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Original Paper

Substrates based on swine wastewater in the production of seedlings of *Guazuma ulmifolia* (Malvaceae)

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Abstract

Swine wastewater (sw) can boost seedling growth and development in several species as this residue is rich in nutrients required by plants. This study tested the hypothesis that seedlings of *Guazuma ulmifolia* grown in a substrate based on swine wastewater showed better physiological and morphological performance. The seedlings were cultivated in seven substrates: T1 - rice husk and vermiculite; T2 - 20% sw; T3 - 40% sw; T4 - 60% sw; T5 - 80% sw; T6 - 100% sw; and T7 - 100% Bioplant®. Were evaluated the height (H), diameter (D), number of leaves (NF), as well as the H to D ratio, chlorophyll indices, gas exchange, biomass, allometric ratios, Dickson Quality Index (DQI), and mortality percentage of the seedlings. The data were analyzed by analysis of variance, and the means were compared by Tukey's test. The substrates with the highest percentage of swine sludge promoted the highest H, D, NF, chlorophyll indices, gas exchange, stem biomass and IQD. The highest mortality was obtained in commercial substrate (85%) and carbonized rice husk and vermiculite (37.5%). Can be concluded that the substrates with high swine wastewater content were better for seedling *G. ulmifolia.*
Key words: alternative substrates, early growth, *Mutambo*, swine wastewater.

Resumo

A água residuária de suínos (ars) pode impulsionar o crescimento e o desenvolvimento de mudas em várias espécies, pois esse resíduo é rico em nutrientes necessários às plantas. Este estudo testou a hipótese de que mudas de *Guazuma ulmifolia* cultivadas em substrato à base de lodo suíno apresentam melhor desempenho fisiológico e morfológico. As mudas foram cultivadas em sete substratos: T1 - casca de arroz e vermiculita; T2 - 20% ars; T3 - 40% ars; T4 - 60% ars; T5 - 80% ars; T6 - 100% ars; e T7 - 100% Bioplant®. Foram avaliados a altura (H), diâmetro (D), número de folhas (NF), bem como a razão H para D, índices de clorofila, trocas gasosas, biomassa, razões alométricas, Índice de Qualidade Dickson (IQD), e a porcentagem de mudas mortas. Os dados foram analisados pela análise de variância e as médias comparadas pelo teste de Tukey. Os substratos com a maior porcentagem de lodo suíno promoveram a maior H, D, NF, índices de clorofilas, trocas gasosas, biomassa caulinar e IQD. A maior mortalidade foi obtida no substrato comercial (85%) e casca de arroz carbonizada e vermiculita (37,5%). Pode-se concluir que os substratos com alto teor de lodo de suíno foram os melhores para as mudas de *G. ulmifolia.*
Palavras-chave: substratos alternativos, crescimento inicial, Mutambo, lodo suíno.

Introduction

Projects aimed at the recovery of degraded areas, commercial reforestation, conservation, or exploitation of forest species depend on the availability of seedlings with a certain quality level (Dionísio *et al.* 2017; Marques *et al.* 2018), like being healthy, growing vigorously with robust stems, and being free from disease, these

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characteristics can be evaluated through biometric measurements and visual aspects. The use of substrates that meet the nutritional demands of plants is among the factors that can provide higher quality (Martins *et al.* 2012; Siqueira *et al.* 2018). There are several possibilities of combinations and proportions for substrate formulation. However, residues deserve special attention, especially those of agro-industrial origin, such as swine wastewater, since large volumes of this product are generated and represent an environmental problem when its destination is not appropriate. Therefore, the use of this residue as a substrate, in addition to saving costs with seedling production, also ensures its appropriate destination, preventing the occurrence of environmental problems (Caldeira *et al.* 2014; Nogueira *et al.* 2014; Krause *et al.* 2017), as contamination of surface and underground waters by leaching and runoff and accumulation of nutrients and potentially polluting elements that compromise the chemical, physical and biological characteristics of the soil (Tessaro *et al.* 2016).

If properly used, swine wastewater can boost seedling growth and development in several species as this residue is rich in nutrients required by plants (Miyazawa & Barbosa 2015). Some studies have already verified that the use of swine farming residues promoted positive results in seedlings of forest species (Vieira *et al.* 2014; Rocha *et al.* 2017; Araújo *et al.* 2019; Santinato *et al.* 2019). On the other hand, swine wastewater can be harmful to some species, causing growth reduction and even the death of seedlings grown under high doses (60%), due to the high content of nutrients, generating phytotoxicity (Pereira *et al.* 2017). Therefore, knowledge about the use of this residue is extremely important. Since there is no information in this regard for several species, further studies are necessary to evaluate seedling performance and determine the ideal dose of swine wastewater that is not harmful to plant growth.

