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Substrates and Fertilization of Mamacadela

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Abstract

The Cerrado has fruit species of great potential of use in commercial systems of agricultural production. They are obliged to carry out studies on the production of seedlings, contributing to a perpetuation of these species. The objective of this study was to evaluate the effect of different substrates and different doses of Basacote® on the emergence and early development of *B. gaudichaudii* plants. The experiment was conducted in a greenhouse in the experimental area of the Goiano Federal Institute-Campus Ceres. Experiment 1 was composed of six treatments (six compositions) and experiment 2 consisted of 5 treatments (five doses of Basacote®). The experimental design was a randomized complete block with four replicates and 12 plants per experimental plot. The variables analyzed were emergence, height, lap diameter, number of leaves, root system length, survival rate and fresh and dry matter of the aerial part and root system. The substrate composed of bovine manure + Plantmax® + soil provides better conditions for growth and development of mamacadella plants. The mamacadela seedlings do not tolerate high levels of organic matter in the substrate. For the production of *Brosimum gaudichaudii* seedlings the use of the 6.48 g dose of Basacote® plant^{-1} is indicated.

Keywords: moráceae, cerrado, *Brosimum gaudichaudii*, slow release fertilizer, organic compound

1. Introduction

Cerrado presents a vast flora, an unequaled medicinal potential and fruits with high nutritional value. This biome has fruit species of great potential for economic, industrial and environmental purposes, yet to be explored, enabling income generation, guaranteeing economic progress and sustainability (Pereira & Pasqualeto, 2011). However, this exploitation often occurs in an extractive way, exhausting such resources without prior scientific knowledge of the species present in this biome.

Most of Cerrado fruits present high levels of sugars, proteins, vitamins and minerals, besides a unique characteristic flavor (Ávila et al., 2010).

Brosimum gaudichaudii Trécul, popularly known as mamacadela, also has great agronomic potential and is considered a relevant species, mainly because it has medicinal characteristics. According to Oliveira (2011), it has bergapten, which is used in the treatment of vitiligo and other diseases that cause depigmentation in the skin. In addition to bergapten, it contains in its roots large amounts of psoralen, another furanocoumarin used to treat skin diseases (Morais et al., 2018). For this reason the plant is extracted indiscriminately from its natural habitat.

It has been a great challenge in the conservation of the species the lack of scientific information on cultivation protocol. Thus, studies of efficient methods of seedling production are necessary, contributing to the species' perpetuation. Quality seedlings are fundamental for satisfactory results, because the more vigorous, the higher the survival rate, the substrate and nutrition being essential elements to guarantee this quality.

The substrate has the function of providing adequate conditions to the root development and support to the seedlings, and substrates obtained close to their use present a reduction of seedling production costs (Santos, Costa, Leal, Nardelli, & Souza, 2011). According to Eilers et al. (2015) the different physical properties of the material used in the substrate composition affect the porosity, the ability to store water, and consequently the germination and distribution of roots.

The mamacadela develops well in poor soils, presenting efficient extraction of nutrients due to characteristics of its root system. However, the presence of fertilizers in adequate doses and preferably with mechanisms of slow release of nutrients, avoiding losses due to leaching and volatilization, should be used to guarantee the quality of the seedlings.

Considering the above, this study aimed to evaluate the effect of different substrates and different doses of Basacote® on the emergence and initial development of *Brosimum gaudichaudii* plants.

2. Method

2.1 Experimental Area

The experiment was conducted in a greenhouse at the Goiano Federal Institute-Ceres Campus (15°21′0.6″S, 49°35′55.6″W and 565 m altitude), located in the city of Ceres, State of Goiás, from October 2016 to June 2017. The temperature and relative humidity of the average air registered inside the greenhouse during the period of conduction of the experiment was 25.9 ºC and 75.5%, respectively.

2.2 Seed Collection for Seedling Production

The seeds were collected from fruits of mamacadela in plants located in an area of natural occurrence, in the cities of Faina and Itapuranga, during the maturation period of the fruits (September/October), when the spontaneous fall began. The fruits were manually pulped soon after harvest and the seeds washed in running water until complete removal of the mucilage.

After the processing, the moisture content of the seeds was determined by the greenhouse method of gravitational circulation at 105±3 ºC for 24 hours and the mass of one thousand seeds (Brazil, 2009). The biometric characteristics of the seeds were also determined: length, width and thickness, using a digital caliper, in 50 seeds, randomly selected. The sowing was done soon after, using three seeds per container, 1.5 cm deep. The containers used were polyethylene bags with dimensions of 30 cm × 12 cm.

2.3 Experimental Design and Treatments

The design was a randomized complete block design, with four replications and 12 plants per experimental plot. Two experiments were implemented in which experiment 1 consisted of 6 treatments and experiment 2 was composed of five treatments.

