Growth and development of seedlings barauna (*Schinopsis brasiliensis Engl.*) in different shadow levels

Ana Luíza de Melo Lucena[1*], Manoel Bandeira de Albuquerque[1], Magnólia Martins Alves[1], Nubya Aparecida[1], Raul Santos Rocha de Araújo[1], Cássio Ricardo Gonçalves da Costa[2]

[1] Department of Phytotechnics and Environmental Sciences, Federal University of Paraiba, Areia, Paraíba, Brazil

[2] Department of Agronomy and Forest Sciences, Federal Rural University of the Semi-Arid, Mossoró, Brazil

Correspondence Author: Ana Luíza de Melo Lucena

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Abstract

Baraúna (*Schinopsis brasiliensis* Engl.), is a typical species of the caatinga, considered in immediate danger of extinction, studies of techniques that assist in the multiplication of this species in forest nurseries are necessary. Little is known about its physiological behavior under shading conditions. The objective was to evaluate the physiological behavior and initial development of plants of *Schinopsis brasiliensis* Engl. under different levels of shading. The experiment was carried out at the Plant Ecology Laboratory of the Department of Phytotechnics and Environmental Sciences, at the Center for Agricultural Sciences, at the Federal University of Paraíba. The experimental design was a randomized block with 5 treatments (40%, 50%, 65%, 70% shading and full sun) and 10 repetitions. The height of the stem and the number of leaves were evaluated every thirty days. Dry mass weight (leaf, stem, root and total), chlorophyll content and fluorescence emission were determined. Plants grown under 40% shade had higher height, number of leaves and higher values of dry leaf, root and total dry matter. A higher chlorophyll a / b ratio was found in plants at 70% shade, but the one who showed the most efficiency in the use of light energy was the treatment of 40% shade.

Keywords: forest species, Caatinga, shading

1. Introduction

Baraúna (*Schinopsis brasiliensis* Engl.), is a plant species belonging to the Anacardiaceae family, with arboreal, thorny and deciduous behavior, reaching up to 15 m in height in adulthood, being one of the largest trees in the caatinga with slow growth. and at court age generally between 20 to 30 years. (Embrapa, 2009). Its wood is of great economic value for the Northeast region (Paes, Moraes & Lima, 2004). *S. brasiliensis* is a long-lived species with high natural resistance to decomposition, which is why it was widely exploited for civil construction and furniture manufacturing and, therefore, it is currently threatened with extinction (Gonzaga *et al*, 2003; Brasil, 2008), which is one of the factors that justifies studies aimed at its propagation through seeds. (Felix, 2013; Fernandes, 2011; Moreira, 2009) [5].

To alleviate these environmental problems, it is necessary to develop basic morphophysiological and anatomical studies, especially with regard to the initial growth of plants and seedling production, in order to support programs for the restoration of these degraded environments (Almeida *et al*. 2004). For the formation of seedlings to be transplanted in the field, the aim is to obtain higher quality plants to withstand the weather and adequate growth in the final production site (Salles *et al*., 2017) [13]. Irradiance is one of the environmental factors that most affects the growth and development of plant species, having a wide influence on the quality of seedlings. The management of the quantity and quality of light is associated with the partition of plant assimilates under nursery conditions (Marana *et al*., 2015) [10].

The manipulation of shading on forest species under nursery conditions can provide important data on the ideal amount of shading for the best increment of the studied species (Sabino *et al*., 2016) [12]. The different degrees of luminosity cause, in general, morphological and physiological changes in the plant, and the degree of adaptation is dictated by particular characteristics of each species in interaction with its environment (Scalon *et al*., 2003). Little is known about the behavior of the species *S. brasiliensis*, regarding shading. To produce quality seedlings, increasing the number of viable seedlings for use in reforestation projects, morpho-physiological studies are needed. This type of information is of paramount importance as it standardizes lighting conditions, to be used in projects to recover degraded environments. Therefore, this study aimed to evaluate the physiological behavior and initial development of *Schinopsis brasiliensis* plants under different shading levels.

