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SIDEROXYLON OBTUSIFOLIUM (ROEM. & SCHULT) T.D. PENN. SEEDLING PRODUCTION IN DIFFERENT SUBSTRATES

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ABSTRACT

The species *Sideroxylon obtusifolium* (Roem. & Schult.) T.D. Penn., belongs to the Sapotaceae family, is native to the Caatinga, and currently some of its populations are going through an increasingly scarcity. Studies focused in the obtaining of seedlings of forest species using industrial residues as components of substrates have been the subject of some research, however, there is lack of information for many species, including for *Sideroxylon obtusifolium*. The objective of this study was to evaluate the growth of *Sideroxylon obtusifolium* seedlings in different substrate composition. The experiment was carried out in a randomized block design in a protected environment located at the Departamento de Fitotecnia e Ciências Ambientais of Centro de Ciências Agrárias of Universidade Federal da Paraíba, Areia–PB. The substrates evaluated were formulated from the mixture of washed sand (75-100%), subsoil (75-100%), kaolin waste (50-100%) and Basaplant® commercial substrate, totaling 13 treatments. The plants were measured 195 days after transplanted for the following variables: plant height, stem diameter, height/stem diameter ratio, number of branches, root length, shoot and root dry matter, total dry matter, dry matter ratio of shoot/roots and Dickson quality index. The kaolin waste and bovine manure can be used in the composition of the substrates for the production of *Sideroxylon obtusifolium* seedlings, the substrate formulated with subsoil soil (55%) + washed sand (20%) + kaolin waste %) + EB (5%) is recommended for the production of seedlings of this species. Among the substrates evaluated, that composed of 100% subsoil soil (S_1) and subsoil soil associated only with washed sand (S_3) are not adequate because they do not promoted the obtaining of vigorous seedlings.

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INTRODUCTION

Brazil stands out among other countries for its animal and vegetal diversity and, at the same time, as one of the most damaging countries to the environment and natural resources. Among its forest formations, the Caatinga is distributed in the States of the Northeast (Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia) and in the northern region of Minas Gerais (FERREIRA; PRATA; MELLO, 2013). The species *Sideroxylon obtusifolium* (Roem. & Schult.) TD. Penn., popularly known as quixaba, quixabeira, rompe-gibão, among other names, belongs to the Sapotaceae family, has dense canopy, height that ranges from 7 to 18 meters, and is found in humid wetlands and riverside of the Northeastern Caatinga.

This taxon has environmental importance (maintenance of ecological balance and recovery of degraded areas), economic (wood of quality and edible fruits) (LORENZI, 2002) and pharmaceutical (antinociceptive and anti-inflammatory properties) (AQUINO *et al.*, 2017). The removal of the bark due to its high medicinal utility has made the species susceptible to disappearance, what requires indispensable measures aiming the conservation of this species (MELO; AMORIM; ALBUQUERQUE, 2009). Due to the environmental problems of the Caatinga, in addition to the economic potential of quixabeira (*Sideroxylon obtusifolium*), studies that lead to a fast production, high quality, and efficient production model systems of its seedlings are essential. In the last years, the propagation of seedlings in nurseries has been developed seeking alternatives for increasingly efficient substrates, taking into account the maintenance of natural resources and costs reduction (MARANHO; PAIVA, 2012). Independently of the materials used in the formulation of substrates, satisfactory results of emergence, initial growth and development of plants depends on characteristics such as structure, texture, water retention capacity, nutrient availability (SILVA *et al*., 2008), pH and absence of pathogens (ARAÚJO *et al*., 2013). Organic fertilizers, such as manure, have been used in substrates for forest seedlings production, improving the physico-chemical properties, such as nutrient availability, porosity, aggregation and water retention. Due to the increasing technological development, the amount of discarded waste has increased, which is aggravated by the decrease of available areas for disposal of industrial waste (VERAS; POVINELLI, 2004), resulting in the inappropriate disposals, and consequently, environmental disturbances. Industrial waste represents losses of raw materials and energy and, after being generated, it needs an adequate destination, since many of them can create environmental problems (KLEIN, 2015) given its non-specific utilization (MIZOBATA; CASSIOLATO; MALTONI, 2017).

The use of residues of different sources in the formulation of substrates for forest seedlings production is of great importance, making possible reduction in cost production, it also contributes to reduction of disposal in inappropriate areas. One of the most environment damaging industrial waste is the kaolin waste resulted of its industrial exploitation. This product has been highlighted as a potential polluter. From the total kaolin extracted, 70% are discarded as rejects, resulting in air, soil and water pollution (ROLIM, 2003). An alternative to minimize the problems caused by the deposition of this residue is recycling (MENEZES *et al*., 2007) or its use as a substrate component for the seedlings production (OLIVEIRA, et al., 2014). Considering the lack of research related to the formulation of substrates, especially focused on the incorporation of kaolin mining residues, the objective of this study was to evaluate the growth of *Sideroxylon obtusifolium* seedlings in different substrate compositions.

