

## Influence of artificial shading on seedling production of *Tachigali myrmecophila* (Ducke) Ducke.

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### Abstract

The objective of this work was to evaluate the influence of shade level on the production of *T. myrmecophila* seedlings. After 30 days of seedling transplantation, the seedlings were submitted to the following treatments: 100% light (full sun), 75% light and 50% light. The statistical design was completely randomized with 5 replicates of 10 seedlings each per treatment. The data were analyzed by repeated measures in time, in 5 measurements, performed every 30 days (150 days of evaluation). The analyzed variables were shoot height and diameter. The environment with 75% luminosity was the one that contributed most to the growth in height of the seedlings, having presented higher mean values over time, in the 5th month (34.94 cm). The most pronounced effect for growth in diameter was verified in the 5th month of evaluation, where the highest average was obtained in the environment with 50% of shading (4.61 mm). The *T. myrmecophila* seedlings were influenced by the shading levels used. From the results evaluated, treatments with 75% and 50% of solar radiation provided superior growth for dendrometric variables height and diameter, respectively. Therefore, we recommend environments with 75% and 50% of solar radiation for the production of *T. Myrmecophila* seedlings.

**Keywords:** environment, photosynthetic acclimatization, development solar radiation; tachi-preto.

**Abbreviations:** DC\_diameter; H\_shoot height; PAR\_photosynthetically active radiation; TEMP\_temperature; RU\_relative air humidity.

### Introduction

The species *Tachigali myrmecophila* (Ducke) Ducke, belonging to the subfamily Caesalpinioideae, is known in the northern region by the common names of tachi-preto, tachi, tachi-pitomba and tachizeiro, occurring throughout the Amazon region, commonly in upland forests (Ribeiro, 1999; Santos et al., 2007). It is inserted in the ecological group of species intolerant to the shade, being still outstanding to present obligatory mutualistic relation with ants (Carvalho et al., 2004). According to Van der Werff (2010), they are large trees, reaching up to 45 meters in height and have medium density wood. The species has been little explored by the producers, but is eventually used for the production of coal (Souza Filho et al., 2005). Due to its rapid growth and nitrogen fixation capacity, *T. myrmecophila* has potential to be adopted in the formation of agroforestry systems (Santos et al., 2007).

Many native tree species are potentially suitable for rational cultivation and may serve various purposes, such as for ornamental, timber, food or preservation (Santos et al., 2014). As technical knowledge of planting these species are not always available, the improvement of the seedling production system is necessary due to increased demand for commercial production and for the recovery of degraded areas (Nietsche et al., 2004), through production of seedlings with higher morphological characteristics and lower costs, capable of supplying the demand in quantity and species richness (dutra et al., 2012). The production of seedlings of native tree species with quality and ideal morphological characteristics is one of the most important factors for the process of implantation of forest stands for both commercial and conservation purposes (Dutra et al., 2012).

Each species has its own individual characteristics and requirements according to its need for an ideal development, interacting with the biotic and abiotic factors that make up its habitat, such as the availability of light, water, temperature and edaphic conditions. Most intolerant or shade tolerant plants are able to adapt according to the amount of available light, promoting changes in their morphology and physiology to maximize total carbon gain, which will directly influence their development. However, each species may present a different response to light energy, according to its acclimatization capacity and dependence on the quantity or quality of light, acting at all stages of plant development (Silva et al. 2007).

According to Rego and Possamai (2006), the artificial shading applied to the nurseries using sombrite type screens is an efficient and widely used method in the study of light needs of different species. The attenuation of solar radiation is one of the most important factors for the production of seedlings, because it acts directly on the energy balance, and consequently on the environmental conditions (Hernandes et al., 2004). The general recommendation by several authors is 50% shading due to their significant influence on temperature (Galvão, 2000; Lang and Botrel, 2008).

