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SHADING LEVELS ON GROWTH OF *SIDEROXYLON OBTUSIFOLIUM* (ROEM. & SCHULT.) T.D.PENN. SEEDLINGS

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ABSTRACT

The species *Sideroxylon obtusifolium* (Roem. & Schult.) T.D.Penn. has environmental, economic, ecological and social importance, but despite that, the native populations are difficult to be located. The objective of this study was to evaluate the production of *Sideroxylon obtusifolium* seedlings at different levels of shading. The experiment was carried out in the forest nursery of the Universidade Federal da Paraíba, in Areia - PB. The seedlings were produced at the following levels of shading: full sun (0), 30, 50 and 70%, in black polyethylene bags with dimensions 15 x 28 cm (width x height), containing substrate formulated with subsoil soil (55%) + washed sand (20%) + kaolin waste (20%) + bovine manure (5%). The plants were measured every 30 days for the following variables: plant height, stem diameter and plant height/stem diameter ratio. In the last evaluation, in addition to the previous mentioned variables, the following variables were determined: number of branches, root length, roots dry matter, leaves, stems, shoots, and total dry matter, shoot dry matter/root dry matter ratio, Dickson quality index, percentage of leaves and roots. The initial development of *Sideroxylon obtusifolium* in the nursery was consistent with the expected patterns for the occurrence species in the Caatinga, with a stabilization of growth of its morphological characteristics in the lower levels of shading, investing in the formation of roots and in the height/stem diameter ratio. For the production of seedlings is recommended environment of full sun light or with up to 15% of shading.

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INTRODUCTION

Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn. species (Sapotaceae), commonly known as quixaba, quixabeira, gibão, among other names (Lorenzi, 2002), is a tree that can reach up to 18 meters and is found in the Caatinga biome (Kiill & Lima, 2011). This species is known for its ecological importance, economic and medicinal potential, given its anti-bacterial activity (Leandro *et al*., 2013), antifungal properties (Pereira *et al*., 2016), the use of its leaves and bark in folk medicine (Aquino *et al*., 2016), as an antibiotic, against chronic inflammations, cardiac, respiratory and blood problems, menstrual disorders and intestinal tract pain (Albuquerque *et al*., 2011). In addition, its fruits, have a high concentration of sugars (Kiill *et al*., 2012), and can be commercially exploited (Garrido, *et al*., 2007).

There is lack ofinformation in the literature regarding native fruit trees, such as *Sideroxylon obtusifolium* (Garrido *et al*., 2007), especially on the propagation of the species under shaded conditions and that have the potential to recover degraded areas of the Caatinga. The Caatinga is a dry tropical forest, characterized for its high temperatures, associated with low annual precipitation (Azerêdo *et al*., 2016), shallow, often stony, and low fertility soils (Trovão *et al*., 2007; Santana & Souto, 2011). The reduction of plant species in the Caatinga is a result of deforestation, exploitation of the medicinal and/or artisanal properties of its species (Araújo & Sousa, 2011). The indiscriminate removal of natural vegetation has resulted in the loss of plant species that have never been studied and which, in addition to their ecological importance in their occurrence area, have medicinal, economic and consequently social potential (Gonçalves *et al*., 2011).

Considering the anthropic influence on the Caatinga, mitigating activities such as the production and planting of native seedlings, that aims the recovery of degraded areas, recovery of the soil, reestablishment of ecological processes of natural regeneration (pollination and dispersion), recharge of the water table through the roots, attraction of local fauna and recovery of its scenic beauty are necessary (Araújo Neto *et al*., 2003; Silva *et al*., 2011; Ferreira *et al*., 2016). Therefore, studies that promote the recovery of populations and the sustainable use of forest species, such as the production of seedlings, are of ecologicaland economic importance, which enable the elaboration of projects for reforestation activities, commercial plantations (Rocha *et al*., 2014) and management of preserved areas.
To guarantee an efficient production of seedlings by thesexual process, and the rational use of native species in the environment recovery, it is very important to use seeds of good quality (Piveta *et al*., 2010), in addition to adequate techniques, regarding recipient, substrate (Costa *et al*., 2015) and shade level, which will directly reflect in the quality of the final product (Dantas *et al*., 2011).

Therefore, the objective of this study was to evaluate *Sideroxylon* obtusifolium seedlings production under different shading levels.

MATERIAL AND METHODS

Place of Conduction of the Experiment: The experiment was carried out from December of 2015 through June of 2016 in the forest nursery of the Departamento de Fitotecnia e Ciências Ambientais of the Centro de CiênciasAgrárias of Universidade Federal da Paraíba (DFCA/CCA/UFPB), Areia-PB. The local climate, according toköppen (1948), is classified as type AS', a semi-humid tropical climate, with a rainy season during the fall-winter season. During the period of research, data on average temperature (°C), relative air humidity (%) and precipitation (mm) were obtained at the CCA meteorological station (Figure 1).

Place of Harvest of Fruits: Fruits of *Sideroxylon obtusifolium* were obtained from matrix trees located in the rural area of Boa Vista city/PB (7 °13'50 " S, 36 ° 13'57.7 'W), Northeast Brazil. The fruits were stored in plastic bags and taken to the Laboratório de Análise de Sementes (LAS), and immediately placed in buckets of water to ferment for five days. The fruits were rubbed in sieves, and tap water was added for pulp removal and seed cleaning. After cleaned, the seeds were placed in plastic trays covered with paper towel and placed to dry in a laboratory environment for 48 hours.

