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Production of cassava seedlings on substrates based on decomposed buriti stem

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ABSTRACT

In the cassava (*Manihot esculenta* Crantz) cultivation system, planting seedlings directly in the field is widely used. However, establishment of plants by this method is slow, taking about 15 days to start the formation of shoots and roots. The plant in this phase is not very competitive, which leads to the formation of uneven and low-productivity areas. Production of seedlings on substrates is an alternative that can improve the uniformity of the plant stand, as well as allow more careful selection of the best propagules. Viability of this propagation method depends on the substrate, which must have ideal physical and chemical properties to meet the needs of the crop. The objective of this work was to evaluate the use of decomposed buriti stem (*Mauritia flexuosa* L. f) as a substrate in the propagation of cassava seedlings. The substrates were composed of decomposed buriti stems and soil in the following proportions: 0:100; 20:80; 40:60; 60:40; 80:20; and 100:0 (volume). The addition of decomposed buriti stem improved development of the aerial part, provided greater survival for cassava seedlings in an increasing linear fashion, and promoted increases in the levels of N, P, K, Ca, and Mg of cassava seedlings. It was determined that there is agronomic efficiency in the use of buriti residue for the production of cassava seedlings.

KEYWORDS
Manihot esculenta; *Mauritia flexuosa*; quality seedlings; sustainable agriculture

The traditional system of cultivating cassava (*Manihot esculenta* Crantz) with planting the stem directly in the field is used by most producers; this type of system can delay the development of the crop due to slow initial growth. Cuttings take up to 15 days to produce the first shoots, which makes it uncompetitive at this stage (Silva et al., 2018). An alternative is the production of seedlings by cuttings, which can promote greater growth in a shorter period and allow multiplication of preselected genotypes that provide more uniform stands (Loss et al., 2009).

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The choice of appropriate substrate directly influences the quality of seedlings, and the physical and chemical characteristics are decisive, affecting growth and production (Maggioni et al., 2014). Some decomposed tree residues can be used as substrates, so knowledge of regional biodiversity is important in the search for alternative substrates to reduce the cost of seedling production (Coelho et al., 2013). Buriti (*Mauritia flexuosa* L. f) is a palm tree native to the Brazilian Cerrado; it is a species with potential for use as a substrate. The objective of this work was to evaluate the production of cassava seedlings with the use of decomposed buriti stem (DBS) in the composition of the substrates.

Materials and methods

The experiment was carried out in a greenhouse, from 2 February 2019 to 3 March 2019, at the Center for Agricultural and Environmental Sciences, at the Federal University of Maranhão at 3º44′17” S and 43º20′29”W, and an altitude of 107 m, located in the municipality of Chapadinha, MA. The region’s climate is classified as humid tropical (Selbach and Leite, 2008), with annual rainfall totals ranging from 1600 to 2000 mm (Nogueira et al., 2012), and average annual temperature 27°C (Passos et al., 2016).

The experiment was arranged in a completely randomized design with four replications with six substrates composed of DBS in the following proportions: S1 = 0% DBS + 100% soil; S2 = 20% DBS + 80% soil; S3 = 40% DBS + 60% soil; S4 = 60% DBS + 40% soil; S5 = 80% DBS + 20% soil; and S6 = 100% DBS + 0% soil. Each replication had 4 units, totaling 16 experimental units per plot. Chemical and physical (Tables 1 and 2) characterization of substrates were carried out following accepted methods (Anonymous, 2007; Schmitz et al., 2002).

For the production of cassava seedlings, stem cuttings were collected from the middle portion of matrix plants (healthy plants aged 10–14 months), variety Dona Diva, containing two nodes, and about 12 cm long. One stem cutting was placed in a 12 × 20 cm polyethylene bag. Irrigation was carried out twice daily, with a watering can with a capacity of 5 L of water.

Table 1. Values for pH, electrical conductivity (EC), and contents of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) of the substrates.