2. Material and Methods

2.1. Place of study and obtainment of seedlings

The experiment was carried out at the Laboratory of Plant Ecology of the Department of Plant Science and Environmental Sciences, at the Center for Agricultural Sciences of the Federal University of Paraíba (UFPB), located in the municipality of Areia. The area is under the influence of the As' (hot and humid) climate of the Köppen classification, with autumn-winter rains, average temperatures ranging between 26 and 18 ºC and annual rainfall of 1600 mm, concentrated in the months of June to August. (Brasil, 1972). Baraúna fruits were collected from matrix trees in the municipality of Areia, PB. After collection, the seeds were taken to the Laboratory of Vegetal Ecology, where manual processing was carried out to extract the seeds. The seeds were placed to germinate in beds containing forest substrate, under these conditions they remained until 60 days. After emergence, 50 Baraúna plants were transplanted into polyethylene bags 10 cm in diameter and 20 cm deep, containing forest soil, clayey texture, with the following characteristics: pH in water = 5,1; Al = 0,23 $cmol_c dm^{-3}$; Ca = 1,90 $cmol_c dm^{-3}$; Mg = 1,68 $cmol_c dm^{-3}$; K = 27,34 $mgdm^{-3}$; P = 0,38 $mgdm^{-3}$; Organic Matter = 34,12 $dagkg^{-1}$; Sand = 560 g kg^{-1}; Silt = 13 g dm^{-3} e Clay = 427 gdm^{-3}. An application of 1g of dolomitic lime per kg of soil was made, in order to increase soil pH and neutralize acidity.

2.2. Experimental conditions and data analysis

The seedlings were taken to the experimental area and were divided into five treatments: full sun, 40%, 50%, 65% and 70% shading, using black nylon shading screens. The experimental design adopted was completely randomized, with 50 plants in total, where each treatment consisted of ten replications. The data obtained were subjected to analysis of variance and the average results compared by Tukey test at 5% probability.

2.3. Characteristics evaluated

2.3.1. Morphological parameters

The plants were kept in the treatments mentioned above for a period of 180 days. At 30, 60, 90, 120 and 180 days after germination, height (H) and number of leaves (NL) were evaluated. After 180 days, the plants were gently removed from the polyethylene bags to determine the leaf dry mass/stem/root/total (g) of plants. Plant height – considering the height of the seedlings as the distance between the plant's neck and the apical bud, measured with the aid of a millimeter ruler (cm). Number of leaves per seedling – manual counting of the number of leaves in all seedlings of each treatment. Dry mass – Plants were harvested and separated into leaves, stem and root system. Then they were washed in running water and dried in an oven with forced air circulation, at approximately 65 ºC, until constant weight. Leaf dry mass (LDM), stem dry mass (SDM) and root dry mass (RDM) were determined on an analytical balance with a precision of 0.001g and the data expressed in g $plant^{-1}$. From the primary data, the total dry mass was determined.

2.3.2. Physiological parameters

After 180 days, the chlorophyll and fluorescence emission indices were determined. Chlorophyll indices - The determination of the chlorophyll indices (α, b and total) was measured by means of the ChlorofiLog chlorophyll meter (Falker CFL 1030, Brazil), in the middle third of the plants, in all individuals to obtain an average. Fluorescence emission - The determination of the signal levels of the fluorescence emission kinetics (F_0 and F_M) was performed on dark-adapted sheets and, to simulate the dark-adaptation of the sheets, tweezers accompanying the fluorometer were used. They were placed in the middle region of the fourth leaf from the apex to the base. After 30 minutes of adaptation of the leaf to the dark, a 10 second pulse of saturating light was emitted, at a frequency of 0.6 KHz, on the abaxial face of the leaf, using a portable fluorometer (PEA – Plant Efficiency Analyzer, Hansatech), with initial (F_0) and maximum (F_M) fluorescence values being recorded.