Studies evaluating the production of *Schizolobium amazonicum* seedlings under different shade levels verified a higher initial development of the plants in more shaded environments (Rosa et al., 2009). However, Vieira et al. (1998), observed a significant increase in height of *Schizolobium parahyba* seedlings at the end of the evaluation, regardless of the environment to which the seedlings were destined. The results show that the response of the species occurs as a function of the physiological plasticity in relation to the available photosynthetically active radiation (Almeida et al., 2005a), demonstrating the need for studies to evaluate initial growth in relation to different levels of shading. In this sense, the objective of the present work was to evaluate the influence of the level of shading on the production of *T. myrmecophila* seedlings.

## Results and discussion

### Height growth assessment

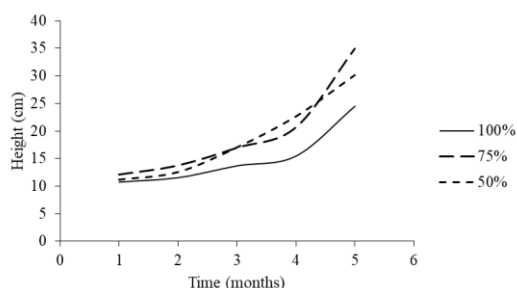
The environments with different luminosities contributed in a significant way to the height development of the tachipreto plants during their stage of change over time (Table 1). The results demonstrate that the light variation presents an interaction with time in the growth in height of the tachipreto seedlings.

According to Table 2, the environment with 75% of luminosity was the one that contributed the most to the growth in height of the seedlings, having presented larger means over time, differing from the environments of 100% and 50% light. In the 5th month, the environment with 75% of luminosity presented a mean height increase of 34.94 cm, followed by the environment at 50% with a mean of 30.09 cm and the environment at full sun, with a mean of 24.50 cm, being that the last two treatments did not differ statistically. The results demonstrate that the excessive incidence of solar radiation in the molting phase can exert a negative effect on growth in height. Similar results were found by Santos et al. (2010), in which seedlings of *Eucalyptus grandis* Hill ex Maiden presented the lowest

values of height growth for treatment in full sun (12.68 cm) to the detriment of the environment with 30% and 50% shading. This presented mean values of 18.88 cm and 19.20 cm, respectively, at 60 days of evaluation. The higher average values of plant height under shading have been reported by Almeida et al. (2005b); Câmara and Endres (2008); Zanella et al. (2006); and Fonseca et al. (2002). The increase of the height of the plant under light restriction can be explained by the action of the phormonium auxin, which is synthesized in young leaves of the aerial part and at the apex of the stem, and later transported to the root, with light a stimulus for this transport (Santos et al., 2010). When light incidence restriction occurs, auxin is redistributed laterally to the epidermis and cortical cells of the hypocotyl, causing the elongation of these tissues and; therefore, the erosion. As can be seen in Fig 1, the light restriction exerted a positive effect on plant height and growth mainly in the 5th month. Felseburgh et al. (2016) studied the effect of different shading levels on initial growth and the morphophysiological parameters of *Aniba parviflora* (Meisn.) Mez. seedlings in the nursery. They concluded that the seedlings showed better development under shade conditions with 50% interception solar radiation. In the same experiment, during the first 120 days of treatments, the seedlings had a similar performance in relation to height in all treatments, and at 180 days, a significant difference was observed between treatments 0% and 70% shading. From the 240 days, there was a significant difference between the treatments with 0% and 50% and 0% and 70% of shading, corroborating in part with the present work, where the *T. myrmecophila* seedlings differed significantly between treatments in times. Saraiva et al. (2014) investigated the phenotypic plasticity and acclimatization of Guanandi (*Calophyllum brasiliensis*) seedlings and under the conditions of the experiment verified that the species can respond plastically to the variations in its environment, being able to exhibit a superior growth in high luminosity conditions. This corroborates with the hypothesis that changes in the spectral characteristics of solar radiation and microclimate can modify the structural and physiological characteristics of the plants, leading to a process of acclimatization due to phenotypic plasticity. However, the results of acclimatization studies should not be generalized, since the influence of the quality of the radiation on the growth and development of seedlings is also directly associated with the plant species in question. Thus, in the process of acclimatization resulting from phenotypic plasticity, one must observe the individuality of each species and the environment, in which the plant is located. Costa et al. (2015) studied protected environments and substrates in emergence and initial formation of *Dipteryx alata* Vog. They found that 50% black shading shading provided better quality, in contrast to aluminized shading with 50% shading. Pinto et al. (2016) evaluated the initial growth and development of young plants of *Mimosa caesalpinifolia* Benth. with different levels of shading (0, 30, 50 and 70%) in the semi-arid region of northeastern Brazil. They observed that the best growth indicators were in the shrubs maintained under shading under 50% shading, which provided an increase in height of the plants when compared to treatment in full sun.