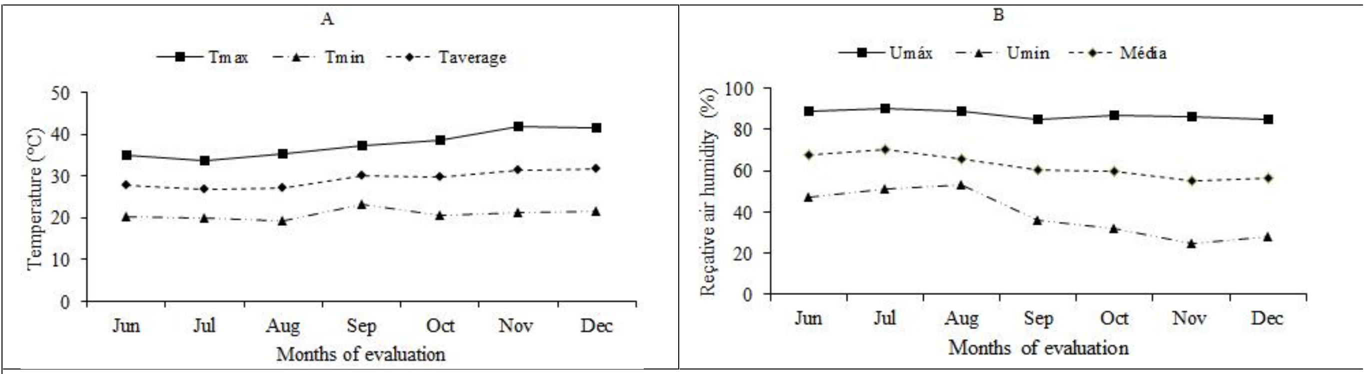
MATERIAL AND METHODS

The experiment was carried out from June to December of 2015, in a protected environment at the Laboratório de Análise de Sementes of the Departamento de Fitotecnia e Ciências Ambientais of the Universidade Federal da Paraíba, *Campus* II, Areia– PB. The local climate, according to Köppen (1948), is classified as type AS ', a tropical, semi-humid, with rains in the autumn-winter season. During the research conduction, air temperature and relative humidity data (maximum, minimum and average) of the protected environment were collected using a hygrometer, expressed in degrees Celsius (°C), and percentage (%), respectively (Figure 1). Fruits *of Sideroxylon obtusifolium* were obtained from matrix trees located in the rural area of Boa Vista - PB, at the geographic coordinates 7° 13'50 " S, 36° 13'57.7 'W (Campina Grande microregion). The harvest was carried out directly in the canopy of the plants with aid of a trimmer and, after harvested, the fruits were taken to the Laboratório de Análise de Sementes (LAS) and placed in buckets with water, to ferment for five days. The fruits were then rubbed in sieves, tap water was added for pulp removal and seed cleaning. After cleaned, the seeds were placed in a laboratory environment in plastic trays lined with paper towel to dry for 48 hours. In order to obtain seedlings of *Sideroxylon obtusifolium*, seeds were scarified with sandpaper #80 without imbibition (REBOUÇAS *et al*., 2012 - adapted), seeded in polyethylene trays (47 x 33 x 7 cm), containing vermiculite as substrate. After placed in the trays, the seeds were covered with a layer of vermiculite so that they were not visible. After emergence, the appearance of the first pair of leaves and when the seedlings were about 5 cm tall, they were transferred to black polyethylene bags with dimensions of 15 x 28 cm (width x height) with different compositions of substrates. This polyethylene bags were determined as the best for this species in a preliminary test. The seedlings were transplanted at the end of the afternoon, in order to reduce the stress caused by the temperature and, thus, favor the seedlings survival index.

The substrates (treatments) used were formulated from the mixture of subsoil soil (SS), washed sand (WS), bovine manure (BM), kaolin waste (KW), and commercial Basaplant® substrate, in a total of 13 compositions, which were submitted to the physico-chemical analysis in the Laboratório de Química e Fertilidade do Solo of *Campus* II, at the Universidade Federal da Paraíba. The substrates used are listed in Table 1.The *Sideroxylon obtusifolium* seedlings were evaluated at the end of the experiment (195 days after transplanted), for: a) Plant height (H) - measured with a ruler graduated in centimeters from the substrate level until the apical meristem (cm plant^{-1}); b) Stem diameter (SD) - measured with a digital caliper, accuracy of 0.01 mm, at the base of the plant stem (mm plant^{-1}); c) Height/Stem diameter ratio (H/SD) - resulted from the division of the values obtained for height and stem diameter; d) Number of branches (NB) - obtained by manual counting of the main branches, originated from the stem (branches plant^{-1}); e) Root length (RL) - measured with a ruler graduated in centimeters (plant^{-1}). For this, the seedling bags were cut laterally and the substrate adhered to the roots was removed, in order to avoid damages or losses; f) Height/Root length ratio - Resulted from the division of height and root length values; g) Shoot (SDM) and root dry matter (RDM) - shoots and roots were previously washed (in order to remove the substrate adhered to its parts), placed separately in Kraft paper bags and taken to a stove of forced air circulation, regulated at a temperature of 65 °C until reach a constant weight (g plant^{-1}); h) Total dry matter (TDM) - obtained by the sum of the dry matter of roots and shoots (g plant^{-1}); i) Shoot and root dry matterratio (SDM/ RDM) - obtained by the division of thevalues obtained for shoot and root dry matter; Dickson quality index - calculated according to the formula: DQI= $\frac{TI\ \ (g)}{\frac{H(C\ \ )}{S\ \ (m\ \ )}+\frac{SI\ \ (g)}{Ri\ \ (g)}}$(DICKSON; LEAF; HOSNER, 1960). A randomized block experimental design was used, with four replications, and the experimental unit composed of eight seedlings. Data obtained from the evaluations in time were submitted to analysis of variance by the F test ($p \leq 0.05$) and polynomial regression, and the linear and quadratic models were evaluated, the models with the highest significant degree and coefficient of determination ($R^2 \geq 0.5$) were chosen. The data obtained at the end of the experiment were submitted to analysis of variance and the Scott and Knott grouping test at 5% of probability. The SISVAR software (FERREIRA, 2011) was used.

