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Growth of parica seedlings *(Schizolobium amazonicum* Huber ex Ducke*)* cultivated in different organic substrates

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The forest plantations depends on appropriate initial seedling establishment, which occurs when primary factors (water, light, CO_2 and nutrients) are within appropriate ranges. The purpose this study was to evaluate the growth of young parica plants (*Schizolobium amazonicum* Huber ex Ducke) grown in different organic substrates (chicken manure, goat manure and organic matter) in proportions of 5, 10, 15 and 20% in yellow argisol. Among the studied treatments, the best response in plant height growth was observed in T_2 (5% goat manure in yellow argisol). For the mean diameter, it was observed that T_4 (15% goat manure in yellow argisol) allowed greater of growth parica seedlings. In addition, for the quality parameters: ratio of shoot height and root collar diameter (H/RCD), heigh and dry mass air part relation (H/DMAP) and Dickson Quality Index (DQI), the best values were for seedlings cultivated with goat manure, in relation to the other treatments. Therefore, young parica plants grown on substrates with goat and chicken manure showed significant improvements in growth performance, according to fundamentally chemical characteristics of these substrates.

Key words: Chicken manure, goat manure, organic matter, seedling production.

INTRODUCTION

In the Brazilian Amazon, forest cover comprises approximately 321 million hectares, of which about 19% have already been altered by some exploitation activity, be it timber, livestock, agriculture, mining or urbanization (Costa et al., 2014). On the other hand, the counterpart for deforestation actions is technically limited, an expressive knowledge gap exists concerning the forest plantation (Ferreira et al., 2016), given the diversity of species and variation in ecophysiological traits of the different species, besides the limited knowledge about growth and plant nutrition of tropical tree species (Jaquetti and Gonçalves, 2017).

Stimulating research aimed at the recovery of deforested areas is fundamental, since they can develop technological improvements, mainly aiming at reducing deforestation in order to minimize the ecological and economic threats caused by global warming, due to the emissions of greenhouse effect gases (Tollefson, 2015). Knowledge about nutritional, light and water requirements is diffuse, and in addition, the introduction of silvicultural practices that improve the production of seedlings are also limited.

Currently, several Amazonian tree species, particularly from the botanical family Leguminosae, should receive attention, with an emphasis to their timber and non-timber potential. *Schizolobium amazonicum* Huber ex Ducke (parica tree) stands out due to its silvicultural characteristics, for its rapid growth and high market value (Tavares et al., 2013). Parica is a species with great value for the industrial sector, since its wood is accepted in the plywood industry, making it possible to manufacture sheets with good market acceptance (Galeão et al., 2005). In the field, it is a rustic species and can be used in the recovery of degraded areas, due to its good performance in terms of growth in altered environments, allowing its use in environmental recovery programs (Tavares et al., 2013).

In addition, the demand for good quality wood and the application of stricter environmental legislation in the context of the exploitation of natural forests for selective harvesting has led to a decrease in the supply of this product (Hoffmann et al., 2011). Thus, plantations with native species such as *S. amazonicum*, when well conducted since the production of seedlings, have the capacity to supply part of the growing demand for wood. The production of seedlings should receive greater technical and scientific attention, aiming at the successful installation of forest stands, which in turn depends on the characteristics of the substrate, that are fundamental for the growth and establishment of seedlings after the planting (Sena et al., 2010). The choice of the appropriate substrate for seedling production is important to ensure growth, since it interferes with the structure and functionality of the produced seedlings, and in addition, promotes substantial increases in productivity (Silva and Queiroz, 2014). The use of organic residues from animal and plant remains as a nutrient source for plants in the seedlings production process. It has been constituted as a viable alternative for the certification of agricultural activities and environmental conservation; promoting a significant reduction at application of chemical fertilizers. This is to ensure the minimization of environment contamination with the use of low-cost raw materials (Santos et al., 2010).

Considering these benefits, investigating the chemical characteristics of different organic substrates and their interactions with soils, aiming at the adaptation of growth substrates for tree seedlings production, can contribute to improving the knowledge about techniques in tropical forestry with a strongly applied bias. In this research, the purpose was to verify the response of young parica plants (*S. amazonicum*) to different levels of organic substrates, derived from the use of goat manure, chicken manure and organic matter, as a way of using these compounds in the production of good quality seedlings.