% decomposed buriti stem	pH	EC ($dS\ m^{-1}$)	N ($g\ kg^{-1}$)	P ($mg\ kg^{-1}$)	K	Ca	Mg	S
					($cmol_c\ kg^{-1}$)			
0	5.06	0.1	0.63	13	0.07	0.8	0.3	1.5
20	5.4	0.9	3.03	7	0.63	3.1	1.5	5.4
40	5.8	1.31	5.74	14	0.98	5.2	2.2	7.5
60	6.1	1.72	9.31	25	1.21	6.4	2.4	12.4
80	6.7	1.44	11.41	47	1.28	7.2	3.1	16.4
100	6.9	1.71	24.36	51	1.54	8.9	7.2	17.3

Table 2. Global density, particle density, and porosity of substrates.

% decomposed buriti stem	Density (g cm^{-3})		
	Global	Particle	Porosity (%)
0	1.44	2.678	45.99
20	1.62	3.04	58.24
40	1.34	2.62	62.47
60	1.08	1.92	64.34
80	0.84	1.34	68.87
100	0.38	0.92	71.52

The percent of seedling survival was based on the number of live cuttings. Numbers of shoots per cutting were counted. All leaves were removed and scanned on a printer with scanner, and the computer program ImageJ® used to calculate leaf area. Height of the largest sprout was determined from the insertion point in the stem to the apex; the diameter of the largest sprout was determined at the base close to its insertion in the plant. Root length was measured and root volume determined by measuring displacement of a column of water in a graduated cylinder after immersing the samples.

After biometric evaluations, seedlings were placed in a kiln with forced air circulation at a temperature of 65°C for 72 h. Dry mass of the aerial part and the root system was determined. The relationship between dry mass of the aerial part and the dry mass of roots was determined. Evaluation of macronutrient concentrations in seedlings was determined following Malavolta et al. (1997) for (a) nitrogen in solutions obtained from extracts prepared by sulfuric digestion with the semi-micro-Kjeldahl method; (b) total phosphorus extracted by colorimetry of metavanadate; (c) potassium with from emission flame photometry; and (d) calcium and magnesium determined using the chelatometric method by EDTA titration.

Data were subjected to analysis of variance and means separated with the *F* test. When a significant effect occurred, a polynomial regression was performed using Infostat® software, ver. 2011 (Di Rienzo et al., 2011).

Results and discussion

Percent survival, leaf area, height, and diameter of the largest shoots were affected by substrate composition; numbers of sprouts was not affected (Table 3). When evaluating aeration space (AS) of some substrates, it was determined that DBS has 34.7% AS, a value considered ideal for use as a substrate (Brito et al., 2017). Despite this, increasing proportions of DBS did not influence length, volume, and dry mass of root variables. There are differences between varieties of cassava, which may have greater or lesser rooting capacity (Rodrigues et al., 2008), and propagation of seedlings of other cassava varieties on substrates may differ.

Table 3. Analysis of variance results for survival percent (S), number of sprouts (NS), leaf area (LA), height of largest sprout (HLS), diameter of largest sprout (DLS), root length (RL), root volume (RV), dry mass of aerial part (DMAP), root dry mass (RDM), and dry mass of aerial part ratio and root dry mass (DMAP/RDM) of cassava seedlings as a function of proportion of decomposed buriti stem in substrates.

Item	S	NS	LA	HLS	DLS	RL	RV	DMAP	RDM	DMAP/RDM
F	3.50*	1.00^{ns}	2.86*	6.83**	5.62**	1.98^{ns}	0.79^{ns}	2.84*	0.67^{ns}	1.56^{ns}
CV[a]	19.79	24.77	43.58	23.71	24.88	29.59	47.92	40.8	58.72	58.53

^{ns},*,** not significant or significant at 5 or 1% probability level.
[a]CV = coefficient of variation (%).