Mutambo (*Guazuma ulmifolia* Lam., Malvaceae) is among the species that demand this type of study, being highly recommended in reforestation programs (Calzavara *et al.* 2017) due to its rapid growth and for attracting the fauna. It also has medicinal importance, with the aqueous extract from its bark and leaves showing efficient antimicrobial, antioxidant, and cardioprotective properties (Dos Santos *et al.* 2018). The species has been used as an alternative treatment to HIV in Brazil and Venezuela (Gouveia 2018; Folha de São Paulo 2018; Singer 2018; Macedo 2019).

It is known that *mutambo* has the potential for wide exploitation by the industrial sector, either as food or as a therapeutic plant (Pereira *et al.* 2019). However, studies related to seedling production in substrates based on agro-industrial residues are still scarce. Considering that substrates based on swine wastewater promoted positive results in other species, the hypothesis was raised that *mutambo* seedlings grown in a substrate containing swine wastewater show better physiological and morphological performance. In order to test this hypothesis, this study aimed to evaluate the physiological and morphological characteristics of *mutambo* seedlings cultivated in different substrates, part of them containing swine wastewater in their composition.

Material and Methods

Cultivation conditions and experimental design

The present study was developed in the plant nursery of the Laboratory of Plant Tissue Culture, belonging to the Institute Federal Goiano - Campus Rio Verde, Goiás, Brazil, from March to October 2019. The climate of the region where the experiment was conducted is type Aw (Tropical), that is, markedly seasonal with a hot and rainy season (from October to March) and another cold and dry season (from April to September), with annual rainfall from 1,600 to 1,900 millimeters and mean annual temperature from 19 to 20 °C (Alvares *et al.* 2018).

The seeds were collected from 10 parent plants located at the Federal University of Lavras, Minas Gerais, Brazil, between August and September. Seed dormancy was overcome with hot water at 70 °C for approximately 30 minutes or until the water temperature was reduced to 50 °C (Nunes *et al.* 2006). The seeds were planted seven days after the formulation and addition of the substrates to the tubes, sowing three seeds per tube. After germination, thinning was performed by allowing only one plant per tube, the criterion used was that of selective thinning, in which defective, diseased and dead seedlings selected on the basis of their visual and individual characteristics are removed.

The seedlings were cultivated in 50 cm^3 polypropylene tubes disinfected with 1% sodium hypochlorite before installing the experiment. Expanded polystyrene trays upheld by one-meter-high benches were used to ensure a consistent water supply to the seedlings.

The experimental design was in randomized blocks, composed of seven treatments/substrates (v v^{-1}), represented in Table 1: T1 - 50% carbonized rice husk (crh) + 50 % vermiculite (ve); T2 - 20% sw + 40% crh and 40% ve; T3 - 40% sw and 30% crh + 30% ve; T4 - 60% sw + 20% crh + 20% ve; T5 - 80% sw + 10% crh + 10% ve; T6 - 100% sw; and T7 - 100% commercial substrate - Bioplant® (composed of Pinus bark, manure, sawdust, coconut fiber, vermiculite, rice husk, ash, agricultural gypsum, calcium carbonate, magnesium, magnesium thermophosphate, and fertilizer additives) and four replications, each composed of ten plants, with a total of 40 plants per treatment, being 28 experimental units. A sample of each substrate was collected for chemical characterization, according to the methods of Embrapa (1997).

The previously dried sludge used in this study was collected during the finishing phase in a swine farm in the municipality of Rio Verde, Goiás. Five days after the collection, the sludge was sanitized by solarization with a transparent plastic sheet for 20 days (Bueno 1999). When each treatment was composed, samples were removed for the chemical characterization of each substrate.

The *mutambo* seedlings grew under full sunlight, with daily irrigation provided by an automatic micro-sprinkler system (4.3 liters/m²) four times a day, at 7:00 a.m., 11:30 a.m., 3:00 p.m., and 6:00 p.m.

Biometric measurements

At 210 days after sowing, plant height (H) was measured, between the stem and stem apex, with a millimeter ruler the stem diameter (D) was measured with a digital caliper. The number of expanded leaves was also counted (NF). The height to diameter ratio was calculated after obtaining these individual measurements.

Photosynthetic pigment indices

At 200 days after sowing, the Falker® indices of chlorophyll a (Chl *a*) and b (Chl *b*) were determined in fully-expanded leaves of three sampling units from each replication per treatment. A ClorofiLOG chlorophyll meter was used for these analyses (Model CFL1030, Falker *Automação Agrícola* LLC, Porto Alegre, Brazil). Subsequently, the chlorophyll *a* to *b* ratio (Chl *a*/Chl *b*) and the total chlorophyll index (Chl *a* + Chl *b*) were calculated.