**Table 1.** Result of the chemical analysis of the substrate used in the experiment, before correction. Belém-PA, Brazil, 2016.

Identification	P	O.M.	pH	K	Ca	Mg	H+Al	Al	SB	T	V	m
	mg dm <sup>-3</sup>	g dm <sup>-3</sup>	CaCl <sub>2</sub>	mmol <sub>c</sub> dm <sup>-3</sup>						%	%	
Substrate	8.7	29	3.8	0.5	2	1	49	14	4.3	53.3	8	76.5

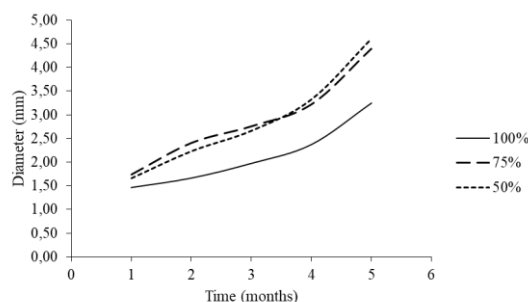


**Fig 1.** Height growth of *T. myrmecophila* seedlings grown in treatments in 100% light (full sun), 75% light and 50% light in months of experiment.

**Table 2.** Analysis of variance of measures repeated in time for height in *T. myrmecophila* seedlings submitted to different levels of shading.

Source of variation	df	Mean squares	F Valor	Pr > F
Time	4	8,276.27	472.81**	<.0001
Treatments	2	1,387.33	20.4**	<.0001
Time* Treatments	8	230.58	13.17**	<.0001
Error (Time)	588	17.5		
Error (Treatments)	147	68.01		

\*\* and \*\*\* significant at 5% and 1% probability, respectively.

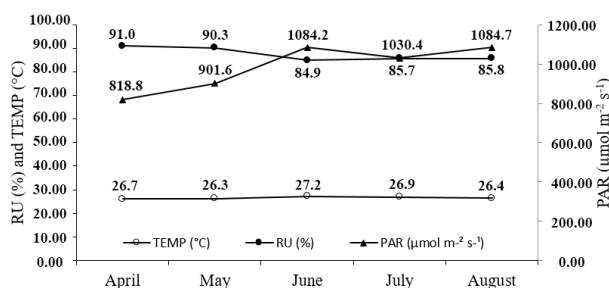


**Fig 2.** Growth in diameter of *T. myrmecophila* plants grown in treatments in 100% light (full sun), 75% light and 50% light in months of experiment.

**Table 3.** Comparison of mean values for height of *T. myrmecophila* plants in treatments in 100% light (full sun), 75% light and 50% light.

Treatments	Time (months)				
	1	2	3	4	5
100%	10.746a	11.536a	13.69a	15.46a	24.5a
75%	12.09b	13.74b	16.94b	20.65b	34.94b
50%	11.156a	12.54a	17.00b	22.6b	30.09a

Means followed by the same letter in the column do not differ from each other by the Tukey test, at the 5% probability level.



**Fig 3.** Monthly mean values of photosynthetically active radiation (PAR), air temperature (TEMP) and relative air humidity (RU), during the experiment period.

**Table 4.** Analysis of variance of measures repeated in time for diameter in *T. myrmecophila* seedlings subjected to different levels of shading.