Seedlings Production and Shading Levels: 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 (Silva *et al*., 2014). After placed in the trays, the seeds were covered with a layer of vermiculite so that they were not visible. After emergence, appearance of the first pair of leaves, and when the seedlings reached approximately 5 cm, they were transferred to black polyethylene bags with dimensions of 15 x 28 cm (width x height), containing substrate formulated with subsoil soil (55%) + washed sand (20%) + kaolin waste (20%) + bovine manure (5%). This substrate was chosen based on its efficiency in the production of seedlings of this species and given its small percentage of manure (Cruz, 2018). The substrate used was analyzed in the Laboratório de Química e Fertilidade do Solo at the Centro de Ciências Agrárias of the Universidade Federal da Paraíba and presented the following properties: pH (in H_2O) = 5.0; exchangeable aluminum (Al^{3+}) (cmolc/dm)=0.0; calcium (Ca^{2+}) = 0.51 cmol/dm; phosphorus (P) = 51.21 mg/dm; magnesium (Mg^{2+}) = 0.28 cmolc/dm = potassium (K) = 404.30 mg/dm; organic matter (OM) = 14.25 g / kg; cation exchange capacity (CEC) = 4.75 cmolc/dm; sum of bases (SB) = 2.15 cmolc/dm^3. Plants were transplanted to polyethylene bags at the end of the afternoon, to reduce stress and favor the survival index. To evaluate the light intensity demand of the plants, black shading screens with different shading levels(treatments), expressed as a percentage, were used: N1 = 0% (full sunlight, control); N2 = 30%; N3 = 50% and N4 = 70%. The plants were irrigated according to necessity, maintaining the substrate wet (Silva *et al*., 2017).

Evaluated Variables: Seedlings of each treatment were evaluated at 15 (first evaluation - T0) to 195 (T-180) days after transplanted (last evaluation), with intervals of 30 days, for:plant height (H)- measured with a ruler graduated in centimeters from the substrate level until the apical meristem (cm plant^{-1});stem diameter (SD) - measured with a digital caliper, accuracy of 0.01 mm, at the base of the plant stem (mm plant-^{1}); height/ stem diameter ratio (H/SD) - resulted from the division of the values obtained for height and stem diameter; at 15 days after transplanted the survival index of the seedlings was also calculated. At the end of the experiment (195 days after transplanted) the following variables were evaluated: number of branches (NB)- obtained by manual counting of the main branches, originated from the stem (branches plant^{-1}); root length(RL)- measured with a ruler graduated in centimeters (cm plant^{-1}); root dry matter (RDM) - roots were previously washed (to remove the substrate adhered to its parts), and proceeded as described before to access dry matter weight; leaf dry matter (LDM), stem and branches dry matter(SBDM)-leaves were separated from the stem and branches (Böhm, 1979), placed separately, in Kraft paper bags and taken to astove of regulated air circulation at 65 °C until reach a constant weight, the results were expressed in g plant^{-1}; shoot dry matter (SDM) - obtained by the sum of leaves, branches and stem dry matter;total dry matter (TDM)- obtained by the sum of root and shoot dry matter (g plant^{-1});shoot/root dry matter ratio (SDM/ RDM)- obtained by the division of the values obtained for shoot and root dry matter;Dickson quality index-

calculated according to the formula: $DQI = \frac{TDM}{\frac{H}{SD} + \frac{SDM}{RDM}}$

(Dickson *et al*., 1960); leaf and root percentage - determined the division of leaf and root dry matter by the total total dry matter, and the result multiplied by 100.

Data Analysis: A randomized block experimental design was used, with four replications, and the experimental unit composed of ten seedlings, with a total of 160 seedlings. Data obtained from the evaluations in time were submitted to analysis of variance (ANOVA) and polynomial regression at 5% probability by the F test, the linear and quadratic models were evaluated and the models with the highest significant degree were chosen. Data obtained at 195 days of evaluation were submitted to analysis of variance and polynomial regression, where the shading levels were considered as quantitative factors. The SISVAR*software* (Ferreira, 2007) was used.

RESULTS AND DISCUSSION

Plant height had a significant effect for isolated factors, whereas only for stem diameter and height/ stem diameter ratio was observed a significant effect on the interaction between the shading levels and period of evaluation (Table 1). The seedlings height was influenced, independently, by the evaluation period and shading levels, with the highest increments observed at 60 days of evaluation (Figure 2A) and the regression curve estimated higher heights under shaded environment (Figure 2B). The stem diameter (SD), adjusted quadratically to all levels of shading according to the evaluation period. In the first evaluation, performed at 15 days after transplanted, the initial values of SD were higher under 50 and 70% shading, compared to those obtained under full sunlight and 30% shading. Between 30 and 60 days of evaluation, the values obtained were close at all levels, with a significant variation between 90 and 120 days, with the highest values obtained at the shading levels of 30%, full sunlight, 50 and 70% shading, respectively, up to 180 days of evaluation (Figure 2C). A crescent linear behavior was observed for height/stem diameter ratio of the seedlings under the shading levels of 70, 50 and 30%, respectively, according to the evaluation period, this indicates a rapid increase in height compared to stem diameter, as observed in Figure 2D. From a biological perspective, in forests, the shade caused by the trees induce young plants to invest in height, in

