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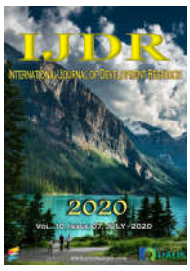

RESEARCH ARTICLE OPEN ACCESS

ALTERNATIVE SUBSTRATES IN THE ROOTING OF CUTTINGS *BOUGAINVILLEA SPECTABILIS*

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ABSTRACT

The present work aimed to evaluate different proportions of decomposed babassu stem in the composition of substrates for vegetative propagation of bougainville. The experiment was conducted in a completely randomized design (CRD), with six treatments and four replications totaling 24 plots. The substrate (S) used was soil based with decomposed babassu stem (DBS), in the following proportions: 0%, 20%, 40%, 60%, 80% and 100% of DBS, plus soil. At the end of the experiment, 98 (ninety-eight) days after planting, the following variables were evaluated: I) number of leaves; II) plant height (cm); III) stem diameter (mm); IV) root length (cm); V) root volume (cm^3); VI) fresh root and shoot mass (g). The data were submitted to analysis of variance by the "F" test, for diagnosis of significant effect, and the treatments compared to each other by the Tukey test at 5% probability, through the InfoStat® computer program. According to the analysis of variance, there was no significant effect for any of the variables studied, but the substrates composed of 20 to 100% DBS provided the highest averages for the variables studied. Since for most variables, the substrate with 80% DBS + 20% soil presented the highest average, therefore the most recommended, in the vegetative propagation of bougainville.

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INTRODUCTION

Bougainville (*Bougainvillea spectabilis*) is a shrub ornamental plant that has a vigorous growth, reaching up to five meters in height, it is considered a rustic climbing-type species with flowers of varied color (white, orange, red, yellow and purple), its trunk is covered by strong thorns (Pereira Júnior *et al*., 2018). It is also known as spring, onion, three-marias or paper-flower, belonging to the Nyctaginaceae family, it is used in floriculture and landscaping in several ways, such as on walls and fences or even framing windows, especially in zones of Mediterranean architecture (Moura *et al*., 2015; Costa *et al*., 2015). According to Pereira Júnior *et al*. (2018) the best way to spread bougainville is via cuttings. According to Moura *et al*. (2015) cutting is a propagation method widely used in the production of seedlings because it is an easy method, of low cost and of quick execution, producing seedlings with greater uniformity, with the same characteristics of the mother plant and with earlier flowering. There are some external and internal factors to the plants that can influence this propagation process, the most important are: the physiological conditions of the parent plant, its age and the type of cutting (Vernier & Cardoso, 2013). As for the external factors according to Dutra *et al*. (2012) the type of substrate is one of the most significant for the development of a seedling. Because, it must maintain a balance between humidity and aeration, retaining water without reducing the availability of oxygen and the transport of carbon through the roots, being a physical and nutritional support for the plant (Reges *et al*., 2018). Using organic materials as substrates for the production of quality seedlings is also a way to reduce

production costs, in addition to being a method for the development of more sustainable agricultural activities (Pantoja Neto & Redig, 2017). The decomposed babassu palm (*Attalea speciosa* Mart.) Stem is an organic material that can be used in the composition of substrates (Silva*et al*., 2017). In this context, the objective was to evaluate different proportions of decomposed babassu stem in the composition of substrates for vegetative propagation of bougainville.

MATERIAL AND METHODS

The experiment was installed in a greenhouse, with a 75% brightness control screen, at the Center for Agricultural and Environmental Sciences (CAES) at the Federal University of Maranhão (FUM). Located in the municipality of Chapadinha, Maranhão State, located at 03°44'30" south latitude and 43°21'37" west longitude, and average altitude of 107 m. In this region the climate is classified by Koppen as Aw being hot and humid, with an average annual temperature of 27.9 °C and presenting an average precipitation of 1613 mm per year (Passos *et al*., 2016). The experiment was conducted in a completely randomized design (CRD), with six treatments and four repetitions, totaling 24 plots. The substrates were formulated with 0%, 20%, 40%, 60%, 80% and 100% decomposed babassu stem (DBS), plus soil. Polyethylene bags in the dimension of 15 x 20 cm were used as containers for the seedlings, with a stake in each container, irrigation was carried out twice a day, meeting the water needs required by the plants. The cuttings were collected and planted on the same day to avoid their infeasibility. Woody cuttings were obtained from healthy and well formed branches of the mother plant, these were duly cut into bevels in order to preserve 4 buds in each cut, removing all leaves and inserting only two buds in the appropriate substrates.