MATERIALS AND METHODS

The experiment was conducted at the forest nursery of the Universidade Federal do Acre (UFAC), Campus Floresta, in Cruzeiro do Sul - Acre state, located at the coordinates 70°36'66" L and 72°40"52" W. The climate of the region is described as Af tropical humid with well distributed rainfall throughout the year and absence of dry season (Alvares et al., 2013).

Parica seeds (*Schizolobium amazonicum* Huber ex Ducke) were obtained from the Fundação de Tecnologia do Estado do Acre - FUNTAC, after being collected in the area of the Colocação São Sebastião, Flona Macauã - Sena Madureira, Acre state. After collection, seeds were stored for a period of 10 months in a cold room, under a temperature of 13ºC. For the beginning of the experiment, seeds were submitted to dormancy breaking using the mechanical scarification method with sandpaper n. 50, opening three striae in the opposite part of the embryo (Rodrigues Filho et al., 2019). The germination process was completed 15 days after sowing.

The organic materials used in this experiment were: chicken manure, goat manure and organic matter mixed in different concentrations with yellow argisol. The chicken and goat manure were tanned outdoors for 60 days. A soil surface layer of 20 cm (organic horizon) was used as organic matter. The substrates were prepared using Becker 500 mL graduated to measure the volumes of the compounds, which were sieved using a 2 cm diameter sieve, thoroughly homogenized and used as treatments in this study. These treatments were as follows: T1: yellow argisol 100%; T2: 5% chicken manure; T3: 10% chicken manure; T4: 15% chicken manure; T5: 20% chicken manure; T6: 5% goat manure; T7: 10% goat manure; T8: 15% goat manure; T9: 20% goat manure; T10: 5% organic matter; T11: 10% organic matter; T12: 15% organic matter and T13: 20% organic matter in yellow argisol. Samples of the different concentrations of the substrates were collected and sent to the Soil Laboratory of the Federal University of Acre, in Rio Branco, for chemical analysis of nutrients (Table 1).

The container used in the experiment to produce parica seedlings were black polyethylene bags with dimensions, 15 cm wide and 20 cm long. The experiment was conducted in a greenhouse with a

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Table 1. Chemical composition of the different substrates.

Treatments	pH	Al	H + Al	C.Org.	P	K	Ca	Mg	Na
	water	cmolc/dm³		g/Kg	mg/dm³		cmolc/dm³		mg/dm³
T_1	4.4	1.55	2.25	0.58	4.7	7.0	0.55	0.10	2.0
T_2	3.8	3.8	6.86	6.52	43	200	1.35	0.8	85
T_3	3.9	1.8	7.0	10.42	128	455	2.5	1.5	16
T_4	3.9	1.2	6.86	10.42	128	559	3.6	1.5	20
T_5	3.8	1.5	7.25	10.51	120	546	3.3	1.4	21
T_6	4.2	4.5	7.35	6.23	10	2.6	0.3	0.55	25
T_7	4.4	2.7	6.61	7.98	26	5.50	0.9	0.85	49
T_8	4.5	0.6	5.48	10.9	59	9.15	1.5	1.25	98
T_9	5.2	0.15	3.92	11.68	128	8.46	1.6	1.3	14
T_{10}	4.0	5.5	8.33	4.01	0.6	38	0.3	0.2	4.0
T_{11}	4.1	5.0	8.57	7.4	0.8	35	0.25	0.65	4.0
T_{12}	4.1	5.2	8.91	10.12	1.4	60	0.3	0.45	6.0
T_{13}	4.2	5.1	8.57	10.51	0.8	36	0.35	0.65	5.0

* Potential of hydrogen (pH), aluminum (Al), potential acidity (H+Al), organic carbon (C. Org.), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na).