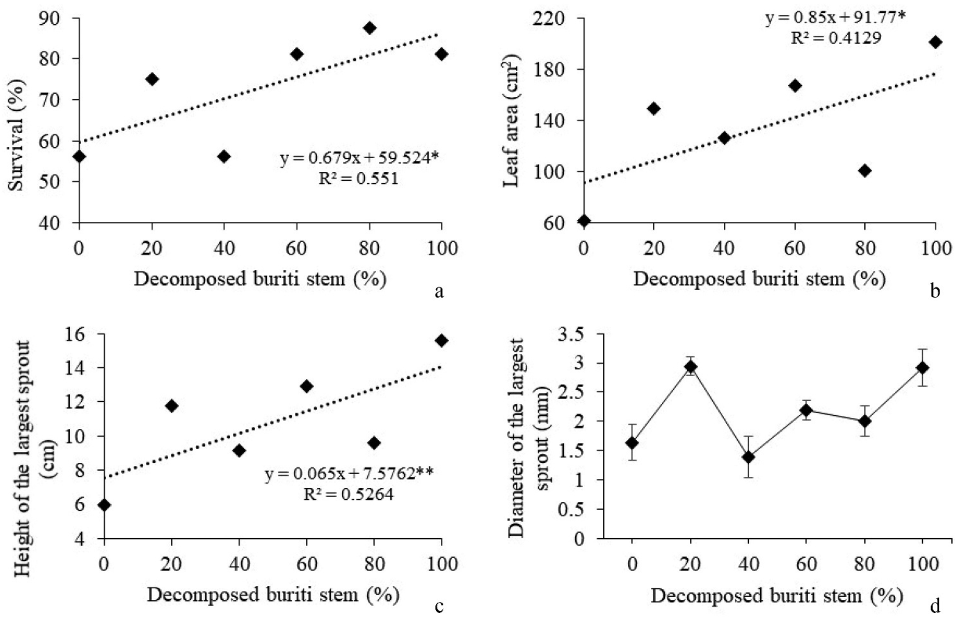

Figure 1. Survival (A), leaf area (B), height of the largest sprout (C), and diameter of the largest sprout (D) of cassava seedlings according to different proportions of decomposed buriti stem.

Higher survival of cassava seedlings was obtained with the highest proportion of DBS in substrates (Figure 1A). Improvement of substrate fertility contributes to a greater number of live seedlings at transplanting (Santos et al., 2009).

There was an increase of about 227% in seedlings leaf area when grown in 100% DBS compared to seedlings grown in 100% soil (Figure 1B). With larger leaf area, there is a greater capacity to produce photoassimilates, favoring plant growth and development (Costa et al., 2017).

The length of the largest sprout of each seedling increased with addition of DBS (Figure 1C). Seedlings grown on 100% DBS had an increase of 162% in relation to the control treatment (100% soil). However, the seedling sprout diameter did not fit any regression model (Figure 1D).

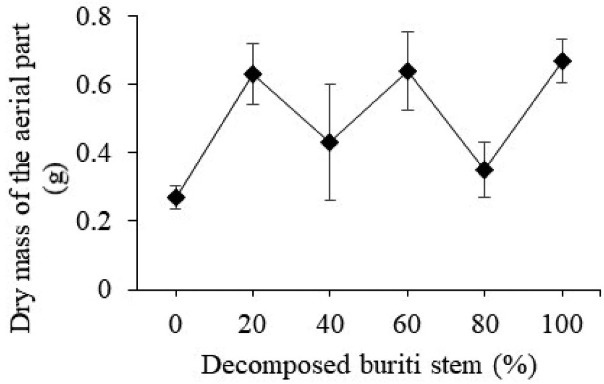

Figure 2. Dry mass of the aerial part of cassava seedlings as a function of different proportions of decomposed buriti stem.

Dry mass of the aerial part did not fit polynomial regression models (Figure 2). Based on analysis of variance (ANOVA), seedlings from substrates supplemented with DBS had an overall average of 0.54 g; those grown on substrate composed only of soil had an average of 0.27 g. Although there are several ways of using practically all parts of cassava, only roots have added economic value, and this is a factor masking the importance of aerial part growth (Silva et al., 2014).

Levels of N, P, K, Ca, and Mg in aerial parts varied (Table 4). The nitrogen level responded in a quadratic manner, indicating ideal accumulation with use of substrates containing 45% of DBS (Figure 3A). The ideal range for absorption of this nutrient by the plants varies from 5.5 to 6.5 and reduces from higher values (Malavolta, 1979).

Better results for the phosphorus ester were obtained (Figure 3B) in seedlings grown with between 40% and 80% DBS. Potassium responded in a quadratic manner, with the best results in seedlings grown with 60%, 80%, and 100%, and the lowest content in seedlings with 0% (Figure 4A). Calcium content was higher in seedlings grown in 60%–100% (Figure 4B). These results probably occurred due to nutrition from DBS, which is rich in organic matter. Use of soil to compose substrates is widely used for the production of seedlings as it is economically viable and a material always available. This material is often poor

Table 4. Analysis of variance for levels of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) in cassava seedlings as a function of proportion of decomposed buriti stem in substrates.

