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PRODUCTION AND NUTRITION OF SEEDLINGS FROM TWO SPECIES NATIVE TO THE BRAZILIAN CERRADO CULTIVATED IN ORGANIC SUBSTRATES

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ABSTRACT: Little is known about the use of alternative substrates for the production of seedlings of species native to the Brazilian Cerrado. Thus, this study aimed to evaluate the effect of different substrate compositions (poultry litter and cattle manure) mixed with sandy soil on the development of *Hymenaea stigonocarpa* and *Tabebuia heptaphylla* seedlings. In a nursery in Nova Andradina, two experiments were carried out (one for each species), comparing two organic substrates (poultry litter and cattle manure). In addition to different types of substrates, ten proportions of cattle manure (BM), poultry litter (PL) mixed with sandy soil were tested: BM1 = 100% cattle manure; BM2 = 75% cattle manure + 25% soil; BM3 = 50% cattle manure + 50% soil; BM4 = 25% cattle manure + 75% soil; T5 = 100% soil; PL6 = 100% poultry litter; PL7 = 75% poultry litter + 25% soil; PL8 = 50% poultry litter + 50% soil; PL9 = 25% poultry litter + 75% soil; and Control = 100% commercial substrate. The design used was completely randomized with eight replicates for each treatment, comparing these substrates for each species evaluated. The variables evaluated were seedling emergence percentage; average emergence time; plant height; number of leaves; stem diameter; and dry mass accumulation in the roots and shoots of these plants. In addition to these variables, the concentration of macronutrients in plant shoot was also evaluated. Finally, the addition of cattle manure and poultry litter benefited the development of *Tabebuia heptaphylla* seedlings, in which substrates EB2, EB3, CF7 and CF8 showed excellent results compared to commercial substrate. On the other hand, *Hymenaea stigonocarpa* seedlings were not responsive to the use of poultry litter, with emphasis on the use of cattle manure, since substrate EB3 stood out in relation to the others. It is noteworthy that low-cost substrates demonstrated results similar to commercial substrate.

KEYWORDS: Cattle manure; Poultry litter; *Hymenaea stigonocarpa*; Sandy soil; *Tabebuia heptaphylla*.

PRODUÇÃO E NUTRIÇÃO DE MUDAS DE DUAS ESPÉCIES NATIVAS DO CERRADO CULTIVADAS EM SUBSTRATOS ORGÂNICOS

RESUMO: Pouco se sabe sobre o uso de substratos alternativos para produção de mudas de espécies nativas do Cerrado. Desta maneira, com o presente trabalho objetivou-se avaliar o efeito de diferentes composições de substratos (cama de frango e esterco bovino) misturados com solo arenoso no desenvolvimento de mudas de *Hymenaea stigonocarpa* e *Tabebuia heptaphylla*. Em viveiro em Nova Andradina, foram realizados dois experimentos (um para cada espécie) que comparavam dois substratos orgânicos (cama de frango e esterco bovino). Além dos tipos de substratos, foram testadas dez proporções entre esterco bovino (EB), cama de frango (CF) misturados com solo arenoso: EB1 = 100% esterco bovino; EB2 = 75% esterco bovino + 25% solo; EB3 = 50% esterco bovino + 50% solo; EB4 = 25% esterco bovino + 75% solo; T5 = 100% solo; CF6 = 100% cama de frango; CF7 = 75% cama de frango + 25% solo; CF8 = 50% cama de frango + 50% solo; CF9 = 25% cama de frango + 75% solo; e Controle = 100% substrato comercial. O delineamento utilizado foi inteiramente casualizado com oito repetições para cada tratamento, sendo feita a comparação desses substratos para cada espécie avaliada. As variáveis avaliadas foram: porcentagem de emergência de plântulas; tempo médio de emergência; altura da planta; número de folhas; diâmetro do colo; e acúmulo de massa seca de raiz e da parte aérea dessas plantas. Além dessas variáveis, foi avaliada também a concentração de macronutrientes na parte aérea das plantas. Por fim, a adição de esterco bovino e cama de frango beneficiou o desenvolvimento de mudas de *Tabebuia heptaphylla*, nas quais os substratos EB2, EB3, CF7 e CF8 apresentaram excelentes resultados comparados ao substrato comercial; por outro lado, as mudas de *Hymenaea stigonocarpa* responderam ao uso de cama de frango, ressaltando-se o uso de esterco bovino, visto que o substrato EB3 se sobressaiu em relação aos demais. Destaca-se que os substratos de baixo custo demonstraram resultados semelhantes ao substrato comercial.

