Scientia Agraria Paranaensis

Scientia Agraria Paranaensis – Sci. Agrar. Parana.
ISSN: 1983-1471 – Online
DOI: https://doi.org/10.18188/sap.v20i1.26292

PRODUCTION OF BARUEIRO SEEDLINGS IN DIFFERENT SUBSTRATES

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SAP 26292 Received: 16/11/2020 Accepted: 26/03/2021
Sci. Agrar. Parana., Marechal Cândido Rondon, v. 20, n. 1, jan./mar., p. 62-68, 2021

ABSTRACT - Barueiro (*Dipteryx alata* Vog.) is one of the species native to the Brazilian cerrado that has economic potential. Thus, for the implantation of commercial orchards of this fruit tree, it is important to produce quality seedlings. This study aimed to evaluate the growth of barueiro seedlings under different substrates containing organic residues in the municipality of Nova Xavantina-MT. The experimental design used was randomized blocks (RBD), with 7 treatments [soil (control); soil + bovine manure (2:1); soil + coffee husk (3: 1); soil + humus (2:1); soil + coffee husk + humus (3:1:1); soil + coffee husk + bovine manure (3:1:1); and soil + humus + bovine manure (3:1:1)] and 4 replicates, with ten plants per plot, totaling 280 seedlings. Treatments consisted of substrates formulated with different proportions of soil, bovine manure, coffee husk and earthworm humus. Substrate containing only soil (control) provided greater plant height, stem diameter, number of leaves, number of leaflets, shoot and root fresh and dry mass and Dickson Quality Index. In general, residues tested did not favor the growth parameters evaluated, possibly because barueiro is a species native to the Cerrado, not very demanding in soil fertility. Under the conditions of this work, it is recommended the use of soil in the formulation of substrates to produce barueiro seedlings. The addition of organic matter to the soil had negative effect on seedling development.
Keywords: *Dipteryx alata* Vog., cerrado fruits, propagation, nursery.

PRODUÇÃO DE MUDAS DE BARUEIRO EM DIFERENTES SUBSTRATOS

ABSTRACT - O barueiro (*Dipteryx alata* Vog.) é uma das espécies nativas do cerrado que apresenta potencial econômico. Assim, para a implantação de pomares comerciais desta frutífera é importante a produção de mudas de qualidade. O presente trabalho teve como objetivo avaliar o crescimento de mudas de barueiro sob diferentes substratos contendo resíduos orgânicos, no município de Nova Xavantina-MT. O delineamento experimental utilizado foi blocos casualizados, contendo 7 tratamentos [solo (testemunha); solo + esterco bovino (2:1); solo + casca de café (3:1); solo + húmus (2:1); solo + casca de café + húmus (3:1:1); solo + casca de café + esterco bovino (3:1:1); e solo + húmus + esterco bovino (3:1:1)] com 4 repetições, dez plantas por parcela, totalizando 280 mudas. O substrato contendo apenas solo (testemunha) proporcionou maior altura de plantas, diâmetro do caule, número de folhas, número de folíolos, massa fresca e seca da parte aérea e das raízes e índice de qualidade de Dickson. De maneira geral, os resíduos testados não favoreceram os parâmetros de crescimento avaliados, possivelmente devido o barueiro ser uma espécie nativa do Cerrado, pouco exigente em fertilidade do solo. Nas condições deste trabalho, recomenda-se a utilização de solo na formulação dos substratos para a produção de mudas de barueiro. A adição de matéria orgânica ao solo interfere negativamente no desenvolvimento das mudas.
Palavras-chave: *Dipteryx alata* Vog., frutíferas do cerrado, propagação, viveiro de mudas.

INTRODUCTION

Barueiro (*Dipteryx alata* Vog.) is a fruit tree that produces almond known as 'baru' or 'cumbaru', belonging to the Fabaceae family and found in the Cerrado biome, being quite common in the states of Goiás, Minas Gerais, Mato Grosso, Mato Grosso do Sul and Federal District (FERREIRA et al., 2018).