3. Results and Discussion

During the period of evaluation of the *S. brasiliensis* seedlings, it was observed, greater growth under 40% of shading, with an average of 24.15 cm in height, a similar average obtained in plants grown in an environment of 70% shading, with 23, 95 cm high, while plants under an environment with 65%, 50% shading and in full sun had averages of 22.75, 22.6 and 16.67 cm in height, respectively, where all models fit the regression model linear. (Figure 1). Similar results were found with the species *Tapirira guianensis* Alb., from the Anacardiaceae family. It is observed that plants grown under 70% shading had longer stem and root system lengths. (Figure 1).

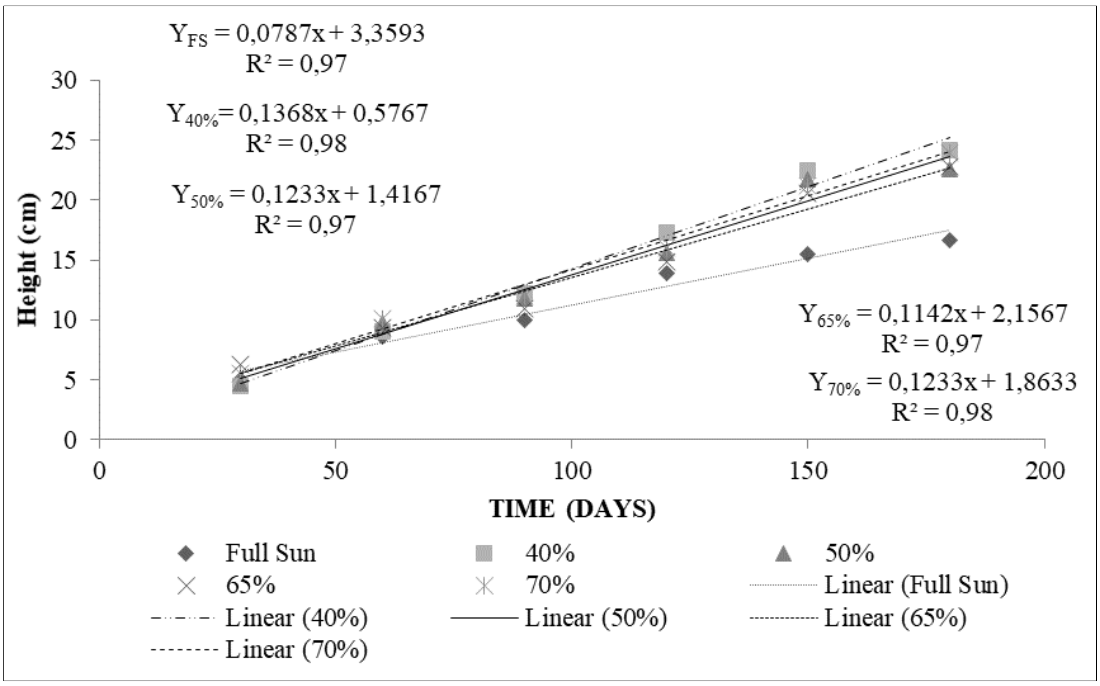

Fig 1: Average height values as a function of days for treatments submitted in Full Sun (FS), 40, 50, 65 and 70% shading. And significant by Student's t test

Among the morphological characteristics, the plant height provides an excellent estimate of the initial growth in the field, being technically accepted as a good measure of the seedling performance potential, however, it can be influenced by some practices that are adopted in forest nurseries. However, it is an easily determined characteristic, not being a destructive method, in addition to its measurement being very simple. (Gomes, *et al*. 2011) [6].

As for the number of leaves, it was observed that plants grown in environments under full sun had a greater number of leaves when evaluated at 180 days, with an average of 28.33 leaves, in which the data fit the quadratic regression model. Similar behavior was observed by Aguiar, *et al* (2011) with seedlings of *Caesalpinia echinata* Lam. Up to about 500 days after the start of cultivation, a large increase in the number of leaves in seedlings kept under full sun (0% shading) was observed.