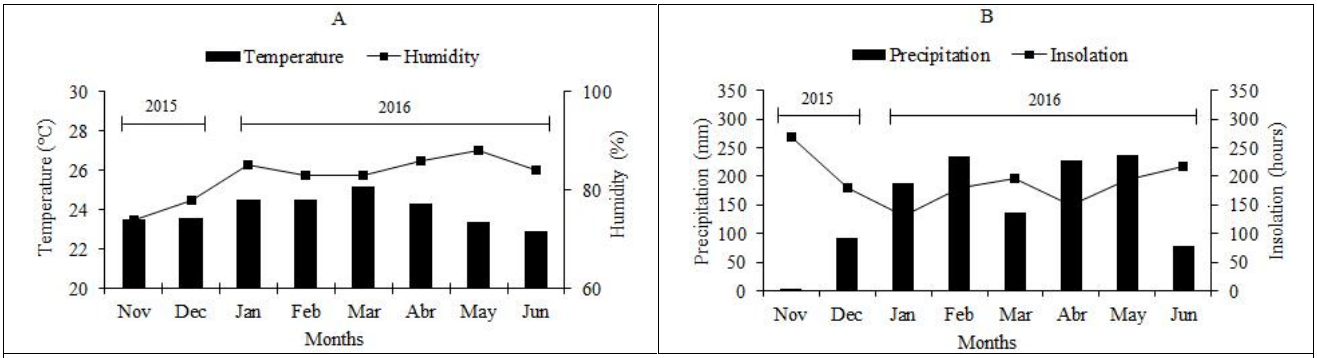

Figure 1. Meteorological data of average air temperature (A), precipitation and insolation (B) during the experiment, from December of 2015 through June of 2016. CCA / UFPB / Areia / PB

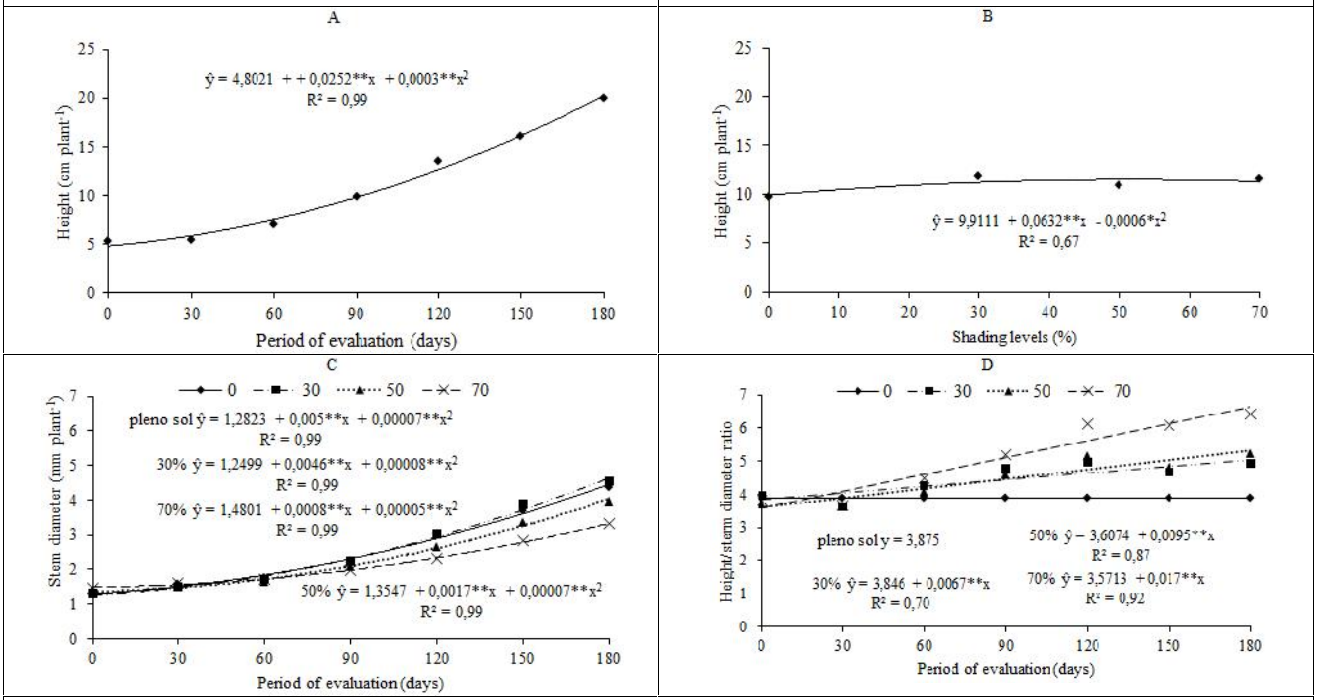

Figure 2. Plant height over time and at 180 days of evaluation, respectively (A-B), stem diameter (C) and height/stem diameter ratio (D) of *Sideroxylon obtusifolium* seedlings, at different levels of shading and evaluation period

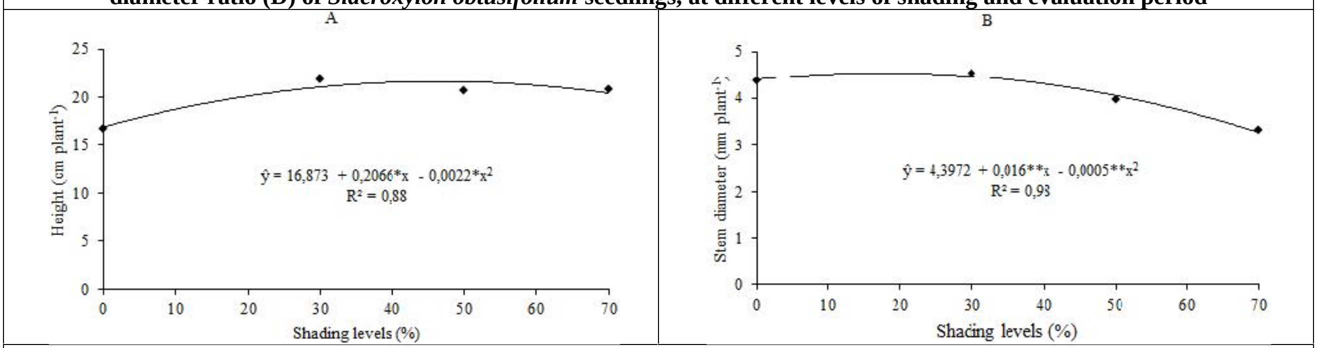

Figure 3 - Plant height (A) and stem diameter (B) of *Sideroxylon obtusifolium* seedlings produced under different shading levels, 195 days after transplanted

