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PROTECTED ENVIRONMENTS AND SUBSTRATES FOR ACHACHAIRU SEEDLINGS

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KEYWORDS

Garcinia humilis, cattle manure, exotic fruit, plant's environment, soil, vermiculite.

ABSTRACT

The Achachairu *(Garcinia humilis)* is a Bolivian exotic fruit that has been produced and commercialized a few years in Brazil. Information about the production of high quality seedlings is essential for the implementation and the renewal of orchards. The objective was to evaluate protected environments and substrates for Achachairu seedlings. Two protected environments were evaluated, one covered with aluminized thermal reflector screen of 50% of shading and the other with Sombrite® of 50% of shading. Inside the protected environments were tested substrates derived from combinations of various proportions of cattle manure (CM), ravine soil (RS), medium vermiculite (MV), super fine vermiculite (FV) and sand (S). For each protected environment was adopted a completely randomized design with 5 replications of 5 seedlings. Protected environments were compared by analysis of groups of experiments. All substrates studied formed high quality seedlings for the implementation of *Garcinia* orchards, with low rates of aerial and root phytomasses, low rates between height and stem diameter, providing higher Dickson quality index. The Aluminet® promoted the best seedlings with larger shoot, root and total dry mass.

INTRODUCTION

The lack of knowledge of the potential of using natural resources, the disregard of environmental protection laws and the intensity of agricultural exploitation have caused incomparable damages to the Brazilian Cerrado (Ferreira et al., 2007). The great possibility of using native or occurring fruit species, as well as the introduction of new species may be an alternative for small producers in the region who wish to diversify their production and increase their income. In addition to the introduction of orchards, fruit species can be used to recover deforested areas, forming forests to protect springs and, as a consequence, the preservation of local flora as well as assisting in the complementation of riparian forests and providing fruit for the Cerrado fauna.

Exotic fruits are those that have different flavor and characteristics distinguished from other fruits by the shape, color, texture and flavor, traded in less volume in the market (Watanabe & Oliveira, 2014). Fruit of Bolivian origin produced and appreciated in the country, the Achachairu (*Garcinia humilis*) of the same Mangosteen (*Garcinia mangostana* L.) genus that is originated in the Asian tropics has its production expanded in Brazil. It presents globose-oblong fruits, white and juicy pulp, with a mucilaginous texture and sweet-acidulated balanced flavor (Barbosa et al., 2008) with one to three seeds per fruit, whitish, elongated and large. Its bark is yellow-orange in color, thick, smooth and resistant. In the Brazilian northeast, fruit maturation occurs from February to April (Barbosa & Artioli, 2007), and in the Cerrado region (Ipameri-GO, Paranaíba-MS) from October to November.

For implementation, management and recovery of orchards in deforested areas, the primordial is to have high quality seedlings. High quality seedlings must possess superior genetic quality, well formed, free of phyto-pathogenic organisms, without physical damages, free of weeds, low cost, easy handling and commercialization (Minami, 1995) associated to a robust and well distributed root system with low distribution of aerial and root phyto-masses (desirable from 1 to 2), low relation height and stem diameter and higher quality Dickson indexes (Costa, et al., 2011, Costa et al., 2015, Arrua et al.,2016, Sanches et al., 2017).

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The use of suitable materials for the substrates formulation and the constitution of suitable types of protected environments, the correct cultivation, management and reproduction of plants (fertilization, irrigation and cultivation), and phytosanitary (pest and disease control) are essential to achieve the high quality of seedlings production.

The substrate can be composed by mineral, organic material or the mixture of both showing a balance between moisture and aeration, free of pathogens and without the presence of propagules and invasive seeds, besides having adequate aeration physical properties, retention and release of water (Kämpf, 2004). Normally, substrates consisting of more than one material are more likely to meet the chemical and physical needs of plants.

The use of protected environments for seedlings production facilitates phytosanitary control, promotes protection against bad weather and the possibility of production at any time of the year (Reisser Junior et al., 2008). The plant environment is the set of micrometeorological conditions of the production area, aiming to identify better development conditions for the plants, thus obtaining better productivity. For this reason, it is very important to study production in protected environments, such as greenhouses with controlled temperature, agricultural greenhouses, among others (Costa et al., 2012a).

In order to seek for more knowledge about the production of high quality seedlings, this study had as objective to evaluate protected environments and substrates in seedlings formation of Achachairu (*Garcinia humilis*).

MATERIAL AND METHODS

The experiments were installed and conducted at the State University of Mato Grosso do Sul (UEMS), University Unit of Cassilândia (UUC), located in the municipality of Cassilândia from November 2014 to May 2015. The place has latitude of 19º07’21”S, longitude of 51º43’15” W and altitude of 516 m (CASSILANDIA-A742 Automatic Station). According to the climatic classification by Köppen, presents Rainy Tropical Climate (Aw).