Item	N	P	K	Ca	Mg
F	4.83**	9.09**	10119.63**	6.49**	58.63**
CV[a]	8.73	31.28	0.4	41.2	8.86

** Significant at 1% probability level.
[a]CV = coefficient of variation (%).

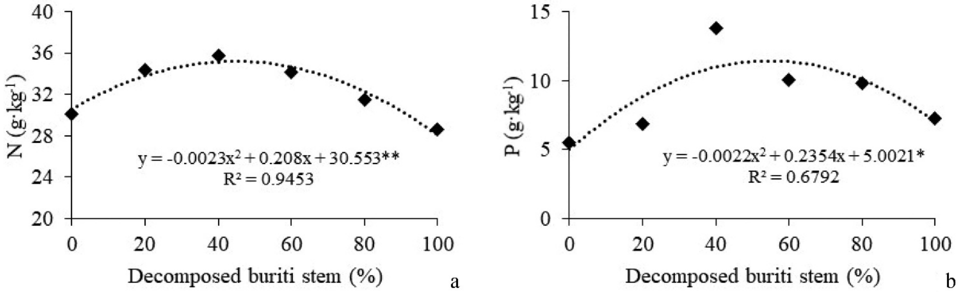

Figure 3. N (A) and P (B) contents of cassava seedlings as a function of different proportions of decomposed buriti stem.

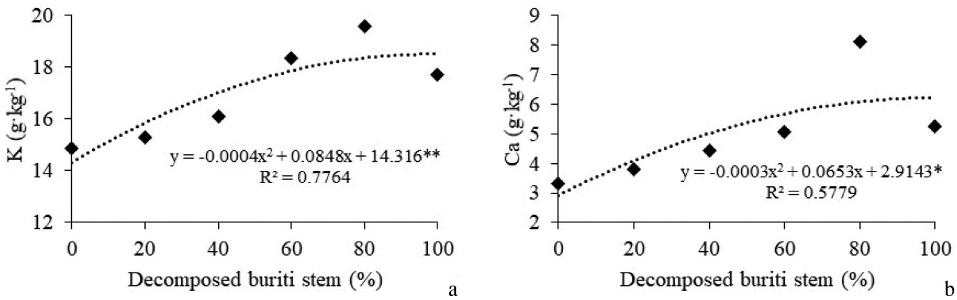

Figure 4. K (A) and Ca (B) contents of cassava seedlings as a function of different proportions of decomposed buriti stem.

in organic matter and nutrients. Addition of plant residues provides nutritional content and acts as a substrate conditioner (Sousa et al., 2013).

The best results for magnesium content were with substrates composed of 40%, 60%, and 80% DBS, which responded in a quadratic manner, with an optimal level estimated at 61% (Figure 5). Magnesium is directly linked to structure and performance of chloroplasts, and with participation in activation

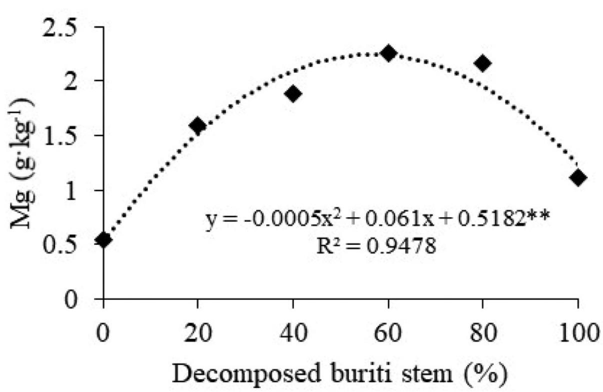

Figure 5. Mg content of cassava seedlings as a function of different proportions of decomposed buriti stem.

of enzymes involved in respiration, photosynthesis, and synthesis of nucleic acids (Taiz and Zeiger, 2013).

Substrates based on DBS positively influenced the growth and nutrition of cassava seedlings. It is necessary to evaluate the development of these seedlings in the field, as well as the evaluation of other substrates, for the establishment of techniques and procedures ideal for the formation of good quality propagation material.

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