The treatments consisted of different substrates S1 (coarse soil + soil, 1:1), S2 (Substrate commercial-Plantmax®), S3 (Plantmax® + coarse sand + soil, 1:1:1), S4 (1:1:3), S5 (bovine manure + soil, 2:3) and S6 (charcoal rice husk + Plantmax® + soil, 1:1:1) and different doses of Basacote® D1 g plant^{-1}), D2 (2.5 g plant^{-1}), D3 (5 g plant^{-1}), D4 (7.5 g plant^{-1}) and D5 (10 g plant^{-1}). Fertilizer doses were tested on the substrate prepared with coarse sand + soil (1:1).

The Basacote formulation used was 16-25-6. Basacote® is a fertilizer with a release time of about 3 to 9 months containing 16% N, 25% P_2O_5 and 6% K_2O, 1% MgO, 2.5% S, 0.27 % Fe, 0.01% B, 0.015% Zn, 0.05% Cu, 0.05% Mn and 0.015% Mo (Compo Expert, 2018).

2.3.1 Variables Analyzed

The seedling emergence count started on the 19th day after sowing (DAS) and was performed daily, considering as emerged those that reached 1 cm in height. The emergence data were used to analyze the variables: emergence percentage (PE), emergence speed index (IVE) and emergence time (TE) (equations 1, 2 and 3). The IVE was calculated by the formula proposed by Maguire (1962).

$$IVE = E1/N1 + E2/N2 + \dots En/Nn \quad (1)$$

where, IVE = emergence speed index; *E1*, *E2*, … *En* = number of normal seedlings computed in the first, second and last count; *N1*, *N2*, ... *Nn* = number of days of sowing at the first, second and last count.

$$TE = DE1+DE2+\dots DEn/NS \quad (2)$$

where, TE = emergence time; *DE1*, *DE2* ... *DEn* = number of days of sowing at the emergence of the first, second and last seedlings in each package; NS = number of seeds used in each package.

$$PE = NPE/TS \times 100 \quad (3)$$

where, PE = emergence percentage; NPE = number of seedlings emerged for each treatment; TS = total of seeds for each treatment.

After the emergence stability, at 55 DAS, the thinning was done leaving the seedling more vigorous by packaging and the biometric evaluation was started.

The biometric evaluation was performed monthly, in a six-month period, the initial seedling height (ALTI), final seedling height (ALTF), initial lap diameter (DIAI), final lap diameter (DIAF), initial leaf number (NFI), final leaf number (NFF), height growth rate (TCALT), growth rate in diameter (TCDIA) and leaf number growth rate (TCNF). The variable growth rates were calculated by estimating a linear regression coefficient of the original variable over time, for each plant, from the data obtained from six height readings, basal diameter and number of leaves of each seedling for seven months.

At the end of the experiment, the following numbers were analyzed: the survival rate (SOBR), root system length (COMR), fresh mass of the aerial part (MFA), fresh mass of the root system (MFR), dry mass of the aerial part (MAS) and dry mass of the root system (MSR). Three plants per treatment were used for the destructive analysis. In order to determine the dry mass, the aerial part was separated from the root system and conditioned in paper envelopes, later transferred to a forced circulation oven at 60 ºC, remaining until reaching a constant mass. The constant weight was obtained between the third and seventh day.

2.3.2 Statistical Analysis

The results of experiment 1 were submitted to analysis of variance, and the treatments were compared by the Skott Knott test, at 5% probability, and the results of experiment 2 were submitted to regression analysis, both using the statistical program R version 3.4 .3.

3. Results and Discussion

The moisture content of the seeds (wet basis) was 41.68% and the mass of one thousand seeds was 2135.93 g.

The weight of a thousand seeds is important to verify the vigor of the seeds, because the more reserves the seeds have, the greater the value of their mass. And consequently, the greater amount of reserves favors the emergence and development of the seedlings.

The analyzed seeds presented length, width and average thickness of 19.56 mm, 15.81 mm and 11.26 mm, respectively (Table 1).

Table 1. Medium, minimum, maximum values and coefficient of phenotypic variation (CV%) of the length, width and thickness of mamacadela seeds, Ceres, GO, 2017

Size	Lenth (mm)	Width (mm)	Thickness (mm)
Maximum	24.09	19.44	13.63
Medium	19.56	15.81	11.26
Minimum	14.98	11.35	8.79
CV (%)	11.68	11.35	9.9

According to Ma et al. (2019) Plants originating from larger seeds have survival advantages and higher biomass growth after emergence. They present, more vigorous seedlings (Faria, Albuquerque, & Coelho, 2013). According to Silva, Mendonça, Medeiros, Freitas, and Góis (2010) the classification of seeds by size or weight is a strategy that can be adopted to standardize emergence of seedlings and to obtain seedlings of similar size or greater vigor.

3.1 Experiment 1

Seedling emergence started at 19 DAS, stabilizing at 55 DAS, but seedlings emerged up to 86 DAS. Viu, Costa, Viu, Silva, and Campos (2007), evaluating the germination and growth of *B. gaudichaudii* seedlings under different substrates, also observed the onset of emergence around 19 DAS. The percentage of emergency, time of emergency and index of emergency speed were not influenced by the substrate (Table 2).

