Mauritia vinifera Mart Substrates and Nitrogen Doses in *Acacia mangium* Willd Growth

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Abstract

The objective of this study was to evaluate the effect of the combination of a substrate formulated with decomposed buriti stem (*Mauritia vinifera* Mart.) and nitrogen doses in the production of *Acácia mangium* Willd seedlings. A completely randomized design was used in a 3×5 factorial scheme, being the factors constituted of substrates formulated from decomposed buriti stem (DBS) mixed with dystrophic yellow oxisol in three proportions (0; 25 and 50%) and nitrogen doses (0; 100; 200; 300 and 400 mg dm^{-3}) applied in cover. After 60 days from the emergency, it was made the following evaluations: Plant Height (PH), stem diameter (SD), internodes number (IN), dry mass of the shoot part (DMA), length and dry mass of the roots, robustness quotient through stem height/diameter relation, roots/dry mass relation and Dickson Quality Index (DQI). The multivariate analysis of variance showed a significant difference ($p < 0.01$) among averages vectors of treatments. The grouping analysis for the evaluated treatments allowed the division into four distinct groups. In the bi-dimensional plane formed by the first two canonical variables (Can.1 and Can.2) that withheld 99,47% of the total variance contained in the nine original variables, it is observed that the group II of treatments, composed of substrates formulated with 50% of soil + 50% of DBS supplemented with the doses of 200, 300 and 400 mg dm^{-3} of nitrogen, has provided a greater initial growth of *A. mangium* plants, as stated by the highest averages in all evaluated variables.

Keywords: nitrogen fertilization, decomposed buriti stem, multivariate

1. Introduction

The *Acácia mangium* Willd is a large tree species from Australia, also coming from Papua New Guinea and Indonesia, cultivated worldwide for its good wood features, quick growth, and easy adaptation to various soil types and climate conditions (Ren et al., 2018; Tran et al., 2018). Such characteristics make possible its utilization in cellulose production, energy, sawn wood, windbreak, recovering of degraded areas, and other applications, turning it of big importance to the forest sector (Araújo et al., 2018; Ren et al., 2018; Tran et al., 2018).

It is known that the success of forest planting, among other factors, depends on the production of quality seedlings (Araújo et al., 2018). The substrates are widely used in this phase, and a lot of times, the mineral supplementation. Among the essential elements required by the plants, stands out the nitrogen, macronutrient required in larger quantities by plants, constituent of various compounds and physiological processes (nucleic acids, enzymatic cofactors, proteins, photosynthesis, respiration, and others) (Shiri-Janagard et al., 2012; Egamberdieva et al., 2018).

However, the commercial organic substrates and the mineral fertilization are, most times, expensive (Chae et al., 2018), thus becoming inaccessible to small and medium producers, but they are still essential to the production of more vigorous seedlings, which increases the chances of field survival. The organic substrates improve the chemical, physical and biological characteristics of the soil, hence providing suitable conditions for the good development of the seedlings (Cavalcante et al., 2019; Oliveira et al., 2019).

In this way, it has resorted to the search for alternative substrates that present good availability, aiming to reduce the production costs and also ensure a better destiny for sediments found and/or produced in the rural properties (Costa Júnior et al., 2018; Sousa et al., 2019). The decomposed buriti stem (*Mauritia vinifera* Mart.) has been showing promising results in some studies and it is a species of wide distribution, mainly in the cerrado regions, reaching up to 30 meters in height (Horn et al., 2012; Araújo et al., 2018; Oliveira et al., 2018; Fonseca et al., 2019). Buriti is the most abundant palm in the Brazilian territory and occurs in almost homogeneous groups called buritizais (Lorenzi et al., 2004). It is a full sun palm, adapted to permanently flooded soils, with a simple trunk (Santelli et al., 2009).

Therefore, the decomposed buriti stem supplemented with nitrogen may become an alternative source of substrate for the production of *A. mangium* Willd seedlings, hence decreasing the production cost. Thereby, the objective was the evaluation of the initial development of the *A. mangium* Willd seedlings in the substrate of the decomposed stem of *M. vinifera* Mart under doses of nitrogen.

2. Material and Methods

2.1 Study Site Description

The experiment was conducted in a greenhouse at the Agronomic Experimental Station of the Federal University of Piauí (UFPI), in Bom Jesus, Piauí State, Brazil (09°04′28″ S, 44°21′31″ W, and altitude of 277 m), from October to November 2015. The regional climate, according to the Köppen classification, is Aw, characterized as tropical, with hot summers and a tendency toward high rainfall levels between October and April, and dry winters, with a dry season between May and September. The mean annual temperature is 26.5 ºC, with a mean annual rainfall of 900 to 1,200 mm (Viana et al., 2002).