PALAVRAS CHAVE: Esterco bovino. Cama de frango. *Hymenaea stigonocarpa*. Solo arenoso. *Tabebuia heptaphylla*.

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INTRODUCTION

The Cerrado is one of the largest Brazilian biomes, with a vast diversity of tree species, but with the acceleration of the deforestation in this biome, there has been a great demand for the production of native species for forest restoration projects. As a result, the Forest Code was created, which stipulates general rules on where and how the native vegetation of all Brazilian biomes can be exploited, as well as general rules for the reforestation of degraded areas (Artioli and Corrêa., 2019). In this way, a demand was created for the production of seedlings of native species for reforestation purposes, with *Hymenaea stigonocarpa* and *Tabebuia heptaphylla* standing out among the most used seedlings for forest restoration projects (Carvalho, 2003; Carvalho, 2007).

Hymenaea stigonocarpa, known as “jatobá”, is a forest species of the *Fabaceae* family. The *H. stigonocarpa* species can be used for various purposes, such as food and its wood is highly valued in civil and naval construction (Carvalho, 2007). However, little is known about the nutritional requirements of this species during its initial development. Costa et al. (2021) reported that the species presents significant response to potassium fertilization for physiological and biometric parameters. Silva et al. (2020) reported the marked effect of phosphorus absorption on the morphophysiological behavior of *H. stigonocarpa* seedlings. Siva et al. (2019) also reported that *H. stigonocarpa* seedlings are tolerant to low natural soil fertility. Similarly, for *H. Stigonocarpa*, there are few studies in literature showing the nutritional composition of *Tabebuia heptaphylla* in its initial development

The *Tabebuia heptaphylla* species, known as “ipê-roxo” is a species belonging to the *Bignoniaceae* family (Carvalho, 2003). Bocchese et al. (2008) reported that substrates with high organic matter levels led to greater development of *T. heptaphylla* seedlings. In addition to the response to high organic matter levels, the initial development of *T. heptaphylla* is responsive to the increase in base saturation in the cultivation substrate (Vieira et al., 2020). De Oliveira (2021) highlighted that adequate nutrient absorption rate in the initial development of *T. Heptaphylla* seedlings is stimulated in the cultivation of substrates that associate high organic compound levels with another substrate that allows high water retention (De Oliveira, 2021).

To obtain optimal seedling production, it is essential to choose substrates with good physical, chemical and biological characteristics to meet the needs of the plant (Kratz and Wendlig., 2016). Furthermore, there is a need to choose substrates that are low-cost and easy to obtain (Ferraz et al., 2005). Choosing the substrate is not always simple and easy, as quality must be related to whether it is ideal for the species and low cost must also be taken into account. Sometimes there is the possibility of reducing cost with the use of organic material such as cattle, sheep or poultry manure. Substrates of animal origin are rich in nutrients, being excellent options. However, it should be used in the correct proportion (Dousseau et al., 2008). The study of the substrate by species is fundamental in the seedling production process, since different species respond differently to the nutritional and physiological needs in the seedling formation process (Germer et al., 2017; Moreira et al., 2018; Silva et al., 2017; Moreira et al., 2018; Silva et al., 2018).

In this context, studies should be carried out to evaluate different low-cost substrates for the production of seedlings of native species. In this way, this research is justified by the exploration and testing of substrates of low economic cost, using sandy soils in its composition, often marginalized. Therefore, the question is: is it possible to produce quality *Hymenaea stigonocarpa* and *Tabebuia heptaphylla* seedlings with low-cost alternative substrates and, even, with better results than the commercial substrate? So, the aim of this study was to evaluate the effect of different substrate compositions (poultry litter and cattle manure) mixed with sandy soil on the development of *Hymenaea stigonocarpa* and *Tabebuia heptaphylla* seedlings.