Table 2. Average data of emergence percentage (PE), emergence time (ET), emergence velocity index (IVE) and root system length (COMR) of mamacadela seedlings as a function of different substrates, Ceres, GO, 2017

Treatment	PE (%)	TE (dias)	IVE
S1	85.41 a	30.94 a	1.02 a
S2	73.61 a	31.62 a	0.90 a
S3	82.64 a	31.50 a	1.01 a
S4	72.92 a	32.68 a	0.86 a
S5	79.86 a	31.05 a	0.97 a
S6	74.30 a	30.33 a	0.92 a
CV (%)	10.76	6.130	14.09

Note. Averages followed by the same letter in each column do not differ from each other by the Skott Knott Test, at 5% probability. S1: coarse sand + soil (1:1); S2: Commercial Substrate-Plantmax®; S3: Plantmax® + coarse sand + soil (1:1:1); S4: bovine manure + Plantmax® + soil (1:1:3); S5: bovine manure + soil (2:3) and S6: charcoal rice husk + Plantmax® + soil (1:1:1).

The substrates that provided the greatest growth to the characters related to aerial development and growth rates, in height and diameter, of the mamacadela plants were treatments S4 and S5 (Table 3). Probably, this occurred due to the porosity of the substrates, facilitating the growth of the seedlings. The substrate S4 and S5 presented in their composition organic matter, also influenced positively in the growth of the species, promoting the increase in the diameter and number of leaves of plants of mamacadela.

Table 3. Data on the initial height (ALTI), final height (ALTF), height growth rate (TCALT), initial diameter (DIAI), final diameter (DIAF), diameter growth rate (TCDIA), initial leaf number (NFI), final leaf number (NFF) and growth rate of leaf number (TCFN) of plants of mamacadela in different substrates, Ceres, GO, 2017

Treat.	ALTI (cm)	ALTF (cm)	TCALT (cm/month)	DIAI (mm)	DIAF (mm)	TCDIA (mm/month)	NFI	NFF	TCNF
S1	7.85 a	10.65 b	0.47 b	1.68 b	2.30 b	0.11 b	3.10 b	4.21 b	0.16 b
S2	6.68 b	7.97 c	0.21 b	1.65 b	1.98 c	0.06 c	3.02 b	2.73 b	-0.06 c
S3	7.78 a	8.83 c	0.18 b	1.66 b	2.03 c	0.06 c	3.23 b	3.50 b	0.05 c
S4	8.38 a	14.47 a	1.14 a	1.79 b	2.76 a	0.18 a	3.44 a	5.75 a	0.36 a
S5	8.84 a	14.35 a	1.04 a	1.99 a	2.85 a	0.17 a	3.63 a	4.74 a	0.19 b
S6	6.73 b	7.76 c	0.19 b	1.73 b	2.11 c	0.07 c	2.91 b	3.56 b	0.15 b
CV(%)	11.07	9.85	41.98	7.20	5.69	23.48	8.19	17.32	80.18

Note. Averages followed by the same letter in each column do not differ from each other by the Skott Knott Test, at 5% probability. S1: coarse sand + soil (1:1); S2: Commercial Substrate-Plantmax®; S3: Plantmax® + coarse sand + soil (1:1:1); S4: bovine manure + Plantmax® + soil (1:1:3); S5: bovine manure + soil (2:3) and S6: charcoal rice husk + Plantmax® + soil (1:1:1).

Silva, Oliveira, Mendonça, and Soares (2011) also observed significant increases in the height, diameter of the lap and number of leaves in mangaba plants, when cultivated in substrates that presented in their composition manure and carbonized rice husk. However, Paiva Sobrinho et al. (2010), verified that this same composition presented low increments when compared to the soil. According to Santos et al. (2011) the soil fertility itself was sufficient to meet the needs, so the addition of organic compound promoted nutritional imbalance, consequently causing a phytotoxic effect, impairing the absorption of certain nutrients.

It was observed that plants cultivated in substrate with organic matter in their composition showed an increase in the number of leaves. This efficiency occurred due to the presence of nitrogen in the bovine manure, favoring the vegetative growth, and consequently the emission of leaves.

The leaf number growth rate decreased during the experimental period, since in the final evaluation the number of leaves was lower than that observed in the initial evaluation, thus assuming a negative value (Table 3). This occurred due to the survival strategy adopted by this species against the reduction of temperature and humidity of the air, with loss or replacement of the leaves.

This hypothesis corroborates the reports that the Cerrado species present a high degree of phenotypic plasticity, that is, they are able to modify functional characteristics in response to variations in environmental conditions, guaranteeing the maintenance and survival under limiting conditions (Ribeiro, 2015).

The climatic data, referring to the period of conduction of the experiment, can be observed in Figure 1.