Table 1 -Summary of analysis of variance for plant height (H) - (cm plant^{-1}), stem diameter (SD) - (mm plant^{-1}) and plant height/stem diameter ratio (H/SD) of *Sideroxylon obtusifolium* seedlings under different shading levels and periods of evaluation

SV	DF	MS		
		H	SD	H/SD
Shading (S)	3	23,016**	1,074**	7,051**
Periods (P)	6	519,283**	16,887**	5,490**
S x P	18	3,286^{ns}	0,260**	0,913**
Residue	84	2,083	0,037	0,241
Total	111	-	-	-
CV (%)	-	13,11	8,04	10,99

^{ns} = non-significant; ** Significant F value at 1% probability; MS = mean square; SV = source of variation; DF = degree of freedom; CV (%) = coefficient of variation.

search for light, nevertheless, the diameter does not follow this growth. The increase in diameter is only observed after the plant reaches a sufficient level, in which photosynthetic requirements are completed. This behavior was expected for *Sideroxylon obtusifolium*, since it is a climax species (Scipioni *et al*., 2013) with seeds that germinate and seedlings that grow preferentially under shade. Similarly, pau-ferro seedlings (*Libidibia ferrea* var. *leiostachya* (Benth.) L.P.Queiroz (climax species) had a greater increase in stem diameter when produced under 50% shading compared to those under 70% shadingat 90 days after transplanted (Lenhard *et al*., 2013). The intensification of shading reduces the production of photoassimilates, this fact is apparently more related to growth in stem diameter than to shoot growth (Kozlowski, 1962). The plant growth traits are used to evaluate their tolerance, or not, to conditions of low light availability, since it may reflect the adaptability of the species to different environments according to their photosynthetic efficiency (Almeida *et al*., 2004), helping in the establishment of production patterns.

The survival index, evaluated at 15 days after transplanted under the shading levels of 0, 30, 50 and 70% was 77.5; 85; 70 and 85%, respectively, which were high and approximate for all shading levels. The high survival index of *Sideroxylon obtusifolium* seedlings under full sunlight was expected, given that this is a native Caatinga species and is, therefore, adapted to the xerophilic conditions of this biome. Regardless of the shading or sunlight conditions, the species *Sideroxylon obtusifolium* had a high survival index, which confirms the ease propagation of forest species, although adapted to semiarid conditions, can developwell under shade when produced in an environment in which the precipitation and temperature fluctuations are distinct from its natural environment. It is important to mention that *Sideroxylon obtusifolium*, similar to other species included in the ecological group of the climax species, has neutral photoblastic seeds (Silva *et al*., 2014), which means that these species do not require direct light for germination and posterior seedling growth (Carvalho *et al*., 2006). Determination of the survival index, is very important, since shading reduces the direct incidence of solar rays on plants and substrate, minimizes the loss of water by evaporation and favors the establishment of the seedlings.

Other species of Caatinga vegetation also had high survival index, as observed for timbaúva [*Enterolobium contortisiliquum* (Vell.) Morong], with survival index higher than 80%, under full sunlight until 25 days after transplanted (Melo *et al*., 2008). Ipê-roxo seedlings (*Tabebuia avellanedae* Lorentz ex Griseb.), climax species, under sunlight and submitted to 30, 60 and 80% shading had 100% of survival index (Engel & Poggiani, 1990). The survival indexof mulungu seedlings (*Erythrina velutina* Willd.), a secondary species, under full sunlight was 68%, 25 days after sown (Melo & Cunha, 2008), however it was low compared to other shading levels (20, 40, 60 and 80%). Chaves & Paiva (2004) evaluated the influence of different shading periods on the survival of fedegoso seedlings [*Senna macranthera* (DC. ex Collad.) H.S.Irwin & Barneby], a pioneer species, and found that the increase in theshadingperiod resulted in a higher survival index.A significant effect was observed by the F test for all variables, as observed in Table 2.

Data obtained for height and stem diameter were adjusted to the quadratic regression models (Figure 3A-B). As the level of shading increased, an increase in seedling height was observed, with a maximum value (21.7 cm) under 47% shading, with a subsequent decrease (Figure 3A). This means that an optimum shading range, around 50%, favors the development of *Sideroxylon obtusifolium* seedlings that, in its natural habitat, is only possible in preserved areas, by the shading provided by the tree canopies already established. This suggests that, in anthropic areas, the germination and the establishment of new individuals of *Sideroxylon obtusifolium* are compromised, and the production of seedlings for the reforestation are necessary. For other economically important species, a similar behavior was also observed, such as Brazil nut tree seedlings (*Bertholletia excelsa* Bonpl.), with higher height of the seedlings observed under 25-50% shading (Albuquerque *et al*. 2015).

