Research, Society and Development, v. 9, n. 7, e878974508, 2020
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v9i7.4508

# O sombreamento e seus reflexos no crescimento e nas trocas gasosas de mudas de Microdesmia rigida (Benth.) Sothers & Prance

# Shading and its reflections on growth and gas exchanges of Microdesmia rigida (Benth.) Sothers & Prance

# Sombreado y sus reflejos en el crecimiento y el intercambio de gases de las plántulas de Microdesmia rigida (Benth.) Sothers & Prance

Recebido: 14/05/2020 | Revisado: 30/05/2020 | Aceito: 01/06/2020 | Publicado: 16/06/2020

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## Resumo

Este trabalho teve como objetivo avaliar o efeito do sombreamento no crescimento e nas trocas gasosas de mudas de oiticica (Microdesmia rigida), mantendo-as a 0% (pleno sol), 50% e 70% de sombreamento, dispostos em delineamento inteiramente casualizado (DIC), com quatro repetições. Foram analisados os parâmetros altura da planta, diâmetro do caule, razão altura/diâmetro, taxa de crescimento absoluto, área foliar, peso da matéria seca da planta, razão raiz/parte aérea, Índice de qualidade de Dickson (DQI), taxa de transpiração, condutância estomática, taxa de fotossíntese, concentração interna de CO2, teores de clorofila a, b e total. Foi verificada redução na taxa de transpiração e aumento na condutância estomática, taxa de fotossíntese e concentração interna de CO2 com o aumento do sombreamento. O sombreamento diminuiu a concentração de clorofila a enquanto promoveu aumento da clorofila b e clorofila total, sem diferença significativa entre os níveis de 50% e 70% do sombreamento. Os ambientes sombreados proporcionaram maior crescimento em altura, diâmetro, área foliar, além de propiciar maior acúmulo de massa seca e DQI. Recomenda-se a produção de mudas de mudas de oiticica, durante a fase de viveiro, sob 50% de sombreamento, pois essa condição possibilita a obtenção de melhores índices de qualidade de mudas.

**Palavras-chave:** Luminosidade; Comportamento estomático; Pigmentos; Caatinga.

## Abstract

The objective of this research was to evaluate the effect of shading on growth and gas exchange of seedlings of Microdesmia rigida, keeping them under the levels of 0% (full sun), 50% and 70% shading, arranged in a completely randomized design (DIC), with four replications. Plant height, stem diameter, height/diameter ratio, absolute growth rate, leaf area, plant dry matter weight, dry root/shoot weight ratio, Dickson Quality Index (DQI), transpiration, stomatal conductance, photosynthesis rate, internal CO2 concentration, chlorophyll contents a, b and total were analysed. There was a reduction in the rate of transpiration and increase in stomatal conductance, photosynthesis rate and internal CO2 concentration with increased shading. Shading decreased the concentration of chlorophyll a while promoting an increase in chlorophyll b and total chlorophyll, with no significant difference between the levels of 50% and 70% of shading. The shaded environments provided greater growth in height, diameter, leaf area, in addition to providing greater accumulation of dry mass and IQD. It is recommended to produce seedlings of M. rigida seedlings, during the nursery phase, under 50% shading, as this condition provides the achievement of better seedling quality indexes.

**Keywords:** Luminosity; Stomatal behavior; Pigments; Caatinga.

## Resumen

Este trabajo tuvo como objetivo evaluar el efecto del sombreado en el crecimiento y el intercambio de gases de las plántulas de oiticica (Microdesmia rigida), manteniéndolos al 0% (pleno sol), 50% y 70% de sombreado, dispuestos en un diseño completamente al azar (DIC), con cuatro repeticiones. Se analizaron los parámetros altura de la planta, diámetro del tallo, relación altura / diámetro, tasa de crecimiento absoluto, área foliar, peso de la materia seca de la planta, relación raíz / brote, índice de calidad de Dickson (IQD), tasa de transpiración, conductancia estomática, tasa de fotosíntesis, concentración interna de CO2, niveles de clorofila a, b, y total. Se verificó una reducción en la tasa de transpiración y un aumento en la conductancia estomática, la tasa de fotosíntesis y la concentración interna de CO2 con el aumento del sombreado. El sombreado disminuyó la concentración de clorofila a mientras que promovió un aumento en clorofila b y clorofila total, sin diferencias significativas entre los niveles de sombreado del 50% y 70%. Los ambientes sombreados proporcionaron un mayor crecimiento en altura, diámetro, área foliar, además de proporcionar una mayor acumulación de masa seca y IQD. Se recomienda producir plántulas de plántulas de pulpo, durante la fase de vivero, bajo un sombreado del 50%, ya que esta condición permite obtener mejores índices de calidad de plántulas.