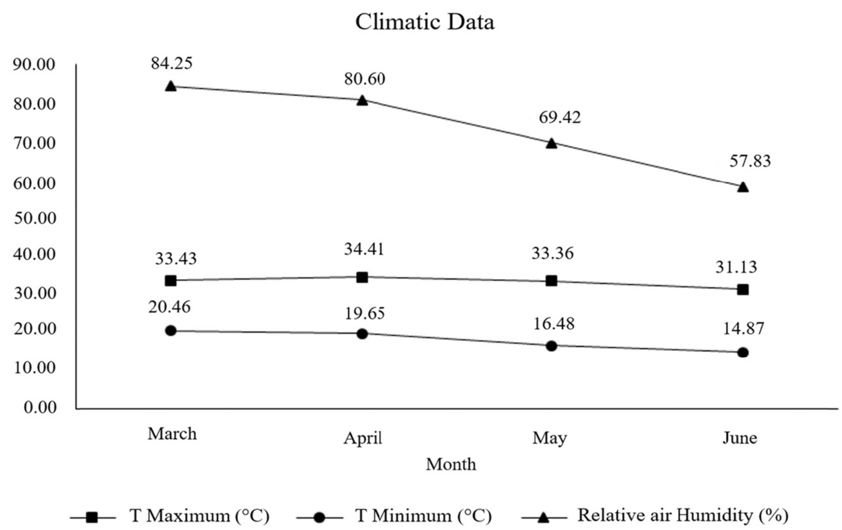


Figure 1. Maximum temperature (°C), minimum temperature (°C) and relative air humidity (%) from March to June 2017, Ceres, GO, 2017

Note. It was not possible to collect the data from all the months of the experiment conduction period due to the acquisition of the equipment after the experiment was implemented.

The treatment S4 (bovine manure + Plantmax® + soil, 1:1:3) showed a greater increase of fresh and dry biomass of both aerial part and root system of mamacadela plants (Table 4). This is reinforced by Silva, Maruyama, Oliveira, and Bardiviesso (2009) who observed better performance of mangaba plants, in relation to the height, diameter, number of leaves and biomass, in substrates that contained bovine manure in its composition.

Table 4. Data of fresh mass of the aerial part data (AFM), dry mass of the aerial part (ADM), fresh mass of the root system (RFM), dry mass of the root system (RDM) and survival (SURV) of mamacadela plants, Ceres, GO, 2017

Treat	AFM (g plant^{-1})	ADM (g plant^{-1})	RFM (g plant^{-1})	RDM (g plant^{-1})	COMR (cm)	SURV (%)
S1	1.65 b	0.59 c	11.10 b	4.36 b	27.54 a	97.91 a
S2	0.93 b	0.18 c	5.72 c	2.20 c	26.08 a	100.00 a
S3	0.91 b	0.26 c	6.62 c	2.54 c	23.61 a	97.92 a
S4	4.13 a	1.72 a	20.72 a	7.63 a	27.67 a	100.00 a
S5	2.86 a	1.10 b	13.08 b	4.68 b	19.73 a	89.58 b
S6	1.08 b	0.33 c	7.74 c	2.84 c	26.61 a	100.00 a
CV (%)	45.99	48.92	35.12	35.18	15.23	4.83

Note. Averages followed by the same letter in each column do not differ from each other by the Skott Knott Test, at 5% probability. S1: coarse sand + soil (1:1); S2: Commercial Substrate-Plantmax®; S3: Plantmax® + coarse sand + soil (1:1:1); S4: bovine manure + Plantmax® + soil (1:1:3); S5: bovine manure + soil (2:3) and S6: charcoal rice husk + Plantmax® + soil (1:1:1).

Animal manure provides advantages in agricultural soil quality by increasing soil organic matter content, thus improving porosity, aeration, water holding capacity, structural stability, stimulating microbial activity, providing improved soil chemical attributes of substrates and increases nutrient availability (Das, Jeong, Das, & Kim, 2017).

The mamacadela is a species adapted to nutrient-poor soils, so the presence of organic matter in the substrate was sufficient to allow greater gains in biometric characteristics and plant biomass. The dry mass is important, since through this parameter one has an indicative of the intensity of growth and the absorption of nutrients by the plant.

The length of the root system (Table 4) observed in this study was similar to that found by Jacomassi, Moscheta, and Machado (2007), who reported that the roots of *B. gaudichaudii* plants are long and are approximately 10 to 30 cm deep. The morphology of the plant clearly shows a great investment in the development of the subterranean part with the maintenance of a minimum aerial part (Palhares & Silveira, 2007). This is a characteristic observed in Cerrado plants as a way of adapting to periods of water deficit, promoting the elongation of their roots in order to search for water and nutrients in deeper layers of the soil.

The production of seedlings in packages had some difficulties, because, with the development of the plant, it is inevitable that there will be a folding of the root system.

(Figure 2). Root folding, often caused by the polyethylene bag, compromises the entire plant growth, since the root system and the plant absorption system are compromised (Souza & Borges, 2014).

Figure 2. Folding of mamacadela plant roots produced in polyethylene bags, at 235 days after sowing, Ceres, GO, 2017

All substrates, except S5, were efficient in guaranteeing the survival of the seedlings. The lower survival rate presented in S5 treatment plants is probably due to the lack of a higher proportion of organic matter in the composition than the species required, since they are adapted to soils with very low amounts of organic matter. The mamacadela is responsive to the presence of organic matter in the substrate, however, in small amounts.