MATERIAL AND METHODS

Two experiments (one for each species) were implanted and conducted in the seedling production nursery at IFMS - Campus Nova Andradina, municipality of Nova Andradina, Mato Grosso do Sul, for 110 days; Rodovia MS 473, KM 23 - Fazenda Santa Bárbara, s/n, with the following geographic coordinates (22°04'58.0"S, 53°28'12.3"W). The experimental area has flat to gently undulating relief with average slope of 3% and average altitude of 380 m a.s.l. The region has average temperatures between 20 and 22° C and precipitation from 1500 to 1700 mm/year (Souza, 2010) and according to Köppen; Geiger (1936), the climate is classified as Tropical with rainy months in the summer (Am). For seedling production, greenhouse with galvanized steel structure (6.40 m in width x 18.00 m in length x 4.00 m in height) was used, with zenith opening on the ridge, covered with 150μm polyethylene film and light diffuser, with aluminized thermoreflective screen of 50% shading under the film and with lateral and front closings with black monofilament screen, and mesh for 50% shading. Plants were cultivated in 15 x 21.5 cm plastic bags with capacity of 1.8 L. Seedlings were irrigated with manual watering throughout the experiment.

Initially, seeds were collected according to the time of fruit maturation. Ripe *Hymenaea stigonocarpa* fruits were collected from 40 mother trees in good phytosanitary condition. The pulp of fruits was removed and seeds were washed in running water on a sieve and dried in the shade for 24 hours. Seeds were selected in order to eliminate those with flattened shape and those with mass less than 3.0 g. Due to seed dormancy (seed coat impermeability), mechanical scarification was performed. Subsequently, seeds were soaked in water at room temperature for 24 hours and directly sown into the plastic bag containing the cultivation substrate, placing one seed per container and lightly buried at depth of 3 cm.

Tabebuia heptaphylla seeds came from fruits collected from 28 mother trees. After collection, seeds were extracted from fruits with subsequent manual selection, aiming to eliminate broken and empty seeds (with membrane only), in addition to standardization in size and shape. Sowing was carried out in plastic bags (same size as those used for the cultivation of *Hymenaea stigonocarpa* seeds), directly on the cultivation substrate, placing two seeds in each container at depth of 1.5 cm.

It is noteworthy that the seeds of both species used in the experiment came from collection of the largest possible number of trees (a population sampling) and from different populations in order to prevent a strong genetic component from jeopardizing the results.

The soil used to prepare substrates was collected in the city of Nova Andradina (MS), which is classified as sandy-textured Quartzite Neosol (EMBRAPA, 2006), with the following characteristics: Sand = 86%; Silt = 4%; Clay = 10%; P (Mehlich) = 2.05 mg dm^{-3}; K = 0.03 cmolc dm^{-3}; Ca = 1.25 cmolc dm^{-3}; Mg = 1.10 cmolc dm^{-3}; H+Al = 2.13 cmolc dm^{-3}; pH ($CaCl_2$) = 5.20; O.M. = 9.03 g dm^{-3}. The organic substrates used in seedling production were poultry litter, cattle manure and commercial organic compost (control treatment). Soil, cattle manure and poultry litter were passed through a 2 mm mesh sieve and dried in the open air before mixing the fractions. The manure used in the experiment presented the following chemical characterization: 2.82% N; 0.67% P; 1.92% K; 0.32% Na; 1.54% Ca; 0.78% Mg; 0.54% S; 22.43% CO; 7.65 C/N; 125 ppm Zn; 4364 ppm Fe; 291 ppm Mn; 31 ppm Cu; 11 ppmB; pH = 7.8; and 42.4% moisture. The poultry litter used in the experiment presented the following chemical characterization: 3.58% N; 1.29% P; 2.46% K; 0.31% Na; 1.39% Ca; 0.72% Mg; 0.56% S; 19.63%CO; 5.44 C/N; 135 ppm Zn; 4134 ppm Fe; 238 ppm Mn; 37 ppm Cu; 22 ppmB; and pH = 7.2 and 24.5% moisture.