Prior to setting up the experiment, a chemical and physical analysis of the substrates was carried out (Tables 1 and 2), and a granulometric analysis of the soil that makes up the substrates: 780 g kg^{-1} of total sand, 90 g kg^{-1} of silt, 130 g kg^{-1} of total clay, sandy textural classification. At the end of the experiment, 98 (ninety-eight) days after planting, the plants removed from their substrates to evaluate the following variables: I) number of leaves; II) plant height (cm); III) stem diameter; IV) root length (cm); V) root volume (cm^3), according to Basso's methodology (1999); VI) fresh mass of root and shoot (g), weighed on a semi-analytical balance. The data were submitted to analysis of variance by the "F" test, for diagnosis of significant effect, and the treatments compared to each other by the Tukey test at 5% probability, using the InfoStat® software version 2015 (Di Rienzo *et al*., 2011).

RESULTS AND DISCUSSION

According to the analysis of variance, there was no significant effect for any of the variables studied, under the different proportions of substrates basedon DBS in the production of bougainville seedlings (Table 3). For the variables NL, LLS and DLS, substrates with 80, 20 and 40% DBS were the treatments with the highest averages, 22.5; 11.65 and 2.93 (Figures 1A, B and C) respectively. The aforementioned variables depend on some nutrients, acting on the development of early leaf, such as calcium, magnesium and phosphorus. Calcium, by stimulating the emission of new leaves, magnesium is a component of the chlorophyll molecule, and ATP phosphorus, an essential energy currency (Andrade *et al*., 2013). According to Cruz *et al*. (2018) the substrate containing DBS, can assist in the development of the aerial part because it contains satisfactory amounts of nitrogen.

Table 1. pH values, electrical conductivity (EC) and total contents of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S), of the substrates based on decomposed babassu stem (DBS), plus soil

DBS	pH	EC	N	P	K	Ca	Mg	S
%		$dS\ m^{-1}$	$g\ kg^{-1}$	$mg\ kg^{-1}$		$cmol_c kg^{-1}$		
0	5.06	0.10	0.63	13	0.07	0.80	0.30	1.05
20	4.88	0.61	1.23	14	0.67	1.60	1.00	3.8
40	5.11	1.36	1.46	13	1.82	3.20	1.70	7.6
60	4.83	1.79	2.02	13	2.35	4.40	2.80	10.8
80	5.16	3.00	3.47	27	6.17	10.90	4.60	24.6
100	5.32	4.34	5.88	33	3.63	20.60	15.20	41.5

Tabela 2. Global density (GD), particle density (PD) e porosity (P) of substrates based on decomposed babassu stem (DBS), plus soil

DBS	GD	PD	P
%		$g\ cm^{-3}$	%
0	1.44	2.67	45.99
20	1.28	2.64	51.53
40	1.18	2.57	54.01
60	0.98	2.24	56.22
80	0.73	1.88	60.91
100	0.33	0.97	65.95

Table 3. Summary of the analysis of variance, with the sources of variation (SV), number of leaves (NL), length of the largest shoot (LLS), diameter of the largest shoot (DLS), root length (RL), root volume (RV), fresh root mass (FRM) and fresh shoot mass (FSM) of bougainville seedlings submitted to different substrates based on decomposed babassu stem

SV	NL	LLS	DLS	RL	RV	FRM	FSM
Treatment	1.00 ^{ns}	0.74 ^{ns}	0.57 ^{ns}	0.98 ^{ns}	1.68 ^{ns}	1.81 ^{ns}	0.78 ^{ns}
Residue	99.09	47.88	0.85	84.37	8.10	1.55	6.57
MSD	22.36	15.5	2.06	20.64	6.39	2.79	5.75

MSD: minimum significant difference; ns: not significant.