Source of variation	df	Mean squares	F Valor	Pr > F
Time	4	169.18	102.65	<0.0001
Treatments	2	1.01	0.37	0.6909
Time* Treatments	8	10.87	6.59	<0.0001
Error (Time)	588	1.65		
Error (Treatments)	147	2.72		

\*\*\* and \*\*\*\* significant at 5% and 1% probability, respectively.

**Table 5.** Comparison of mean values in diameter of the *T. myrmecophila* seedlings grown in the treatments in 100% light (full sun), 75% light and 50% light by Tukey test in months.

Treatments	Time (months)				
	1	2	3	4	5
100%	1.46a	1.66a	1.97a	2.37a	3.25a
75%	1.73b	2.40b	2.75a	3.22a	4.40a
50%	1.66b	2.23b	2.66a	3.33a	4.61b

Means followed by the same letter in the column do not differ from each other by the Tukey test, at the 5% probability level.

**Table 6.** Monthly mean values of photosynthetically active radiation (PAR) at each level of shading applied to the experiment.

Months	Light Retention (%)		
	0	75	50
	Photosynthetically available radiation (PAR) ( $\mu\text{mol m}^{-2} \text{s}^{-1}$ )		
April	818.80	614.10	409.40
May	901.60	676.20	450.80
June	1084.22	813.17	542.11
July	1030.40	772.80	515.20
August	1084.68	813.51	542.34
Average	983.94	737.96	491.97

#### Growth assessment in diameter

The different treatments did not show a significant effect on the diameter (Table 3), but their interaction in time was positive. The 50% luminosity environment presented a larger diameter development, but this did not differ continuously in time, as can be seen in Table 5 and Figure 2. The most pronounced effect for growth in diameter was verified in the 5th month of evaluation, where the highest average was obtained in the environment with 50% of shading (4.61 mm), in detriment to the treatments with 75% (4.40 mm) and full sun (3.25 mm), whereas the latter two showed no difference.

The result for the variable morphological diameters found in the present work contrast with the results of other studies, such as Almeida et al. (2005b), working with *Acacia mangium* and Siebeneichler et al. (2008) evaluated the species *Tabebuia heptaphylla* (Vell.) which verified reduction in the diameter in plants with increased shading. Almeida et al. (2005b) working with *Macluratinctoriae* and *Hymenaea courbaril* and Silva et al. (2007) evaluated the species *Theobroma grandiflorum* (Willd. ex Spreng.) Schum and did not find differences in the development of the plant colon under 50% shading in relation to seedlings cultivated in the sun. According to Taiz and Zieger (2002), in some species the higher luminosity allows a higher photosynthetic rate; thus, greater accumulation of photoassimilates in the stem of the plants. However, we were not able to verify it in the present work on *T. myrmecophila* seedlings.

In a similar work, Câmara and Endres (2008) found that *Mimosa caesalpinifolia* seedlings cultivated under 50% shade presented better results in vegetative growth and diameter. Felfili et al. (1999) verified an increase on

diameter under full sun conditions and 50% shading for *Sclerobium paniculatum*. Working with seedlings of *Trema micranta*, Fonseca et al. (2002) observed that there was a linear decrease in the diameter as a function of the increase of the stay period under shading. In the present study, Campos and Uchida (2002) did not find significant differences in collecting diameter when evaluated the influence of solar radiation attenuation on three species of native Amazonian seedlings. Already Mazzei (1999), observed better conditions for the development of the plant with respect to the diameter parameter of collection in *Hymenaea courbaril*, which were 50 and 70% shading. Frigotto et al. (2015), studied shade levels in seedlings of *Schizobolium amazonicum*. At the end of the evaluations, they observed that the variation of the lap diameter was positive but very low from 5.8 mm to 6.6 mm. This aspect is of paramount importance, because according to Carneiro (1995), the diameter is one of the best indicators of the quality standard of seedlings. According to him, the seedlings must have a minimum diameter, according to the species and that is compatible with their height. So that their performance in the field corresponds to the expectations, since the initial increment and survival are strongly correlated with diameter at the moment of planting.