Gas exchange measurements

At 200 days after sowing, the gas exchange analyses were determined on a leaf of the second pair from the apex of the plant, in three sampling units per treatment. These analyses were performed using the same leaf in which the chlorophyll indices were measured. The variables evaluated were: photosynthetic rate [A, μmol (CO2) m^{-2} s^{-1})], transpiration rate [E, mmol (H2O) m^{-2} s^{-1}], stomatal conductance [gs, mol (H2O) m^{-2} s^{-1}], internal CO2 concentration (Ci, μmol mol^{-1}), external CO2 concentration (Ca, μmol mol^{-1}), ratio between the internal and external CO2 concentration (Ci/Ca), ratio between photosynthesis and internal CO2 concentration (A/Ci), and electron transport rate (ETR, μmol e- m^{-2} s^{-1}) was established through the fluorescence of the chlorophyll *a* from seedling leaves with a portable infrared gas analyzer (model Li-6800xt, Li-Cor, Nebraska, USA) with photosynthetically active radiation (PAR) of 1,500 μmol photons m^{-2} s^{-1}, atmospheric concentration

Table 1 – Treatments used in the production of seedlings of *mutambo* (*Guazuma ulmifolia*, Malvaceae).

Treatment	Substrates composition (%)		
	Carbonized rice husk	**Vermiculite**	**Swine wastewater**
T1	50	50	0
T2	40	40	20
T3	30	30	40
T4	20	20	60
T5	10	10	80
T6	0	0	100
T7	Comercial substrate Bioplant@		

of CO_2 (C_a) de ~400 µmol mol^{-1}, temperature of ~25 °C and humidity of ~50%, between 8:00 a.m. and 11 a.m.

Biomass determinations and allometric relationships

At 210 days after sowing, ten plants per treatment were removed from the tubes and washed. Subsequently, these plants were cut into leaves, stems, and roots and dried in a forced-air oven at 65 ºC until constant weight. Finally, the leaf dry mass (LDM), stem dry mass (SDM), and root dry mass (RDM) were obtained with a digital balance. With these data, it was possible to calculate the total dry mass (TDM), which, in turn, was used to calculate the leaf mass ratio (LMR), the stem mass ratio (SMR), and the root mass ratio (RMR).

Dickson Quality Index (DQI) and Mortality Percentage

Based on the growth and biomass data, it was possible to calculate the Dickson Quality Index (Dickson *et al.* 1960) of ten plants per treatment. At 210 days after sowing, the mortality percentage was calculated according to the formula: number of dead plants divided by the total of plants in the treatment, multiplied by 100.

Statistical analysis

The data collected were tested regarding the assumptions of normality and homogeneity and after the subjected to analysis of variance (ANOVA) with the software SISVAR (Ferreira 2014), and the means were compared by Tukey's test at 5% probability.

Results

The results the chemical characterization of each substrate is represented in Table 2.

Treatments 1, composed of 50% carbonized rice husk and 50% vermiculite, and 7, composed of 100% Bioplant®, resulted in *mutambo* seedlings with insufficient leaf area (the leaves were too small to be reached by the IRGA and ClorofiLOG tweezers) to perform the Falker® chlorophyll indices and gas exchange analyses; thus, Figures 1 and 2, respectively, do not depict the results of these analyses for such treatments.

Statistically, the treatments containing swine wastewater promoted a significant effect on the chlorophyll indices. Treatments 4, 5, and 6 promoted the highest indices of chlorophyll *a* and total in the *mutambo* seedlings (Fig. 1a,c). However, treatments 5 and 6 did not differ from treatments 2 and 3. The highest indices of chlorophyll *b* were recorded in treatments 3, 4, 5, and 6 (Fig. 1b). The chlorophyll *a* to *b* ratio did not differ across treatments (Fig. 1d).

There was a significant effect as a function of the treatments on the photosynthetic rate (*A*), stomatal conductance (*gs*), transpiration rate (*E*), ratio between photosynthesis and internal CO_2 concentration (*A/Ci*), and electron transport rate (ETR) of the *mutambo* seedlings. For all these variables, the results promoted by treatments 4

Table 2 – Chemical characterization of the substrates used for the production of *mutambo* seedlings (*Guazuma ulmifolia*, Malvaceae). T1 = carbonized rice husk (crh) and vermiculite (ve); T2 = 20% of swine wastewater (sw); T3 = 40% sw; T4 = 60% sw; T5 = 80% sw; T6 = 100% sw; and T7 = Bioplant ® commercial substrate. Different letters differ significantly by Tukey's test at 5% probability.

