg potassium chloride (KCl), 1.5 kg dolomitic limestone filler (PRNT 100% pure) and 50 g of N (108.33 g of urea, 46% N) per cubic meter.

TABLE 3. Percentage of cassava cuttings shredded particles, retained on each sieve. Aquidauna, MS, 2010-2011.

Sieve (ABNT nº)	Holes (mm)	% of material
5	4.0	3.03
10	2.0	50.76
16	1.2	15.55
30	0.6	19.91
50	0.3	7.50
100	0.15	2.27
Bottom	0.0	0.95

Medium Geometric Diameter (MGD) = 1.81 mm; Thinness Module (TM) = 4.1

RESULTS AND DISCUSSION

For all evaluated parameters, the residual mean square relation (RMS) of experiment individual variable analyses did not exceed 7:1 ratio (Tables 4; 5 and 6); thus, enabling joint experiment analysis. The culture environments for plant height (PH) at 30 DAS (Table 4) and for neck diameter (ND) (Table 5), as well as interactions for root system dry phytomass (RDP), for total phytomass (TP) and Dickson quality index (DQI) showed no significant differences (Table 6).

For the other parameters, both isolated factors (environments and substrates), and their interactions were significant (Tables 4 and 5), revealing that the two factors acted to provide better development conditions for *Acrocomia aculeata* seedlings. Interactions between substrates and protected environments were observed in fruit seedlings by SANTOS et al. (2011) with "jatobazeiro-do-cerrado", COSTA et al. (2010a) with passion fruit, and COSTA et al. (2011a) with the papaya plants.

Seedling shoot height provides excellent estimate of plant initial growth, being a measure of seedling development potential in field. However, this parameter can be affected by cultural practices (CRUZ et al., 2010) and high shading levels. For this parameter, joint factor analysis showed that there was significant response of bocaiúva seedlings to used environments and substrates (Table 4), where there was predominance of higher seedlings in ½ M + ½ V e ⅓ M + ⅓ CB + ⅓ V substrates in LDPE greenhouse; and for screens (black aluminized screen) higher plants were observed in 100% M, ½ M + ½ V e ⅓ M + ⅓ CB + ⅓ V substrates.

For environment and substrate interaction, it appears that higher seedlings (cm), in all environments and samples, were recorded for substrates containing manure, mainly in ½ M + ½ V e no ⅓ M + ⅓ CB + ⅓ V. In screens (black screen and aluminized screen) seedlings in substrate containing pure manure did not differ in plant height from the aforementioned substrates (Table 4). Besides chemical fertilizer, substrates containing manure provided higher amount of nutrients to *Acrocomia aculeata*, not even improved substrate physical structure but also obtained higher water adsorption by the manure organic matter.

TABLE 4. Environment and substrate interactions for plant height (PH) at 30, 60, 90 and 120 days after sowing bocaiúva seedlings. Aquidauna - MS, 2010-2011.