The high coefficient of variation values are justified by the fact that the mamacadela is still an undomesticated plant, thus presenting varied characteristics and behaviors.

3.2 Experiment 2

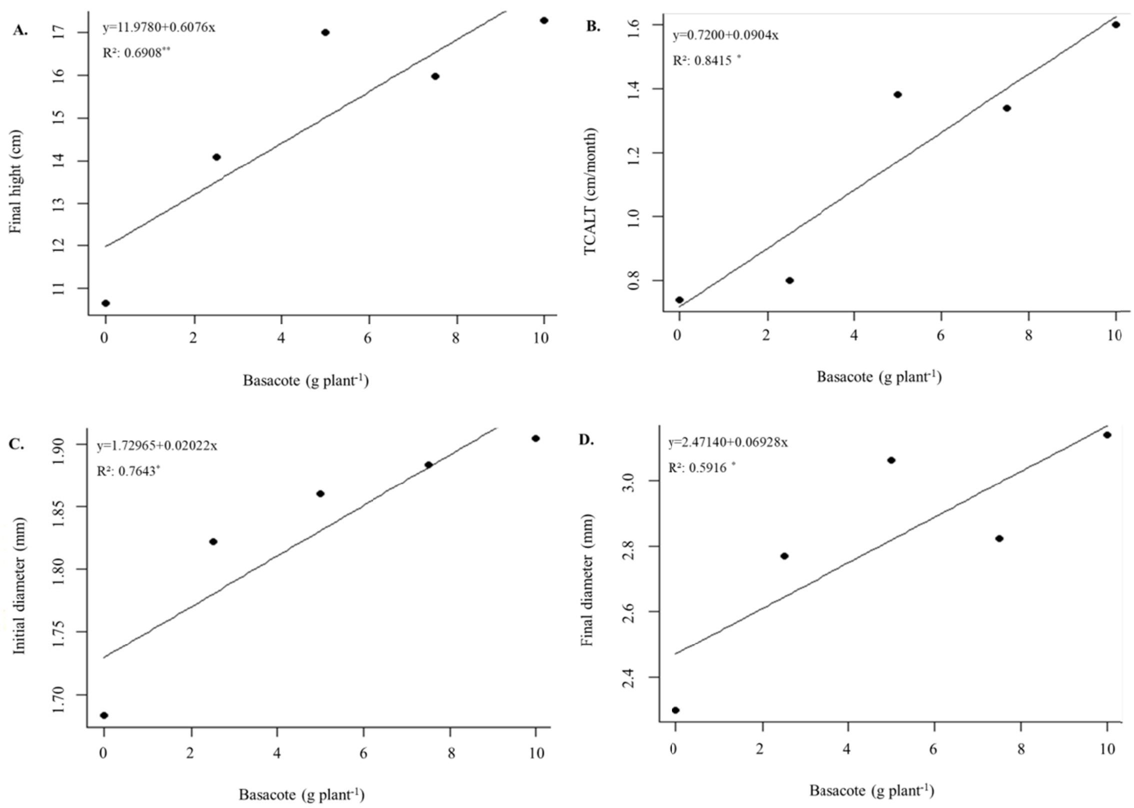
Seedling emergence started at 19 DAS, stabilizing at 55 DAS, but seedlings emerged up to 86 DAS.

The doses of slow release fertilizers positively influenced the growth of mamacadela seedlings. There was an increase in the variables final height, height growth rate, initial diameter, final diameter, diameter growth rate, number and initial and final leaves, fresh and dry matter of shoot and root system.

The final height, growth rate, initial diameter, final diameter, diameter growth rate and initial number and leaves of mamacadela seedlings presented linear behavior (Figures 3A-3F). It is evident that the use of the slow release fertilizer promotes the increase of these variables as the doses of slow release fertilizer in the substrate increase.

The number of leaves presented a differentiated behavior, in the initial evaluations there was an increase in the number of leaves as the doses of Basacote® increased, but this response was modified throughout the experiment. In the final evaluation, it was verified that there was a saturation point in which the dose that provided the largest number of leaves was 6.48 g of Basacote® plant^{-1} (Figure 3G).

Rosa et al. (2013b) observed larger plants of forest species, with an increase in the dose of slow-release fertilizer and a larger diameter of plants in treatments with 6 and 10 kg m^{-3} of Basacote®. Such behavior was also confirmed by Elli et al. (2013), who observed that the application of slow-release fertilizer in pitwheel seedlings led to significant gains in height.