Substrates	Al	Ca	K	Mg	P	pH	V
	cmol$_c$ dm^{-3}		mg dm^{-3}	cmol$_c$ dm^{-3}	mg dm^{-3}		%
T1	0.100b	0.50f	445.2b	4.3f	181.1g	7.7a	87.0a
T2	0.098b	0.04g	430.0c	5.4e	373.2f	7.6a	86.7b
T3	0.096b	1.58e	414.9d	6.7d	565.0e	7.5b	86.7b
T4	0.094c	2.12d	399.7e	7.8c	757.0d	7.4b	86.6c
T5	0.083d	2.66c	384.6d	8.9b	904.0c	7.3c	86.6c
T6	0.080d	3.20b	369.5g	10.2a	1,141a	7.2c	86.6c
T7	0.931a	6.90a	602.0a	3.6g	938.6b	5.2d	61.7d

Ca, Mg and Al Extractor KCl - 1 mol/L, P and K Extractor Mehlich 1, pH in CaCl2, V - Base Saturation Index.

and 5 were superior to the remainder (Fig. 2a-e) but did not differ from each other. For photosynthetic rate, stomatal conductance, and transpiration rate, treatments 2 and 3 did not differ from each other, only from treatment 6 (Fig. 2a-c). Treatments 2, 3, and 6 did not differ from each other for the ratio between photosynthesis and internal CO_2 concentration and electron transport rate variables (Fig. 2d-e).

For the biometric variables of height (H), base diameter (D), number of leaves (NF), and height to diameter ratio of *mutambo* seedlings, there was a significant effect across treatments (Fig. 3). The substrates that provided the highest height and number of leaves values were substrates 4 and 5, which were statistically similar for both variables (Fig. 3a,c). Treatments 3, 4, and 5 provided the highest diameter values, with no statistical difference between the results (Fig. 3b). The treatments were statistically similar for the height to diameter ratio, except for treatments 1 and 7 (Fig. 3d), whose substrates promoted the lowest values for all biometric variables.

The treatments promoted significant effects on the biomass variables and allometric relationships of the *mutambo* seedlings (Fig. 4). For the leaf dry mass (LDM) and stem dry mass (SDM), the largest accumulations were obtained with treatments 4 and 5, which were similar to each other for both variables (Fig. 4a,c), while for the accumulation of root dry matter (RDM), the results promoted by treatments 2, 3, and 4 were superior to the remainder (Fig. 4e). Treatments 5 and 6 promoted seedlings with the highest values of leaf mass ratio (LMR), being similar to each other and different from the remainder (Fig. 4b). For the stem mass ratio (SMR) and root mass ratio (RMR), treatments 1 and 7 were statistically similar and stood out from the remainder as their seedlings showed the highest values for these variables (Fig. 4d,f).

The treatments promoted significant differences in the Dickson Quality Index of the *mutambo* seedlings. The highest indices were found with treatments 4, 5, and 6, which did not differ from each other, while treatments 1 and 7 promoted the lowest indices (Fig. 5a).

The treatments also promoted significant differences in the mortality percentage of the seedlings. Treatments 1 and 7, in addition to promoting low-quality *mutambo* seedlings, were also the substrates in which the highest mortality percentage were recorded (Fig. 5a-b). Treatment 7 promoted the highest mortality (85%), followed by treatments 1 (37.5%), 6 (15%), 2 (5%), and 5 (2.5%). For treatments 3 and 4, the seedling mortality was zero (Fig. 5b).