	LDPE Greenhouse	Black Screen	Aluminized Screen	LDPE Greenhouse	Black Screen	Aluminized Screen
**		PH (cm), 30 DAS			PH (cm), 60 DAS	
100% M	10.0 Bb	13.8 Aa	12.4 ABab	16.9 Bb	26.3 Aa	20.3 Ab
100% CB	9.4 Ba	9.3 Ba	7.4 Ca	14.1 Ba	17.3 Ca	12.8 Ca
100% V	10.3 Ba	9.8 Ba	11.6 Ba	16.5 Ba	20.0 BCa	19.2 ABa
½ M + ½ CB	12.8 ABa	10.7 ABa	10.8 BCa	19.6 Ba	20.8ABCa	17.7 ABCa
½ M + ½ V	14.2 Aa	13.4 Aa	15.2 Aa	25.6 Aa	26.4 Aa	22.8 Aa
½ CB + ½ V	9.7 Ba	9.4 Ba	7.6 Ca	16.8 Ba	16.4 Ca	13.7 BCa
⅓ M + ⅓ CB + ⅓V	14.0 Aa	12.8 ABa	11.7 ABa	27.7 Aa	24.8 ABa	20.0 Ab
VC (%)		16.6			15.8	
RMS		2.1			1.2	
Fcal(environments)		0.7 ns			11.9**	
Fcal(substrates)		17.9**			23.4**	
Fcal(interactions)		2.4**			2.7**	
		PH (cm), 90 DAS			PH (cm), 120 DAS	
100% M	22.4 Bc	33.2 Aa	28.2 Ab	31.4 Bb	40.2 ABa	38.5 ABa
100% CB	20.9 Ba	23.5 Ba	20.8 Ca	26.6 Ba	24.4 Da	26.2 Da
100% V	23.7 Ba	25.8 Ba	27.3 ABa	25.8 Ba	29.0 CDa	29.3 CDa
½ M + ½ CB	26.2 Ba	27.1 Ba	26.1 ABCa	29.9 Bb	35.1 BCa	35.1 BCa
½ M + ½ V	32.1 Aab	36.3 Aa	31.3 Ab	38.7 Ab	46.0 Aa	43.3 Aab
½ CB + ½ V	23.0 Ba	24.8 Ba	22.0 BCa	25.9 Ba	26.8 Da	26.4 Da
⅓ M + ⅓ CB + ⅓V	34.0 Aa	32.8 Aa	27.3 ABb	39.6 Aa	41.0 ABa	40.1 ABa
VC (%)		10.5			9.9	
RMS		1.5			1.1	
Fcal(environments)		12.8**			11.5**	
Fcal(substrates)		31.9**			64.4**	
Fcal(interactions)		3.8**			1.94*	

* Same uppercase letters in columns and lowercase letters in rows do not differ from each other by the Tukey test at 5% probability for each variable; M - manure; CB - cassava branches; V - vermiculite; VC - variation coefficient; RMS - ratio between the largest and smallest residual mean square of the individual substrates analysis residue inside the cultivation environments. Fcal F - calculated; * significant at 5% probability; ** significant at 1% probability; ns not significant.

Cultivation environments influenced seedling growth. At 30 DAS for 100% substrate and black screen seedlings, which did not differ from the aluminized screen seedlings, were higher than those from the LDPE greenhouse. At 60 DAS and 90 DAS for 100% substrate and black screen seedlings were greater than in other environments; and for ⅓ M + ⅓ CB + ⅓ V substrate smaller seedlings were observed in aluminized screen. Still at 90 DAS for ½ M + ½ V substrate black screen seedlings, which did not differ from LDPE greenhouse seedlings, were higher than aluminized screen. At 120 DAS for 100% M, ½ M + ½ CB and ½ M + ½ V substrates taller seedlings were observed for both screens (Table 4).

Quality seedlings were obtained with manure use in substrate formulation at 33.33; 50 and 100 % rates (Table 4, 5 and 6). Being different from that result obtained by DIAS et al. (2009a) who found that manure above 10% in substrate did not form high quality “mangabeira” seedlings and DIAS et al. (2009b) found that doses above 30% manure decrease dry mass buildup in coffee seedlings.

This shadow effect (black screen and aluminized screen with 50% shade), combined with rainwater input which assisted on organic matter degradation and nutrients release, promoted less evapotranspiration in environments due to solar radiation reduction, providing better conditions for bocaiúva growth, producing taller plants at the end of the experiment in substrates with manure.

These results are in agreement with those obtained by COSTA et al. (2010b), in which screen environments (monofilament and aluminized) promoted taller 'Sunrise Solo' papaya plants.

Assessing substrates inside cultivation environments, it is verified that seedlings in substrates containing pure cassava branches or mixed with vermiculite had lower neck diameters than those grown in substrates containing manure (Table 5). Cassava branches, even with composting time equal to cattle manure, showed the highest C/N ratio (Table 1), promoting lower availability of nutrients in substrates that contained it due to lower organic matter degradation, restricting seedlings development.

COSTA et al. (2011d) working with vermiculite and crushed non-composted cassava branches with C/N ratio of 31.12 found that a mixture of approximately 50% of each material provided quality in eggplant seedlings. In this research, the 30 day compost decreased the C/ N ratio (18.09), but it was not enough to provide bocaiúva seedling high quality, possibly due to their required time in nursery (120 DAS).