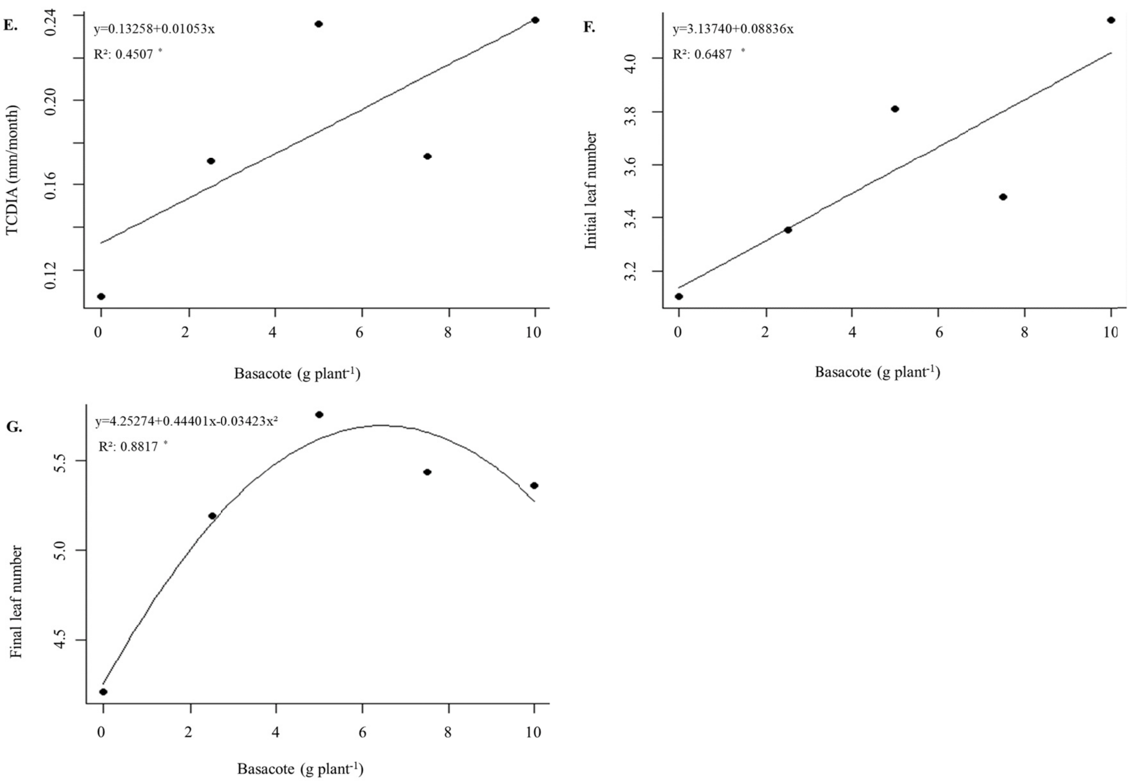


Figure 3. Final height (A), height growth rate (TCALT) (B), initial diameter (C), final diameter (D), diameter growth rate (TCDIA) (E) initial number of leaves (F) and number of final leaves (G) of mamacadela plants submitted to different concentrations of Basacote®, Ceres, GO, 2017

Note. *: significant in 5% probability; **: significant in 1% probability; ***: significant in 0.1% probability.

The improvement of the biometric characteristics of the plants provides the best establishment in the field. This fact was reinforced by Paiva Sobrinho et al. (2010) who verified plants with smaller diameter of the stem tend to have difficulties to remain erect after planting, which could result in tipping, death or deformation. This compromises the quality of the seedling, consequently its marketing value.

The fresh and dry mass of the aerial part had the same behavior of the majority of the variables, presenting increment in the phytomass of the plants as the doses of Basacote increased. The fresh and dry mass of the root system showed a quadratic regression, with a maximum point, where the 5.80 and 5.37 g Basacote® plant^{-1} doses provided the best conditions for fresh and dry matter gain, of the root, respectively (Figure 4).