**Palabras clave:** Luminosidad; Comportamiento estomatal; Pigmentos; Caatinga.

## 1. Introduction

Since they are photosynthetic beings, growing plants can be affected by many environmental factors, such as light, temperature, water, nutrients and so on. Light is the source of energy for photosynthesis and one of the most important environmental factors for growing plants (Vandenbussche et al., 2003). Low light severely affects seed germination and plant growth, decreasing photosynthesis (Walters et al., 2004; Jiang et al., 2005) and dry matter, inhibiting the activities of antioxidant enzymes (Yang et al., 2008) and influencing the location of chloroplasts (Williams; Gorbon & Witiak, 2003).

Tree species have different responses to the availability of light in the environment, in which, in order to survive under inadequate light conditions, plants develop mechanisms such as adjusting the photosynthetic apparatus, in order to use the light in the most efficient way possible, reflecting directly on the growing from them (Dantas et al., 2009). Thus, some plants have greater plasticity in response to changes in light in the environment, so that there are species that are favored in sunny environments and others that benefit more efficiently in shaded environments (Pompelli et al., 2012) and these responses vary with the ecological class to which they belong (Siebneichler et al., 2008; Reis et al., 2016).

The intensity and quality of light are factors that can also affect the gas exchange of plants (Costa & Marenco, 2007) and the study of these ecophysiological variables allows a better understanding of the vegetative behavior of plants under varying conditions of the environment in which they are found (Nogueira & Silva, 2001). During the seedling phase, it is essential to consider the light levels to which the plants are exposed, as high levels of irradiance can cause damage to them, altering the levels of chloroplast pigments, reducing the activity of antioxidant enzymes, and also, photoinhibition in the centers photosynthesis reaction (Gonçalves et al. 2001; Gonçalves et al., 2005; Liu et al., 2006; Morais et al., 2007).

For the production of quality seedlings, the ecophysiological knowledge of the initial phase of the plants becomes essential (Souza et al., 2013), because the rapid growth observed in some plants under shade can be considered an important adaptation of the plants to survive in low light conditions (Siebeneichler et al., 2008). Often, as a result of changes in the level of luminosity, variations can occur in aspects such as chlorophyll a/b ratio, leaf thickness, stomatal density, and changes in photosynthetic tissues in relation to non-photosynthetic ones leading to changes in biomass distribution (Freitas et al., 2012; Matos et al., 2011).

The oiticica (Microdesmia rigida) (Benth.) Sothers & Prance), typical of the Caatinga biome, belongs to the Chrysobalanaceae family and occurs mainly in marginal alluvial soils of rivers (Duque, 2004). Its plants reach up to 20 m in height, having a trunk that can branch off close to the ground. Its accentuated xerophilism is characterized by the perpetuity of its rough leaves (coreaceous), due to the thick cuticle that protects its surface against evaporation, in addition to remaining green throughout the year, even in periods of droughts helping the fauna and flora for providing a milder microclimate (Beltrão & Oliveira, 2007). The species has several uses, and in folk medicine the leaves are used in the treatment of diabetes and inflammation (Albuquerque et al., 2007), and the oil can be extracted from the seeds, which is used as a raw material for the production of several products (Bezerra at al., 2009). It is a meliferous plant of great importance in the biome, as it blooms during the dry period, between August and December, favoring the beekeeping activity of farmers, constituting a source of income for them during this period of water scarcity (Fernandes et al., 2005; Silva et al., 2010).

To better understand the growth and development of tree species, studies aiming to assess the adaptation of tree species to different light intensities are extremely important (Lima et al., 2010), and several have been developed in this direction (Farias et al., 2007; Gonçalves & Santos, 2005). Despite the importance of light in controlling the growth rate of plant species, and shading being important in the initial establishment of seedlings, the number of researches regarding native species in the Caatinga is still incipient. Studies with M. rigida, addressing aspects of shading, whether in the nursery phase or growing in the field, are non-existent, and the answers arising from this research will contribute to expand knowledge about this species, which is not explored from the scientific point of view. In view of this, the objective of the research was to evaluate the effect of shading on growth and gas exchange of M. seedlings in a nursery.