2.2 Experimental Design and Treatments

The completely randomized design was used in a 3 × 5 factorial scheme (decomposed buriti stem × nitrogen doses), being the treatments (Table 1) composed of substrates formulated from decomposed buriti stem mixed with Dystrophic Yellow Oxisol in three proportions (0; 25 and 50%) and, nitrogen doses (0; 100; 200; 300 and 400 mg dm^{-3}) applied in treatments, fractioned in two applications at 20 and 40 days after an emergency. The source of nitrogen was urea (45% of N).

Table 1. Treatments are formulated from the mix of soil with decomposed buriti stem under nitrogen doses

Treatments	Formulation		
	Soil (%)	Decomposed buriti stem (%)	Nitrogen dose (mg dm^{-3})
T1	100	0	0
T2	100	0	100
T3	100	0	200
T4	100	0	300
T5	75	0	400
T6	75	25	0
T7	75	25	100
T8	75	25	200
T9	75	25	300
T10	75	25	400
T11	50	50	0
T12	50	50	100
T13	50	50	200
T14	50	50	300
T15	50	50	400

The decomposed buriti stem was obtained in the settlement Agrovila Formosa, in Redenção do Gurguéia-PI. The chemical compound of the soil is presented in Table 2.

Table 2. Chemical characterization of the soil used in the experiment in a 0-0.20m layer.

pH	P	K	S	H+Al	Al	Ca	Mg	K	SB	T	m	V	MO
H$_2$O	----- mg dm^{-3} -----			--------------------------- cmol$_c$ dm^{-3} ---------------------------							------- % -------		g/Kg
5.4	14.19	192.5	-	4.95	0.00	2.24	0.86	0.49	3.59	8.54	0.00	42.1	20.9

Note. pH in water; P = Phosphorus; S = Sulfur; H + Al = hydrogen + aluminum; Al = aluminum; Ca = calcium; Mg = magnesium; K = potassium; SB = Sum of exchangeable bases; T = effective CEC; m = Aluminum Saturation Index; V = Base Saturation Index; MO = Organic Matter.

The substrates were packed in plastic bags (commercial dimensions 12.5 × 10 cm) in which it was made the manual seeding of five seeds of *A. mangium* seeded ±2 cm deep. Ten days after the emergency of seedlings, was realized the thinning, leaving only one plant composing the experimental unity. The substrate's water content was kept close to the capacity of water retention with daily irrigations.

3.3 Evaluations in the Trials

At 60 days after the emergency, it was evaluated: plant height (PH)—determined from the soil surface to the insertion of the last leaf with the assistance of a millimeter ruler; stem diameter (SD)—measured at the plant height using a digital caliper (Clarke-150 mm), with an accuracy of ±0.01 mm; internodes number (IN); roots length (RL): measured with digital caliper. The plants were then separated into shoots and roots, packed in paper sacks, taken to the greenhouse at 65 ℃ for 72 hours, and weighted in analytical balance with an accuracy of 0.0001 g to the determination of the dry mass of the shoot part (DMAP) and dry mass of roots (DMR).

Based on these evaluations, it was determined the total dry mass (TDM) and calculated the morphological indexes: dry mass of shoot part/roots (DMAP/DMR); the robustness quotient (RQ), which was determined by the function of the plant height/stem diameter (PH/CD); and the Dickson Quality Index (DQI), through Equation 1, proposed by Dickson et al. (1960):

$$IOD = \frac{TDM}{\frac{PH}{SD} + \frac{DMAP}{DMR}} \tag{1}$$

Where, TDM is the total dry mass (g); PH is the height of the shoot part (cm); SD is the diameter of the stem (mm); DMAP is the dry mass of the shoot part (g), and DMR is the dry mass of the roots (g).

3.4 Statistical Analysis

The data were submitted for analysis of multivariate normality through the Doornik-Hansen test (2008) ($p <$ 0.05), and analysis of multivariate variance (MANOVA) through tests of Wilk's Lambda, Pillai's Trace,

Hotelling-Lawley Trace, and Roy's Maximum Root at the levels of 5% of significance. Sequentially, the grouping of treatments was realized using Ward's method (formation of hegemonic groups by the smallest minimum internal variance), being used as reference Euclidean distance and Pearson coefficient.

To discriminate the groups of treatment in function of the agronomic variables of *A. mangium*, it was realized canonical discriminant analysis, which was represented in a biplot graphic built for the first two canonical variables. Ellipses of 95% trustworthiness were built to detect statistical differences ($p < 0.05$) among treatment groups. All the analyses were realized using the software R version 3.6.1 (R CORE TEAM, 2019). The canonical discriminant analysis was made with the assistance of the candisc package (FRIENDLYE FOX, 2015).

3. Results

According to the summary of the multivariate analysis of variance, there was a significant difference ($p < 0.01$) between the averages vectors of treatments in the multivariate tests of Wilk's Lambda, Pillai's Trace, Hotelling-Lawley's Trace, and Roy's Maximum Root (Table 3).