RESULTS AND DISCUSSION

As observed in Table 2, the substrates that had no bovine manure in its composition, S_1, S_2, S_3 and S_9presented the lowest values for pH, what indicates high acidity low levels of phosphorus (P). The addition of bovine manure, in the substrates containing kaolin waste and in those without it, resulted in the decrease of the aluminum content (Al^{3+}), and increases in pH, phosphorus (P), potassium (K), sum of bases (SB) and organic matter (OM). In the analysis of variance summary (Table 3) it is possible to observe that there was a significant effect for plant height, stem diameter, plant height/stem diameter ratio and number of branches per plant at the level of 1% probability by the F test. The values obtained for plant height, stem diameter, plant height/stem diameter ratio and number of branches of *Sideroxylon obtusifolium* seedlings are shown in Table 4. The commercial substrate S_2 promoted the lowest value (8.9 cm plant^{-1}), while intermediate values were obtained in the substrates S_1 (13.23 cm plant^{-1}) and S_3 (14.68 cm plant^{-1}), 195 days after transplanted. Although the pH of the substrate (S_9) was 4.1, the values obtained for the height was grouped among the best ones, however the seedlings that were developed in the substrates with manure had an increase of 3.96 cm plant^{-1} compared to the substrate S_9. The seedlings that were developed in the substrate S_5 presented the highest plant height (24.89 cm plant^{-1}), however, it did not differ from the other substrates with bovine manure (with and without kaolin waste) (Table 4). The combination of different materials in the formulation of substrates for the production of seedlings of forest species results in mixtures where nutritional properties cannot be easily predicted a condition that may favor or hinder the growth and development of plants.



Source: Authors (2015)

Figure 1. Meteorological data of temperature (A) and relative air humidity (B) of the experimental greenhouse, from June to December of 2015, Areia–PB

Table 1. Substrates used in the production of *Sideroxylon obtusifolium* seedlings

Substrates	Subsoil soil (%)	Basaplant® (%)	Washed sand (%)	Bovine manure (%)	Kaolin waste (%)
S_1	100	-	-	-	-
S_2	-	100	-	-	-
S_3	75	-	25	-	-
S_4	75	-	15	10	-
S_5	60	-	20	20	-
S_6	52,5	-	17,5	30	-
S_7	45	-	15	40	-
S_8	37,5	-	12,5	50	-
S_9	75	-	-	-	25
S_{10}	55	--	20	5	20
S_{11}	50	-	15	20	15
S_{12}	45	-	10	35	10
S_{13}	40	-	5	50	5

Source: Authors (2015)

Table 2. Physico-chemical properties of the substrates used in *Sideroxylon obtusifolium* seedlings production

Substrates	pH	P	K	Na^+	H^++Al^{+3}	Al^{+3}	Ca^{+2}	Mg^{+2}	SB	CEC	OM	Sand	Silt	Clay
	$Water_{(1:2,5)}$	---mg/dm³---		------------------------------cmolc/dm³-----------------------------							------------------g/kg------------------			
S_1	4,1	6,10	60,23	0,14	7,71	0,60	0,31	0,35	0,95	8,66	20,69	554	68	121
S_2	4,2	207,34	280,28	0,10	10,38	0,20	2,45	0,62	3,89	14,27	11,38	-	-	-
S_3	4,3	4,02	35,62	0,04	4,82	0,55	0,07	0,44	0,64	5,46	21,88	716	52	232
S_4	5,2	86,71	556,77	0,23	3,25	0,05	0,37	0,54	2,57	5,82	36,53	658	66	276
S_5	5,9	198,57	1134,22	0,74	3,18	0,00	0,72	0,66	5,03	8,22	32,57	686	105	209
S_6	6,5	305,17	1514,43	0,74	2,67	0,00	0,86	0,90	6,39	9,06	69,78	685	105	210
S_7	6,9	485,34	2221,38	0,97	2,90	0,00	1,19	0,30	8,15	11,06	85,13	705	107	188
S_8	6,7	608,46	2779,81	1,29	2,46	0,00	1,21	0,81	10,44	12,90	65,83	668	194	138
S_9	4,1	3,24	135,48	0,22	5,61	0,35	0,23	0,55	1,35	6,96	20,69	524	141	335
S_{10}	5,0	51,21	404,30	0,33	2,59	0,00	0,51	0,28	2,15	4,75	14,25	655	159	186
S_{11}	5,7	147,52	997,59	0,54	3,51	0,00	0,78	0,31	4,19	7,70	24,75	638	125	237
S_{12}	6,8	318,68	2589,56	0,86	2,57	0,00	1,56	0,40	9,46	12,04	132,64	620	161	219
S_{13}	6,9	585,94	2744,17	1,29	2,59	0,00	1,61	0,37	10,31	12,90	78,20	567	186	247