#### Materials and methods

##### Site description and substrate preparation

The experiment was conducted in a greenhouse at the Institute of Agrarian Sciences of the Federal Rural University of Amazonia, in Belém, state of Pará, Brazil, from May to November 2016. During the experiment period, temperature

and relative humidity in the interior of the greenhouse (75% and 50% shading levels) were measured with a thermohygrometer, and the mean values of  $29.6 \pm 1.02$  °C and  $73.7 \pm 3\%$  were presented, respectively.

The soil used as substrate, yellow latosol, which was chemically characterized (Table 1), through an analysis conducted by the Brazilian Institute of Analyzes (IBRA). Subsequently, the substrate was air-dried, sieved in a 5 mm mesh and acidity corrected using a mixture of  $\text{CaCO}_3$  and  $\text{MgCO}_3$  at a stoichiometric ratio of 4:1. The need for liming was calculated based on the chemical analysis of the soil, present in Table 1, with the aim of increasing the saturation by bases to 60%. After incorporation of the corrective, the soil samples were conditioned in plastic bags kept open and incubated for a period of 30 days to maintain the moisture content of the samples at the field capacity.

#### **Plant materials, treatments and experimental design**

The seeds of tachi-preto show integument dormancy; therefore, the pre-germinative treatment was applied to promote, accelerate and standardize the germination. In order to overcome the dormancy, a small portion of the tegument was removed at the end opposite the embryonic axis to facilitate the process of imbibition of the seed and thus to initiate the germination. They were placed to germinate in sowing, with sand washed as substrate, and after 30 days of germination, transplanted to 15 x 25 cm bags of  $1.9 \text{ dm}^3$  soil. After 30 days, the plants were separated into three treatments (environments): 100% light (full sun), 75% light and 50% light. The levels of shading were obtained with agricultural screen of high density polyethylene of black color, with anti-UV stabilizer to block the actions of ultra violet rays. The screens covered upper and lateral portions of galvanized steel structure, 8.00 m wide by 18.00 m long and 4.00 m high, 90° closed, two environments with 75% and 50% shading. Table 6 shows the monthly average data on the photosynthetically active radiation (PAR), temperature (TEMP) and relative air humidity (RU) of the daily readings performed during the experiment by an automatic meteorological station (Davis Vantage PRO, Davis Instruments Corporation, California, USA) installed at the experiment site. The mean values of photosynthetically active radiation in each shade treatment evaluated in the experiment were set out in Figure 3, which were evaluated once in each setting from 9 to 10 o'clock local time, with five measurements being taken 20 cm high, with automatic data acquisition system (HOBO MX2303 datalogger, Onset Computer Corporation, Massachusetts, USA) coupled to a S-LIA-M003 quantum sensor and a combined temperature (°C) and humidity sensor (RU, %), in order to measure how light was actually blocked by the shading screens. The statistical design was completely randomized, with 5 replicates of 10 plants per treatment, totaling 150 plants. After 60 days of application of the treatments, data collection was started, performed every 30 days, totaling 150 days of evaluation (5 measurements).

#### **Morphological variables analyzed**

In each evaluation, the measurements of diameter (DC, mm) and shoot height (H; cm) were collected. The height of the aerial part was obtained with a centimeter ruler, measuring

the distance between the soil level and the insertion of the last pair of expanded leaves. The collecting diameter was determined with a digital caliper at the stem region at the substrate level.

#### **Statistical analysis**

Initially, the data of the experiment were submitted to Shapiro-Wilks (Shapiro; Wilks, 1965) and Levene (BOX, 1953) tests for data normality and homoscedasticity of the residues, respectively. Subsequently, with the assumptions of data normality, we performed the analysis of measures repeated in time ( $p < 0.05$ ).

#### **Conclusion**

The *Tachigali myrmecophila* seedlings were influenced by the shading levels used. From the results evaluated, the attenuation of 25% and 50% of the solar radiation provided superior growth for the dendrometric variables height and diameter, respectively. From the results of the present work, it is recommended that for the production of *Tachigali myrmecophila* seedlings environments with 75% and 50% of solar radiation are suitable.

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