This fruit species is part of a group of about 110 species native to the Brazilian Cerrado, which have economic potential and is among the 10 most promising for cultivation due to the multiple possibilities of use, high seed germination and seedling establishment rates and low fertilization demand. It is also indicated for the recovery of degraded areas, protection of springs, banks of rivers and streams, thus favoring its conservation. It is one of the few species that presents fruits with fleshy pulp during the dry season in the Cerrado biome, being important for feeding the fauna at this season (SANO et al., 2016).

Producers can achieve good results by producing quality seedlings and cultivate them in agrosilvopastoral systems, that is, intercropped with other trees, pasture or grain crops and through this strategy, they can benefit from the commercialization of fruits.

The production of high-quality seedlings is essential to obtain uniform, productive and long-lived orchards. In seed propagation, the substrate has the purpose of providing adequate conditions for germination and/or initial seedling development (OLIVEIRA et al., 2016). In order to guarantee success in seedling growth and development after planting, it is necessary to use appropriate substrate, protected environment when possible, irrigation and planting and post-sowing

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fertilization in the seedling production phase, in addition to proper management of pests, diseases and weeds, which are factors that will provide conditions for obtaining quality seedlings (MARANHO; PAIVA, 2012).

Substrates must present the necessary nutrients to promote seedling development in balanced proportions, favor root development, provide good water absorption and retention capacity, aeration and drainage (PIO et al., 2005). Currently, the search for substrates consisting of organic residues stands out in order to reduce chemical fertilization costs, promoting environmental and economic gains (LEAL et al., 2016).

In the substrate composition, the organic source is responsible for retaining moisture and providing part of nutrients for seedling growth. Organic residue can be of animal or vegetable origin and after decomposition, results in organic matter (FINATTO et al., 2013). Bovine manure is one of the organic fertilizers most commonly used for the production of seedlings of the most diverse species due to its low cost and high availability, increasing the organic matter content, which improves soil structure, water retention capacity, and the occurrence of microbial activity (BASSO et al., 2008; PAIVA et al., 2010).

Another organic source with potential to be used in the formulation of substrates for seedling development is earthworm humus, which is rich in nutrients, promotes greater aeration and, consequently, greater rooting, increasing the nutrient uptake capacity (TEIXEIRA, 2021). Coffee husk, residue generated by the process of grain peeling during processing, is also an alternative of organic source that can be used in the formulation of substrates to obtain fruit seedlings.

The growth and development of quality seedlings varies according to species, sources used in the formulation of substrates and their proportions (KLEIN, 2015). However, there are few studies that indicate the sources and proportions of organic compounds suitable for the germination and growth of seedlings of fruit species. Thus, the aim of this study was to evaluate the growth of barueiro seedlings (*Dipteryx alata* Vog.) under different substrates containing organic residues in the municipality of Nova Xavantina-MT.

MATERIAL AND METHODS

The experiment was implemented and conducted in the seedling production nursery of the State University of Mato Grosso (UNEMAT), Nova Xavantina *Campus* (MT) from November 2019 to March 2020. The municipality of Nova Xavantina is located at 14°41’25”S and 52°20’55”W, at altitude of 275 m a.s.l.

According to the Köppen classification, the climate is Aw type, predominantly tropical, with four months of drought, from May to August, annual precipitation from 1300 to 1500 mm and average monthly temperature of 26° C (INMET, 2017). The region is located in the Cerrado/Amazon transition, and the predominant vegetation is that of the Cerrado biome (MARQUES et al., 2019). The soil used in the experiment was classified as Yellow Latosol (SANTOS et al., 2018), collected from an area within the State University of Mato Grosso, Nova Xavantina *Campus*, in the 0-20 cm layer. After homogenization, a soil sample was collected and sent to the Solocria Agricultural Laboratory for chemical and physical analyses. The results of analyses are described in Table 1.

TABLE 1 - Chemical and physical analysis of soil used in the formulation of substrates for the production of barueiro seedlings.