## 2. Methodoloy

### Plant material and growth conditions

This field research, of quali-quantiative nature (Pereira et al., 2018), was carried out in the Forest Nursery of the Federal University of Campina Grande, Patos Campus (7o03’34” S and 37o16’30” O), during 135 days. The region's climate is Bsh type, hot and dry, with well-defined seasons. The dry season from July to December, and the rainy season from January to May, with average annual rainfall of 600mm, average annual temperature of 25.5°C (Alvares et al., 2014; Monteiro et al., 2013).

Fruits of M. rigida were collected near adult plants on the banks of Rio da Cruz, in Patos, Paraiba State, Brazil, and after drying them in the shade, the seeds were removed, selected for uniformity and sanitary aspects, and placed to germinate in seed containing sand. At 15 days after emergence (DAE), the seedlings were transferred to black plastic bags containing 3kg of substrate, formed by the mixture of subsoil (0-20 cm layer) and bovine manure, in a 3:1 ratio. The seedlings remained in an environment under 50% shade, for 30 days, for adaptation and, after this period, were distributed according to the treatments

Three treatments were evaluated (0% - full sun, 50% and 70% shading), arranged in a completely randomized design (DIC), with four replications of 15 plants. The levels of shading evaluated were obtained through the use of a black shade screen. The plastic bags containing the seedlings remained at ground level with the covering structure with the screen of 1m high, with the screen also distributed on the sides, in order to provide the desired level of shading on all sides. The plants were moved (dance) on the structure weekly, aiming to maintain the greatest possible uniformity of the plants in relation to shading and competition for light. Irrigation was performed manually, using the watering can, daily.

## Parameters

a) Initial and final plant heights: at the beginning of the treatments (45 DAE), the plant height was measured, corresponding to the initial height (IH), and 90 days after, the final height (FH) was taken at the end of the experiment.

b) Absolute growth rate: with the initial and final height values, the Absolute Growth Rate (AGR) was calculated using the equation (Benincasa, 2003): $AGR = HF – HI/\Delta t$, where $\Delta t$ is the time interval between measurements (days).

c) Stem diameter (D): it was measured at ground level, using a digital caliper.

d) Leaf area: the leaves were collected, digitalized on a flatbed scanner and, using the software DDA (Digital Area Determiner), the leaf area was determined (Ferreira; Rossi & Andrighetto, 2008).

e) Dry mass of plants: the stem, roots and leaves after digitalization, were packed in paper bags, taken to dry in an oven at 65 oC, for 72 hours. Then, they were subjected to weighing to determine the dry matter weight of these components.

f) The Index of Dickson Quality (IDQ) was determined according to FH, DC, PDM (plant dry mass), DMS (shoot dry mass), and DMR (roots dry mass), using the equation $IDQ = PDM/[(FH/DC) + (SDM/RDM)]$, according Dickson; Leaf; Hosner (1960).

g) Gas exchange: transpiration (E), stomatal conductance (gs), net photosynthesis (A), and internal CO2 concentration (Ci) were determined at the end of experiment, using the portable photosynthesis analyzer LCpro-SD (ADC BioScientific Ltd.) (IRGA). The readings were performed on fully expanded leaves inserted in the second node from the apex of the plants, between 10:00 and 11:00 am. For these readings, the photosynthetic active radiation (PAR) levels were those measured by the IRGA, in each treatment evaluated (Table 1).

h) Chlorophylls quantification: approximately, 0,5 g of fresh leaves were homogenized with 25 mL of 80% acetone, centrifuging up at 3,000 rpm for 3 minutes according to the method described by Linder (1974). The spectrophotometric quantifications of chlorophylls a and b was determined by analysis of their absorbance at 645, 652 and 663 nm wavelengths. The amount of those pigments and the total chlorophyll was estimated using the followings equations, where A, m and V means absorbance, fresh mass and final volume of chorophyll-acetone extracte, respectively. Pigments content was expressed in milligrams per gram of fresh weight: Chl a = [(12.7. A663 – 2.69. A645)/1000m].V; Chl b = [(22.9.A645 – 4.68.A663)/1000m].V; Chl total = [(12.7.A663 – 2.69.A645)/1000m].V

### Statistical analysis

The data were submitted to analysis of variance and when differences were detected, the means compared by Tukey test, at 5% probability using the ASSISTAT software version 7.7 (Silva & Azevedo, 2002).