Two types of protected environments were used: (A1) aluminized mesh, of galvanized steel structure having 8.0 m wide by 18.0 m long with height of 4.0 m, lateral and frontal closures by 90° inclination with monofilament mesh, mesh for 50% shading and aluminized mesh fabric for 50% shading on the cover (Aluminet®) at 3.3 m; (A2) galvanized steel frame, having 8.0 m wide by 18.0 m long and 3.5 m high, closing at 45° inclination, with monofilament mesh in all its extension, with 50% shading (Sombrite®).

The seed propagation method was collected in the municipality of Ipameri-GO, in November 2014. Inside the protected environments, the seedlings were formed in bags of black polyethylene (15.0 x 25.0 cm) with capacity to 1.8 liters. These containers were filled with substrates (Subs) derived from combinations (%) of cattle manure (CM), ravine soil (RS), medium vermiculite (MV), super fine vermiculite (FV) and sand (S) (Table 1). The mixture was homogenized with the aid of hoes, until a uniform coloration of the substrate.

TABLE 1. Substrates containing various proportions of cattle manure (CM), ravine soil (RS), medium vermiculite (MV), super fine vermiculite (FV) and sand (WS). Cassilândia-MS, 2014-2015.

Substrate	Cattle Manure (CM)	Ravine Soil (RS)	Medium Vermiculite(MV)	Super fine vermiculite (FV)	Sand (S)
	-------------	-------------	%-------------	-------------	
S1	50	30	10	10	0
S2	40	30	10	10	10
S3	30	30	10	10	20
S4	20	30	10	10	30
S5	10	30	10	10	40
S6	50	30	10	0	10
S7	30	30	10	20	10
S8	20	30	10	30	10
S9	10	30	10	40	10
S10	50	30	0	10	10
S11	30	30	20	10	10
S12	20	30	30	10	10
S13	10	30	40	10	10

Ravine soil and manure substrates were characterized chemically (Table 2). The cattle manure was obtained from a local slaughterhouse and composted, that is, revolved every two days, for 30 days in opened place prior to the implantation of the experiment. The ravine soil was collected in the university area itself and the vermiculite and fine washed sand purchased from commercial companies.

TABLE 2. Chemical characteristics of cattle manure (CM) and soil (RS). Cassilândia-MS, 2014-2015.

CM	N	P_2O_5	K_2O	Ca	Mg	S	M-65ºC	C
	------------------% natural ------------------							
	0.9	0.3	0.1	0.3	0.1	0.2	2.0	11.0
	Na	Cu	Fe	Mn	Zn	C/N	pH $CaCl_2$	OM
	--------mg kg^{-1} natural --------							% natural
	624	18	12103	204	53	12/1	5.3	20.0
RS	P_{resin}	K	Ca	Mg	RS	CTC	V%	
	mg dm^{-3}	_ _ _ _ mmolc dm^{-3} _ _ _ _						
	4	0.6	7	3	11	50	22	
	pH water	MO g dm^{-3}	B	Cu	Fe	Mn	Zn	
			_ _ _ _ mg dm^{-3} _ _ _ _					
	4,6	6	0.21	0.5	15	8.3	0.1	

M = moisture; OM = organic matter; C/N = carbon and nitrogen ratio.

Seeding was carried out on November 22, 2014 with two seeds per container being sown at a depth of 1 to 3 cm. Subsequently, thinning was performed leaving only one plant per container. Seedling emergence was verified on January 9, 2015, 48 days after sowing (DAS). The irrigation was performed daily with a watering can, without drenching the substrates, maintaining good conditions for the seedlings development.

From January 9 to February 23, 2015 data were collected for analysis of emergence speed index (ESI) and emergency percentage (EP). Plant height (PH) data were collected at 145, 160, 175 and 190 days after sowing (DAS). The number of leaves (NL), the stem diameter (SD), shoot dry mass (SDM) and the root dry mass (RDM) were also measured at 190 DAS. From these data we determined the total dry mass (TDM), height and diameter ratio (HDR), shoot and root dried mass^{-1} ratio (SRR), height and shoot dry mass^{-1} ratio (HSR), Dickson quality index (DQI) and root and total mass (RTM).

The sum of the number of emerged plants was divided by the number of days after sowing to determine the emergence speed index (ESI). For the emergency percentage it was performed the proportion of the quantity of seed sown by the emerged quantity.

The determination of plant height (PH) was performed with a ruler (cm), measuring the distance from the plant bottom to the apex; the number of leaves (NL), by counting; the stem diameter (SD) with digital caliper (mm); the root dry mass (g) (RDM) and shoot dry mass (g) (SDM) in an analytical weight scale after drying in forced air circulation oven at 65°C until constant mass; the total dry matter mass (TDM) by the sum of the shoot dry mass and the root dry mass.