Source: Authors (2015) Where S_1 - SS (100%); S_2 - Basaplant® (100%); S_3 - SS (75%) + WS (25%); S_4 - SS (75%) + WS (15%) + BM (10%); S_5 - SS (60%) + WS (20%) + BM (20); S_6 - SS (52,5%) + WS (17,5%) + BM (30%); S_7 - SS (45%) + WS (15%) + BM (40%); S_8 - SS (37,5%) + WS (12,5%) + BM (50%); S_9 - SS (75%) + KW (25%); S_{10} - SS (55%) + WS (20%) + KW (20%) + BM (5%); S_{11} - SS (50%) + WS (15%) + KW (15%) + BM (20%); S_{12} - SS (45%) + WS (10%) + KW (10%) + BM (35%); S_{13} - SS (40%) + WS (5%) + KW (5%) + BM (50%); pH = hydrogen potential; SB = sum of bases; CEC = cation exchange capacity; OM = organic matter.

Table 3. Analysis of variance Summary for plant height (H) - (cm plant^{-1}), stem diameter (SD) - (mm plant^{-1}), plant height/ stem diameter ratio (H/SD) and number of branches (NB) of *Sideroxylon obtusifolium* seedlings in different substrate composition

SV	DF	MQ			
		H	SD	H/SD	NB
Block	3	6,554	0,113	0,245	4,946
Substrates	12	107,972**	2,097**	1,270**	6,730**
Residue	36	7,5378	0,117	0,282	1,201
Total	51	-	-	-	-
CV(%)	-	13,22	9,07	9,71	29,08

Source: Authors (2015) Where: ** F value significant at 1% probability by the F test; MQ = mean square; SV = source of variation; DF = degree of freedom; CV (%) = coefficient of variation.

When evaluating different organic residues in the production of candlestick seedlings [*Senna alata* (L.) Roxb] Faria et al. (2013) found that the highest shoot growth was obtained with substrates composed of 60% sewage sludge + 40% organic compost and 20% sewage sludge + 80% organic compost, 150 days after sowing. For *Schinus terebynthifolius* seedlings production, the sewage sludge doses in combination with carbonized rice husk should be between 40 and 60% (TRIGUEIRO; GUERRINI, 2014). For stem diameter, the substrates that contained bovine manure in the percentages of 5, 20 and 35%, associated with the pre-established concentrations of subsoil, washed sand and kaolin waste (S_{10}, S_{11}, S_{12}) promoted the highest values, followed by substrates S_4 and S_5 (Table 4). Still according to the data in Table 4, for the substrates with manure and without kaolin waste, the increments in diameter were smaller in those with manure in 30 to 50%, while for those that had manure and waste, the decrease in the diameter was verified when constituted of 50% manure.

Since the addition of 50% bovine manure in the substrate S_8 and S_{13} provided intermediate values for the stem diameter of the seedlings (Table 4), the use of 50% bovine manure to increment this variable is considered infeasible. The use of the kaolin waste with the minimum of bovine manure (S_{10}) favored the production of *Sideroxylon obtusifolium* seedlings with a satisfactory diameter, what indicates, again, the possibility of incorporation of this residue in the production of seedlings without the use of excessive doses of bovine manure. For the production ofjatobá (*Hymenaea courbaril* L.) seedlings, the substrate was formulated with 40% of subsoil and 60% of kaolin waste, combined with a volume of 1.090 cm^3 and 1.660 cm^3, which promote a greater growth in stem diameter (OLIVEIRA *et al*., 2014). The substrate S_2 promoted the lowest value (3.73) for plant height and stem diameter ratio (H/SD), statistically different from the other treatments, which were statistically not different among themselves, considered as an inadequate characteristic for the differentiation of seedlings in terms of quality (Table 4). For the seedlings with a higher H/SD ratio, there is a tendency of it to be thinner (GOMES *et al*., 2002), the lower this ratio is, greater are the chances of survival and establishment at the definitive site (GOMES; PAIVA, 2012).

The highest number of branches of *Sideroxylon obtusifolium* was observed when produced in the substrates with the highest percentages of bovine manure S_7, S_8 and S_{13}, which were statistically not different. In the other substrates, except for S_2, the values were intermediate (Table 4). When evaluated the growth, nutrition and quality of guapeva seedlings [*Pouteria gardneriana* (A. DC.) Radlk.] (Sapotaceae), Mota *et al*. (2016), verified that the mixture of subsoil and bovine manure, in the proportion of 3:1, favored the growth and quality of the seedlings. The species *Sideroxylon obtusifolium*, in the seedling stage, is characterized by having a large number of leaves, which are small and well distributed throughout the above ground part of the plant, which makes its quantification a complex activity. For species with this characteristic, the determination of the number of branches, a variable that receives low attention in research aimed at the production of seedlings, becomes an important tool in understanding the effect of the different substrates in the formation of vigorous plants, since it may help in the selection of those seedlings with greater chances of survival, after planted at the definitive site.
It was observed that, except for the root length, there was a significant effect for the variables: plant height and primary root length ratio, shoot and root dry matter, total dry matter, shoot dry matter / primary root ratioand Dickson quality index at 1% probability level by the F test (Table 5).