Jutaí-mirim (*Hymenaea parvifolia* Huber) seedlings also presented higher height under 50 and 70% shading (Silva *et al*., 2007).The same behavior was observed for jatobá (*Hymenaea courbaril* L.) and orelha-de-macaco seedlings [*Enterolobium contortisiliquum* (Vell.) Morong] (Lima *et al*., 2010). The regression curve of stem diameter estimated a maximum value (4.5 mm) under 16% shading, with a subsequent decrease (Figure 3B). Although the seedlings under fun sunlight had a lower value for height, compared to other shading levels, the regression curve estimated close average stem diameter values up to 30% shading, which may be related to the greater stress suffered by plants under full sunlight environment and lower shading levels. Under these conditions, there was an attempt to strengthen the stem, given the adversity, for subsequent growth and development of the plant. Some species had a similar behavior, as observed in ipê seedlings [*Tabebuia heptaphylla* (Vell.) Toledo], (Siebeneichler *et al*., 2008), Jequitibá-rosa [(*Cariniana legalis* (Mart.) Kuntze)] (Rego & Possamai, 2006), paineira (*Choroisia speciosa* A.St.-Hil.) (Pacheco *et al*., 2013) and mulungu (*Erythrina velutina* Willd) (Santos & Coelho, 2013) with a largestem diameter observed under conditions of greater availability of light.

Different results were obtained by Santos *et al*. (2014) for pau-de-balsa seedlings [*Ochroma pyramidale* (Cav. ex Lam.) Urb.], with a larger stem diameter observed under 30% shade screen and 50% thermally reflective screen. For seedlings of baru (*Dipteryx alata* Vogel) (Ajalla *et al*., 2012) and pau-rainha (*Brosimum rubenscens* Taub.) (Marimon *et al*., 2008), the larger stem diameter was observed under 50% shading. The increase in plant height/diameter ratio as the shading level increased, indicates that the *Sideroxylon obtusifolium* seedlings had higher growth in height than in stem diameter (Figure 4A). This imbalance expresses that seedlings produced under higher shading levels may be more vulnerable after planted in the field, since shorter diameter facilitates injuries caused by external factors, such as windbreaking or trample by animals. *Sideroxylon obtusifolium* is a climax species, and consequently, a slow growth plant (Scipioni *et al*., 2013; Tsukamoto Filho *et al*., 2013), the increase in height/ stem diameter ratio expresses the seedlings ability to seek luminosity, and demonstrate their tolerance to shading, a characteristic of species of this ecological group. The jacarandá species [*Dalbergia nigra* (Vell.) Allemão ex. Benth.), economically important and with climax species characteristics had an increase in H/SD ratio under higher shading levels(Pacheco *et al*., 2013). The amplitude of plant response to light is variable, mainly for growth and vegetative development of shoots and seedlings survival (Santos & Coelho, 2013). The lower the value for plant height/stem diameter ratio, the less thin is the plant, what indicates a balanced growth. Each species has its own oscillation range for plant height/stem diameter ratio (Paula *et al*., 2013), thus, there is no established pattern for all species.

Plants with short stem diameter have more difficulties to stand erect after planted, and for this, the plant height/stem diameter ratio is a variable used to identify seedling quality (Pacheco *et al*., 2013). In addition to the low height observed for *Sideroxylon obtusifolium* seedlings produced under full sunlight, greater shoot densification was observed due to a greater presence of leaves and branches. The number of branches decreased linearly in all shading levels, with the highest values verified under full sunlight (Figure 4B). For forest species, the determination of number of branches often receives few attention, although being a tool that assists in the selection of more vigorous seedlings to be selected before planted in the field. In addition, it becomes essential for species such as *Sideroxylon obtusifolium*, which have large numbers of leaves arranged irregularly, which makes it difficult to be quantified. A significant effect by the F test was observed for all variables as observed in Table 3. A linear decrease was observed for number of branches, root length and dry matter of *Sideroxylon obtusifolium* seedlings, as the shading levels increased, with the highest values recorded for the seedlings under full sunlight (Figure 5A-B). Taxi-branco seedlings (*Sclerolobium paniculatum* Vogel) (Freitas *et al*., 2012) and mulungu seedlings (*Erythrina velutina* Willd.) under full sunlight also had their root biomass favored (Santos & Coelho, 2013). Plants that grow under full sunlight are more exposed to water stress, which favors the

Table 2. Summary ofanalysis of variance of the regression analysis for the variables: 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 under different shading levels,195 days after transplanted

SV	DF	MS			
		H	SD	H/SD	NB
Shading	3	20,630*	1,216**	4,579**	7,442**
Residue	12	4,552	0,063	0,272	1,142
Total	15	-	-	-	-
CV (%)	-	10,67	6,25	10,24	33,80

* Significant F value at 5% probability; ** Significant F value at 1% probability; MS = mean square; SV = source of variation; DF = degree of freedom; CV (%) = coefficient of variation.

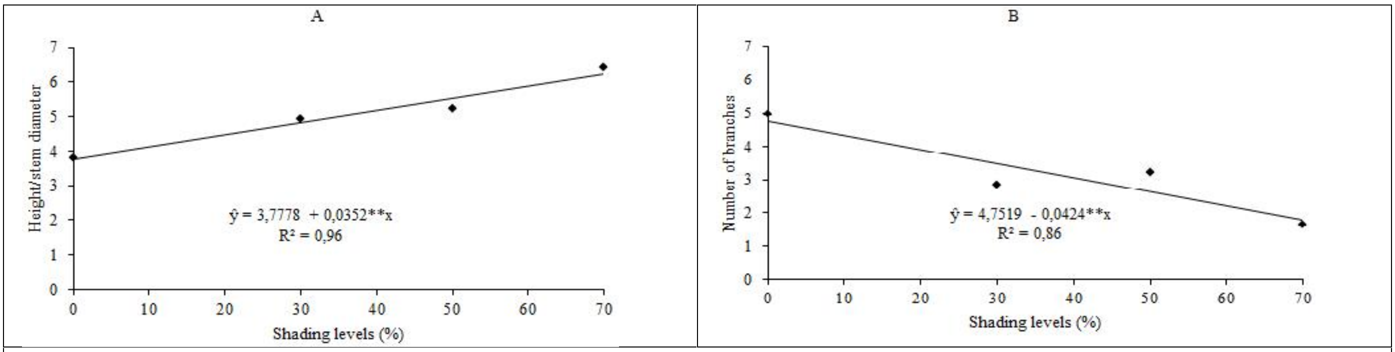

Figure 4. Plant height/stem diameter ratio (A) and number of branches (B) of *Sideroxylon obtusifolium* seedlings under different shading levels, 195 days after transplanted