Plants grown in environments with 40 and 65% shading tended to have higher levels of leaf quantity, where the data fit the linear regression model, with averages of 27.2 and 26.8 number of leaves concomitantly. The lowest values were found in the shadings of 70% and 50% where they obtained averages of 22 and 19.2 respectively. With the exception of the full sun treatment, all others fitted the linear regression model. (Figure 2).

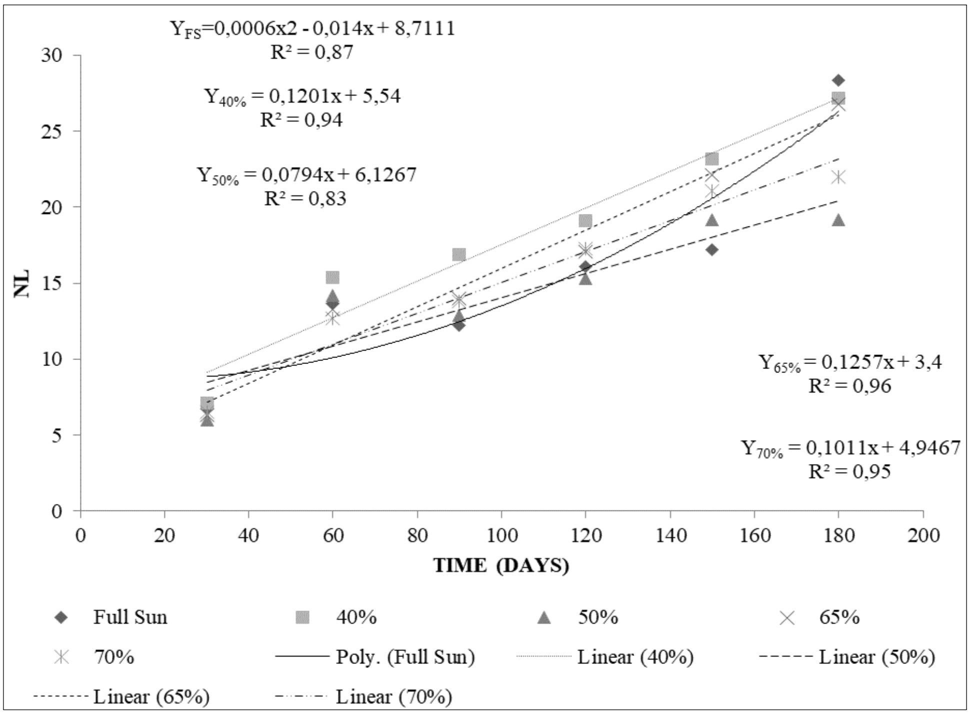

Fig 2: Values of number of leaves as a function of days for treatments submitted in Full Sun (FS), 40, 50, 65 and 70% shading. And significant by Student's t test

Regarding the accumulation of dry mass, the shading caused differences in the leaves, stems, roots and total dry mass of the *S. brasiliensis* plants, in which it was observed that under 40% of shading there was a greater accumulation of total biomass, followed by the sunny condition full. (Figure 3D). This result for total biomass corroborates those found by Silva *et al*. (2018) [14] evaluating seedlings of *Plathymenia foliolosa* Benth. The highest leaf dry mass value was verified in plants subjected to 40% shading and full sun, which presented averages of 1.0 and 0.8 g plant^{-1}, respectively. The lowest values were found under environments of 50%, 70% and 65% shading, with means that varied from 0.6, 0.5 and 0.4 g plant^{-1} respectively. (Figure 3A).