control system of 50% of the daily irradiance, and the monitoring of seedlings was carried out during 60 days, with daily watering. This period is considered as ideal to take *S. amazonicum* seedlings to the field (Carvalho, 2007). The variables used to estimate the initial growth of the seedlings were: shoot height (H) and root collar diameter (RCD). Measurement of height and diameter were performed weekly, using a millimeter ruler and a digital caliper, respectively. The quality parameters of the seedlings were also determined through ratios among the variables: ratio of shoot height and root collar diameter (H/RCD); heigh and dry mass air part relation (H/DMAP); and the Dickson Quality Index (DQI) (Dickson et al., 1960). The Dickson quality index was calculated from the formula, verifying the conceptual adjustments of the applied concentrations (Equation 1):

$$IQD = \frac{TDM}{\frac{H}{RCD} + \frac{SDM}{RDM}}$$

With: Total dry matter in grams (TDM); Shoot dry matter in grams (SDM); Root dry matter in grams (RDM); Shoot height in cm (H); Root collar diameter in mm (RCD).

In order to quantify the dry mass of the seedlings, five individuals were separated randomly from each treatment (concentration). After collection, roots and shoots were washed in distilled water to remove substrate traces, and later, they were packed in paper bags and taken to a forced air circulation oven at a temperature of 45±1 °C, to dry until constant weight. The used design was a completely randomized one, with a factorial arrangement of 3 (organic substrates) x 4 (concentrations) + control treatment, totaling 13 treatments with 20 replications for each treatment; for the quality parameter of the seedlings, 5 replications were randomly used. The data were submitted to the normality test (Shapiro-Wilk) and homogeneity of variances (Levene) to verify the fulfillment of the premises of the parametric statistic. Subsequently, the data were submitted to the Multivariate Variance Analysis (MANOVA) and analysis of variance (ANOVA) associated with the Scott-Knott test ($p > 0.05$). In addition, the main components were analyzed to verify the relationship between the chemical variables of the substrates together with growth and biomass accumulation results of the seedlings. The statistical programming language R was used for the analysis of this work (R Development Core Team, 2017).

RESULTS AND DISCUSSION

As for the results of the Multivariate Analysis of Variance - MANOVA, considering the growth variables (H, D, RDM, SDM and TDM), it was possible to observe a strong joint contribution of these variables to confirm the statistical difference between the treatments used in this study ($p < 0.0001$; Pillai = 1.4889). Young parica plants presented satisfactory results when cultivated on organic substrates, suggesting the use of agroindustrial residues in the production of quality seedlings. The use of organic substrates may be an alternative for production of quality seedlings promoting a good supply of nutrients to the plants (Mota et al., 2016).

Thus, mean height (H) values of *S. amazonicum* seedlings were observed in an amplitude of 17.00 ± 0.88 at 64.00 ± 4.20 cm, the highest means were verified for seedlings under the influence of the substrate with 15% goat manure – T_8 (Table 2) ($p < 0.0001$), being statistically equal to the treatments: T_5, T_6, T_7 and T_9. For the substrates containing chicken manure, it was possible to observe the lowest values for the height variable. Even this treatment with relatively high nutrient values, when compared to the others, did not provide good results for the height growth variable (Table 1). However, among other factors, under certain conditions the substrate pH is considered as a limiting factor on the availability of nutrients for plants (Ghosh et al., 2016). As for the mean diameter, in this research it was possible to identify values in the range from 3.33 ± 0.08 to 3.90 ± 0.03 mm observing in T_4 (15% chicken manure), the best growth of parica seedlings (Table 2), which in turn did not present

Table 2. Performance of young plants of *S. amazonicum* under the influence of substrates at different concentrations.