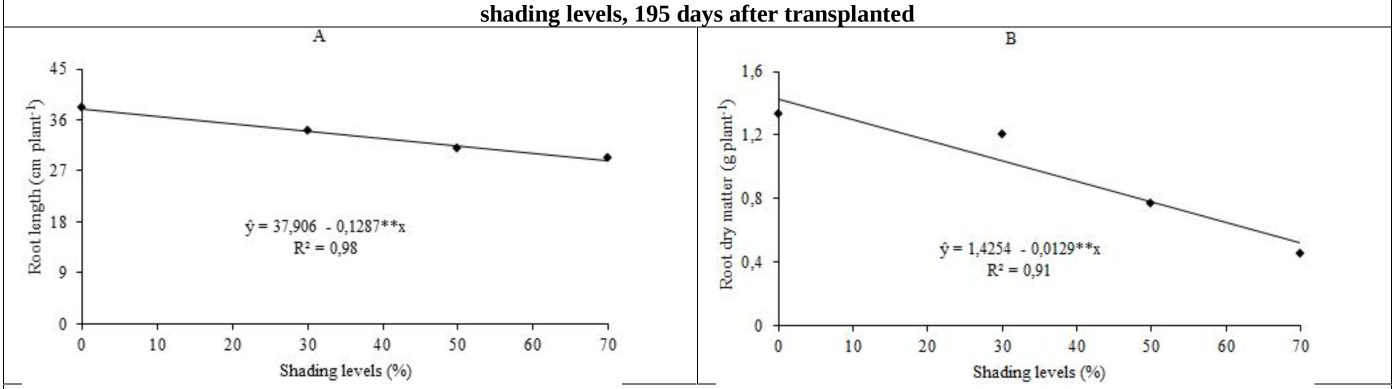

Figure 5. Root length (A) and root dry matter (B) of *Sideroxylon obtusifolium* seedlings under different shading levels, 195 days after transplanted

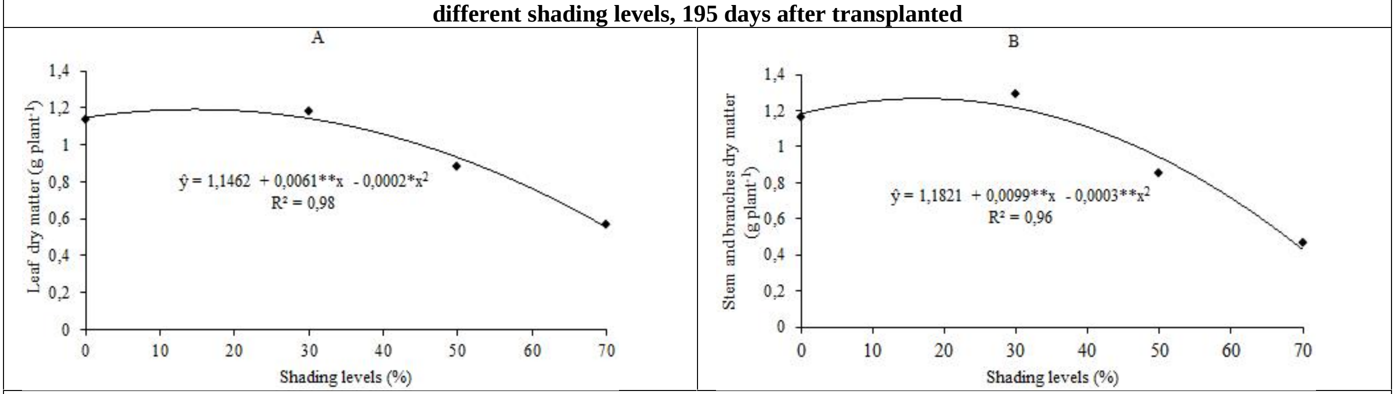

Figure 6. Leaf dry matter (A) and stem and branches dry matter (B) of *Sideroxylon obtusifolium* seedlings under different shading levels, 195 days after transplanted

Table 3. Summary of analysis of variance for root length (RL), root dry matter (RDM), leaf dry matter (LDM) and stem and branch dry matter (SBDM) of *Sideroxylon obtusifolium* seedlings under different shading levels, 195 days after transplanted

SV	DF	MS			
		RL	RDM	LDM	SBDM
Shading	3	59,866*	20,630**	0,317**	0,541**
Residue	12	16,264	4,552	0,025	0,044
Total	15	-	-	-	-
CV (%)	-	12,19	10,67	17,09	22,26

* Significant F value at 5% probability; ** Significant F value at 1% probability; MS = mean square; SV = source of variation; DF = degree of freedom; CV (%) = coefficient of variation.