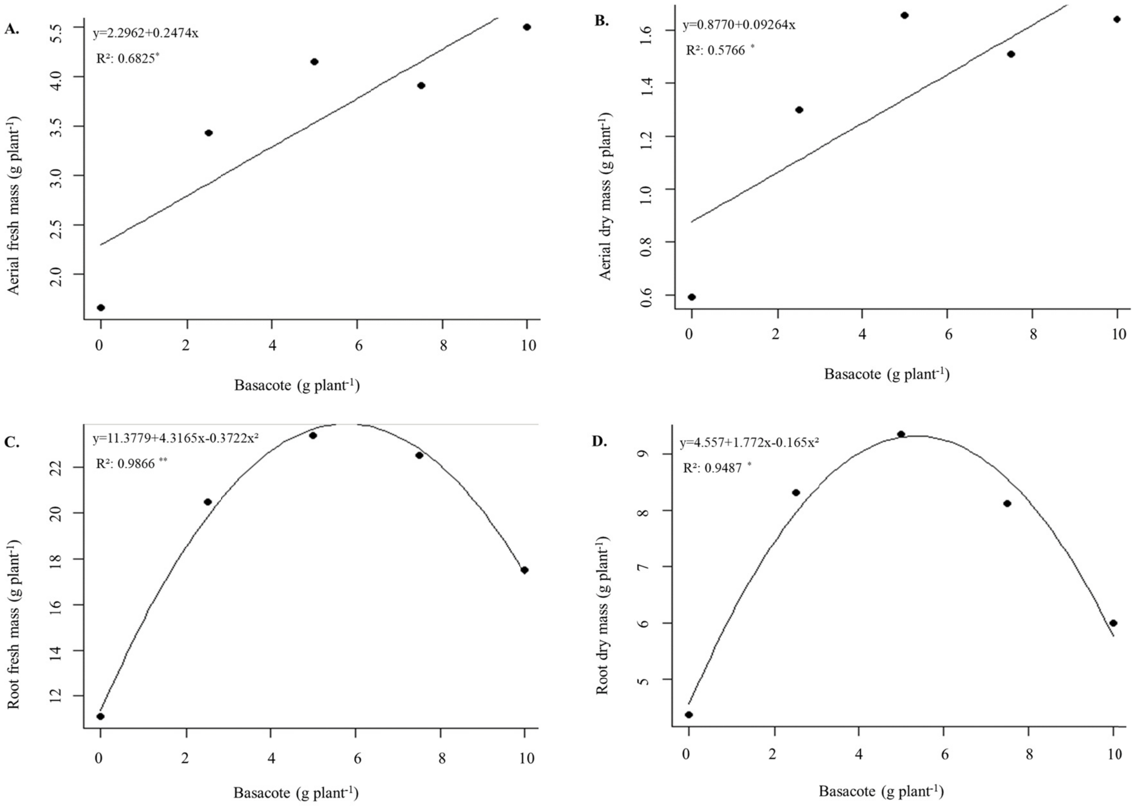


Figure 4. Fresh mass of aerial part (A), dry mass of aerial part (B), fresh mass of the root system (C) and dry mass of the root system (D) of mamacadela plants submitted to different concentrations of Basacote®, Ceres, GO, 2017

Note. *: significant in 5% probability; **: significant in 1% probability; ***: significant in 0.1% probability.

Rosa et al. (2013a) observed different behavior in paricá seedlings, in which larger increases of fresh and dry biomass of the aerial part were obtained with the dose of 8 kg m^{-3} and for the dry biomass of the root system, there was an increase as the doses increased.

The addition of fertilizers to substrates boosts the increase of biometric characteristics. According to Ferrari et al. (2016) controlled release fertilizers are characterized by allowing the continuous supply of nutrients during the development of the plants, avoiding losses by leaching and volatilization.

The mamacadela is responsive to the addition of fertilizer of slow release in the substrates, promoting, therefore, the quality improvement of the seedlings.

The species has great environmental and social importance, however little is known about the characteristics of this plant. Therefore, the study of substrate composition and increment of slow release fertilizers is fundamental for the production of quality seedlings, contributing to the cultivation and knowledge of the species.

References

Brasil, MAPA (Ministério da Agricultura, Pecuária e Abastecimento). (2009). *Rules for seed analysis* (p. 399). Secretariat of Agricultural Defense. Brasilia: MAPA/ACS.

Compo Expert. (2017). Retrieved August 2, 2018, from https://www.compo-expert.com/fileadmin/user_upload/compo_expert/br/documents/Folders_Logo_Novo/0695_LAMINA_BASACOTE_STARTER_BR_2017-site.pdf

Das, S., Jeong, S. T., Das, S., & Kim, P. J. (2017). Composted cattle manure increases microbial activity and soil fertility more than composted swine manure in a submerged rice paddy. *Frontiers in Microbiology, 8*, 1702. https://doi.org/10.3389/fmicb.2017.01702

Eilers, E. J., Veit, D., Rillig, M. C., Hansson, B. S., Hilker, M., & Reinecke, A. (2015). Soil substrates affect responses of root feeding larvae to their hosts at multiple levels: Orientation, locomotion and feeding. *Basic and Applied Ecology, 17*, 115-124. https://doi.org/10.1016/j.baae.2015.09.006

Elli, E. F., Cantarelli, E. B., Caron, B. O., Monteiro, G. C., Pavan, M. A., Pedrassani, M., & Eloy, E. (2013). Osmocote® in the development and physiological behavior of pitangueira seedlings. *Comunicata Scientiae, 4*, 377-384. Retrieved from https://www.comunicatascientiae.com.br/comunicata/article/view/257

Faria, R. A. P. G., Albuquerque, M. C. F., & Coelho, M. F. B. (2013). Seed size and shading in early development of *Brosimum gaudichaudii* trécul. *Caatinga, 26*, 09-15. Retrieved from https://periodicos.ufersa.edu.br/index.php/caatinga/article/view/2680

Ferrari, M. Cantarelli, E. B., Souza, V. Q., Nardino, M., Carvalho, I. R., Pelegrin, A. J., ... Pelissari, G. (2016). Influence of controlled release fertilizer on *Tabernaemontana catharinensis* seedlings. *Pesquisa Florestal Brasileira, 36*, 543-547. https://doi.org/10.4336/2016.pfb.36.88.968

Jacomassi, E., Moscheta, I. S., & Machado, S. R. (2007). Morfoanatomy and histochemistry of *Brosimum gaudichaudii* Trécul (Moraceae). *Acta Botanica Brasilica, 21*, 575-597. https://doi.org/10.1590/S0102-3306 2007000300006