The division of height by neck diameter (HD_r) may indicate damping off, probability of transplanted seedling to fall down resulting death. In all substrates and cultivation environment there was balanced distribution between height and diameter and did not characterize seedling downfall (Table 5). For forest seedlings, it is emphasized that this relation is an important index, so the lower the value, the better the seedling survivability in plantations. For these reasons, all bocaiúva seedlings would be suitable for adequate field development.

The plant height and shoot dry mass ratio ($HSDP_r$) is not normally used to assess seedling quality standard. However, it is determinant to estimate seedling field survivability (CRUZ et al., 2010). The lower this variable value, the more lignified and resistant the plant is in field (CRUZ et al., 2010). For substrate evaluation within each cultivation environment, it was found that substrates containing manure plants showed lower HSDP (Table 4). For 100% CB, the lowest $HSDP_r$ was obtained at the black screen; for ½ M + ½ CB it was the screens; for ½ CB + ½ V it was the LDPE greenhouse; and for the other substrates there were no differences between the cultivation environments.

As observed for seedlings heights, in all environments seedlings with greater shoot dry phytomass were found in substrates containing manure, mainly in ½ M + ½ V and in ⅓ M + ⅓ CB + ⅓ V. In screens (black and aluminized screen) shoot phytomass of seedling in substrate containing pure manure did not differ from those previously mentioned (Table 5). Probably manure gave better physical condition to substrates and increased nutrient availability to plants.

Except for 100% M, it was verified that mixture of two or more components with presence of manure provided shoot phytomass buildup (Table 5) as greater seedling growth. Probably diverse material mixture in substrate (manure, vermiculite and crushed cassava branches) provided better physical and chemical properties to bocaiúva seedlings development, as reported by LIMA et al. (2006), who highlighted the mixture of soil, manure, peanut hulls, sisal mucilage, sugar cane bagasse and chicken manure in castor seedling formation; and LIMA et al. (2011), who highlighted the mixture of castor hulls, compost, manure, sewage sludge and castor bean in “jatropha” seedling production. Also, similar results were observed by SILVA et al. (2009), in which better mangabeira seedlings (*Hancornia speciosa*) were obtained in substrates based on cattle manure + Plantmax®+ soil (1:1:3) and manure + soil (2:3) mix.

TABLE 5. Environment and substrate interactions for neck diameter (ND), height and diameter ratio (HD_r), plant height and dry phytomass ratio (HDP_r), shoot dry phytomass (SDP), shoot and root dry phytomass ratio ($SRDP_r$) for bocaiúva seedlings. Aquidauna - MS, 2010-2011.