The Dickson quality index (DQI) is a balanced formula which includes the relations of the morphological variables as TDM, SDM, RDM, PH and SD, described below:

$$DQI = \frac{TDM(g)}{\frac{PH(cm)}{SD(mm)} + \frac{SDM(g)}{RDM(g)}}$$

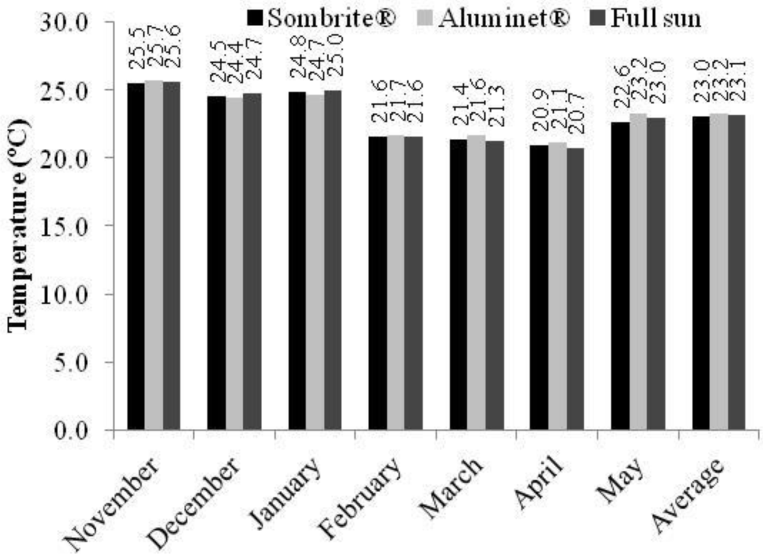
Inside of the protected environment were monitored: air temperature (ºC), relative humidity (%), global solar radiation (W m^{-2}), photosynthetically active total and diffuse radiation (μmol.m^{-2}.s^{-1}) from specific sensors connected to *datalloger* (Delta T Devices brand, GP2 model) installed in the geometric center of the environment. The sensors used were: ES2-05 (solar radiation sensor); RHT2nl-02 (relative humidity sensor and air temperature) and BF5 light sensor (photo-synthetically active radiation).

The system was programmed to perform readings at 10-second intervals with averages every minute. For the radiations, the daily average was calculated from 7am to 6pm. For the external environment, the values of air temperature, relative humidity and global solar radiation were acquired from the Cassilândia automatic data collection platform (A742, from INMET-SONABRA). Data collected from November 22, 2014 to May 29, 2015 (Table 3, Figure 1).

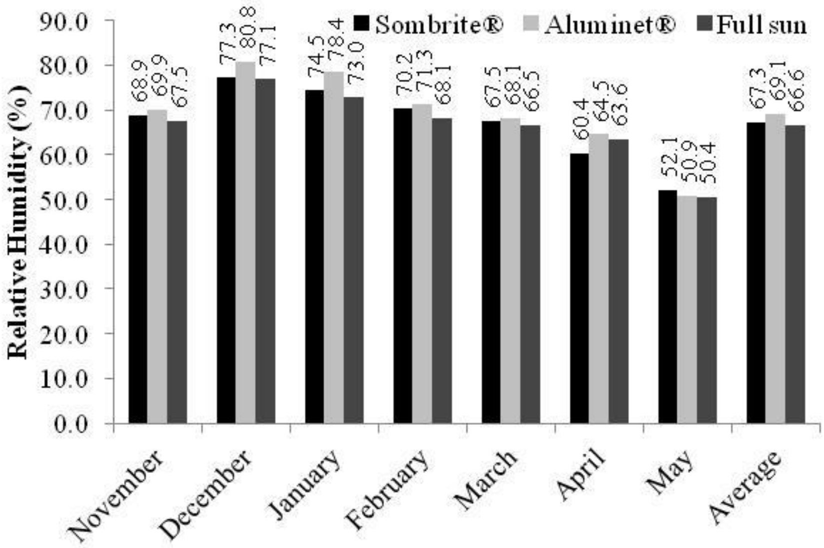
TABLE 3. Temperature (°C), relative humidity (%), global solar radiation (W m^{-2}), total photosynthetically active ($\mu mol.m^{-2}.s^{-1}$) and diffuse photosynthetically active radiations ($\mu mol.\ m^{-2}.s^{-1}$). Cassilândia-MS, 2014-2015.

Micrometeorological Variables	Aluminet®	Sombrite®	Full sun
Temperature (°C)	23.03	23.21	23.12
Relative humidity (%)	67.27	69.13	66.58
Global solar radiation (W m^{-2})	171.75	188.69	454.73
Total photosynthetically active radiation ($\mu mol.m^{-2}.s^{-1}$)	362.93	367.27	-
Diffuse photosynthetically active radiation ($\mu mol.m^{-2}.s^{-1}$)	160.48	199.49	-