Stem dry mass differed from the others, presenting linear behavior. The highest value of SDM was found in full sun with an average of 0.8 g plant^{-1}, differing from plants under 40% to 70% shading that ranged from 0.6 to 0.3 g plant^{-1}. (Figure 3B). Dutra *et al*. (2012) [4] presented a similar result working with Copaíba, found that the production of SDM had a decreasing linear behavior in response to the shading treatments, which can be understood by the possible rustification of the stem of the seedlings in full sun (0% shading), as a result of the higher increase in dry mass and the occurrence of stem etiolation of plants subjected to low light intensities. A similar fact was observed by Azevedo *et al*. (2010) [2] in the production of marupá (*Simarouba amara*) seedlings under different shading levels.

The highest averages of root dry mass were obtained by plants under 40%, 50% and full sun, with averages of 2.0, 1.6 and 1.57 g Plant^{-1}, respectively. (Figure 3C). The seedlings that received more radiation had a higher root percentage, this is a mechanism that allows the plant to absorb more water and nutrients to support high rates of photosynthesis and transpiration under high light intensity. Plants with this type of strategy should be used in the initial groups in areas undergoing the process of recovering degraded areas, as they guarantee the initial development and condition the continuity of the successional stages (Carvalho, *et al*. 2006) [3].

In the variables leaf dry mass, root dry mass and total dry mass, it is possible to observe a similarity in behavior, both adjusted to the quadratic regression model, where the highest values were found in plants under 40% shading and sun environments full and the smallest values between 50%, 70% and 65% shading. (Figure 3).