For the experiment, ten cattle manure (EB), poultry litter (CF) and commercial substrate (control) proportions were tested, mixed with sandy soil: EB1 = 100% cattle manure; EB2 = 75% cattle manure + 25% soil; EB3 = 50% cattle manure + 50% soil; EB4 = 25% cattle manure + 75% soil; T5 = 100% soil; CF6 = 100% poultry litter; CF7 = 75% poultry litter + 25% soil; CF8 = 50% poultry litter + 50% soil; CF9 = 25% poultry litter

+ 75% soil; and Control = 100% commercial substrate. The commercial substrate used has in its composition pine bark, vermiculite, 14 g kg^{-1} of Potassium Nitrate, 16 g kg^{-1} of Simple Superphosphate and 18 g kg^{-1} of Peat.

At 30 days, when plants had two pairs of leaves, thinning was performed, leaving only one plant per container. The irrigation procedure used during the experiment was to maintain substrate humidity, so as not to flood it, since excess water leads to seed rot and pathogen attack.

After 60 days of experimental conduction, the following parameters were measured: number of leaves, stem diameter (mm), with the aid of digital caliper at 1 cm from the substrate level and shoot height (cm), with the aid of a millimeter ruler. After these evaluations, plants were removed from containers, washed, separating shoots and roots in *Hymenaea stigonocarpa* and *Tabebuia heptaphylla* plants, placed in paper bags and subsequently dried in a forced circulation oven (±65°C) for 72 hours. After drying, the dry mass of roots (g) and shoots (g) was determined using a precision scale. These data were used to calculate the Dickson quality index:

$$DQI = \frac{MST(g)}{\frac{H(cm)}{Dc(mm)} + \frac{MSPA(g)}{MSR(g)}}$$

Finally, this material was ground and used to determine the concentration of macronutrients in plant shoots (nitrogen, phosphorus, potassium, calcium, magnesium and sulfur), as described in Malavolta et al (1997). The adopted experimental design was completely randomized with eleven treatments and eight replicates for each treatment. Data were submitted to analysis of variance and compared by the Tukey's test at 5% probability level with the aid of the SAS® statistical software.

RESULTS AND DISCUSSIONS

Hymenaea stigonocarpa seedlings

By analyzing the results obtained, it was observed that the poultry litter did not allow the germination of *Hymenaea stigonocarpa* seedlings; therefore, statistics were performed only for compositions based on cattle manure. Valadão et al. (2011) incorporated poultry manure into the soil and identified excess acidification of its pH. Thus, it is possible that the amount of some elements contained in substrates with poultry litter may have caused a phytotoxic effect on *Hymenaea stigonocarpa* seedlings, which possibly inhibited growth in these substrates (LARSON et al., 2018; RAMALHO et al., 2019).

Regarding the dry shoot mass of *Hymenaea stigonocarpa* seedlings, substrate EB3 (50% organic + 50% soil) stood out, being responsible for the highest value, with average mass of 11.42 g/seedling; the lowest values were observed in seedlings from seeds sown in EB1 (100% cattle manure), EB2 (75% cattle manure + 25% soil), EB4 (25% or cattle manure + 75% soil) and T5 (100 % soil), whose average values corresponded to 7.26, 7.90, 7.25 and 6.36, g/seedling, respectively (Table 1). The evaluated dry mass and the Dickson's quality index showed similar behavior.

Table 1. Root dry mass (MSR); shoot dry mass (MSPA); height (Alt); stem diameter (DC); number of leaves (NF); and Dickson quality index (DQI) of *Hymenaea stigonocarpa* seedlings grown in substrates with different soil and cattle manure (EB) proportions.