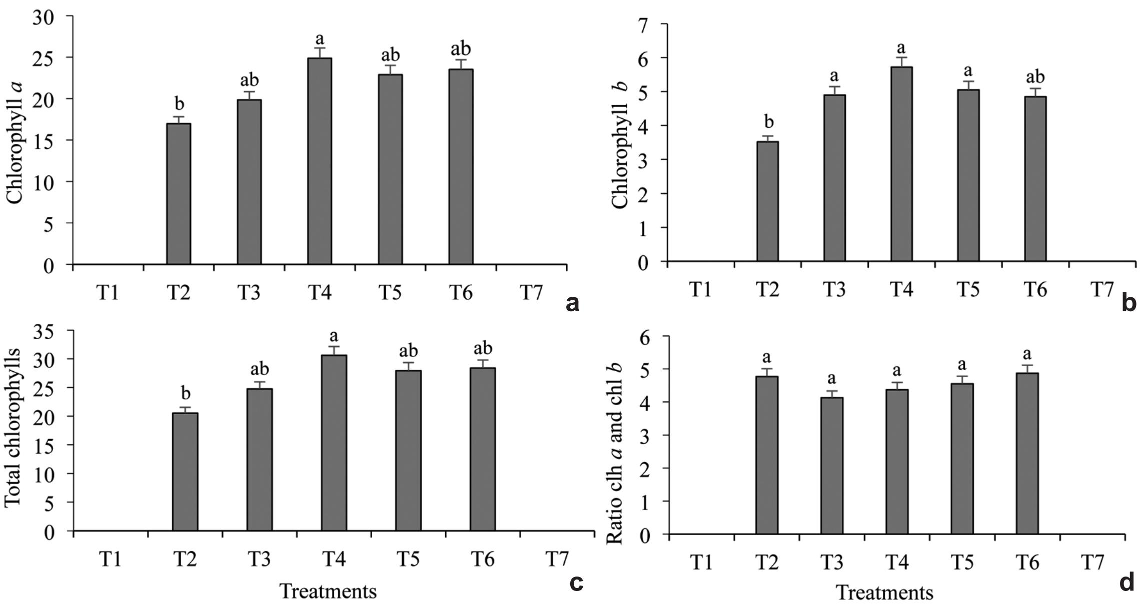

Figure 1 – a-d. Chlorophyll indices of *mutambo* seedlings (*Guazuma ulmifolia*, Malvaceae) grown in different substrates at 200 days after sowing – a. chlorophyll *a* index; b. chlorophyll *b* index; c. total chlorophylls; d. chlorophyll *a* to *b* ratio. Standard deviation (±). Means with different letters differ significantly by Tukey's test at 5% probability.

Discussion

Based on the results obtained, it was found that as *mutambo* seedlings when cultivated in substrates with higher concentration of sw presented better physiological and morphological performance when compared to each other, since the impossibility of measuring physiological variables of the treatment seedlings 1 and 7, not possible the comparison between all tested treatments. Although the Bioplant® substrate (T7) has provided higher nutrient contents (except for Mg) than the remaining treatments, it was not the substrate that promoted the greatest growth and development of *mutambo* seedlings. This behavior can be associated with the water conditions to which all substrates were subject, which did not favor treatment1 and 7, since both promoted similar results. Therefore, these treatments were the most harmful to the seedlings as they resulted in high mortality (37.5 and 85%, respectively) and reduced growth.

One of the features of the substrate rice husk and vermiculite (T1) and Bioplant® (T7) is its high-water retention capacity, which may result in root rot in species that do not tolerate high moisture (Moura *et al.* 2019), since water accumulation results in low oxygenation for root development (Zorzeto *et al.* 2014), leading to plant death. High irrigation levels constitute another factor that can be attributed to this result, causing nutrient loss by leaching since it is a light and uncompacted product, which explains the fact that seedlings from treatment 1 and 7 have invested more in biomass the roots of the that in the area when compared to the other treatments (Fig. 4f). Thus, the results may differ depending on how irrigation management is carried out, as the physical properties of the substrates are different. The treatments containing