No statistical difference was found for the root length of *Sideroxylon obtusifolium* seedlings, which is explained by the fact that they reached the bottom of the recipient used, during the period required for the evaluation of the seedlings (Table 6). Therefore, it is important to highlight that the longer the seedling remains in the nursery stage, the greater the growth of the root system and, consequently, the greater the risk of damage during the transplantation (ZACCHEO *et al*., 2013).

Seedlings with a well-developed root system have higher chances of survival in the field due to its better absorption of water and nutrients (AZEVEDO *et al*., 2010). The ratio between the plant height and the root of plants is a variable that show us how much the shoot was superior or inferior to the root length. Among the substrates that contained manure and no kaolin waste, the highest values were found in the substrates S_4, S_5 and S_8. For the substrates with kaolin and bovine manure, only S_{11} stood out among the others, which did not statistically differ from the previous mentioned treatments (Table 6).
The commercial substrate S_2, which was formulated exclusively with subsoil soil (S_1), the substrates that had 75% of this material in its composition, and the substrate with no bovine manure (S_3 and S_9), resulted in seedlings with the lowest shoot dry matter, indicating the positive influence of manure in phytomass production. These substrates provided the lowest pH values, and ranged from 4.1 to 4.3, considered a high acidity level, according to fertility analysis (Table 1). The low pH of the substrate S_9 indicated that this residue did not influence positively in this characteristic and did not provided the values for substrates used in the seedling production (6.0 to 7.0).

The negative influence of substrate acidity in shoots of *Sideroxylon obtusifolium* is more related to the dry matter (reduction in number of branches) than to the seedlings height, since the substrate S_9 had no statistical difference for shoot length compared to those with manure in its composition. No direct influence on the chemical properties of the substrates by the kaolin waste was observed, which may explain its low efficiency in the growth of *Sideroxylon obtusifolium* seedlings when associated with subsoil at the proportions of 3 to 1 (S_9). All substrates that contained bovine manure (with or with no addition of kaolin waste) resulted *Sideroxylon obtusifolium* seedlings with higher SDM, and the substrate S_8 resulted in plants with a more homogeneous distribution, since the highest values, from the statistical perspective, were obtained in this substrate for number of branches, H/RL and SDM/RDM ratio. The increase in shoot dry matter of *Sideroxylon obtusifolium* seedlings, observed in the substrate S_{13}, is more related to the number of branches than to height increases, since their H/RL ratio did not stand out between the highest values obtained.

Although the substrate S_{10} had a 5.0 pH, this can be considered the minimum value tolerated by *Sideroxylon obtusifolium* seedlings under the evaluated conditions, given the good results obtained for the morphological characteristics. However, the use of subsoil, although commonly used for the production of native tree species seedlings, usually has high acidity and low availability of nutrients (FREITAS *et al*.,2017)what requires the pH to be corrected with limestone, mineral and organic fertilizers (ARTUR *et al*., 2007). The root dry matter indicated a greater or lesser influence of the substrates used in the production of secondary roots, since no statistical differences were observed for root length (Table 6). The addition of bovine manure (10 and 20%) to the subsoil soil (75 and 60%) and the washed sand (15 and 20%) S_4 and S_5, respectively, in addition to the incorporation of 5% of manure to the mixture composed of SS (55%) + WS (20%) + KW (20%) - (S_{10}) resulted in the highest values. The seedlings that grew on substrates S_1 and S_2 had the lowest values for this variable. Similar to what was observed for stem diameter, increased phosphorus (P) with incorporation of bovine manure did not increase root dry matter (S_6, S_7, S_8, S_{11}, S_{12} and S_{13}). The absence or deficiency of this nutrient in the substrate impairs the root development, especially of secondary roots, reducing the ability of the seedlings to absorb water and other nutrients necessary for its development (SILVA *et al*., 2010). Based on these results it could be observed that the lower concentrations of manure in the substrate are sufficient to improve the root system observed by the increases in dry matter. For seedlings of camboatã (*Cupaniavernalis* Cambess.) The substrates composed of Plantmax® + wood sawdust + bovine manure, and, Plantmax® + carbonized rice husk + bovine manure provided the best results for seedling height, stem diameter, shoot and root dry matter, components indicated for the production of seedlings of the species in specific concentrations (BORTOLINI *et al*., 2016).