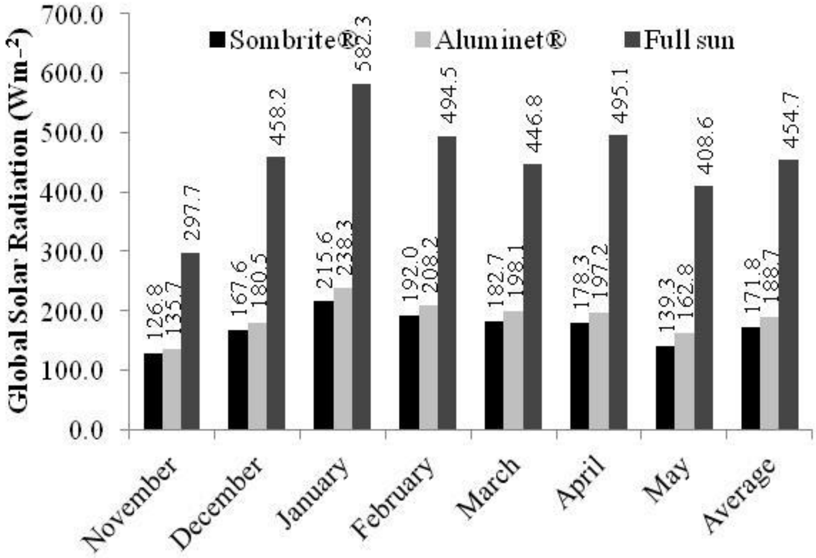
(A)



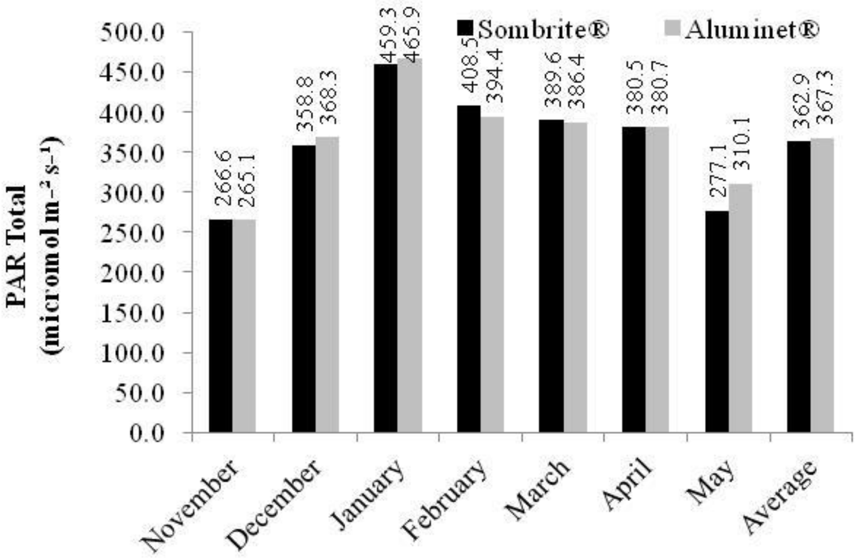
(B)



(C)



(D)



(E)

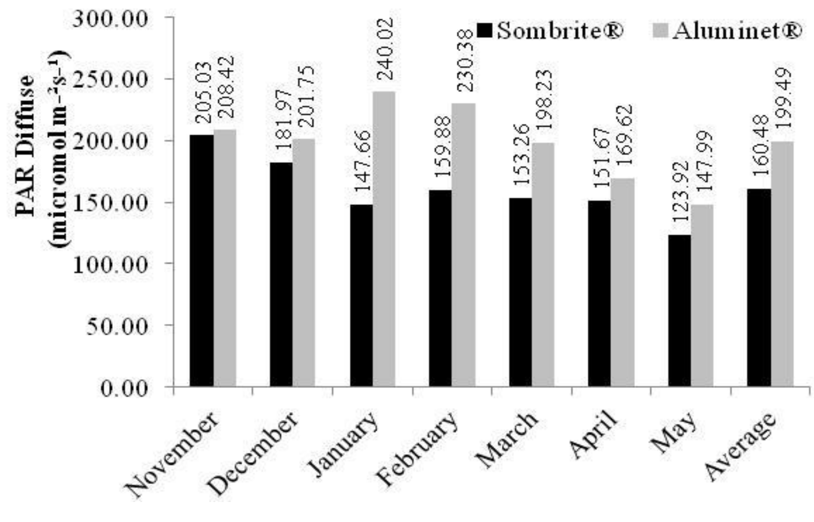


FIGURE 1. Air temperature (a), relative humidity (b), global solar radiation (c) total photosynthetically active radiation (d) and diffuse photosynthetically active radiation (e) recorded in the growing environments during the trial period.

The data were submitted to analysis of variance (test F) and the means were compared by the Tukey test at 5% probability for the substrates and by the student t test for the culture environments, with the Sisvar software (Ferreira, 2010). Because there were no replications for growing environment, each was considered one experiment. For each culture environment, it was adopted a completely randomized design for substrates evaluation with 5 replicates of 5 seedlings each. The environments were evaluated by the groups of experiments analysis (Banzatto & Kronka, 2013). The percentage data were transformed into arcsine root of x / 100.

RESULTS AND DISCUSSION

In the protected environments there was no significant difference for the emergence speed index (ESI) and the emergence percentage (EP) of the Achachairu seedlings, as well as in different studied substrates for the emergence speed index (ESI) and the ratio between the seedling height and stem diameter (HDR) (Table 4).