## 3. Results and Discussion

### Gas exchanges and chlorophyll contentes

Shading reduced the transpiration (E), being that at 60 days there was an average decrease of 33.5% in transpiration, when comparing plants kept in full sun (13.91 mmol m-2 s-1) to at 50% (9.34 mmol m-2 s-1) and 70% (9.17 mmol m-2 s-1) (Table 1).

**Table 1** – Photosynthetic active radiation (PAR), transpiration (*E*), stomatal conductance (*gs*), net photosynthesis (*A*) and internal $CO_2$ concentration (C*i*) of *Microdesmia rigida* seedlings at 30, 60 and 90 days of shading.

| Shading (%) | PAR ($\mu$mol mol$^{-2}$ s$^{-1}$) | *E* (mmol m$^{-2}$ s$^{-1}$) | *gs* (mol m$^{-2}$ s$^{-1}$) | *A* ($\mu$mol m$^{-2}$ s$^{-1}$) | *Ci* ($\mu$mol mol$^{-1}$) |
|---|---|---|---|---|---|
| 30 days | | | | | |
| Full sun | 1840 | 11,92 a | 0,51 c | 16,7 b | 110,8 b |
| 50 | 926 | 11,74 a | 1,99 b | 29,0 a | 158,1 a |
| 70 | 562 | 9,55 b | 3,72 a | 29,1 a | 142,6 a |
| 60 days | | | | | |
| Full sun | 1924 | 13,91 a | 0,97 a | 16,7 a | 264,8 a |
| 50 | 965 | 9,34 b | 0,49 b | 8,2 b | 221,8 b |
| 70 | 574 | 9,17 b | 0,57 b | 13,3 a | 196,7 b |
| 90 days | | | | | |
| Full sun | 1573 | 15,84 a | 1,81 a | 27,7 b | 315,6 b |
| 50 | 782 | 16,28 a | 1,18 b | 27,5 b | 336,2 b |
| 70 | 474 | 14,81 b | 0,78 c | 34,9 a | 379,3 a |

Means followed by the same letter are not significantly different at $P < 0,05$.
Source: Silva et al. (2020).

However, at 30 and 90 days, shading at 70% provided the lowest rate of transpiration, with no significant difference between plants in full sun and 50% shade. There was an increase in *gs* (Table 1) with an increase in shading, and at 30 days, in which at 50% and 70% shade *E* was 3.9 and 7.2 times higher than the value observed in plants under full sun. however, the reverse occurred at 60 and 90 days, with the effect being more adverse at 90 days, in which the values of this variable decreased from 1.81 mol $m^{-2}$ $s^{-1}$ (full sun) to 0.78 mol $m^{-2}$ $s^{-1}$ (70% shading), representing a reduction of 57%. Shading also favored *A*, with increase of 73% in shaded treatments in relation to full sun (Table 1). At 90 days there was an increase in *A* of about 12.5% between treatments full sun and 50% shading (27.7 µmol $m^{-2}$ $s^{-1}$), and 70% shading (34.9 µmol $m^{-2}$ $s^{-1}$). Regarding *Ci* (Table 1), the behavior was similar to that reported for *A*, except at 60 days, in which there was a decrease in the proportion that the light intensity incident on the plants decreased.

The decrease in *E* may have been due to the lower light availability to the leaves due to shading, since the stomatal opening is directly related to the amount of incident light (Costa & Marenco, 2007). In addition, the lower evaporative demand of the microenvironment provided by shading, in addition to the decrease in radiation (Kirchner, 2010; Gonçalves et al., 2012) may have contributed to the reduction in *E*. Besides that, shading may have affected the translocation rate of K to guard cells (Taiz & Zeiger, 2009), thus influencing the stomatal mechanism.

However, this smaller opening of the stomata did not interfere with the flow of $CO_2$ into the leaves, as the values of Ci and photosynthesis increased with shading, in the evaluations at 30 and 90 days, indicating that there was no limitation in the absorption of $CO_2$, necessary for the photosynthetic process.

The increase in luminous intensity may have resulted in an increase in ambient temperature, typical of semi-arid conditions, increasing perspiration and promoting greater water loss, leading to stomata closure, decreased stomatal conductance and $CO_2$ availability for carboxylation, resulting in decreasing plant photosynthesis. As a result, there will be damage to the growth and production of plant biomass and, consequently, to the quality of the seedlings.