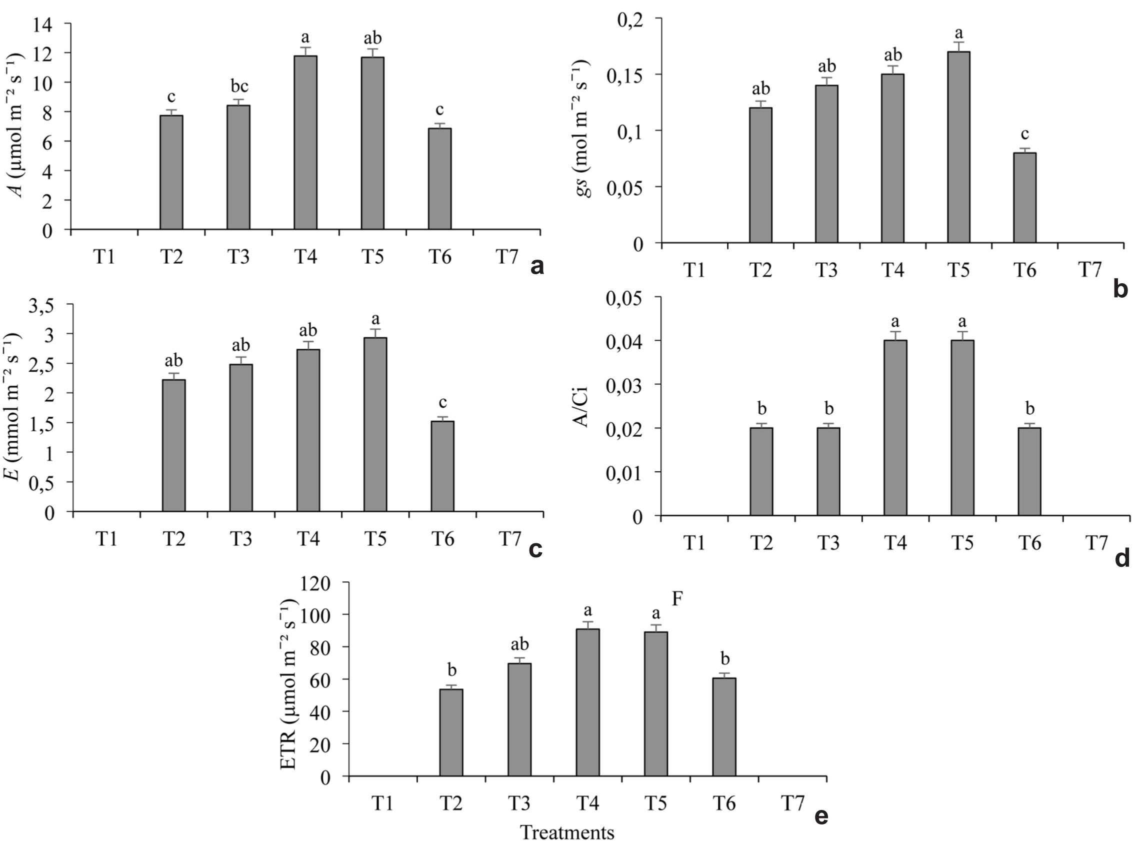

Figure 2 – a-e. Physiological variables of *mutambo* seedlings (*Guazuma ulmifolia*, Malvaceae) grown in different substrates at 200 days after sowing – a. photosynthetic rate; b. stomatal conductance; c. transpiration rate; d. ratio between photosynthesis and internal CO2 concentration; e. electron transport rate. Standard deviation (±). Means with different letters differ significantly by Tukey's test at 5% probability.

swine wastewater are denser by nature, which may have benefited such substrates. Several other studies also verified inferior results for seedlings grown in Bioplant® compared with other substrates (Alves *et al.* 2012; Dutra *et al.* 2015; Borges *et al.* 2016; Lima *et al.* 2016). In this study, the commercial substrate Bioplant® also showed a very low or acid pH (5.2). According to Carvalho (2007), the studied species prefers soils or substrates with pH above 5.5, and this was the only among the tested substrates with pH below this value.

For most variables analyzed, the treatments containing swine wastewater showed superior results. Among the substrates with swine wastewater, treatments T4, T5, and T6 stood out from the remainder. It is worth noting that, after the treatment with Bioplant®, these were the treatments that showed the highest nutritional contents, and T6 even showed Mg and P contents above those of the Bioplant® substrate (Tab. 1). T4 and T5 showed the highest investment in growth, number of leaves, and shoot biomass accumulation in the seedlings compared to the other treatments. Gonçalves *et al.* (2000) reported that the most appropriate substrates for seedling propagation are usually obtained by mixing from 70 to 80% of an organic component with 20 to 30% of a component used to increase macroporosity. In the present study, the proportions that constitute treatments 4 (60% sw + 40% crh and ve) and 5 (80% sw + 20% chr and ve) are very close to those reported by such researchers. Delarmelina *et al.* (2014) also obtained the best results for the growth of *Sesbania virgata* (Cav.) Pers. with the same proportions as treatments 4 and 5 of the present study, although with other constituents (60 to 80% of sewage sludge (sl) and 40 to 20% ve). Cabreira *et al.* (2017), studying three forest species, also verified that the 80% proportion of sewage sludge promoted the best results.

Based on the results achieved in this study, it can be said that the substrates with swine wastewater are indeed an alternative to produce *mutambo* seedlings. For the chlorophyll indices, in general, the best treatments were 4, 5, and 6. For all physiological variables evaluated in this study, treatments 4 and 5 were also the ones that promoted the best results. Among the physiological variables, stomatal conductance and transpiration are highlighted as they are essential regulatory mechanisms of the water vapor and carbon dioxide exchange between the leaf and the surrounding air, directly affecting plant growth (Iseki & Olaleye 2019) and strongly relating to the photosynthetic rate (Wong *et al.* 1979). This strong relationship exists because the greater the stomatal opening,