Table 3. Summary of the multivariate analysis of variance to the averages vectors of treatments

Statistics	Value	[1]num Df	[2]den Df	Aprox. F	Pr(>F)
Wilk's Lambda	0.0229	126	526.2	2.6698	8.12e-15
Pillai's Trace	2.5402	126	675	2.1066	1.67e-09
Hotelling-Lawley's Trace	6.7307	126	587	3.4840	< 2.2e-16
Roy's Maximum Root	3.8408	14	75	20.5760	< 2.2e-16

Note. [1]num Df: numerator degrees of freedom; [2]denDf: denominator degrees of freedom.

The grouping analysis for the evaluated treatments (Figure 1) allowed the division into four distinct groups. The composition of the groups was: group I (T2, T5, T6, T8, and T11), group II (T13, T14, and T15), group III (T7, T10, and T12), and group IV (T1, T3, T4, and T9).
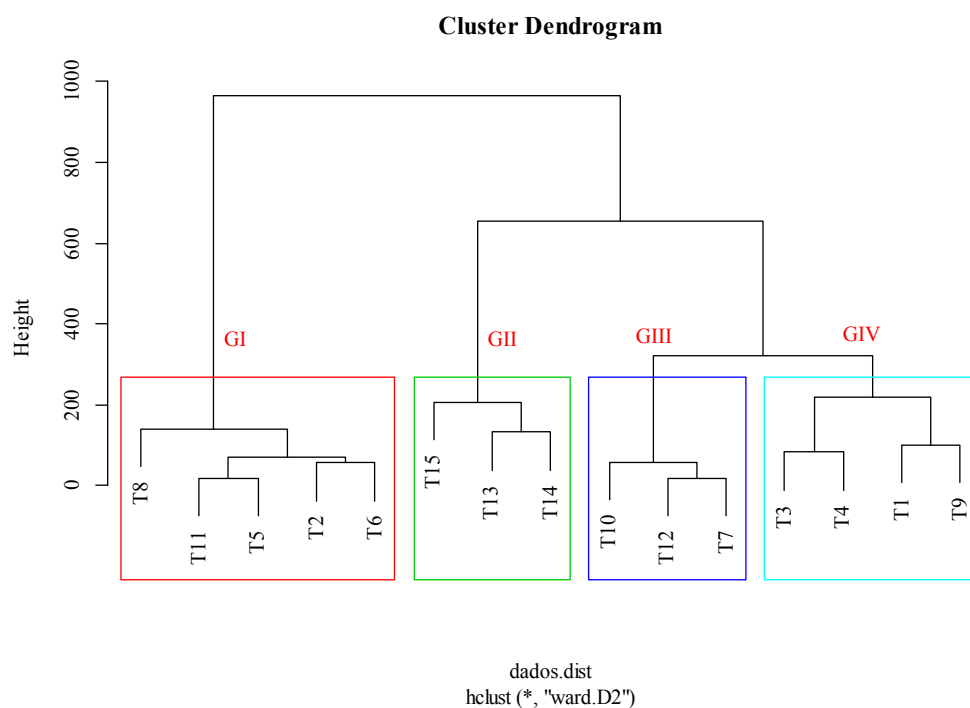

Figure 1. Grouping of treatments in dendrogram with the Euclidean distance considering the agronomic variables of the *A. mangium*

According to the canonical discriminant analysis, it was observed that the first two canonical variables explained 99.47% of the total variance contained in the nine original variables (Table 4). Analyzing the distribution of

weights of each variable, it is possible to observe that the first canonical variable (Can.1) is strongly correlated with all the variables of *A. mangium*, explaining 94.26% of the original variance. Meanwhile, the low correlations of the second canonical variable (Can.2) with the original variables may be related to its retention of only 5.21% of the original variance.

Table 4. Coefficients, eigenvalues, and proportion of variance are explained by the canonical variables for nine variables of *A. mangium* plants

Variables	Canonical variables	
	Can.1	Can.2
PH	0.79	-0.03
SD	0.72	-0.21
IN	0.56	0.00
DMAP	0.95	-0.23
RL	0.43	0.33
DMR	0.10	-0.04
DMAP/DMR	0.62	-0.00
RQ	0.21	-0.05
DQI	0.44	-0.33
Eigenvalue	229.98	12.70
Explained variance (%)	94.26	5.21
Cumulative Variance (%)	94.26	99.47

Note. Variables: plants height (PH), stem diameter (SD), internodes number (IN), dry mass of shoot part (DMAP), root length (RL), dry mass of root (DMR), the relation between the dry mass of the shoot part/roots (DMAP/DMR), robustness quotient (RQ) and Dickson Quality Index (DQI).