Table 4. Height (H) - (cm plant^{-1}), stem diameter (SD) - (mm plant^{-1}), height/stem diameter ratio (H/SD) and number of branches (NB) of seedlings of *Sideroxylon obtusifolium* in different substrates

Substrates	H	SD	H/SD	NB
S_1 - SS (100%)	13,23b	2,68c	5,13a	3,21b
S_2 - Basaplant®	8,90c	2,36c	3,73b	0,78c
S_3 - SS (75%) + WS (25%)	14,68b	2,75c	5,48a	2,96b
S_4 - SS (75%) + WS (15%) + BM (10%)	24,46a	4,49a	5,52a	4,15b
S_5 - SS (60%) + WS (20%) + BM (20%)	24,89a	4,48a	5,64a	3,78b
S_6 - SS (52,5%) + WS (17,5%) + BM (30%)	23,70a	4,03b	5,81a	3,46b
S_7 - SS (45%) + WS (15%) + BM (40%)	22,48a	3,89b	5,72a	4,87a
S_8 - SS (37,5%) + WS (12,5%) + BM (50%)	24,37a	4,08b	6,04a	6,21a
S_9 - SS (75%) + KW (25%)	19,75a	3,65b	5,45a	3,75b
S_{10} - SS (55%) + WS (20%) + KW (20%) + BM (5%)	23,92a	4,23a	5,66a	2,90b
S_{11} - SS (50%) + WS (15%) + KW (15%) + BM (20%)	24,15a	4,32a	5,50a	3,78b
S_{12} - SS (45%) + WS (10%) + KW (10%) + BM (35%)	24,15a	4,36a	5,65a	3,87b
S_{13} - SS (40%) + WS (5%) + KW (5%) + BM (50%)	21,29a	3,80b	5,70a	5,21a

Source: Authors (2015). Where: SS = subsoil soil; WS = washed sand; BM = bovine manure; KW= kaolin waste. Means followed by the same letter do not differ statistically from each other by the Scott-Knott test.

Table 5. Analysis of variance summary for the variables root length (RL) - (cm plant^{-1}), plant height/root length ratio (H/RL), shoot dry matter (SDM) and root dry matter (RDM) - (g plant^{-1}), total dry matter (TDM) - (g plant^{-1}), SDM/RDM ratio and Dickson quality index (DQI) of *Sideroxylon obtusifolium*in different substrates compositions

SV	DF	MQ						
		RL	H/RL	SDM	RDM	TDM	SDM/RDM	DQI
Block	3	19,568	0,008	0,096	0,001	0,114	0,049	0,002
Substrates	12	15,247^{ns}	0,067**	3,864**	0,809**	7,988**	0,714**	0,121**
Residue	36	12,917	0,005	0,119	0,036	0,247	0,049	0,004
Total	51	-	-	-	-	-	-	-
CV(%)	-	7,88	14,13	15,58	17,66	15,10	11,26	14,71

Source: Authors (2015). Where: ns F value not significant; *F value significant at 5% probability; ** F value significant at 1% probability; MQ = mean square; SV = source of variation; Trat. = Treatment; DF = degree of freedom; CV (%) = coefficient of variation.

Table 6. Root length (RL) - (cm plant^{-1}), plant height/root length ratio (H/RL), shoot dry matter (SDM) and root dry matter (RDM) - (g plant^{-1}) of *Sideroxylon obtusifolium* seedlings indifferent substrates

Substrates	RL	H/RL	SDM	RDM
S_1 - SS (100%)	43,09a	0,371c	0,747c	0,400e
S_2 - Basaplant®	46,58a	0,196d	0,171d	0,162e
S_3 - SS (75%) + WS (25%)	46,74a	0,355c	1,047b	0,666d
S_4 - SS (75%) + WS (15%) + BM (10%)	44,09a	0,627a	2,887a	1,512a
S_5 - SS (60%) + WS (20%) + BM (20%)	42,79a	0,625a	3,028a	1,638a
S_6 - SS (52,5%) + WS (17,5%) + BM (30%)	45,59a	0,567b	2,665a	1,272b
S_7 - SS (45%) + WS (15%) + BM (40%)	48,64a	0,504b	2,640a	1,122c
S_8 - SS (37,5%) + WS (12,5%) + BM (50%)	44,37a	0,622a	2,941a	1,169c
S_9 - SS (75%) + KW (25%)	46,78a	0,494b	1,547b	0,909c
S_{10} - SS (55%) + WS (20%) + KW (20%) + BM (5%)	48,29a	0,593b	2,700a	1,553a
S_{11} - SS (50%) + WS (15%) + KW (15%) + BM (20%)	43,79a	0,620a	2,956a	1,312b
S_{12} - SS (45%) + WS (10%) + KW (10%) + BM (35%)	47,57a	0,570b	2,953a	1,378b
S_{13} - SS (40%) + WS (5%) + KW (5%) + BM (50%)	44,93a	0,532b	2,525a	0,969c

Source: Authors (2015). Where: SS= subsoil soil; WS = washed sand; BM = bovine manure; KW = kaolin waste.
Means followed by the same letter do not differ statistically from each other by the Scott-Knott test.

Table 7. Total dry matter (TDM) - (g plant^{-1}), shoot dry matter/ root dry matter ratio (SDM/RDM) and Dickson quality index (DIQ) of *Sideroxylon obtusifolium* seedling sin different substrates