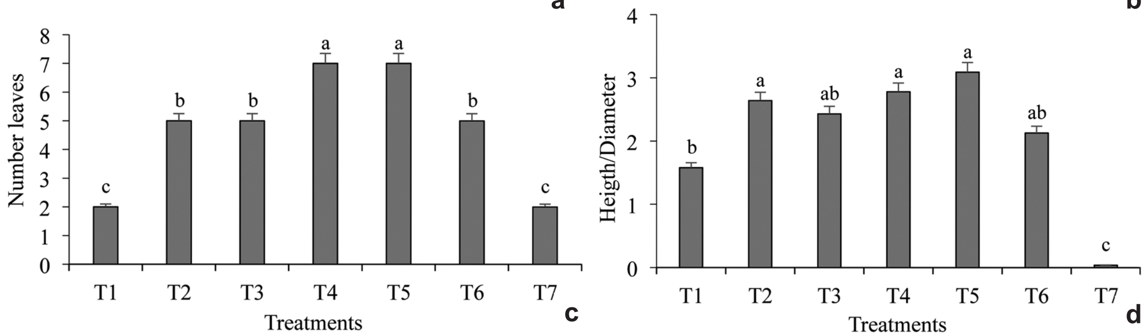

Figure 3 – a-d. Biometric variables of *mutambo* seedlings (*Guazuma ulmifolia*, Malvaceae) grown in different substrates at 210 days after sowing. Standard deviation (±). Means with different letters differ significantly by Tukey's test at 5% probability.

the higher the CO_2 diffusion into the substomatal chamber (Santos *et al.* 2013), which usually allows a higher photosynthetic rate. Therefore, the high values of stomatal conductance and transpiration obtained in the *mutambo* seedlings cultivated under treatments 4 and 5 led to greater CO_2 entry into the substomatal chamber and generated higher photosynthetic rates. With the increased photosynthetic rates compared to the remaining treatments, there was higher CO_2 fixation and greater investment in height, diameter, number of leaves, and biomass accumulation.

Taking into account the important variables when choosing the best treatment for seedling production, the height to diameter ratio stands out as higher values of this variable represent greater balance in seedling development (Souza *et al.* 2017). However, all treatments with swine wastewater were statistically similar. In this case, it is worth considering biomass accumulation, especially root biomass, for which the seedlings showed the best results with treatments 2, 3, and 4. If the interest lies in planting *mutambo* seedlings in the field, it is worth noting that the greater the development of the root system, the higher the water and nutrient uptake as this structure reaches greater depths into the soil profile (Salton & Tomazi 2014). However, the number of leaves can also influence the choice of the ideal treatment as these structures constitute the main photosynthetic organs (Wright *et al.* 2004), and both the size and number of leaves are related to several biological processes, such as plant growth and survival (Tozer *et al.* 2015). In this way, in the present study, substrates 4 and 5 were the ones that provided the highest number of leaves and, therefore, showed the highest values of stomatal conductance, transpiration, and photosynthetic rate, which were also obtained with these treatments, along with the greater accumulation of stem and leaf dry mass.