With an average of 0.11 emerged plants per day it was possible to verify the adequate adaptation of this species in Cassilândia region, both in the protected environments and in the studied substrates reaching an average of 82% emergence with substrate Subs2 in the collected period. In the germination tests at different temperatures, Barbosa et al. (2008) verified rates of 0.015 seedlings per day at room temperature at 25 ± 2ºC, results lower than those observed in this study (Table 4) and with the environmental conditions expressed in Table 3 and Figure 1. At this temperature the authors verified only 30% of germination, and with 30ºC, 92% of germination (Barbosa et al., 2008) confirming the adaptability of this species in Cassilândia region.

The highest number of leaves (NL) and the lowest ratio between plant height and stem diameter (HDR) were verified in the environment with Aluminet® (Table 4). The Aluminet® even with lower relative humidity of the air (%), lower global solar radiation (W m^{-2}) and lower photosynthetically active radiation total and diffuse (μmol.m-2.s-1) (Table 3, Figure 1) did not influence negatively the number of leaves and HDR, that is, these characteristics were not limiting factors for these variables. A smaller ratio between the plant height and its diameter (HDR) is desired to avoid tipping of the seedling when transplanting to its final location. A greater number of leaves (NL) allowed a larger leaf area to capture the photosynthetically active radiation and to increase the mass increment by increasing the photosynthetic rate (Table 4).

Even with substrates (Table 1) showing different amounts of nutrients as a function of the percentage of cattle manure and soil (Table 2), the number of leaves was similar in most of the tested substrates with the largest number of leaves being observed in the substrate S8, in comparison with substrates S3, S9 and S11. In addition to nutrition, the physical characteristics of the substrates promoted by sand porosity (40%) and vermiculite (95%) (Minami, 1995) and their water retentions, promoted adequate conditioning of the seedlings which presented similarity in the number of leaves.

TABLE 4. Emergence speed index (ESI), emergency percentage (EP), plant height and stem diameter ratio (HDR) and leaves number (NL) of *Garcinia humilis* in different protected environments and substrates. Cassilândia-MS, 2014-2015).

Environments	ESI	EP	HDR	NL
Sombrite®	0.108 a	67.65 a	6.02 a	5.95 b
Aluminet®	0.111 a	67.85 a	5.18 b	6.39 a
Substrates	ESI	EP	HDR	NL
S1 = 50%CM + 30%RS + 10%MV + 10%V + 00%S	0.088 a	53.50 b	5.36 a	5.94 ab
S2 = 40%CM + 30%RS + 10%MV+ 10%FV + 10%S	0.126 a	82.00 a	5.51 a	6.21 ab
S3 = 30%CM + 30%RS + 10%MV + 10%FV + 20%S	0.094 a	60.00 ab	5.62 a	5.74 b
S4 = 20%CM + 30%RS + 10%MV + 10%FV + 30%S	0.107 a	68.00 ab	5.84 a	6.10 ab
S5 = 10%CM + 30%RS + 10%MV + 10%FV + 40%S	0.112 a	70.00 ab	5.54 a	5.84 ab
S6 = 50%CM + 30%RS + 10%MV + 00%FV + 10%S	0.096 a	63.00 ab	5.45 a	6.44 ab
S7 = 30%CM + 30%RS + 10%MV + 20%FV + 10%S	0.106 a	63.25 ab	5.35 a	6.41 ab
S8 = 20%CM + 30%RS + 10%MV + 30%FV + 10%S	0.114 a	69.00 ab	5.67 a	6.83 a
S9 = 10%CM + 30%RS + 10%MV + 40%FV + 10%S	0.115 a	69.00 ab	5.76 a	5.73 b
S10 = 50%CM + 30%RS + 00%MV + 10%FV + 10S	0.111 a	69.00 ab	5.52 a	6.58 ab
S11 = 30%CM + 30%RS + 20%MV + 10%FV + 10%S	0.101 a	63.00 ab	5.53 a	5.72 b
S12 = 20%CM + 30%RS + 30%MV + 10%FV + 10%S	0.123 a	73.00 ab	5.75 a	6.09 ab
S13 = 10%CM + 30%RS + 40%MV + 10%FV + 10%S	0.126 a	78.00 ab	5.97 a	6.54 ab
CV (%)	23.80	19.87	11.34	11.52

Means followed by equal letters in the column for each variable do not differ significantly between the t test for the environments and the Tukey test for the substrates, both at 5% probability. Cattle manure (CM), ravine soil (RS), medium vermiculite (MV), super fine vermiculite (FV) and sand (S). CV = coefficient of variation.

At 145 DAS in the growing environments, as well as at 145, 175 and 190 DAS on the substrates no differences in plant height (PH) were observed (Table 5). However, larger seedlings were observed in the Sombrite® at 175 and 190 DAS, as the stem elongation occurs as a function of the phytochrome photo equilibrium influenced by the incident light on the vegetable. Even the substrates (Table 1) showing different amounts of nutrients as a function of the percentage of cattle manure and soil (Table 2) these did not influence the growth and height of the achachairu plants. The physical characteristics of substrates porosity propitiated by sand and vermiculite (Minami, 1995) were adequate for achachairu growth.