Treatments	MSR g	MSPA g	Alt cm	DC mm	NF	DQI
EB1	4.34 c	7.26 c	19.30 b	3.30 b	4.00 b	1.80b
EB2	4.44 c	7.90 c	19.00 b	3.00 b	4.40 b	1.79b
EB3	6.50 a	11.42 a	25.20 a	4.60 a	5.90 a	2.96a
EB4	4.04 c	7.25 c	19.70 b	3.00 b	4.40 b	1.58b
T5	4.34 c	6.36 c	19.30 b	3.30 b	4.10 b	1.64b
Control	5.58 b	9.46 b	25.00 a	4.20 a	6.00 a	2.30a

Equal lowercase letters in columns do not differ from each other at 5% probability by the Tukey's test.

Regarding root dry mass (Table 1), it could be concluded that EB3 had roots with the highest biomass, followed by Control, with average values of 6.50 and 5.58 g, respectively. Adequate root development enables greater survival of plants in the field, due to the increase in the absorption area, thus tolerating certain stressful conditions, such as water deficit and solar irradiation, in the definitive location.

For the height of *Hymenaea stigonocarpa* seedlings (Table 1), the combination of substrates EB3 (50% organic + 50% soil) and Control (100% commercial substrate) showed favorable conditions for their growth, with average values of 25.20 and 25.00 cm, respectively. Variable height is commonly used to assess the quality standard of forest seedlings, since taller ones usually have greater vigor (Caione et al., 2012).

Regarding stem diameter and number of leaves of *H. stigonocarpa* seedlings, it was observed that substrates EB3 (50% organic + 50% soil) and Control (100% commercial substrate) showed the highest values (Table 1). The results observed in substrate EB3 are similar to those obtained by Gonzaga et al. (2016), who carried out an experiment with organic matter sources and doses on peach palm growth and found that cattle manure provided greater height and number of leaves, a demanding species in relation to the soil physical properties.

Plants cultivated in substrates EB3 and Control also had higher concentration of macronutrients (Table 2). Thus, substrate 50% sandy soil + 50% cattle manure provided seedling growth and nutrition similar to commercial substrate, being the most suitable for the production of *H. stigonocarpa* seedlings.

Table 2. Results of nitrogen concentration (N); phosphorus (P); potassium (K); calcium (Ca); of magnesium (Mg); and sulfur (S) in *Hymenaea stigonocarpa* seedlings grown in substrates with different soil and cattle manure (EB) proportions.

Treatments	N	P	K	Ca	Mg	S
	---------------------------------g kg^{-1}---------------------------------					
EB1	9.52 b	1.22 b	8.52 b	10.45 b	4.56 b	2.25 b
EB2	9.54 b	1.32 b	8.62 b	10.65 b	4.02 b	2.52 b
EB3	15.21 a	3.52 a	12.52 a	18.25 a	8.69 a	4.05 a
EB4	9.05 b	1.05 b	8.42 b	10.02 b	4.32 b	2.03 b
T5	9.62 b	1.65 b	8.23 b	10.20 b	4.25 b	2.30 b
Control	15.02 a	3.21 a	12.02 a	18.52 a	8.62 a	4.01 a

It is known that the transformations resulting from the application of organic matter to soil directly affect the availability of nutrients to plants through the impact on the chemical and biological soil properties. In addition, in relation to the availability of macronutrients for *H. stigonocarpa* seedlings, when larger amounts of organic matter (cattle manure) are added to treatments, plants reduce growth, probably by reducing the pH of substrates, which impaired seedling development, corroborating results obtained by Valadão et al. (2011). On the other hand, when larger amounts of soil are added, plant growth is compromised due to the lower amount of retained water, little aeration of roots and, consequently, less presence of essential nutrients for the development of seedlings in substrates (Araújo and Sobrinho, 2011).

According to Soares et al. (2013), *H. stigonocarpa* is a species typical of acidic soils and not demanding in terms of nutrients to develop. Even considering that native Cerrado plants are adapted to soils of low fertility, experimental fertilization studies indicate that woody species can respond to the adequate availability of nutrients in the soil (Scholz et al., 2007). Adequate absorption of macronutrients is essential for seedling survival and growth (Shabnam & Iqbal, 2016).