Ca	Mg	Al	H+Al	K	K	Zn	P (Melich^{-1})	
cmolc cm^{-3}					mg dm^{-3}			
0.90	0.30	0.00	1.50	0.17	65.40	9.40	5.60	
Complementary data								
CEC	Sat.B	Ca/Mg	Ca/CEC	Mg/CEC	K/CEC	H+Al/CEC	O.M.	Carbon
%							g dm^{-3}	
2.87	47.74	3.00	31.36	10.45	5.92	52.26	20.00	11.60
		pH			Texture (g kg^{-1})			
		$CaCl_2$			Clay	Silt	Sand	
		5.00			160.00	50.00	790.00	

CEC = cation exchange capacity, Sat.B = base saturation, O.M.= organic matter, $CaCl_2$ = calcium chloride, pH = hydrogenionic potential.

In total, 1300 ripe fruits were collected in good sanitary conditions after the spontaneous fall in the Bacaba Municipal Park, municipality of Nova Xavantina (MT) from August 14 to 17, 2019. Seeds were extracted with the aid of equipment adapted for the breaking of this fruit, avoiding possible damage to seeds that were selected considering physical, sanitary aspects and absence of injuries. Subsequently, seeds were stored in a plastic bag inside the refrigerator (7ºC).

For seedling production, polyethylene plastic bags with dimensions of 20 x 30 cm were used (3.8 dm³), being filled with substrates corresponding to each treatment, with soil used in the formulation of substrates being previously sieved. Then, bags were placed on metal benches at the Seedling Production Nursery of the State University of Mato Grosso in a 50% shade screen. Three seeds were manually sown in each plastic bag at approximately 2 cm depth, totaling 840 seeds.

Thirty days after sowing, thinning of seedlings was carried out, keeping only the most vigorous per container. Irrigation was daily performed with manual watering can, with water being evenly distributed in each container. Weed control was manually performed by eliminating plants immediately after emergence to avoid possible competition with barueiro seedlings, which remained in the nursery for 120 days after sowing, according to Pinho et al. (2019).

The experimental design adopted was randomized blocks, containing 7 treatments and 4 replicates, with ten plants per plot, totaling 280 seedlings. Treatments used were: T1 = soil (control), T2 = soil + bovine manure (2:1) (v/v), T3 = soil + coffee husk (3:1) (v/v), T4 = soil + humus (2: 1) (v/v), T5 = soil + coffee husk + humus (3:1:1) (v/v/v), T6 = soil + coffee husk + bovine manure (3:1:1) (v/v/v) and T7 = soil + humus + bovine manure (3:1:1) (v/v/v).

Coffee husk and bovine manure used after being tanned for approximately forty days were donated by the Canarinho farm, municipality of Nova Xavantina. Earthworm humus was purchased from the “Minhocas Cristal” company, also in the same municipality. A sample of each residue was sent to the Laboratory of Soil and Plants of the municipality of Água Boa (MT) for analysis of the nutrient content, which results are shown in Table 2.

TABLE 2 - Chemical composition of coffee husk, bovine manure and earthworm humus residues (dry base 65ºC) used in the formulation of substrates for the production of barueiro seedlings (*Dipetyx alata* Vog.).

Residues	N	P	K	Ca	Mg	S	M.O.
	%						
Coffee husk	2.89	0.39	2.55	1.93	0.54	0.26	69,00
Bovine manure	2.08	1.13	2.12	1.04	0.92	0.20	48,00
Earthworm humus	1.41	0.69	0.64	0.95	0.51	0.14	25,00
	Zn	Cu	Mn	Fe	B	Na	
	mg kg^{-1}						
Coffee husk	33.63	67.38	135.21	4061.75	42.8	468. 85	
Bovine manure	108.82	36.54	202.59	18871.69	28.7	4442.98	
Earthworm humus	99.92	27.08	497.70	14459.26	25.01	941.33	
	Dry basis - 65ºC						
	pH ($CaCl_2$)		Density (g dm^{-3})		Moisture at 60-65ºC		
Coffee husk	8.68		0.45		60.62		
Bovine manure	7.26		0.61		47.88		
Earthworm humus	6.82		0.91		30.30		

N - (N - Total) = sulfuric digestion; P, K, Ca, Mg, S, Na, Cu, Fe, Mn, Zn, = nitroperchloric digestion, B = incineration.

One hundred and twenty days after sowing, when seedlings were ready to be sent to the field, the following agronomic variables were evaluated: plant height (cm), measured with the aid of millimeter ruler, measuring the distance between the plant's neck and the insertion of the last leaf; stem diameter (mm) at 2 cm above the ground, with the aid of digital caliper with accuracy of 0.01 mm; number of leaves and number of leaflets.