At 190 DAS there was a slow growth of the Achachairu seedlings which reached a mean height of 12 cm with better ratio between the height and the shoot dry mass (SDM) in the environment with an Aluminet® (Table 5). These results agree with Barbosa et al. (2008) which found 11.85 cm in 6 months and 22.97 cm in 12 months of seedling cultivation. The lowest ratio between the seedling height and its shoot dry mass is desired for better germination in the field.

TABLE 5. Plant height at 145 (PH1), 175 (PH3), 190 (PH4) days after sowing and ratios of plant height and shoot dry mass of *Garcinia humilis* in different protected environments and substrates. Cassilândia-MS, 2014-2015).

Environment	PH1 (cm)	PH3 (cm)	PH4 (cm)	HMR
Sombrite®	8.501 a	12.33 a	12.51 a	8.197 a
Aluminet®	8.263 a	11.06 b	11.21 b	6.651 b
Substrates	PH1 (cm)	PH3 (cm)	PH4 (cm)	HMR
S1 = 50%CM + 30%RS + 10%MV + 10%FV + 00%S	8.44 a	11.27 a	11.35 a	6.55 ab
S2 = 40%CM + 30%RS + 10%MV + 10%FV + 10%S	8.40 a	12.18 a	12.24 a	7.71 ab
S3 = 30%CM + 30%RS + 10%MV + 10%FV + 20%S	8.26 a	11.74 a	11.93 a	7.27 ab
S4 = 20%CM + 30%RS + 10%MV + 10%FV + 30%S	8.34 a	12.13 a	12.41 a	8.21 a
S5 = 10%CM + 30%RS + 10%MV + 10%FV + 40%S	8.26 a	11.15 a	11.27 a	6.79 ab
S6 = 50%CM + 30%RS + 10%MV + 00%FV + 10%S	8.43 a	11.29 a	11.37 a	5.64 b
S7 = 30%CM + 30%RS + 10%MV + 20%FV + 10%S	8.02 a	11.51 a	11.58 a	6.99 ab
S8 = 20%CM + 30%RS + 10%MV + 30%FV + 10%S	8.34 a	12.32 a	12.49 a	7.74 ab
S9 = 10%CM + 30%RS + 10%MV + 40%FV + 10%S	8.61 a	11.02 a	11.20 a	6.37 ab
S10 = 50%CM + 30%RS + 00%MV + 10%FV + 10%S	8.43 a	11.60 a	12.03 a	8.01 ab
S11 = 30%CM + 30%RS + 20%MV + 10%FV + 10%S	8.32 a	11.50 a	11.60 a	8.05 ab
S12 = 20%CM + 30%RS + 30%MV + 10%FV + 10%S	8.42 a	11.90 a	12.04 a	8.50 a
S13 = 10%CM + 30%RS + 40%MV + 10%FV + 10%S	8.72 a	12.44 a	12.67 a	8.66 a
CV (%)	8.33	9.31	9.87	21.67

Means followed by equal letters in the column for each variable do not differ significantly by t test for the environments and by Tukey test for the substrates, both at 5% probability. Cattle manure (CM), ravine soil (RS), medium vermiculite (MV), super fine vermiculite (FV) and sand (S). CV = coefficient of variation.

There was small variation of the stem diameter (SD) in the environments and substrates studied with an overall mean of 2.13 mm higher than those verified by Barbosa et al. (2008) which obtained diameter of 1.88 mm in 6 months and 3.00 mm in 12 months of seedling cultivation. In the Sombrite® environment, plants grown in the S1 substrate had a larger stem diameter than those grown on the S9 substrate. In the Aluminet®, the plants grown in the S2 substrate had a larger diameter than those grown in substrates S1 and S12 (Table 6). However, in both environments the variations of the thickness on the stem diameter of the seedlings in different substrates were small, that is, the substrates were chemically and physically suitable for the seedlings growth.

At 160 DAS the largest seedlings were verified on the Sombrite® in most studied substrates (Table 6). There may have been a tendency for waving (stem elongation), as observed in relation to height and stem diameter (Table 4).

TABLE 6. Stem diameter (SD) and plant height (PH) at 160 DAS of *Garcinia humilis* in different protected environments and substrates. Cassilândia-MS, 2014-2015).