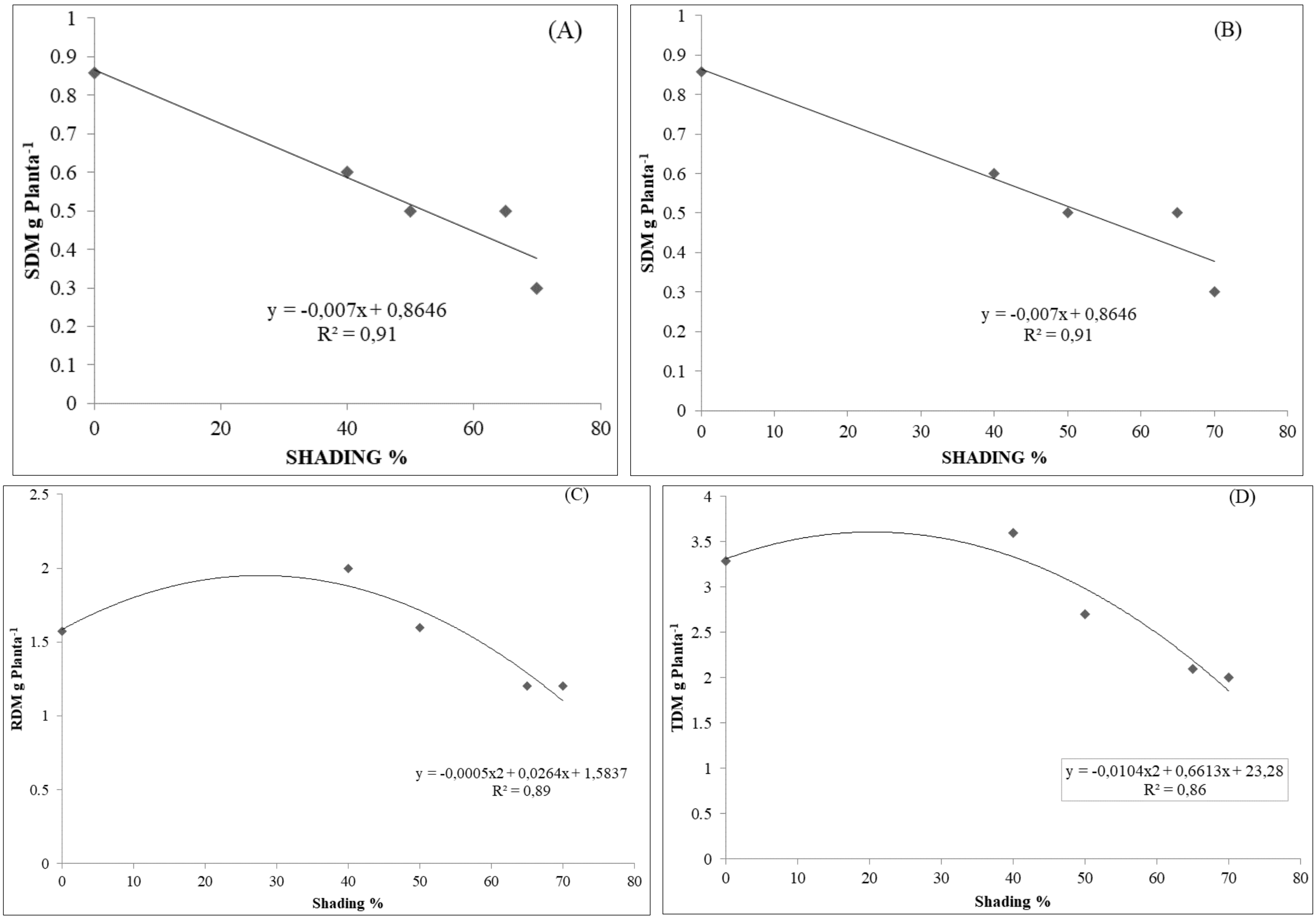

Fig 3: Leaf dry mass (A), Stem dry mass (B), Root dry mass (C), Total dry mass (D), as a function of treatments subjected to full su n, 40, 50, 65 and 70% shading. And significant by Student's t test

The concentrations of chlorophyll *α*, chlorophyll *b* and total did not differ between the tested irradiance levels. Chlorophyll a means ranged between 32.69 and 27.03 ICF. Chlorophyll b varied between means of 10.71 and 6.34 ICF. Mean total chlorophyll ranged between 4.58 and 2.88 ICF.

The chlorophyll *α*/*b* ratio, *S. brasiliensis* showed significant differences, being the highest found in plants grown at 70% shading, with an average of 4.57 ICF, followed by plants under full sun with a chlorophyll *α*/*b* ratio of 4, 48 ICF. The chlorophyll *α*/*b* ratio in plants under 70% shading is directly related to the plants ability to maximize light capture under higher shading conditions. The lowest ratios were found in plants grown in environments with 40, 50 and 65% shading, showing respectively 3.76, 3.66 and 2.88 ICF of chlorophyll *α*/*b* ratio. (Figure 4).

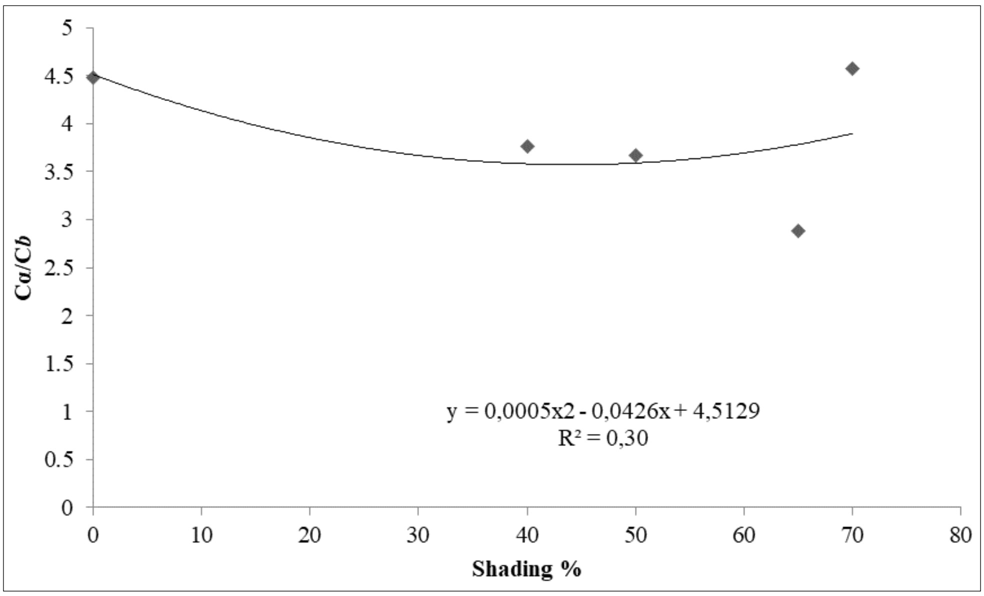

Fig 4: C*a*/C*b* ratio as a function of Full Sun (FS), 40, 50, 65 and 70% shading levels. And significant by Student's t test.