According to the bi-dimensional plan formed by the canonical variables Can.1 and Can.2 (Figure 2), it was observed that the group II of treatments (T13, T14, and T15) provided a larger growth of *A. mangium* plants, as contested by the highest averages of the variables PH, SD, IN, DMAP, RL, DMR, DMAP/DMR relation, RQ and DQI. The group I of treatments (T2, T5, T6, T8, and T11) was the one that showed the lowest averages of *A. mangium* growth, while the groups of treatments III (T7, T10, and T12) and IV (T1, T3, T4, and T9) has showed intermediate results.
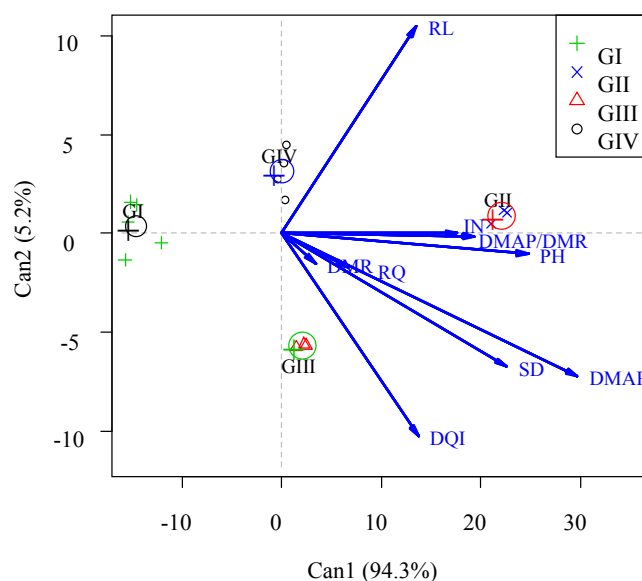

Figure 2. Graphic representation of the canonical discriminant analysis (canonical variables: Can.1 and Can.2) of the agronomic variables of *A. mangium*: plants height (PH), stem diameter (SD), internodes number (IN), dry mass of shoot part (DMAP), roots length (RL), dry mass of roots (DMR), the relation between the dry mass of shoot part/roots (DMAP/DMR), robustness quotient (RQ) and Dickson Quality Index (DQI)

4. Discussion

According to the results presented in this study, it was observed that the substrate formulated with decomposed buriti stem (DBS) and nitrogen doses provides improvement in the growth of *A. mangium* plants. The group II of treatments (T13, T14, and T15), composed of the substrates formulated with 50% of soil + 50% of DBS supplemented with the doses of 200, 300, and 400 mg dm^{-3} of nitrogen, has contributed positively to the shoot and root development of *A. mangium*, when measured by the variables plants height, stem diameter, internodes number, dry mass of the shoot part, roots length, dry mass of root, dry mass of shoot part/roots relation, robustness quotient and Dickson Quality Index.

Thus, the substrates with the highest doses of decomposed buriti stem (50%) associated with the highest doses of nitrogen (200, 300, and 400 mg dm^{-3}) resulted in greater development of *Acacia mangium* Willd seedlings. This fact is related to the chemical characteristics of the buriti stem and the benefits of nitrogen fertilization, for example, the increase in the number of chlorophylls in the leaves and, consequently, the increase in the photosynthetic production of photoassimilates.

The DBS is a substrate that presents favorable physical-chemicals characteristics to development of plants, such as: pH (6.8), electrical conductivity (0.31 mS/cm), nitrogen (1.98 mg/L), potassium (22.77 mg/L), calcium (2.13 mg/L) and magnesium (0.93 mg/L) (Amaral et al., 2010), in addition to the aeration space (35%), wet density (625 kg m^{-3}), dry density (124 kg/m^3), water retention capacity (57%) and pore volume (93%) (Avelino et al., 2010; Silva Júnior et al., 2014). On the other hand, the nitrogen is one of the most abundant elements in plants, being the essential constituent of amino acids, proteins, nitrogenous bases, nucleic acids, hormones, and chlorophyll, among other necessary molecules for the development and growth of plants (Costa et al., 2012; Silva et al., 2014).

Therefore, the combination of the chemical characteristics of the substrate with doses of nitrogen contributed to a greater growth of plants in this study, hence being a viable alternative in the production of *A. mangium* seedlings. The results of this study corroborate the combination of DBS with nitrogen doses also evaluated by Oliveira et al. (2018) and Fonseca et al. (2019) with satisfactory results in the development of umburana seedlings (*Amburana cearensis*) and cagaiteira (*Eugenia dysenterica*), respectively.

5. Conclusions

The substrate formulated with Dystrophic Yellow Oxisol + decomposed buriti stem, 1:1 proportion, supplemented with nitrogen fertilization in doses varying from 200 to 400 mg dm^{-3} is recommended in the production of *A. mangium* seedlings, with positive effects on the growth and development of plants.

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