	SD (mm)		PH2 (cm)	
Substrates	Sombrite®	Aluminet®	Sombrite®	Aluminet®
S1=50%CM+30%RS+10%MV+10%FV+00%S	2.3 Aa	2.03 Bb	10.10 ABa	8.65 Ab
S2=40%CM+30%RS+10%MV+10%FV+10%S	2.12 ABb	2.35 Aa	10.16 ABa	9.08 Ab
S3=30%CM+30%RS+10%MV+10%FV+20%S	2.05 ABb	2.22 ABa	10.28 ABa	8.67 Ab
S4=20%CM+30%RS+10%MV+10%FV+30%S	2.08 ABa	2.18 ABa	9.88 ABa	9.08 Aa
S5=10%CM+30%RS+10%MV+10%FV+40%S	1.99 ABa	2.12 ABa	9.89 ABa	8.25 Ab
S6=50%CM+30%RS+10%MV+00%FV+10%S	2.13 ABa	2.06 ABa	9.71 ABa	8.48 Ab
S7=30%CM+30%RS+10%MV+20%FV+10%S	2.13 ABa	2.22 ABa	9.31 BCa	8.62 Aa
S8=20%CM+30%RS+10%MV+30%FV+10%S	2.13 ABa	2.28 ABa	9.46 ABCa	9.12 Aa
S9=10%CM+30%RS+10%MV+40%FV+10%S	1.87 Bb	2.14 ABa	9.52 ABa	8.81 Aa
S10=50%CM+30%RS+00%MV+10%FV+10%S	2.14 ABa	2.23 ABa	10.24 ABa	8.55 Ab
S11=30%CM+30%RS+20%MV+10%FV+10%S	2.08 ABb	2.20 ABa	8.02 Cb	9.03 Aa
S12=20%CM+30%RS+30%MV+10%FV+10%S	2.15 ABa	2.03 Ba	9.78 ABa	8.79 Ab
S13=10%CM+30%RS+40%MV+10%FV+10%S	2.10 ABa	2.15 ABa	10.84 Aa	9.18 Ab
CV %		6.42	7.43	

Means followed by lower case letters in the row and upper case in the column for each variable do not differ significantly by the t test for the environments and by the Tukey test for the substrates, both at 5% probability. Cattle manure (CM), ravine soil (RS), medium vermiculite (MV), superfine vermiculite (FV) and sand (S). CV = coefficient of variation.

The seedlings with larger shoot masses (SDM), root system (RDM) and total (TDM) (Table 7), as well as the best distribution between the masses and the highest Dickson quality index (DQI) (Table 8) were observed on the Aluminet®. On the Aluminet®, the average photosynthetically active diffuse radiation (μmol.m^{-2}.s^{-1}) in the total evaluation period were smaller than that on the Sombrite® (Table 4) i.e., the lightness was lower in this environment and was not a limiting factor for the seedlings development (Table 3, Figure 1). The amount of shading (luminosity) is an essential factor on the initial growth of achachairu and this requires at least 40% of shade (Daniel, 2009). Better *Acrocomia Aculeata* seedlings were observed in Aluminet®, when compared to Sombrite® and to the greenhouse with low density polyethylene (Costa et al., 2014). However, Costa et al. (2012b) did not find differences between the Sombrite® and Aluminet®, both with better results than in the agricultural greenhouse for 'baruzeiro' seedlings (*Dipteryx alata*), diverging from Costa et al. (2015) who reported better baruzeiro seedlings in Sombrite® compared to Aluminet®.

The amount of photo-assimilates available to be used in the vegetable grown in relation to dry matter mass in the different organs, receives direct influence of the environmental conditions. In the protected cultivation, the environment is modified by action mechanisms, and in the studied case the Aluminet® influenced the rate of liquid photosynthesis of the vegetable due to the incidence of light (less active photosynthetic radiation) and the lower relative humidity of the air.

TABLE 7. Shoot dry mass (SDM), root dry mass (RDM) and total dry mass (TDM) of *Garcinia humilis* in different protected environments and substrates. Cassilândia-MS, 2014-2015).

Environment	SDM	RDM	TDM
Sombrite®	1.615 b	1.723 b	3.338 b
Aluminet®	1.744 a	2.213 a	3.956 a
Substrates	SDM	RDM	TDM
S1 = 50%CM+ 30%RS + 10%MV + 10%FV + 00%S	1.814 ab	2.325 a	4.139 a
S2 = 40%CM + 30%RS + 10% MV+ 10%FV + 10SS	1.608 ab	1.888 a	3.496 a
S3 = 30%CM + 30%RS + 10%MV + 10%FV + 20%S	1.658 ab	1.917 a	3.576 a
S4 = 20%CM + 30%RS + 10%MV + 10%FV + 30%S	1.524 b	1.840 a	3.364 a
S5 = 10%CM + 30%RS + 10%MV + 10%FV + 40%S	1.693 ab	1.866 a	3.559 a
S6 = 50%CM + 30%RS + 10%MV + 00%FV + 10%S	2.120 a	2.073 a	4.193 a
S7 = 30%CM + 30%RS + 10%MV + 20%FV+ 10%S	1.731 ab	2.020 a	3.751 a
S8 = 20%CM + 30%RS + 10%MV + 30%FV + 10%S	1.651 ab	2.107 a	3.758 a
S9 = 10%CM + 30%RS + 10%MV + 40%FV + 10%S	1.849 ab	1.916 a	3.765 a
S10 = 50%CM + 30%RS + 00%MV + 10%FV+ 10%S	1.583 b	1.961 a	3.544 a
S11 = 30%CM + 30%RS + 20%MV + 10%FV + 10%S	1.604 ab	1.975 a	3.579 a
S12 = 20%CM + 30%RS + 30%MV + 10%FV + 10%S	1.471 b	1.845 a	3.315 a
S13 = 10%CM + 30%RS + 40%MV + 10%FV + 10%S	1.524 b	1.846 a	3.370 a
CV	20.83	17.86	16.83

Means followed by equal letters in the column for each variable do not differ significantly between each other by t test for the environment and by Tukey test for the substrates, both at 5% probability. Cattle manure (CM), ravine soil (RS), medium vermiculite (MV), super fine vermiculite (FV) and sand (S). CV = coefficient of variation.