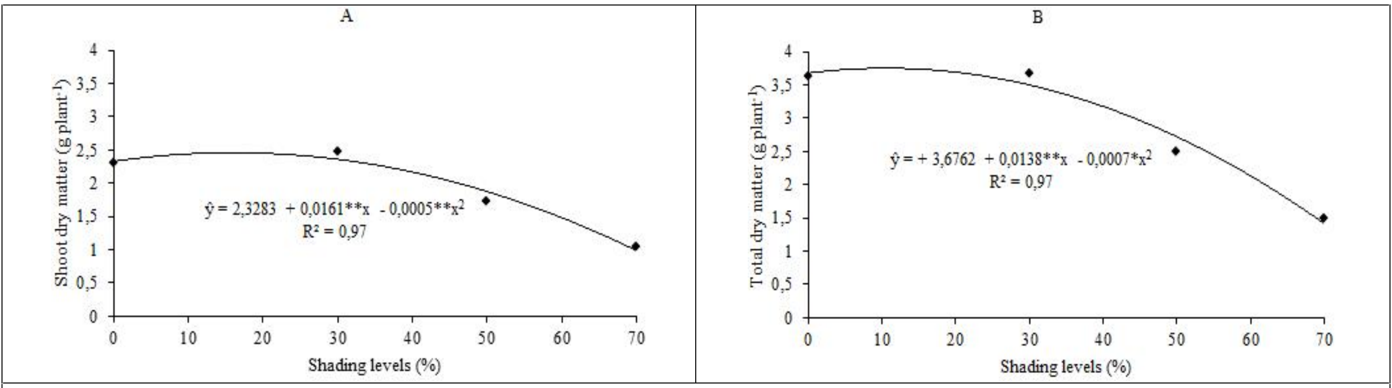

Figure 7- Shoot dry matter (A) and total dry matter (B) of *Sideroxylon obtusifolium* seedlings under different shading levels, 195 days after transplanted

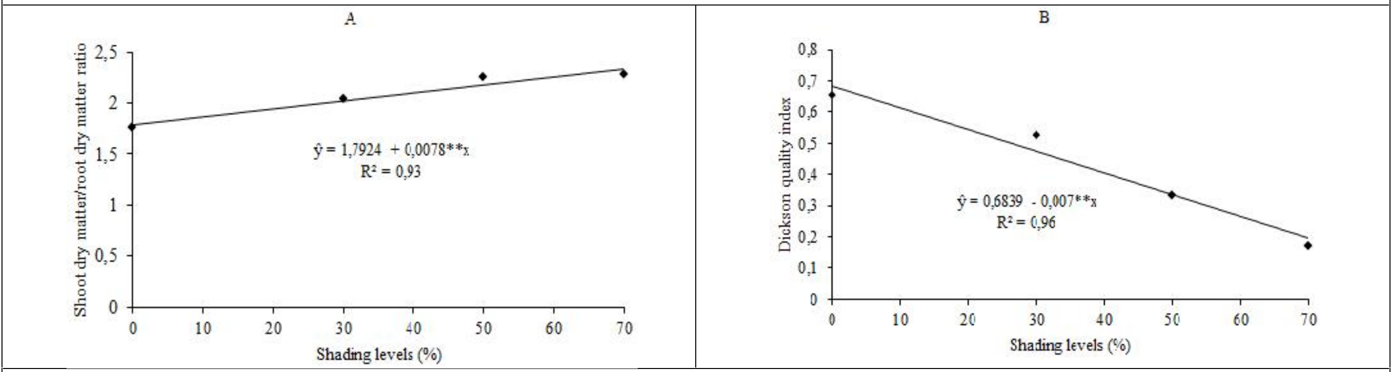

Figure 8. Shoot dry matter/root dry matter ratio(A) and Dickson quality index (B) of *Sideroxylon obtusifolium* seedlings produced under different shading levels, 195 days after transplanted.

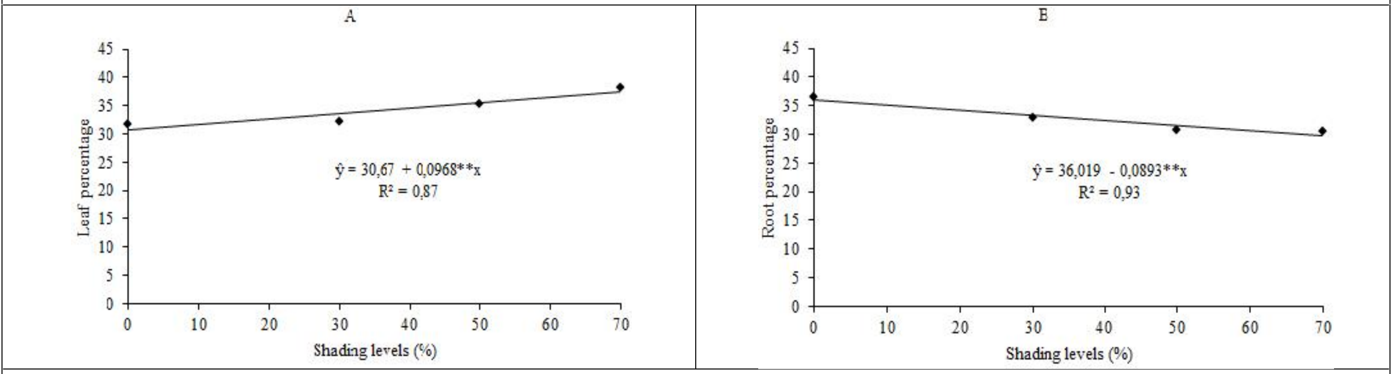

Figure 9. Leaf (A) and root (B) percentage of *Sideroxylon obtusifolium* seedlings produced under different shading levels, 195 days after transplanted

Table 4. Summary of analysis of variance for shoot dry matter (SDM), total dry matter (TDM), shoot dry matter/root dry matter ratio (SDM/RDM) and Dickson quality index (DQI) of *Sideroxylon obtusifolium* seedlings under different shading levels, 195 days after transplanted

SV	DF	MS			
		SDM	TDM	SDM/RDM	DQI
Shading	3	1,685**	4,358**	0,231**	0,180**
Residue	12	0,129	0,290	0,036	0,007
Total	15	-	-	-	-
CV (%)	-	19,09	19,09	9,14	20,83

** Significant F value at 1% probability; MS = mean square; SV = source of variation; DF = degree of freedom; CV (%) = coefficient of variation.