Almeida, *et al*. (2005), working with Cryptocarya aschersoniana Mez. (Lauraceae), verified that the total chlorophyll content was higher in plants grown in 70% shading, the same occurring with the chlorophyll *α*/*b* ratio. Lima Junior, *et al*. (2005), working with seedlings of *Cupania vernalis* Camb. (Sapindaceae), observed that plants grown under 50 and 70% shading had higher levels of chlorophyll *α*, total and *α*/*b* ratio.

4. Fluorescence emission

Photosynthesis occupies a central position in plant metabolism, providing a link between the plants internal processes and the external environment. The chlorophyll a fluorescence technique is widely used in the study of the photosynthetic capacity of plants, allowing the qualitative and quantitative analysis of the absorption and use of light energy by the photosynthetic apparatus (Krause; Weia, 1991) [8].

Thus, through the analysis of fluorescence in *S. brasiliensis* leaves, it is possible to characterize the photosynthetic capacity of the species. The initial flowering values (F_0 - Figure 5A) were adapted to the quadratic regression model, where plants under 40% shading had higher values (F_0=179). From this point onwards there was a decline in F_0 values, in which the averages varied between 149.7 and 140.1, with respect to plants under 50% and 70% shading respectively. Gonçalves, *et al*. (2001) [7] found high values of F_0 and significant differences for F_0 between mahogany (*Swietenia macrophylla* King) plants grown in sun and shade.

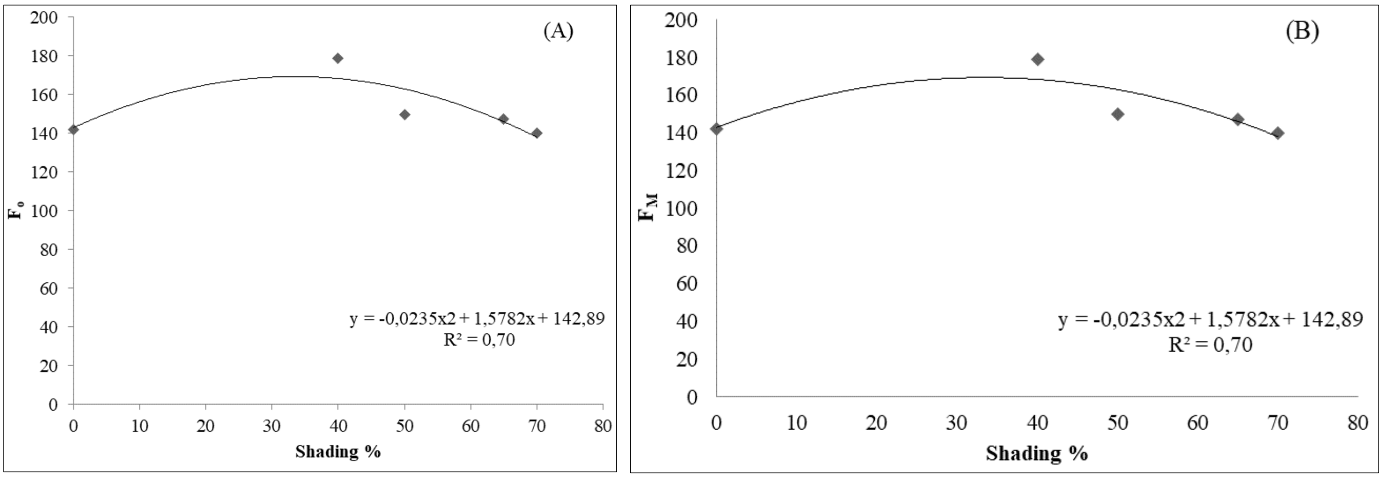

Fig 5: Fluorescence emission parameters. (A) Initial Fluorescence (F_0), (B) Maximum Fluorescence (F_M) as a function of Full Sun (FS), 40, 50, 65 and 70% shading levels. And significant by Student's t test.