Seedlings were removed from bags, washed in running water and roots were separated from shoots with the help of pruning shears. Subsequently, shoots and roots were placed in paper bags, and then weighed separately on analytical scale to determine shoot fresh mass (MFPA) and root fresh mass (MFRA) (g). The material was taken to greenhouse with forced air circulation at temperature of 65ºC, at the Laboratory of Soils of UNEMAT until reaching constant mass and then weighed again to determine the dry mass (g) of each part.

In addition, the Dickson's Quality Index was determined, obtained according to Dickson et al. (1960) applying the following formula (Equation 1):

$$IQD = \frac{MST(g)}{\frac{H(cm)}{DC(mm)} + \frac{MSPA(g)}{MSR(g)}} \quad \text{(Equation 1)}$$

Where:
MST = total dry mass (g) (MSPA + MSR),
H = height (cm),
DC = stem diameter (mm),
MSPA = shoot dry mass (g)
MSR = root dry mass (g).

Data obtained from all variables were submitted to the Shapiro Wilk test at 5% error probability to verify the normality of residuals and the Hartley test at 5% error probability to verify homogeneity of variance. Data were submitted to analysis of variance and means compared by the Tukey test at 5% error probability using the Sisvar® statistical software (FERREIRA, 2019).

RESULTS AND DISCUSSION

According to results of the analysis of variance, it was found that there was significant difference among substrates (Table 3) for all characteristics under study. It was verified in Table 4 that substrate containing only soil (control) provided 34.40% more plant height, 17.45% more stem diameter, 36.76% more leaves and 44.52% more leaflets in relation to the lowest performance treatment for each of these characteristics.

TABLE 3 - Analysis of variance for plant height (H), stem diameter (D), number of leaves (NF), number of leaflets (NFo), shoot fresh weight (MFPA) and root fresh weight (MFR), shoot dry mass (MSPA) and root dry mass (MSR) and Dickson's quality index (IQD) of barueiro seedlings produced under different substrates containing residues.

Sources of variation	GL	H (cm)	D (mm)	NF	NFo	MFPA (g)	MFR (g)	MSPA (g)	MSR (g)	IQD
Substrates	6	32.09**	0.34**	4.97**	241.18**	11.31**	14.60**	2.74**	2.92**	0.269**
Block	3	1.52^{ns}	0.02^{ns}	0.37^{ns}	25.36^{ns}	0.51^{ns}	0.35^{ns}	0.09^{ns}	0.05^{ns}	0.010^{ns}
Error	18	2.03	0.04	0.35	9.42	1.37	0.25	0.21	0.05	0.008
CV (%)		7.72	4.64	9.62	9.17	18.26	13.50	19.12	16.69	15.09

ns = not significant, ** = significant at 1% error probability.

TABLE 4 - Plant height (H), stem diameter (D), number of leaves (NF) and number of leaflets (NFo) of barueiro seedlings produced under different substrates containing residues.

Substrates	H (cm)	D (mm)	NF	NFo
Soil (S)	24.36 a	4.87 a	8.65 a	50.65 a
S+EB	18.48 b	4.32 bc	5.78 b	31.63 b
S+PA	18.81 b	4.53 ab	5.65 b	32.55 b
S+HU	18.21 b	4.10 bc	6.14 b	31.96 b
S+PA+HU	16.12 b	4.02 c	5.62 b	28.10 b
S+EB+PA	17.23 b	4.36 bc	5.82 b	30.90 b
S+EB+HU	15.98 b	4.14 bc	5.47 b	28.49 b
DP	3.77	0.53	1.56	8.12
DMS	3.33	0.47	1.38	7.17

S = soil, EB = bovine manure, PA = coffee husk, HU = earthworm humus. SD = standard deviation, DMS = minimum significant difference.

Stem height and diameter are characteristics used to evaluate the quality of seedlings, because, in addition to reflecting the accumulation of reserves, they also provide greater resistance and better fixation in the soil. These variables are recognized as indicators of the seedling quality standard, being, in general, the most suitable to determine the seedling survival capacity in the field (ARAUJO et al., 2018).