T	Conc. (%)	H (cm)		D (mm)		RDM (g)		SDM (g)		TDM (g)	
T_1	0	36.40± 2.62	bc	3.33 ± 0.08	b	0.21 ± 0.04	ab	1.03 ± 0.12	b	1.24 ± 0.14	b
T_2	5	17.00 ± 0.88	c	3.64 ± 0.06	ab	0.23 ± 0.02	ab	2.03 ± 0.12	ab	2.26 ± 0.09	ab
T_3	10	22.00 ± 1.26	c	3.68 ± 0.10	ab	0.18 ± 0.01	ab	1.93 ± 0.35	ab	2.11 ± 0.35	ab
T_4	15	17.90 ± 1.63	c	3.90 ± 0.03	a	0.14 ± 0.03	b	2.16 ± 0.35	ab	2.29 ± 0.35	ab
T_5	20	48.20 ± 7.00	ab	3.79 ± 0.13	ab	0.11 ± 0.02	b	1.56 ± 0.24	ab	1.67 ± 0.24	ab
T_6	5	56.60 ± 2.48	ab	3.47 ± 0.07	ab	0.25 ± 0.02	ab	2.16 ± 0.21	ab	2.41 ± 0.21	ab
T_7	10	57.60 ± 3.36	ab	3.58 ± 0.09	ab	0.27 ± 0.06	ab	1.97 ± 0.23	ab	2.24 ± 0.23	ab
T_8	15	64.00± 4.20	a	3.79 ± 0.07	ab	0.34 ± 0.08	a	2.57 ± 0.44	a	2.91 ± 0.43	a
T_9	20	53.40 ± 10.29	ab	3.69 ± 0.17	ab	0.32 ± 0.03	a	2.64 ± 0.17	a	2.96 ± 0.17	a
T_{10}	5	35.80 ± 2.69	bc	3.44 ± 0.14	ab	0.34 ± 0.04	a	1.01 ± 0.08	b	1.35 ± 0.08	b
T_{11}	10	37.00 ± 2.61	bc	3.69 ± 0.12	ab	0.32 ± 0.03	a	1.13 ± 0.07	b	1.45 ± 0.07	b
T_{12}	15	37.80 ± 2.89	bc	3.50 ± 0.06	ab	0.26 ± 0.03	ab	1.74 ± 0.30	ab	2.00 ± 0.29	ab
T_{13}	20	25.80 ± 5.71	c	3.50 ± 0.08	ab	0.29 ± 0.04	ab	1.37 ± 0.12	b	1.66 ± 0.12	ab

T: treatments, Conc. (%): Concentration as percentage, H (cm): Height in centimeters, D (mm): Diameter in millimeters, RDM (g): Root Dry Matter in grams, SDM (g) Shoot Dry Matter in grams and TDM (g): Total Dry Matter in grams). * Means followed by the same letters do not present significant difference at the 95% probability level by Scott-Knott's test.

statistical differences when compared to the other treatments. Mendonça et al. (2014) corroborate this work, since, when studying different substrates for the production of *Tamarindus indica* (tamarind) scions, they verified that the best responses as for height were obtained in the treatment containing goat manure (soil + goat manure + cattle manure + humus). The higher the amount of organic compounds, the greater the seedling growth (Gonçalves et al., 2014).

However, it is necessary to consider the chemical composition and the concentration of the substrate to avoid the intoxication of seedlings. In a recent work, the growth of *Ateleia glazioviana* seedlings on substrates containing different concentrations of organic substrates presented, at 120 evaluation days, the best seedling growth as for the height variable in the treatment that contained 30% bovine manure, since the average observed values were went 9.11 to 30.15 cm (Gonçalves et al., 2014).

In addition, it was observed that young parica plants submitted to different concentrations of organic substrates presented different investment strategies in biomass allocation, which is possibly strongly related to the specific nutrient contents of each substrate (Figure 1). Interestingly, there is evidence in this work that parica seedlings grown on substrates with lower phosphorus content presented higher investments in root dry mass production. Phosphorus deficiency is a limiting factor for growth in substrates with high levels of acidity, since it stimulates a greater investment of the plant in the production of roots (Wu et al., 2018).

In general, substrates derived from the concentrations with organic matter allowed higher dry matter productivity in the roots and lower productivity in the shoot (Figure 1). This treatment had the lowest Ca, Ca:Mg ratio, Organic Carbon, K, Na and P contents, while aluminum concentrations and potential acidity presented high levels (Table 1 and Figure 1). However, young parica plants submitted to growth on goat manure substrates had higher values for shoot dry matter (SDM) (2.64 ± 0.17 g), and the highest mean value was observed for the concentration of 20% - $p <0.0001$ - T_9 (Table 2). As for the total dry matter, the mean superiority of the treatments was confirmed for different concentrations of goat manure, especially T9-20% of chicken manure with 2.96 ± 0.17 g ($p <0.0001$). On the other hand, for treatments with different organic matter contents and the control treatment (yellow argisol) the lowest average values for total dry matter were identified ($p < 0.0001$) (Table 1 and Figure 1).