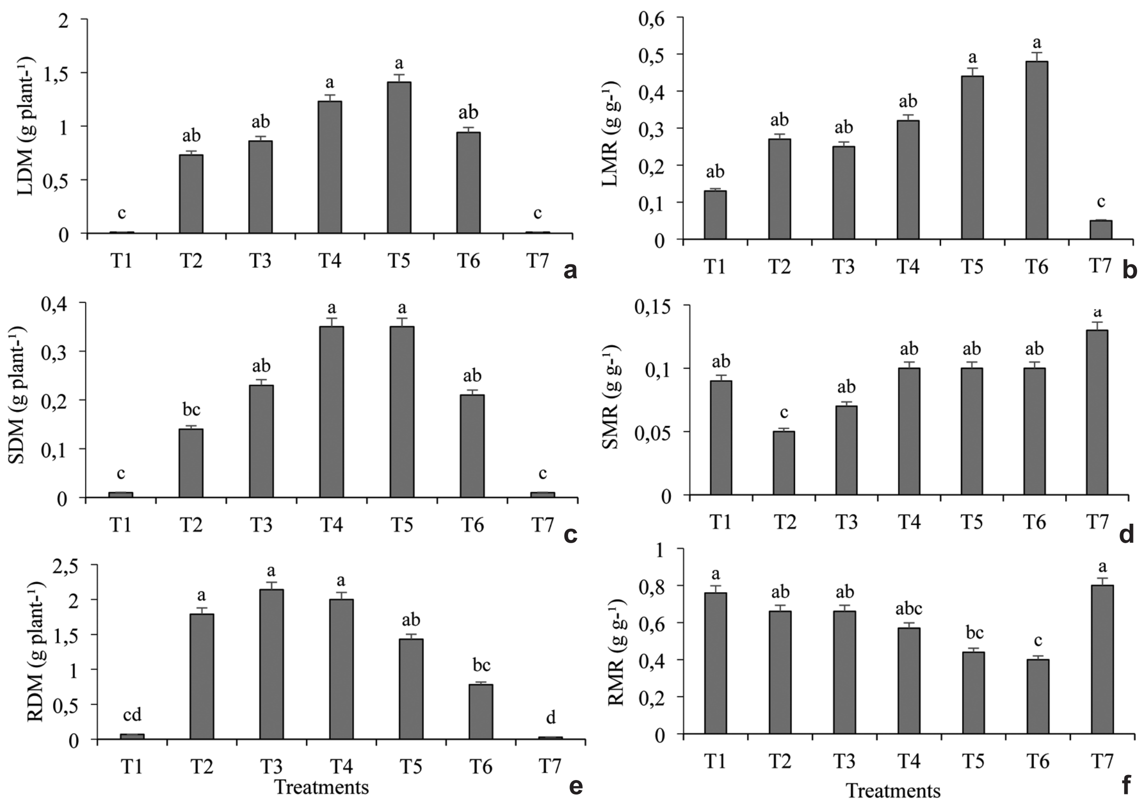

Figure 4 – a-f. Dry mass and allometric relationships of *mutambo* seedlings (*Guazuma ulmifolia*, Malvaceae) grown in different substrates at 210 days after sowing – a. leaf dry mass; b. leaf mass ratio; c. stem dry mass; d. stem mass ratio; e. root dry mass; f. root mass ratio. Standard deviation (±). Means with different letters differ significantly by Tukey's test at 5% probability.

Another variable that should be considered is the Dickson Quality Index, which determines seedling quality based on several morphological features, minimizing possible errors that may occur by using only one or two features (Vieira *et al.* 2019). The higher this index, the higher seedling quality, and so, substrates 4, 5, and 6 were the ones that promoted the highest quality *mutambo* seedlings since the highest indices were obtained with these treatments. This higher seedling quality is related to the nutritional characteristics of these substrates, which provided the seedlings with high contents of calcium, magnesium, phosphorus, and potassium (Tab. 1). Similar results to the present study were found for other species. Coelho *et al.* (2017) also obtained satisfactory results with seedlings of *Corymbia citriodora* [(Hook.) K.D. Hill & L.A.S. Johnson] due to the favorable nutritional conditions provided by the liquid swine wastewater used. Santinato *et al.* (2019), using different substrates to produce seedlings of *Coffea arabica* L., also verified that the treatments that contained swine organic compost showed higher concentrations of P, Ca^{2+}, and Mg^{2+}, which resulted in taller seedlings.

To conclude, the *mutambo* seedlings showed better morphological performance in substrates with swine wastewater than in the substrate composed of carbonized rice husk and vermiculite (T1) and the commercial substrate Bioplant® (T7). As for the physiological performance, it can be said that there is an improvement in the physiological responses with an increase in sw options by up to 80%. In view of these results, it can be said that the substrates with swine wastewater constitute an alternative to produce *mutambo* seedlings, and treatments 4 (60% sw) and 5 (80% sw) are the most indicated for the production of seedlings of this species.

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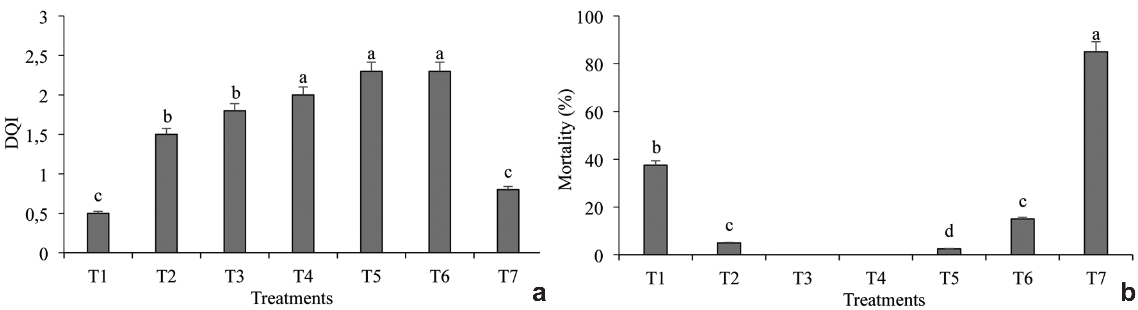

Figure 5 – a-b. *Mutambo* seedlings (*Guazuma ulmifolia*, Malvaceae) grown in different substrates at 210 days after sowing – a. Dickson Quality Index; b. mortality rate.

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