Table 5. Summary of analysis of variance for leaf percentage (% L) and root percentage (% R) percentage of *Sideroxylon obtusifolium* seedlings under different shading levels, 195 days after transplanted

SV	DF	MQ	
		%L	%R
Shading	3	38,443**	30,573**
Residue	12	2,651	5,125
Total	15	-	-
CV (%)	-	4,75	6,93

*** Significant F value at 1% probability; SV = source of variation; MS = mean square; DF = degree of freedom; CV (%) = coefficient of variation.

accumulation of roots dry matter compared to shoot dry matter (Bongarten & Teskey, 1987; Ferreira *et al*., 2012). Greater root biomass in seedlings produced under full sunlight or less intense shading levels may be indicative of their adaptation for conditions of higher transpiratory demand or oligotrophic conditions, in which the presence of intense light suggests an environment with less nutrients and water (Câmara & Endres, 2008). The quadratic adjustments of leaf dry matter, and stem and branches dry matter data (Figure 6A-B) indicated a maximum of 1.2 (15%) and 1.3 g (17%) respectively with a subsequent decrease. From the obtained data, it was verified that the increment in leaf biomass was equivalent to the production of stem and branches, both under full sunlight and in all shading levels. The decrease observed with the shading increase indicates the reduction of the photosynthetic capacity due to the reduction in number of branches and leaves.

The evaluation of leaf dry biomass in studies of seedling production of forest species is important, considering that a greater number of leaves indicates a greater photosynthetic activity and, consequently, significant increases in height and stem diameter (Campos *et al*., 2008; Siebeneichler *et al*., 2008). It was verified that ucuúba seedlings [*Virola surinamensis* (Rol. ex Rottb.) Warb.] produced under 50% shading had the greatest accumulation of leaf and stem dry matter (Lima *et al*., 2006). A significant effect by the F test was observed for all variables according to the shading level, as observed in table 4. Shoot dry matter data adjusted to a quadratic regression model, with an estimated maximum value (2.5 g) under 16% shading (Figure 7A), with a subsequent decrease, which is strongly related to the decrease of shoot density, due to the reduction in the number of branches and the presence of few leaves, considering that the oscillations in plant height and stem diameter were minimal. The highest dry matter production of pintanga seedlings (*Eugenia uniflora* L.), fruit of economic importance, were obtained when produced under full sunlight (Martinazzo *et al*., 2007). The maximum total dry matter (3.7 g) was obtained under 9% shading, with a subsequent accentuated decrease (Figure 7B). This behavior reflects the decrease of root and shoot dry matter due tolight restriction. Aroeira seedlings (*Schinus terebinthifolius* Raddi) also had higher total dry matterwhen produced under full sunlight, however, for sombreiro (*Clitoria fairchildiana* R.A .Howard), 70% shading promoted higher total dry matter (Scalon *et al*., 2006), forsabiá seedlings (*Mimosa caesalpiniifolia* Benth.) the condition of 50% shading promoted the highest total dry matter (Câmara & Endres, 2008).

The shoot dry matter/root dry matterratio (SDM/RDM) increased linearly as the shading level increased, which is probably due to the greater accumulation of biomass of shoots compared to the roots (Figure 8A). Forest species seedlings of good quality have a SDM/RDM of 2, which indicates that the shoot biomass is twice the root biomass (Brissette, 1984). From this perspective, *Sideroxylon obtusifolium* seedlings produced under shading levels between 30 and 70% would have higher quality, however, it is important to consider the evaluation of other variables, such as the Dickson quality index (DQI), a more precise determination of seedling vigor. The seedlings had a decrease in DQI with light restriction, which indicates a decrease in their vigor (Figure 8B). This means that although this species responded to shading according to its ecological group, the seedlings produced in a more shaded environment would result in less suitable plants to the adversities found in the field. The quality of carnauba seedlings [*Copernicia prunifera* (Mill.) H.E.Moore] was also higher when produced without shading (Reis *et al*., 2011). timbaúva seedlings (*Enterolobium contortisiliquum*), had higher DQI under sunlight and 20% shading (Melo *et al*., 2008). A significant effect was observed by the F test, as observed in the summary of analysis of variance for the following variables: leaf percentage (% L) and root (% R) of *Sideroxylon obtusifolium* seedlings under different shading levels (Table 5). The percentage of stem and branches, leaf and root allow us to verify the fraction of these traits in relation to the total dry matter, even if it was reduced as the level of shading increased. The lef percentage data of *Sideroxylon obtusifolium* seedlings was adjusted to a linear regression model, indicating a constant increase with the decrease of light intensity (Figure 9A). Although the shoot dry matter reduced as the shading level increased until 16% shading, the leaf percentage increased in relation to the total dry matter, which is directly related to the decrease of root dry matter. The root percentage had the same behavior as observed for root dry matter and indicated a lower influence of this variable in the total dry matter as the light incidence decreased (Figure 9B). The increase in leaf percentage and the root decrease in relation to the total dry matter of *Sideroxylon obtusifolium* seedlings could be explained by the dominance of biomass allocation in the shoots as the light decreased (Kitajima, 1994).

CONCLUSION

An environment under full sunlight or with up to 15% shading is recommended for *Sideroxylon obtusifolium* seedlings production.

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