Alves et al. (2015) reported that slow-growing species, such as *H. stigonocarpa*, are more adapted to soils with restricted supply of nutrients and less responsive to their supply. However, in a study of phosphorus suppression in *H. stigonocarpa*, the authors reported limited development due to the lack of this nutrient. Thus, there is little information in literature about the nutritional requirements of this species in the seedling phase, and results are controversial (Soares et al., 2013). The present work demonstrated that substrates that allow high absorption of macronutrients enable the development of seedlings with adequate growth.

Kratz and Wendlig (2016) highlighted that a good substrate for seedling formation and production must have the following characteristics: availability of acquisition in the region, low cost, absence of pathogens, richness of nutrients and adequate conditions for plant growth. Thus, the use of cattle manure with soil at 50/50 ratio was the most suitable for optimal water retention and availability of nutrients for plant growth. Finally, it is noteworthy that substrates EB3 and Control stood out in relation to the others.

Tabebuia heptaphylla seedlings

For *Tabebuia heptaphylla* seedlings, it was observed that the substrates that induced the highest root dry mass production were: EB2 (75% cattle manure + 25% soil) and EB3 (50% cattle manure + 50%

soil), whose average mass corresponded to 6.33 and 6.41 g/seedling, respectively (Table 3). On the other hand, substrates CF6 (100% poultry litter), CF8 (50% poultry litter + 50% soil) and CF9 (25% poultry litter + 75% soil) showed the lowest results. It is important to consider other variables in seedling development such as shoot height, concentration of macronutrients, root and shoot dry mass, which also influence the choice of an effective substrate for seedling production (Sousa et al., 2019). Dry mass and Dickson's quality index showed similar behavior.

Analyzing the concentration of macronutrients in substrates EB2, EB3 and CF8, it was observed that they induced greater nutrient absorption, which results in seedlings with greater root development, a characteristic that directly influences root dry mass. On the other hand, it was observed that treatments with smaller amounts of macronutrients, such as CF6 (100% poultry litter) and CF9 (25% poultry litter + 75% soil) also showed lower root dry mass accumulation.

Plants cultivated in substrates EB2 (75% cattle manure + 25% soil) and EB3 (50% cattle manure + 50% soil) showed higher shoot dry mass, with average mass of 12.91 and 12.05 g /seedling, respectively (Table 3). On the other hand, it was observed that substrate CF8 (50% poultry litter + 50% soil) presented the lowest value, followed by CF9 (25% poultry litter + 75% soil), with average mass of 8.36 and 8.23 g/seedling, respectively, even lower than Control.

It could be concluded that plants that obtained the highest shoot dry mass were those from treatments using cattle manure and soil at proportions of 75/25, 50/50, which contribute to the retention of greater amounts of water and, consequently, greater amounts of nutrients are made available for absorption by seedlings in these substrates. The cattle manure organic matter helped with water retention and nutrient availability, resulting in increases in seedling dry mass (Macedo et al., 2011). However, when analyzing seedlings from other treatments, such as 100% cattle manure; 100% poultry litter; and 100% soil, it was observed that they were not able to meet the needs of seedlings for good development, in addition to these, the other soil compositions with organic substrate presented lower results compared to control treatment, emphasizing the importance of the correct evaluation of proportion for each evaluated species.

Observing the height of *T. heptaphylla* seedlings, it was observed that substrates EB2 (75% cattle manure + 25% soil), EB3 (50% cattle manure + 50% soil) and CF7 (75% poultry manure + 25 % soil) provided the highest values (Table 3). EB4 (25% cattle manure + 75% soil) showed the lowest height, not statistically different from substrates EB1 (100% cattle manure) and T5 (100% soil). For variables stem diameter and number of leaves, the highest average values were observed in seedlings from seeds sown in substrates EB2 (75% cattle manure + 25% soil), EB3 (50% cattle manure + 50% soil), CF7 (75% poultry manure + 25% soil) and Control (100% commercial substrate) (Table 3).