According to Bloom and Smith (2017) nitrogen is a nutrient that constitutes numerous plant components such as: amino acids, proteins, nucleic acids, coenzymes and others, essential in plant growth. Because of this, substrates with proportions of DBS stimulate greater NL, length and diameter of the sprout, when compared to 100% soil, for presenting higher amounts of calcium, phosphorus, magnesium and nitrogen (Table 1). Regarding the volume and root length variables, the highest averages were 5.63 (Figure 2A) and 22.81 (Figure 2B), respectively, both obtained on the substrate composed of 80% DBS, which are 4.5 and 2, 5 times higher than the averages found in the substrate with 100% soil.

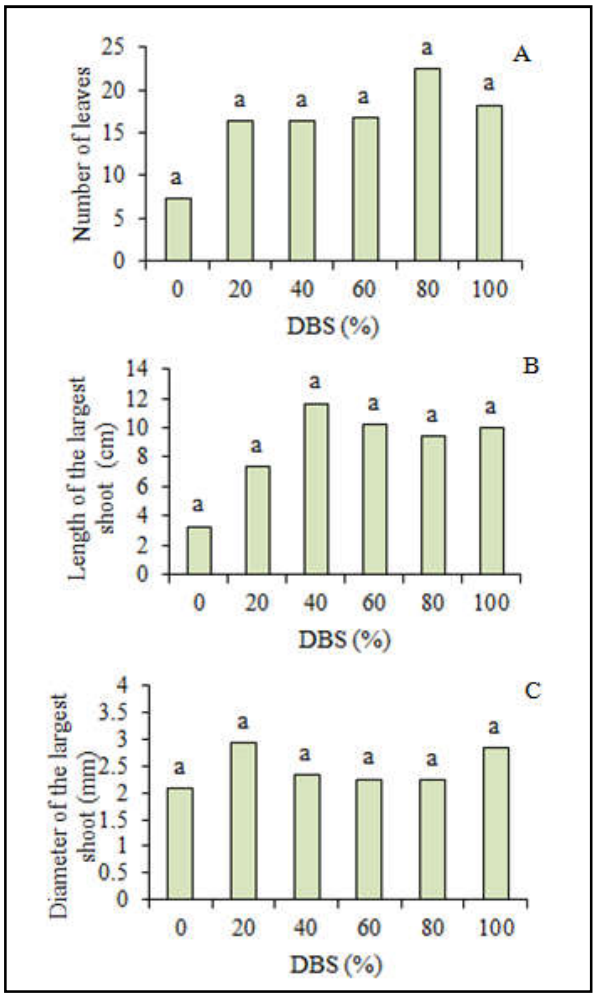

Figura 1.Number of leaves (A), length of the largest shoot (B) and diameter of the largest shoot (C) of bougainville seedlings according to substrates based on decomposed babassu stem (DBS) and soil. Averages with the same letter do not differ by Tukey's test at 5% probability

This occurred, probably due to the physical characteristics of the substrate that provide lower density, greater porosity and an adequate moisture content. Emphasizing the importance of the result obtained, among the characteristics to be observed for the choice of a substrate for the production of ornamental seedlings, it is necessary to carefully observe the physical properties, as its modification after the establishment of the culture causes management difficulties (Lima *et al*., 2019). According to Nunes *et al*. (2018) substrates that have organic matter in their composition, have a higher porosity, which provides the roots with better growth, by absorbing in greater quantities water, nutrients and oxygen.