Barueiro seedlings produced only with soil reached stem height (24.36 cm) and diameter (4.87 mm) similar to those obtained by Pinho et al. (2019) who, when evaluating phosphate and nitrogen fertilization in the production of barueiro seedlings, found 27.37 cm in height and 5.08 mm in diameter for seedlings in the absence of nitrogen fertilization.

Mota et al. (2012) evaluated the seedling emergence potential and the growth of *Dipteryx alata* seedlings at different shading levels (full sun, 50 and 70% shading) using soil + sand + poultry litter substrate in a volume ratio of 1:1:1 (v: v) and found 16.33 cm in height and 4.40 mm in diameter at 125 days after emergence in 50% shading. Berti et al. (2017) evaluated the initial growth of barueiro seedlings in Bioplant® commercial substrate enriched with nitrogen, phosphorus and potassium at 100 days after sowing and obtained similar results for stem height (22.48 cm) and diameter (5.67 mm) compared to results of the present study.

This study corroborates results of Santos et al. (2011), who worked with jatoba seedlings grown with different organic compounds under 50% shade screen and found that only substrate with 100% soil stood out from the other treatments, as it presented better growth response, concluding that jatoba has adaptability to Cerrado soils with high acidity, which is a natural characteristic of the species. Probably, there was less water percolation in treatments with organic matter in the present work, which may have impaired root development due to the lack of oxygenation in roots, causing lower seedling growth in these substrates.

Species native to the Brazilian Cerrado are adapted to emit radicles in substrates with lower organic matter content and lower pH (SANTOS et al., 2011). Thus, humus and bovine manure may have raised the pH value and negatively influenced seedling growth and quality.

The same result was observed by Paiva et al. (2010), who found that mangaba and cagaita seedlings produced under different substrates (soil (control); soil + tanned bovine manure; soil + carbonized rice husk; soil + tanned bovine manure + carbonized rice husk) at 120 days after sowing showed higher height in substrate containing only soil and mangaba and barueiro seedlings obtained larger stem diameter in the control treatment. These authors also reported that mangaba seedlings produced with substrates that contained bovine manure had lower height and, as a result, they considered that the fertility of substrate containing only soil was sufficient to supply the needs of seedlings of Cerrado species (mangaba, cagaita and barueiro), demonstrating that they have low nutrient demand.

Lower plant height, stem diameter and number of leaves and leaflets found in treatments containing organic matter may have been due to the increase in N and P content provided by earthworm humus, bovine manure and coffee husk, since barueiro is a Cerrado species that has little soil fertility demand. As a legume, barueiro has high nitrogen fixation power and capacity to form symbiosis with Rhizobium bacteria in roots, thus, nitrogen fixation becomes more efficient. High phosphorus concentrations in the substrate can reduce the occurrence of Rhizobium in roots, a fact also reported by Mello et al. (2008).

Phosphorus is indicated for seedling production because it plays a key role in photosynthesis and for promoting the initial root formation and growth, increasing the water use efficiency, as well as the absorption and use of all other nutrients by plants. Despite these benefits, it is emphasized that there may be antagonism caused by excess phosphorus (P) in relation to boron (B) and zinc (Zn) (PRADO, 2008). Nitrogen, in turn, makes up the chlorophyll molecule, directly participating in photosynthesis, also playing the role of increasing the protein content in cells, being generally the nutrient most required by plants (SOUZA et al., 2004).

The results found for the growth of barueiro seedlings are consistent with the hypothesis that climatic and secondary species have growth little influenced by the increase in soil fertility levels, which may be indicative of greater adaptation to infertile soils, which is a characteristic of the species, or of strict adjustment of the growth rate to conditions of low nutrient availability, which restricts its response to improvements in soil fertility levels.

The characteristics of the soil used as substrate (Table 1) were adequate to meet the needs of barueiro seedlings and the lower values of variables analyzed in the other treatments may have been due to the nitrogen and phosphorus content provided by the combination of residues, since barueiro is a Cerrado species that is not very demanding in soil fertility (SANTOS et al., 2011). Pinho et al. (2018) evaluated substrates and container sizes in the production of *Dipteryx alata* seedlings and observed that substrate containing only soil or commercial substrate was the most suitable for the production of *Dipteryx alata* seedlings. The authors recommended using substrate containing only soil in container with dimension of 3.8 dm^3, as it provides greater number of leaves.