Substrates	TDM	SDM/RDM	DIQ
S_1 - SS (100%)	1,147d	1,860c	0,164e
S_2 - Basaplant®	0,333e	1,023d	0,069f
S_3 - SS (75%) + WS (25%)	1,712c	1,594c	0,244d
S_4 - SS (75%) + WS (15%) + BM (10%)	4,400a	1,925c	0,590a
S_5 - SS (60%) + WS (20%) + BM (20%)	4,666a	1,853c	0,622a
S_6 - SS (52,5%) + WS (17,5%) + BM (30%)	3,937a	2,104b	0,497b
S_7 - SS (45%) + WS (15%) + BM (40%)	3,762a	2,356b	0,464b
S_8 - SS (37,5%) + WS (12,5%) + BM (50%)	4,109a	2,522a	0,482b
S_9 - SS (75%) + KW (25%)	2,456b	1,755c	0,348c
S_{10} - SS (55%) + WS (20%) + KW (20%) + BM (5%)	4,253a	1,739c	0,573a
S_{11} - SS (50%) + WS (15%) + KW (15%) + BM (20%)	4,268a	2,248b	0,549a
S_{12} - SS (45%) + WS (10%) + KW (10%) + BM (35%)	4,331a	2,196b	0,555a
S_{13} – SS (40%) + WS (5%) + KW (5%) + BM (50%)	3,493a	2,585a	0,420b

Source: Authors (2015) Where: SS = subsoil soil; WS = washed sand; BM = bovine manure; KW = kaolin waste. Means followed by the same letter do not differ statistically from each other by the Scott-Knott test. Source: Authors (2015)

All substrates with bovine manure in its composition resulted in higher total dry matter content of *Sideroxylon obtusifolium* seedlings (Table 7). The minimum concentration of bovine manure in the composition of the substrates S_4 and $S_{10}$was enough to provide satisfactory results for this variable. Only the substrates S_8 and S_{13} promoted the highest indexes for the shoot and root dry matter ratio (Table 7). This is an important characteristic to be evaluated when the seedlings are sent to the field, being recommended that the shoots must have twice the length of the root (2:1 ratio) considering that if the shoot length is much higher than the root length, problems of water absorption to the shoots may occur (CALDEIRA *et al*., 2008).
The Dickson quality index of (DQI) is considered an excellent indicator of seedlings quality, since it has as reference the robustness (H/SD) and the balance of biomass distribution (SDM/RDM). The seedlings with highest DQI are considered seedlings of higher quality (CAVALCANTE *et al*., 2016). The highest DQI were observed in the treatments S_4, S_5, S_{10}, S_{11} and S_{12}, which did not statistically differ from each other (Table 7). These results confirm that lower quantities of manure associated with the subsoil soil and washed sand (S_4), or subsoil soil, washed sand and kaolin waste (S_{10}) was sufficient to produce vigorous *Sideroxylon obtusifolium* seedling. It can be concluded that, eight of the variables evaluated at 195 days after the beginning of the experiment (H, SD, H/SD, RL, SDM, RDM, TDM and DQI) indicated that the treatment with the lowest percentage of manure and without kaolin waste (S_4) was statistically equal to that with the lowest concentration of manure, but composed of kaolin waste (S_{10}). This indicates that the residue of the kaolin industry can be efficiently incorporated into the production of *Sideroxylon obtusifolium* seedlings when a minimal quantity of manure is used. This study showed that kaolin waste can be efficiently used in the production of *Sideroxylon obtusifolium* seedlings, and resulted in seedlings of good quality and, consequently, may reduce environmental impacts resulted from inadequate disposals in the environment.

CONCLUSION

Kaolin waste and bovine manure can be used in the composition of substrates for *Sideroxylon obtusifolium* seedlings the production; Substrate formulated with subsoil soil (55%) + washed sand (20%) + kaolin waste (20%) + BM (5%) is recommended for the production of seedlings of this species; Pure and associated soil (75%) with washed sand and kaolin waste (25%) is not indicated for the *Sideroxylon obtusifolium* seedlings production.

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REFERENCES

Aquino, P.E.A.*et al*. 2017. The anti-inflammatory effects of N-methyl-(2S,4R)-trans-4-hydroxy-L-proline from *Syderoxylon obtusifoliumare* related to its inhibition of TNF-alpha and inflammatory enzymes. Phytomedicine, [s.l.], v.24, p.14-23.

Araújo, A.C.*et al*. 2013. Utilização de substratos orgânicos na produção de mudas de mamoeiro Formosa. Revista Brasileira de Agroecologia, Pelotas, v.8, n.1, p.210-216.

Artur, A.G.*et al*. 2007. Esterco bovino e calagem para formação de mudas de guanandi. Pesquisa Agropecuária Brasileira, Brasília, Brasília, v.42, n.6, p.843-850.

Azevedo, I.M.G.*et al*.O. 2010. Estudo do crescimento e qualidade de mudas de marupá (*Simarouba amara*) em viveiro. Acta Amazônica, Manaus, v.40, n.1, p.157-164.

Bortolini, M.F. *et al*. 2016. Growth of *Cupania vernalis* seedlings produced under different substrates. Científica, Jaboticabal, v.44, n.4, p.599-607.

Caldeira, M.V.W. *et al*. 2008. Composto orgânico na produção de mudas de aroeira-vermelha.Scientia Agraria, Curitiba, v.9, n.1, p.27-33.

Cavalcante, A. L. G. *et al*. 2016. Desenvolvimento de mudas de mulungu fertirrigadas com diferentes soluções nutritivas. Floresta, Curitiba, v. 46, n. 1, p. 47-55.

Dickson, A., Leaf, A.L., Hosner, J.F. 1960. Quality appraisal of white spruce and white pine seedling stock in nurseries. Forestry Chronicle, Mattawa, v.36, n.1, p.10-13.