The substrates containing different concentrations of chicken manure had the highest concentrations of phosphorus (P) and potassium (K). This nutrient is required for the synthesis of adenosine triphosphate (ATP) and other phosphorylated compounds (Taiz and Zeiger, 2013). As a performance strategy, the greatest root investment occurs in order to increase the uptake of nutrients in substrates where there is low resource availability (Lambers et al., 2008). From a nutritional point of view, this substrate had the highest levels of potassium and phosphorus; the first nutrient is considered an activator of enzymes involved in respiration and photosynthesis, and the latter provides the synthesis of important compounds for plant cells, such as sugars phosphates (Taiz and Zeiger, 2013). Phosphorus is regarded as an important nutrient to stimulate growth and dry matter production in young parica plants (Caione et al., 2012).

In addition, seedlings with low root collar diameter values have difficulties in remaining fixed after planting

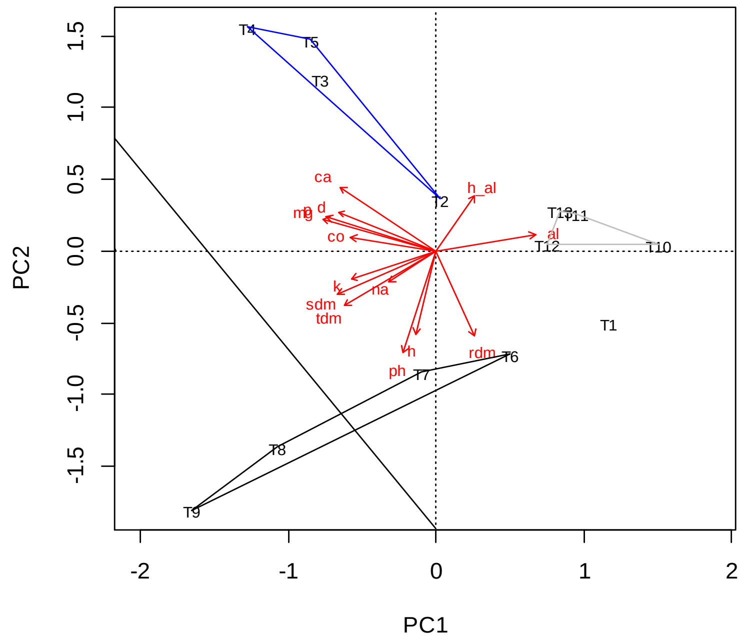

Figure 1. Principal Component Analysis (PCA) considering the chemical variables of the substrates and the growth variables of young plants *S. amazonicum* PC1 = 45% and PC2 = 67%. Blue color polygon (chicken manure treatments); polygon of black color (goat manure treatments) and polygon of gray color (organic matter treatments).

(Cunha et al., 2005). This variable is considered a good indicator of the seedling quality and generally, it is the most appropriate to determine the survival capacity of seedlings in the field (Daniel et al., 1997). In this study, results showed that the use of organic compound provides benefits to the quality of seedlings as for this variable.

In this research, substrates with different levels of goat manure and organic matter presented pH values higher than 4 (Table 1). However, pH values below 4 were found for the chicken manure treatment; this suggests low nutrient availability, resulting in a low increase of young parica individuals under its influence. In addition, the potential of hydrogen (pH) is an important property to consider, since it affects the growth of roots. Root productivity is favoured in substrates with pH values close to 5 and 6, facilitating the availability of K^+, Mg^{2+}, Ca^{2+} and Mn^{2+}, also increasing the solubility of carbonates, sulfates and phosphates (Taiz and Zeiger, 2013). According to the H/RCD relation, it was possible to confirm the superiority of the substrate with goat manure in relation to the other treatments, since the control treatment (T1) and the ones with organic matter (OM) were not statistically different ($p < 0.0001$). On the other hand, plants submitted to the treatments using chicken manure (CM) presented the lowest H/RCD value (Figure 2).