	LDPF Greenhouse	Black Screen	Aluminized Screen	LDPF Greenhouse	Black Screen	Aluminized Screen
**		ND (mm)			HD_r	
100% M	9.92 Aa	9.13 ABa	9.62 ABa	3.21 Bb	4.41 ABa	4.01 Aa
100% CB	7.43 Ba	6.24 Da	6.77 Da	3.59 Ba	3.92 Ba	3.91 Aa
100% V	8.27 Aba	7.71 BCDa	8.12 BCDa	3.18 Ba	3.80 Ba	3.63 Aa
½ M + ½ CB	8.57 Aba	8.27 ABCa	9.18 ABCa	3.56 Ba	4.26 ABa	3.83 Aa
½ M + ½ V	8.47 Abb	9.50 ABab	10.55 Aa	4.63 Aab	4.85 Aa	4.12 Ab
½ CB + ½ V	8.58 Aba	7.10 CDb	7.63 CDab	3.08 Ba	3.79 Ba	3.50 Aa
⅓ M +⅓ CB+ ⅓ V	8.42 Abb	10.01 Aa	9.93 ABa	4.76 Aa	4.10 ABa	4.08 Aa
VC (%)		11.4			12.3	
RMS		1.5			4.1	
Fcal (environments)		2.8ns			7.8**	
Fcal (substrates)		17.7**			9.8**	
Fcal (interactions)		2.4**			2.5**	
		SPD (g)			HDP_r	
100% M	2.23 BCb	2.95 ABa	3.59 Aa	14.37 CDa	14.01 Ba	10.85 Ca
100% CB	0.98 Da	1.08 Da	1.08 Ca	27.87 Aa	23.19 Ab	25.58 Aab
100% V	1.40 Cda	1.61 CDa	1.55 Ca	18.84 BCa	18.29 ABa	19.05 Ba
½ M + ½ CB	1.37 CDb	2.31 BCa	2.69 Ba	22.42 Aba	15.45 Bb	13.72 BCb
½ M + ½ V	2.83 Abb	3.31 Aab	3.97 Aa	14.11 CDa	13.96 Ba	11.16 Ca
½ CB + ½ V	1.45 Cda	1.17 Da	1.38 Ca	18.04 BCDb	23.24 Aa	19.18 Bab
⅓ M +⅓ CB+ ⅓ V	3.28 Aa	3.08 ABa	3.50 ABa	12.25 Da	13.76 Ba	11.52 Ca
VC (%)		20.5			17.8	
RMS		1.3			1.4	
Fcal (environments)		15.2**			5.6**	
Fcal (substrates)		66.9**			36.7**	
Fcal (interactions)		2.8**			2.8**	
		$SRDP_r$			-	
100% M	0.86 Abb	1.18 Aa	1.32 Aa	-	-	-
100% CB	0.60 Bca	0.47 Ba	0.43 Ba	-	-	-
100% V	0.50 Ba	0.59 Ba	0.47 Ba	-	-	-
½ M + ½ CB	0.95 Ab	1.24 Aa	1.19 Aab	-	-	-
½ M + ½ V	0.86 Abb	1.20 Aa	1.11 Aa	-	-	-
½ CB + ½ V	0.49 Ba	0.49 Ba	0.44 Ba	-	-	-
⅓ M +⅓ CB+ ⅓ V	0.98 Ab	1.26 Aa	1.13 Aab	-	-	-
VC (%)		19.6			-	
RMS		1.6			-	
Fcal (environments)		0.02			-	
Fcal (substrates)		0.03			-	
Fcal (interactions)		0.03			-	

* Same uppercase letters in columns and lowercase letters in rows do not differ from each other by the Tukey test at 5% probability for each variable; M - manure; CB - cassava branches; V - vermiculite; VC - variation coefficient; RMS - ratio between the largest and smallest residual mean square of the individual substrates analysis residue inside the cultivation environments. Fcal F - calculated; * significant at 5% probability; ** significant at 1% probability; ns not significant.

Pure manure and equal proportion branch and vermiculite mix substrates under screens have provided higher dry shoot phytomass plants (Table 5). Evaluating the same environments for passion fruit seedlings, COSTA et al. (2011c), observed better plants in LDPE greenhouse than screen, using polyethylene 15.0 x 21.5 cm bags. However, in smaller bags (7.5 cm x 11.5 cm; 10.0 cm x 16.5 cm), there were no differences for total dry phytomass. The same authors also observed that vermiculite was the best substrate and plants grown in it showed no differences for height and phytomass among three tested environments.

Shoot and root dry phytomass ratio ($SRDP_r$) is a safe standard to demonstrate seedling quality, with value equals to 2 for forest species seedlings, it means shoot is twice root phytomass. In our research it ranged from 0.43 (100%CB) to 1.32 (100% M). The environments and substrate results were similar to those observed for other evaluation variables for bocaiúva seedlings, which manure and screens got greater vigor (Table 5).

Thermo-reflective screens obtained higher total and root phytomass as vigor (DQI) for variables without interaction. Manure and vermiculite substrate, pure or mixed, have provided suitable conditions for bocaiúva root growth showing high quality, inferred by Dickson quality index, as the higher this ratio the better seedling quality and vigor. Manure promoted the largest plant total dry phytomass (Table 6). DQI includes height, neck thickness and dry phytomass parameters and is widely used for forest seedlings. This index confirmed results observed in separated parameters, including vermiculite besides manure substrates.

TABLE 6. Root dry phytomass (RDP), total dry phytomass (TDP) and Dickson Quality Index (DQI) for bocaiúva seedlings. Aquidauna - MS, 2010-2011.