Faria, J.C.T., Caldeira, M.V.W., Delarmelina, W.M., Rocha, R.L.F. Uso de resíduos orgânicos na produção de mudas de *Senna alata* (L.) Roxb. Ecologia e Nutrição Florestal, Santa Maria, v.1, n.3, p.133-146, 2013.

Ferreira, D. F. 2011. Sisvar: a computerstati sticalanalysis system. Ciência e Agrotecnologia, Lavras, v.35, n.6, p.1039-1042.

Ferreira, E.V.R., Prata, A.P.N., Mello, A.A. 2013. Floristic list from a Caatinga remnant in Poço Verde, Sergipe, Brazil. Check List, São Paulo, v.9, n.6, p.1354-1360.

Freitas, E.C.S., Paiva, H.N., Leite, H.G., Oliveira NETO, S.N. 2017. Crescimento e qualidade de mudas de *Cassia grandis* Linnaeus f. em resposta à adubação fosfatada e calagem. Ciência Florestal, Santa Maria, v.27, n.2, p.509-519.

Gomes, J.M., Couto, L., Leite, H.G., Xavier, A., GARCIA, S.L.R. 2002. Parâmetros morfológicos na avaliação da qualidade de mudas de *Eucalyptus grandis*. Revista Árvore, Viçosa, v.26, n.6, p.655-664.

Gomes, J.M; Paiva, H.N. 2012. Viveiros florestais: propagação sexuada. Viçosa, MG: Editora UFV. 116p.

Klein, C. 2015. Utilização de substratos alternativos para produção de mudas. Revista Brasileira de Energias Renováveis, Palotina, v.4, n.3, p.43-63.

Köppen, W. 1948. Climatologia:conunestudio de los climas de latierra. Fondo de Cultura Econômica. México. 479p.

Lorenzi, H. 2002. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas do Brasil. 2.ed. Nova Odessa: Instituto Plantarum. 384p.

Maranho, A.S., PAIVA, A.V. 2012. Produção de mudas de *Physocalymma scaberrimum* em substratos compostos por diferentes porcentagens de resíduo orgânico de açaí. Floresta, Curitiba, v.42, n.2, p.399-408.

Melo, J.G., Amorim, E.L.C., Albuquerque, U.P. 2009. Native medicinal plantscommercialized in Brazil - priorities for conservation. Environmental MonitoringAssessement, [s.l.], v.156, n.1-4, p.567-580.

Menezes, R.R. *et al*. 2007. Utilização do resíduo do beneficiamento do caulim na produção de blocos e telhas cerâmicos. Revista Matéria, Rio de Janeiro, v.12, n.1, p.225-235.

Mizobata, K.K.G.S., Cassiolato, A.M.R., Maltoni, K.L. 2017. Crescimento de mudas de baru e gonçalo-alves em solo degradado, suplementado com resíduo, em Ilha Solteira-SP. Ciência Florestal, Santa Maria, v.27, n.2, p.429-444.

Mota, C.S. *et al*. 2016. Growth, nutrition and quality of *Pouteria garderiana* (A. DC.) Radlk. seedlings produced in organic substrates. Cerne, Lavras, v.22, n.4, p.373-380.

Oliveira, L. S. B., Andrade, L. A., ALVES, A. S., Gonçalves, G. S. 2014. Substrato e volume de recipiente na produção de mudas de jatobá (*Hymenaeacourbaril* L.). Nativa, Sinop, v. 2, n. 2, p. 103-107.

Rebouças, A.C.M.N. *et al*. 2012. Métodos para superação da dormência de sementes de quixabeira (*Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn.). Revista Ciência Florestal, Santa Maria, v.22, n.1, p.183-192.

Rolim, H.O. 2003. Potencial de uso agrícola do rejeito de caulim. 2003. 100f. Dissertação (Mestrado em Manejo de Solo e Água) - Universidade Federal da Paraíba, Centro de Ciências Agrárias, Areia.

Silva, E.A.*et al*. 2008. Germinação da semente e produção de mudas de cultivares de alface em diferentes substratos. Semina: ciências agrárias, Londrina, v.29, n.2, p.245-254.

Silva, E.A.*et al*. 2010. Composição de substratos e tamanho de recipientes na produção e qualidade das mudas de maracujazeiro ‘amarelo’. Ciência e Agrotecnologia, Lavras, v.34, n.3, p.588-595.

Trigueiro, R.M., Guerrini, I.A. 2014. Utilização de lodo de esgoto na produção de mudas de aroeira-pimenteira. Revista Árvore, Viçosa, v.38, n.4, p.657-665.

Veras, L.R.V., Povinelli, J.A. 2004. Vermicompostagem do lodo de lagoas de tratamento de efluentes industriais consorciada com composto de lixo urbano. Revista Engenharia Sanitária e Ambiental, Campina Grande, v.9, n.3, p.218-224.

Zaccheo, P.V.C., Aguiar, R.S., Stenzel, N.M.C., Neves, C.S.V.J. 2013. Tamanho de recipientes e tempo de formação de mudas no desenvolvimento e produção de maracujazeiro-amarelo. Revista Brasileira de Fruticultura, Jaboticabal, v.35, n.2, p.603-607.

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