According to the analyses obtained from the relation between height and dry mass air part (H/DMAP), the control treatment (T1) and the ones with goat manure (GM) and organic matter (OM), up to 15% concentration, were not statistically differents ($p < 0.0001$). Treatments with chicken manure (CM), goat manure (GM) and organic matter (OM) at the 20% concentration also did not present significant differences, but they differed significantly from the other treatments/concentrations (Figure 3). On the other hand, the control (T1) treatment presented the highest mean value for H/DMAP, when compared to the others. H/DMAP indicates how lignified the seedlings are, suggesting that the lower their value, the more the chances to survive in the field (Welter et al., 2011). Thus, it was possible to identify in this study that the treatment T_2 (5% chicken manure - CM), allowed obtaining the lowest value (8.46) for H/DMAP, suggesting the production of more lignified young parica plants (Figure 4).

In this study, the values obtained for the Dickson quality index (DQI) presented extreme values from 0.08 to 0.16 (Figure 4). For the DQI, treatments using chicken manure (CM), goat manure (GM) and organic matter (OM) were not statistically different ($p = 0.0038$) (Figure 4b). The control treatment (T1) for this variable was the treatment that provided the lowest values, differing significantly from the others ($p = 0.0038$), and suggesting lower quality seedlings. The Dickson Quality Index (DQI) is considered a good integrated morphological measure, since it encompasses several important characteristics such as height, diameter, shoot dry matter and root dry matter,

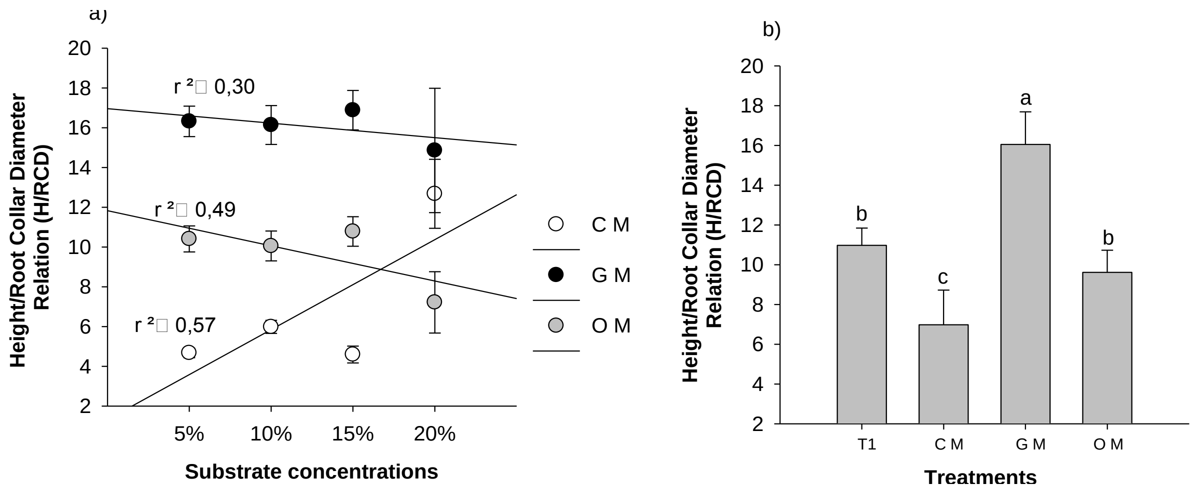

Figure 2. a) Height/Root Collar Diameter relation (H/RCD). (b) Comparison of the values between the different treatments of *S. amazonicum*. T1: control treatment; CM: chicken manure; GM: goat manure and OM: organic matter