Table 3. Root dry mass (MSR); shoot dry mass (MSPA); height (Alt); stem diameter (DC); number of leaves (NF); and Dickson quality index (DQI) in *Tabebuia heptaphylla* seedlings grown in substrates with different bovine manure (EB) and poultry manure (CF) proportions.

Treatments	MSR g	MSPA g	Alt cm	DC mm	NF	DQI
EB1	4.23c	5.06 c	4.31c	1.37b	4.04b	2.33b
EB2	6.33a	12.91a	13.04a	3.58a	8.45a	4.66a
EB3	6.41a	12.05a	14.68a	3.67a	8.97a	4.07a
EB4	4.05c	6.35c	4.07c	1.48b	4.46b	3.07b
T5	4.21c	5.30c	4.36c	1.38b	4.17b	2.41b
CF6	2.47d	4.34c	6.25b	1.37b	4.00b	1.33c
CF7	5.48b	10.33b	10.23a	3.38a	8.40a	4.44a
CF8	2.50d	8.36c	6.23b	1.37b	5.90b	2.24b
CF9	2.27d	8.23c	6.23b	1.37b	4.40b	2.18b
Control	5.38b	10.04b	8.26b	3.30a	8.06a	5.07a

Equal lowercase letters in columns do not differ from each other at 5% probability by the Tukey's test.

The use of only cattle manure and poultry litter impaired seedling growth. This result was already expected, since there is a limit on the use of doses of organic fertilizers, which, from a certain dose, seedling development is reduced mainly due to the high acidity (LARSON et al., 2018). Regarding the nitrogen concentration in *T. heptaphylla* seedlings, substrates EB2 (75% cattle manure + 25% soil), EB3 (50% cattle manure + 50% soil), CF8 (50% poultry manure + 50% soil) and Control (100% commercial substrate) stood out, being responsible for the highest average values (Table 4). On the other hand, the lowest average values were obtained in substrate EB1 (100% cattle manure), EB4 (25% cattle manure + 75% soil) and T5 (100% soil).

For phosphorus concentration in *T. heptaphylla* seedlings, substrate combination EB2 (75% cattle manure + 25% soil), EB3 (50% cattle manure + 50% soil), CF8 (50% poultry manure + 50% soil) and Control (100% commercial substrate) showed the highest average values. On the other hand, EB1 (100% cattle manure), EB4 (25% cattle manure + 75% soil) and T5 (100% soil) provided the lowest values (Table 4).

Table 4. Results of nitrogen concentration (N); phosphorus (P); potassium (K); calcium (Ca); of magnesium (Mg); and sulfur (S) in *Tabebuia heptaphylla* seedlings grown in substrates with different bovine manure (EB) and poultry litter (CF) proportions.

Treatments	N	P	K	Ca	Mg	S
	----------g kg^{-1}----------					
EB1	4.04 c	1.10 c	4.21 c	13.31 c	3.03 b	2.06 b
EB2	15.42 a	4.07 a	18.07 a	28.01 a	9.02 a	4.61 a
EB3	15.24 a	4.06 a	18.08 a	28.06 a	9.60 a	4.63 a
EB4	4.67 c	1.46 c	4.06 c	12.04 c	3.11 b	2.05 b
T5	4.07 c	1.47 c	4.91 c	11.01 c	3.13 b	2.51 b
CF6	8.03 b	1.01 b	4.04 c	12.35 c	3.53 b	2.05 b
CF7	8.41 b	1.34 b	4.72 c	12.31 c	3.02 b	2.21 b
CF8	11.01 a	3.05 a	10.57 b	22.05 b	9.64 a	4.03 a
CF9	8.21 b	1.36 b	4.61 c	13.03 c	3.21 b	2.04 b
Control	11.01 a	3.20 a	10.09 b	21.13 b	9.42 a	4.45 a

Equal lowercase letters in columns do not differ from each other at 5% probability by the Tukey's test.