Ma, Z., Willis, C. G., Zhou, H., Zhang, C., Zhao, X., Dong, S., ... Du, G. (2019). Direct and indirect effect of seed size on seedling survival along an experimental light availability gradient. *Agriculture, Ecosystems and Environment, 281*, 64-71. https://doi.org/10.1016/j.agee.2019.05.009

Maguire, J. D. (1962). Speed of germination aid in selection and evaluationfor seedling emergence and vigor. *Crop Science, 2*, 176-177. https://doi.org/10.2135/cropsci1962.0011183X000200020033x

Morais, M. C., Almeida, P. H. G., Ferreira, N. L. O., Arruda, R. L., Borges, L. L., Freitas, O., & Conceição, E. C. (2018). Validation of a photostability indicating method for quantification of furanocoumarins from *Brosimum gaudichaudii* soft extract. *Revista Brasileira de Farmacognosia, 28*, 118-123. https://doi.org/10.1016/j.bjp.2017.12.002

Oliveira, D. L. (2011).Economic viability of some native medicinal species of the cerrado. *Estudos, 38*, 301-332. Retrieved from http://seer.pucgoias.edu.br/index.php/estudos/article/view/2196/1356

Paiva Sobrinho, S., Luz, P. B., Silveira, T. L. S., Ramos, D. T., Neves, L. G., & Barelli, M. A. A. (2010). Substrates in seedling production of three cerrado tree species. *Revista Brasileira de Ciências Agrárias, 5*, 238-243. https://doi.org/10.5039/agraria.v5i2a741

Palhares, D., & Silveira, C. E. S. (2007). Morphological aspects of young plants of *Brosimum gaudichaudii* Tréc. (Moraceae) produced under alternative cultivation conditions. *Revista Brasileira de Plantas Medicinais, 9*, 93-96. Retrieved from https://www.researchgate.net/publication/289515106_Aspectos_morfologicos_de_plantas_jovens_de_Brosimum_gaudichaudii_Trec_Moraceae_produzidas_em_condicoes_alternativas_de_cultivo

Ribeiro, P. R. G. (2015). *Plasticity of cerrado phytophysiognomies species to the availability of light and water* (p. 62, Master's Thesis, Federal University of Lavras, Lavras, Brazil).

Rosa, U. B., Angelo, A. C., Nogueira, A. C., Bognola, I. A., Pomianoski, D. J. W., Soares, P. R. C., & Barros, L. T. S. (2013a). Slow release fertilization in the growth of paricá seedlings in nursery. *Pesquisa Florestal Brasileira, 33*, 227-234. https://doi.org/10.4336/2013.pfb.33.75.429

Rosa, U. B., Angelo, A. C., Nogueira, A. C., Westphalen, D. J., Bassaco, M. V. M., Milani, J. E. F., & Bianchin, J. E. (2013b). Slow release fertilizer in seedling development of *Schinus terebinthifolius* and *Sebastiania commersoniana. Floresta, 43*, 93-104. https://doi.org/10.5380/rf.v43i1.25690

Santos, L. C. R., Costa, E., Leal, P. A. M., Nardelli, E. M. V., & Souza, G. S. A. (2011). Protected environments and substrates with doses of commercial organic compost and soil in the formation of jatobazeiro seedlings in aquidauana-MG. *Engenharia Agrícola, 31*, 249-259. https://doi.org/10.1590/S0100-69162011000200005

Silva, E. A., Maruyama, W. I., Oliveira, A. C. A., & Bardiviesso, D. M. (2009). Effect of different substrates on the production of mamgabeira (*Hancornia speciosa*) seedlings. *Revista Brasileira de Fruticultura, 31*, 925-929. https://doi.org/10.1590/S0100-29452009000300043

Silva, E. A., Oliveira, A. C., Mendonça, V., & Soares, F. M. (2011). Substrates in the production of mangabeira seedlings in tubes. *Pesquisa Agropecuária Tropical, 41*, 279-285. https://doi.org/10.5216/pat.v41i2.9042

Silva, K. S., Mendonça, V., Medeiros, L. F., Freitas, P. S. C., & Góis, G. B. (2010). Influence of seed size on germination and vigor of jaqueira (*Artocarpus heterophyllus* lam.) seedlings. *Revista Verde, 5*, 217-221. Retrieved from https://www.gvaa.com.br/revista/index.php/RVADS/article/view/359

Souza, G. S., & Borges, K. C. A. S. (2014). Influence of phytoregulators and type of crop on growth of *Ocimum basilicum*. Cadernos UniFOA. *Volta Redonda, 24*, 59-65. Retrieved from http://revistas.unifoa.edu.br/index.php/cadernos/article/view/172

Viu, A. F. M., Costa, E. A., Viu, M. A. O., Silva, J. F. S., & Campos, L. Z. O. (2007). Evaluation of the effect of different substrates on germination and seedling growth of *Brosimum gaudichaudii* Trec. (mama-cadela). *Revista Brasileira de Biociências, 5*, 960-962. Retrieved from http://www.ufrgs.br/seerbio/ojs/index.php/rbb/article/view/785