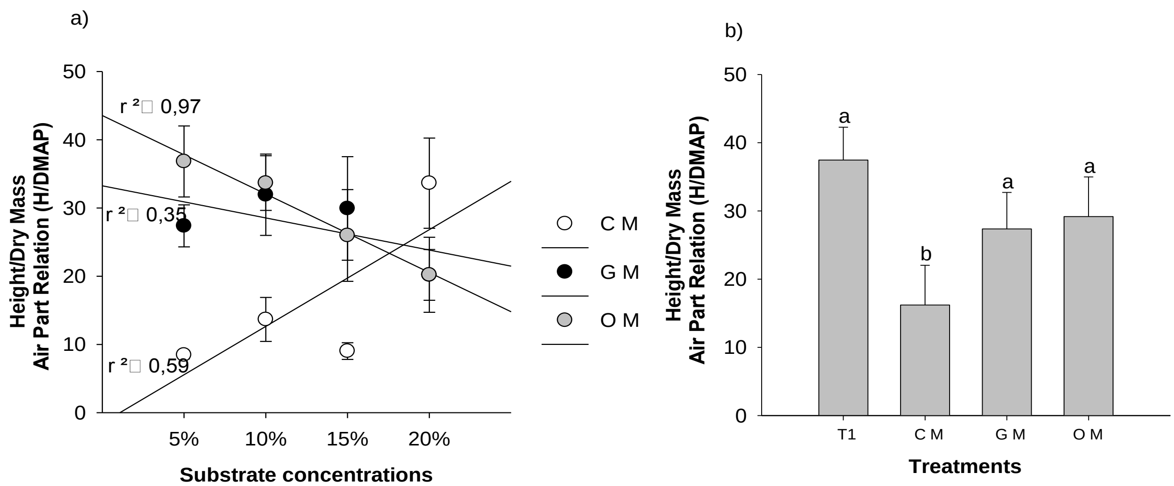

Figure 3. a) Heigh/Dry Mass Air Part relation (H/DMAP) of *S. amazonicum*. b) Comparison of the values between the different treatments. T1: control treatment; CM: chicken manure; GM: goat manure and OM: organic matter.

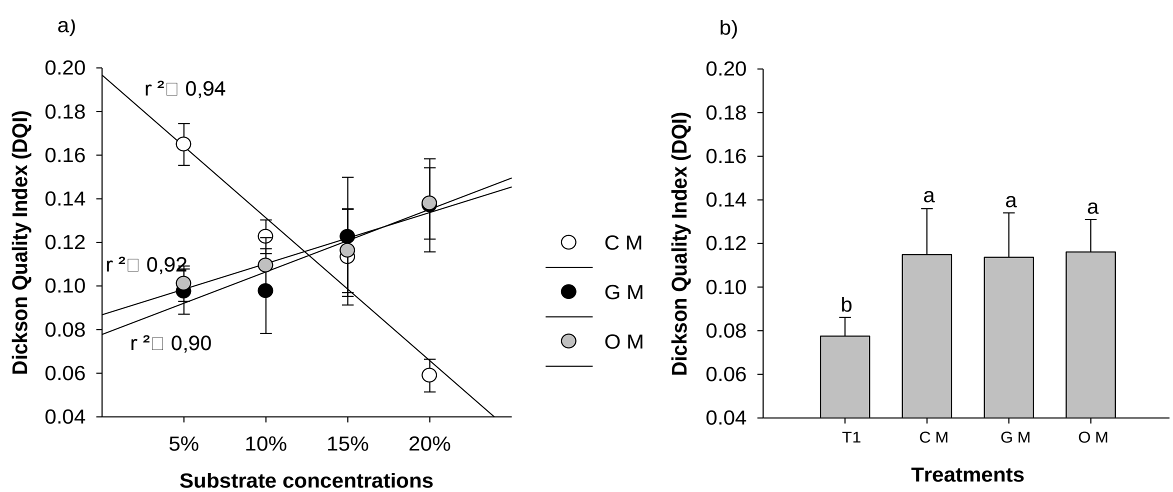

Figure 4. a) Dickson Quality Index (DQI) among the different treatments. b) Comparison of the values between the different treatments. T1: control treatment; CM: chicken manure; GM: goat manure and OM: organic matter.

considering the robustness and balance of mass distribution (Fonseca et al., 2002). Therefore, the success of planting species will depend on the quality of the seedlings, which in turn, depends on the characteristics of the substrate, which are fundamental for the initial growth and establishment of seedlings in the field (Sena et al., 2010).

Conclusion

In terms of initial growth, the use of organic substrates helped the production of *Schizolobium amazonicum* (parica) seedlings. Substrates with 15% goat manure (T4) and 15% chicken manure (T8) were significantly superior to the other treatments, among the used ones, were that provided the highest values, considering the parameters evaluated in this research. The production of good quality seedlings is an important step for excellent silviculture and the use of organic waste supports the supply of nutrients, supplying the initial demands for energy production that will be converted into better performance in the growth and biomass accumulation of seedlings.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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