Even the substrates (Table 1) presenting different amounts of nutrients as function of the percentage of cattle manure and soil (Table 2), as well as different porosities as a function of sand and / or vermiculite in their physical constitution (Minami, 1995) these do not differ much among themselves in the mass accumulation of dry root system and in the total mass of achachairu seedlings (TDM) (Table 8). However, the shoot dry mass of seedlings (SDM) grown in substrate S6 were higher than those grown in the substrates S4; S12 and S13. In this substrate (S6) is observed higher amount of manure than in substrates S4, S12 and S13 (Table 1) with higher nutrients (Table 2) which allowed greater accumulation of mass in the shoot dry mass of the achachairu seedlings. Some studies do not recommend using more than 30% of cattle manure in substrates for some species; other authors recommend no more than 10 or 20%, such as Costa et al. (2015) for baruzeiro, Dias et al. (2009b) and Silva et al. (2009) for mangabeira, Dias et al. (2009a) for coffee plant, a fact not verified for achachairu that was adequately adapted to substrates containing up to 50% of cattle manure.

The adaptability of the achachairu in substrates with high amounts of cattle manure are in accordance with the observations by Silva et al. (2013) who report that substrates containing 50% of cattle manure associated with vermiculite or commercial substrate can be indicated for the formation of coffee plant seedlings, as well as Costa et al. (2014) report that substrates containing 33, 50 and 100% of cattle manure can be indicated in the formation of bocaiúva seedlings (*Acrocomia aculeata*).

TABLE 8. Rates of shoot dry mass and root system dry mass (SRR), rates of root dry mass and total dry mass (RTM) and Dickson quality index (DQI) of *Garcinia humilis* in a different protected environments and substrates. Cassilândia-MS, 2014-2015).

Environment	SRR	RTM	DQI
Sombrite®	0.948 a	0.519 b	0.483 b
Aluminet®	0.796 b	0.559 a	0.667 a
Substrates	RMS	RMR	IQD
S1 = 50%CM + 30%RS + 10%MV + 10%FV + 00%S	0.805 a	0.558 a	0.680 a
S2 = 40%CM + 30%RS + 10%MV + 10%FV + 10%S	0.862 a	0.538 a	0.558 a
S3 = 30%CM + 30%RS + 10%MV + 10%FV + 20%S	0.885 a	0.534 a	0.567 a
S4 = 20%CM + 30%RS + 10%MV + 10%FV + 30%S	0.775 a	0.493 a	0.465 a
S5 = 10%CM + 30%RS + 10%MV + 10%FV + 40%S	0.869 a	0.523 a	0.566 a
S6 = 50%CM + 30%RS + 10%MV + 00%FV + 10%S	0.926 a	0.495 a	0.647 a
S7 = 30%CM + 30%RS + 10%MV + 20%FV + 10%S	0.841 a	0.534 a	0.611 a
S8 = 20%CM + 30%RS + 10%MV + 30%FV + 10%S	0.790 a	0.559 a	0.590 a
S9 = 10%CM + 30%RS + 10%MV + 40%FV + 10%S	0.955 a	0.511 a	0.577 a
S10 = 50%CM + 30%RS + 00%MV + 10%FV + 10%S	0.831 a	0.556 a	0.569 a
S11 = 30%CM + 30%RS + 20%MV + 10%FV + 10%S	0,828 a	0.552 a	0.579 a
S12 = 20%CM + 30%RS + 30%MV + 10%FV + 10%S	0.803 a	0.557 a	0.513 a
S13 = 10%CM + 30%RS + 40%MV + 10%FV + 10%S	0.830 a	0.547 a	0.507 a
CV	20.00	8.16	20.00

Means followed by equal letters in the column for each variable do not differ significantly between each other by t test for the environments and by Tukey test for the substrates, both at 5% probability. Cattle manure (CM), ravine soil (RS), medium vermiculite (MV), super fine vermiculite (FV) and sand (S). CV = coefficient of variation.

CONCLUSIONS

All the studied substrates formed high quality seedlings for achachairu orchards implantation with low ratio between the shoot and root phytomass, low ratio between height and the shoot diameter providing higher Dickson quality index.

Achachairu has an adequate response to the use of up to 50% of cattle manure in the substrate.

The Aluminet® promoted the best seedlings with bigger shoot and root dry masses.

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