The maximum fluorescence (F_M), whose values differed between plants subjected to different levels of shading, fit the quadratic regression model, where the highest value of (F_M = 684.8) in plants under 65% shading, value next obtained the plants under 40% shading showing (F_M = 665.6). Reductions of F_M were found in 50%, 70% of shading and full sun, in which they presented (F_M = 654.2), (F_M =644.1) and (F_M =597.9) respectively.

We can see in Figure 5 that there was a decline in F_0 and F_M with decreasing and increasing shading.

5. Final considerations

It was concluded that plants grown under 40% shading show the best performance in height, number of leaves and better leaf, root and total dry mass values. Higher chlorophyll a/b ratio was found in plants at 70% shading, but the treatment with 40% shading was the most efficient in the use of light energy.

References

1. Aguiar FFA. Growth of pau-brasil (*Caesalpinia echinata* Lam.) seedlings submitted to five levels of shading. Rev. Ceres, Viçosa 2011; 58(6):729-734.
2. Azevedo IMG. Study of the growth and quality of marupá (*Simarouba amara* Aubl.) seedlings in a nursery. Acta Amaz., Manaus 2010; 40(1):157-164.
3. Carvalho NOS, Pelacani CRR, Manuela OS, Crepaldi IC. Initial growth of licuri (*Syagrus coronata* (Mart.) Becc.) plants at different light levels. Tree Magazine 2006; 30(3):351-357.
4. Dutra RT. Initial development of copaíba seedlings under different levels of shading and substrates. Revista Ciência Agronômica 2012; 43(2):321-329.
5. Felix FC. Dry matter of *Schinopsis brasiliensis* Engl. Grown on Different Substrates. Vitória da Conquista, BA, 2013.
6. Gomes JM, Paiva HNde. Forest Nurseries: sexual propagation. Viçosa: UFV, 2011, p116.
7. Gonçalves JFC, Marenco RA, Vieira G. Concentration of photosynthetic pigments and chlorophyll fluorescence of mahogany and tonka bean under two light environments. Brazilian Journal of Plant Physiology, Londrina 2001; 13(2):49–157.
8. Krause GH, Weia E. Chlorophyll fluorescence and photosynthesis: The basics. Annual Review of Pant Physiology and Plant Molecular Biology 1991; 42:313-349.
9. Lima Júnior EC, Alvarenga AA, Castro EM, Vieira CV, Barbosa JPRAD. Physioanatomical aspects of young plants of *Cupania vernalis* Camb. subjected to different levels of shading. Tree Magazine 2006; 30(1):33-41.
10. Marana JP, Miglioranza E, Fonseca EP. Quality of jaracatiá seedlings submitted to different shading periods in a nursery. Tree Magazine 2015; 39(2):275-282.

11. Paes JB. Natural resistance of nine woods from the Brazilian semiarid region to woody fungi in field simulators. Rev. Árvore, Viçosa 2009; 33(3):511-520.
12. Sabino M, Korpan C, Ferneda BG, Silva AC. Growth of ipe seedlings in different shading screens. Native 2016; 4(2):61-65.
13. Salles JS, Lima Alexandre HF, Costa E. Jambolão seedlings under shading levels, reflective benches and sowing depth 2017; 4(1):110-118.
14. Silva RR, Angels BA, Freitas AG, Nogueira MA, Faria GJA. Initial development of *Planthymenia foliosa* Benth seedlings under shading influence. Gaia Scientia Magazine 2018; 12(2):134-143.