	RDP (g)	TDP (g)	DQI
LDPE Greenhouse	1.03 b*	4.56 b	2.63 b
Black Screen	0.92 b	4.67 b	2.46 b
Aluminized Screen	1.17 a	5.55 a	3.01 a
100% M **	1.13 A	5.55 A	2.62 AB
100% CB	0.76 B	3.21 C	2.16 BC
100% V	1.11 A	4.48 B	2.96 A
½ M + ½ CB	0.80 B	4.02 BC	1.89 C
½ M + ½ V	1.19 A	6.59 A	3.22 A
½ CB + ½ V	1.09 A	4.20 BC	2.87 A
⅓ M + ⅓ CB + ⅓ V	1.20 A	6.45 A	3.16 A
VC (%)	22.7	19.3	19.61
RMS	2.2	1.4	1.7
Fcal (environments)	7.5**	11.2**	13.4**
Fcal (substrates)	10.2**	27.5**	12.1**
Fcal (interactions)	1.3ns	1.5ns	1.6ns

* Same uppercase letters in columns and lowercase letters in rows do not differ from each other by the Tukey test at 5% probability for each variable; M - manure; CB - cassava branches; V - vermiculite; VC - variation coefficient; RMS - ratio between the largest and smallest mean square of the individual substrates analysis residue inside the cultivation environments. Fcal F - calculated; * significant at 5% probability; ** significant at 1% probability; ^{ns} not significant.

CONCLUSIONS

The best growing environment is the thermo-reflective screen.

All substrates containing manure are indicated for bocaiúva seedling formation.

The substrate containing crashed cassava branches is not suitable for bocaiúva seedling formation.

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REFERENCES

ABREU, A. G.; PRIOLLI, R. H. G.; AZEVEDO-FILHO, J. A.; NUCCI, S. M.; ZUCCHI, M. I.; COELHO, R. M.; COLOMBO, C. A. The genetic structure and mating system of *Acrocomia aculeata* (Arecaceae). *Genetics and Molecular Biology*, São Paulo, v. 35, n. 1, p. 116-121, 2012.

BORCIONI, E.; NEGRELLE, R. R. B. Aplicação de análogo de brassinosteroide (Biobras 16®) sobre a germinação e crescimento *in vitro* de embriões zigóticos e aclimatização de plântulas de bocaiúva. *Ciência Rural*, Santa Maria, v. 42, n. 2, p. 270-275, fev. 2012.

COSTA, E.; DURANTE, L. G. Y.; NAGEL, P. L.; FERREIRA, C. R.; SANTOS, A. Qualidade de mudas de berinjela submetida a diferentes métodos de produção. *Revista Ciência Agronômica*, Fortaleza, v. 42, n. 4, p.1017-1025, 2011 d.

COSTA, E.; LEAL, P. A. M.; MESQUITA, V. A. G.; SASSAQUI, A. R. Efeitos do Organosuper® e do ambiente protegido na formação de mudas de mamoeiro. *Engenharia Agrícola*, Jaboticabal, v. 31, n. 1, p.41-55, 2011 a.

COSTA, E.; LEAL, P. A. M.; REGO, N. H.; BENATTI, J. Desenvolvimento inicial de mudas de jatobazeiro do cerrado em Aquidauana-MS. *Revista Brasileira de Fruticultura*, Jaboticabal, v. 33, n. 1, p. 215-226, 2011b.

COSTA, E.; LEAL, P. A. M.; SANTOS, L. C. R.; VIEIRA, L. C. R. . Crescimento de mudas de mamoeiro conduzidas em diferentes ambientes protegidos, recipientes e substratos na região de Aquidauana-MS. *Acta Scientiarum. Agronomy*, Maringá, v. 32, n. 3, p. 463-470, 2010 b.

COSTA, E.; LEAL, P. A. M.; SASSAQUI, A. R.; GOMES, V. do A. G. Doses de composto orgânico comercial na composição de substratos para a produção de mudas de maracujazeiro em diferentes tipos de cultivo protegido. *Engenharia Agrícola*, Jaboticabal, v. 30, n. 5, p. 776-787, 2010 a.

COSTA, E.; SANTOS, L. C. R.; CARVALHO, C.; LEAL, P. A. M.; GOMES, V. A. Volumes de substratos comerciais, solo e composto orgânico afetando a formação de mudas de maracujazeiro-amarelo em diferentes ambientes de cultivo. *Revista Ceres*, Viçosa - MG, v. 58, n. 2, p. 216-222, mar./abr., 2011 c.