Table 5 shows that seedlings produced on substrate containing only soil differed from the others, providing 54.17% more fresh weight, 61.21% more shoot dry matter; 68.94% more fresh weight and 75.07% more root dry weight; in addition to 66.10% higher Dickson's Quality Score compared to the lowest performance treatment for each characteristic. In general, the residues tested did not favor growth parameters. This fact may indicate that the species, being native to poor soils, does not always respond to increases of organic matter in the substrate.

TABLE 5 - Shoot fresh weight (MFPA) and root fresh weight (MFR), shoot dry weight (MSPA) and root dry weight (MSR) and Dickson's quality index (IQD) of barueiro seedlings produced under different substrates containing residues.

Substrates	MFPA	MFR	MSPA	MSR	IQD
Soil (S)	9.82 a	8.05 a	4.10 a	3.29 a	1.18 a
S+EB	6.62 b	3.05 b	2.31 b	1.09 b	0.52 b
S+PA	6.08 b	3.24 b	2.56 b	1.22 b	0.60 b
S+HU	6.59 b	3.53 b	2.54 b	1.21 b	0.57 b
S+PA+HU	4.50 b	2.50 b	1.59 b	0.82 b	0.40 b
S+EB+PA	5.95 b	2.96 b	2.15 b	1.08 b	0.54 b
S+EB+HU	5.28 b	3.05 b	1.73 b	0.95 b	0.46 b
DP	3.09	1.34	1.22	0.61	0.24
DMS	2.73	1.19	1.08	0.54	0.21

S = soil, EB = bovine manure, PA = coffee husk, HU = earthworm humus. SD = standard deviation, DMS = minimum significant difference.

Pinho et al. (2018) evaluated substrates containing soil, bovine manure and commercial substrate in two container sizes in the production of barueiro seedlings at 60 days after sowing and obtained greater shoot fresh (3.20 g) and dry (1.20 g) weight and root fresh (2.63 g) and dry (0.69 g) weight in substrate containing only soil. Berti et al. (2017) found results similar to those of the present study for MSPA (5.54 g) and MSR (3.95 g) of barueiro seedlings using Bioplant® commercial substrate.

Regarding the Dickson's quality index, the best result was found for substrate containing only soil (1.18) and the lowest value was found for substrate containing soil + coffee bark + earthworm humus (0.40), which did not differ statistically from the other treatments except for control (soil). The higher the IQD, the better the seedling quality standard, and Santos et al. (2013) consider IQD as a good seedling quality indicator as it takes into account in its calculation the robustness and balance of biomass distribution in the seedling, considering the results of several important parameters used for quality evaluation. Higher IQD (0.47) was found in barueiro seedlings using substrate containing only soil (PINHO et al., 2018), which value is lower than value found in the present study (1.18).

In Figure 1, the superiority of barueiro seedlings produced in substrate containing only soil (T1) was verified, compared to seedlings of the other treatments. The use of soil as substrate is a low-cost and easy-to-obtain alternative; however, its use can bring losses due to the possibility of contamination and often low fertility depending on the soil and species used.

FIGURE 1 - Barueiro seedlings produced under different substrates in the municipality of Nova Xavantina. T1 = soil (control), T2 = soil + bovine manure, T3 = soil + coffee husk, T4 = soil + humus, T5 = soil + coffee husk + humus, T6 = soil + coffee husk + bovine manure, T7 = soil + humus + bovine manure.

Thus, it was observed that the sources of organic matter used in the formulation of substrates for the production of barueiro seedlings impaired seedling growth. It is considered that the characteristics of the soil used in the present work met the requirement of barueiro seedlings. The use of soils with distinct characteristics is suggested in future works with this crop to verify whether or not there is need for the use of organic matter in substrates.

CONCLUSIONS

Under the conditions of this work, the use of soil in the formulation of substrates for the production of barueiro seedlings is recommended.

The addition of organic matter negatively interferes with seedling development.

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