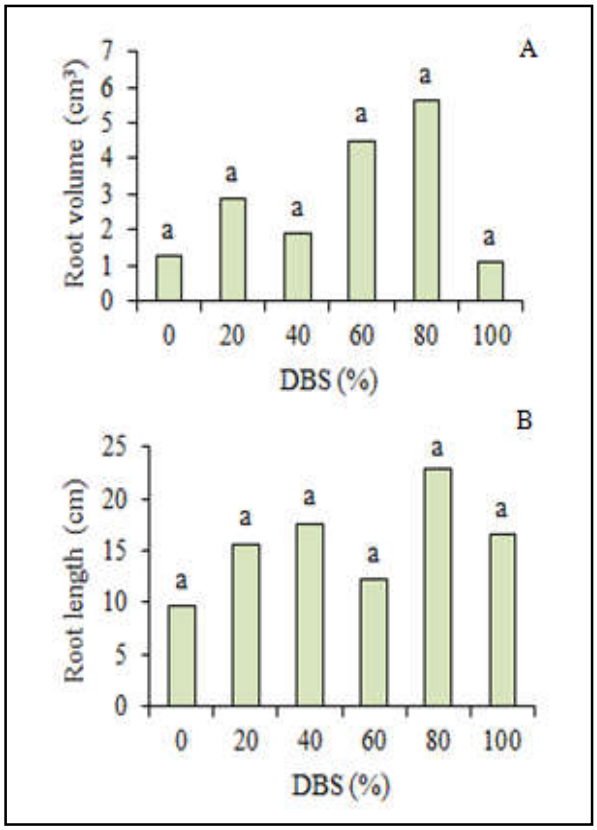

Figure 2. Root volume (A) and root length (B) of bougainville seedlings as a function of different substrates based on decomposed babassu stem (DBS) and soil. Averages with the same letter do not differ by Tukey's test at 5% probability

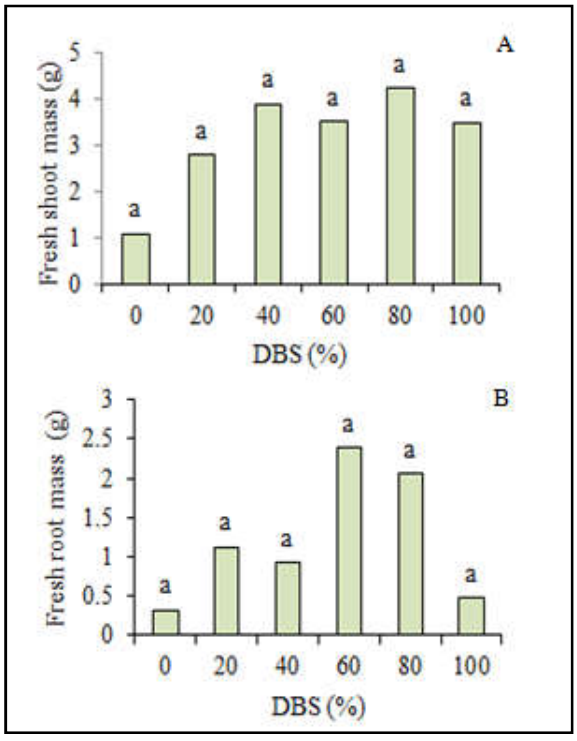

Figure 3. Fresh shoot mass (A) and fresh root mass (B) of bougainville seedlings according to substrates based on decomposed babassu stem (DBS) and soil. Averages with the same letter do not differ by Tukey's test at 5% probability

Despite not having a significant effect numerically, the highest means of the FSM and FRM variables were obtained in the substrates with 60 (Figure 3A) and 80% (Figure 3B) of

DBS respectively. Although there is no significant effect for these variables, the result of this work regarding the FRM was even higher than that found by Cruz *et al*. (2018) who, when evaluating the development of bougainville seedlings under the effects of substrates based on DBS, obtained a mass of 0.55 g, 20.01% less than that found in the proportion of 80% DBS. However, the same authors obtained similar results for the FSM variable with an average of 4.09 g. According to Nunes *et al*. (2018) the most important factors for the development of biomass are the availability of nutrients by the substrates and their porosity, as they directly influence the growth of the aerial part and the root system. Which justifies the responses observed in the variables of the present work, with better performance of seedlings with substrates containing DBS, because as the proportions of DBS increase, the porosity and the values of many nutrients present in the substrates increase (Table 1 and 2).

Conclusion

In this study, it was found that the use of a substrate formulated with decomposed babassu stem, is beneficial for the rooting of bougainville seedlings. When mixed in appropriate proportions with the soil, the decomposed babassu stem can improve the physical and chemical properties of the substrate, favoring the propagation of bougainville cuttings and promoting more vigorous growth. Based on the results, it is recommended to use a substrate with 80% decomposed babassu stem plus a 20% soil formulation to promote the vigorous development of bougainville seedlings. Being an easy to acquire and low cost substrate, this is a good alternative for producers of ornamental seedlings.

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