CRUZ, C. A. F.; PAIVA, H. N. de; NEVES, J. C. L.; CUNHA, A. C. M. C. M. Resposta de mudas de *Senna macranthera* (DC. EX COLLAD.) H. S. IRWIN & BARNABY (Fedegoso) cultivadas em latossolo vermelho-amarelo distrófico a macronutrientes. *Revista Árvore*, Viçosa - MG, v. 34, n. 1, p. 13-24, 2010.

DIAS, R.; MELO, B.; RUFINO, M. A.; SILVEIRA, D. L.; MORAIS, T. P.; SANTANA, D. G. Fontes e proporção de material orgânico para a produção de mudas de cafeeiro em tubetes. *Ciência e Agrotecnologia*, Lavras, v. 33, n. 3, p. 758-764, 2009 b.

DIAS, T. J.; PEREIRA, W. E.; CAVACANTE, L. F.; RAPOSO, R. W. C.; FREIRE, J. L. O. Desenvolvimento e qualidade nutricional de mudas de mangabeiras cultivadas em substratos contendo fibra de coco e adubação fosfatada. *Revista Brasileira de Fruticultura*, Jaboticabal, v. 31, v. 2, p. 512-523, 2009 a.

LIMA, R. L. S.; SEVERINO, L. S.; FERREIRA, G. B. SOFIATTI, V.; SAMPAIO, L. R.; BELTRÃO, N. E. M. Casca de mamona associada a quatro fontes de matéria orgânica para a produção de mudas de pinhão-manso. *Revista Ceres*, Viçosa - MG, v. 58, n. 2, p. 232-237, mar./abr., 2011.

LIMA, R. L. S.; SEVERINO, L. S.; SILVA, M. I.; JERÔNIMO, J. F.; VALE, L. S.; BELTRÃO, N. E. M. Substratos para produção de mudas de mamoneira compostos por misturas de cinco fontes de matéria orgânica. *Ciência e Agrotecnologia*, Lavras, v. 30, n. 3, p. 474-479, 2006.

LOPES, D. C.; STEIDLE NETO, A. J. Potential crops for biodiesel production in Brazil: A review. *World Journal of Agricultural Sciences*, Cambridge, v. 7, n. 2, p. 206-217, 2011.

RIBEIRO, A. C.; GUIMARÃES, P. T. G.; ALVAREZ, V. H. (Eds.) *Recomendações para o uso de corretivos e fertilizantes em Mina Gerais*. 5ª Aproximação. Viçosa - MG: UFV, 1999. 359 p.

RUBIO NETO, A.; SILVA, F. G.; SALES, J. de F.; REIS, E. F. dos; SILVA, M. V. V. da; SOUZA. A. L. Effect of drying and soaking fruits and seeds on germination of macaw palm (*Acrocomia aculeata* [Jacq.] Loddiges ex MART.). *Acta Scientiarum. Agronomy*, Maringá, v. 34, n. 2, p. 179-185, Apr.-June, 2012.

SANTOS, L. C. R.; COSTA, E.; LEAL, P. A. M.; NARDELLI, E. M. V.; SOUZA, G. S. A. Ambientes protegidos e substratos com doses de composto orgânico comercial e solo na formação de mudas de jatobazeiro em Aquidauana-MS. *Engenharia Agrícola*, Jaboticabal, v. 31, n. 2, p. 249-259, 2011.

SILVA, E. A.; MARUYAMA, W. I.; OLIVEIRA, A. C.; BARDIVIESSO, D. M. Efeito de diferentes substratos na produção de mudas de mangabeira (*Hancornia speciosa*). *Revista Brasileira de Fruticultura*, Jaboticabal, v. 31, n. 3, p. 925-929, 2009.

SOARES, J. D. R.; RODRIGUES, F. A.; PESQUAL, M.; NUNES, C. F.; ARAÚJO, A. G. Germinação de embriões e crescimento inicial *in vitro* de macaúba. *Ciência Rural*, Santa Maria, v. 41, n. 5, p. 773-778, 2011.