Regarding potassium levels in *T. heptaphylla* seedlings, it was observed that substrate EB3 (50% cattle manure + 50% soil) presented the highest growth result, followed by EB2 (75% cattle manure + 25% soil), with average values of 18.08 and 18.07 g.kg^{-1}, respectively. In contrast, the lowest values were obtained using the substrate combination EB1 (100% cattle manure), EB4 (25% cattle manure + 75% soil), EB5 (100% soil), CF6 (100% poultry litter), CF7 (75% poultry litter + 25% soil) and CF9 (25% poultry litter + 75% soil) (Table 4).

Substrates EB2 (75% cattle manure + 25% soil) and EB3 (50% cattle manure + 50% soil) provided the highest calcium concentration results, with average values of 28.01 and 28.06 g.kg^{-1}, respectively. Substrates responsible for the lowest values were EB1 (100% cattle manure), EB4 (25% cattle manure + 75% soil), EB5 (100% soil), CF6 (100% poultry litter), CF7 (75% poultry + 25% soil) and CF9 (25% poultry litter + 75% soil) (Table 4). For magnesium and sulfur concentration in *T. heptaphylla* seedlings, the substrate combination EB2 (75% cattle manure + 25% soil), EB3 (50% cattle manure + 50% soil), CF8 (50% poultry manure + 50% soil) and Control (100% commercial substrate) showed favorable conditions for their nutrition. In this way, substrate combinations of 75% cattle manure + 25% soil, 50% cattle manure + 50% soil, 75% poultry manure + 25% soil and 50% poultry manure + 50% soil provided similar seedling growth and nutrition and even superior to commercial substrate, being indicated for *T. heptaphylla* seedlings.

Substrates EB2 and EB3 provided the highest dry mass values, which indicates that 50% and 75% of organic substrate will provide higher water content for the tissues of *T. heptaphylla* seedlings. Caione et al. (2012) highlighted that the initial growth rates and nutrient absorption are important for the best efficiency in the use of seedlings in forest restoration. In this way, the use of cattle manure with soil at proportions of 75/25, 50/50 and poultry manure with soil at 75/25 and 50/50 were suitable for providing nutrients for the growth of *T. heptaphylla* plants.

Substrates EB2 and EB3 showed potential for use in the production of forest seedlings, as they have favorable chemical, physical and biological properties. In addition, cattle manure is easy to find in the Nova Andradina region, and according to ARAÚJO et al. (2013), tanned cattle manure is an excellent source of N, acting as a soil acidity reducer, neutralizing aluminum. For the production of *T. heptaphylla* seedlings, it was observed that substrates CF7 and CF8 also stood out in relation to the others. The high acidity of poultry litter prevents the use of this substrate for species that are more sensitive to pH, such as *H. stigonocarpa* (Larson et al., 2018). However, it is an excellent option as a source of N and P, in addition to providing good water retention.

It could then be concluded that the objectives were met, considering that it was possible to produce seedlings with poultry litter and cattle manure. In addition, the hypothesis was confirmed under specific circumstances, provided that substrates are combined in the appropriate proportions for each species. In this way, further studies should investigate alternative substrates for other native species.

For *H. stigonocarpa*, the addition of cattle manure benefited the development of *H. stigonocarpa* seedlings. On the other hand, poultry litter did not allow the germination of *H. stigonocarpa* seedlings. Substrate EB3 (50% cattle manure + 50% soil) showed excellent results compared to the commercial substrate, which indicates its efficiency in the production of *H. stigonocarpa* seedlings. EB3 provided greater root and shoot dry mass accumulation under the experimental conditions, as well as the greatest accumulation of macronutrients.

For *T. heptaphylla*, the addition of cattle manure and poultry litter benefited the development of *T. heptaphylla* seedlings. Substrates EB2 (75% cattle manure + 25% soil), EB3 (50% cattle manure + 50% soil), CF7 (75% poultry litter + 25% soil) and CF8 (50% poultry litter + 50% soil) presented excellent results compared to the commercial substrate, which indicates their efficiency in the production of *T. heptaphylla* seedlings. Substrates EB2, EB3 and CF8 provided the highest accumulation of macronutrients.

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