The increase in leaf temperature of young plants when exposed to full sun can cause a sharp decrease in the rates of maximum carbon assimilation due to the decrease in stomatal conductance (Franck & Vaast, 2009). In C3 plant leaves, the assimilation of $CO_2$ reaches maximum values in the range between 20-30C°, already at temperatures above 35C°, the assimilation decays quickly (Kerbauy, 2013).

It has been reported that high levels of irradiance can mainly impair stomatal conductance, directly reflecting on net assimilation rates and carboxylation efficiency (Schock et al., 2014). Possibly the levels of luminosity in the full sun treatment, achieved in this study, may have been harmful to plants by reducing the activity of antioxidant enzymes and causing photoinhibition in the reaction centers of photosystems I (PSI) and II (PSII) of photosynthesis, decreasing-a (Gonçalves et al., 2001; Gonçalves & Santos, 2005; Liu et al. 2006; Morais et al., 2007), highlighting the need for shading the plants of *M. rigida* during the seedling phase.

In a study with *Bertholletia excelsa* Bonpl., a demanding species in light, under high (1900-2100 µmol $m^{-2}$ $s^{-1}$), moderate (800-1000 µmol $m^{-2}$ $s^{-1}$) and low light conditions (20-300 µmol $m^{-2}$ $s^{-1}$), Souza et al. (2017) found a higher rate of photosynthesis when subjected to a moderate light condition and greater transpiration under maximum irradiance.

In relation to the pigment concentration, higher values of chlorophyll a were observed in leaves subjected to full sun and 50% of shading, reducing when the level of shading increased to 70% (Table 2). However, the concentrations of chlorophyll b and total chlorophyll showed the opposite behavior, and the 70% shade treatment provided the highest values. These results show a progressive reduction in the chlorophyll a / b ratio as the availability of light to the plants decreases.

**Table 2** – Chlorophyll *a*, chlorophyll *b* and total chlorophyll contents and chlorophyll *a/b* ratio of seedlings maintained at different levels of shading.

| Shading (%) | Chlorophyll *a* | Chlorophyll *b* | Total Chlorophyll | Chlorophyll ratio *a*/*b* |
|---|---|---|---|---|
| | mg $g^{-1}$ MF | | | |
| Full sun | 302,60 a | 125,28 b | 203,48 b | 2,41 a |
| 50 | 283,33 a | 192,06 a | 282,35 a | 1,47 b |
| 70 | 211,28 b | 339,55 a | 351,65 a | 0,66 c |

Means followed by the same letter are not significantly different at P < 0,05.
Source: Silva et al. (2020).

According to Laisk et al. (2005), plants exposed to full sun invest less in complex light collectors, because in high irradiance, the leaves absorb more light energy. Under such condition, there is a discrepancy between the synthesis and degradation of pigments, with superiority in the degradation caused by photo-oxidation (Gonçalves & Santos, 2005; Krause et al., 2012). The increase in chlorophyll b with the reduction in light intensity may constitute a strategy for maximizing light absorption and maintaining the plant's photosynthetic potential (Scalon et al., 2003; Krause et al., 2012). In *B. excelsa*, Souza et al. (2017) found that plants growing under conditions of low irradiance showed higher values of chlorophylls *a*, *b* and total when compared to plants under full sun, and that there was an increase in the Chl *a/b* ratio in the treatments full sun and under medium irradiance in relation to low irradiance.

The reduction in the chlorophyll *a/b* ratio with the increase in the level of shading, verified in this study, can provide an increase in the light absorption capacity, due to the increase in complex light collectors (Hallik et al., 2012; Niinemets, 2010) result of the reduction in the concentration of chlorophyll *a* and the increase in chlorophyll *b* (Table 2). Chlorophyll *b* is located mainly in the light-collecting complexes of photosystems I and II (CCLI and CCLII), and chlorophyll *a* is present in the light-collecting complexes and in the reaction centers of the photosystems (Souza et al., 2017). In plants under shade, morphophysiological changes occur, such as lower chlorophyll a / b ratio, larger but lesser chloroplasts, leaves are thinner and narrower, greater photosynthetic efficiency and saturation under low irradiance (Poorter et al., 2012; Tripathi & Raghubanshi, 2014).

## Seedling growth and quality parameters

The shaded environment positively influenced the height of the plants, the height / diameter ratio, the absolute growth rates and the leaf area of the eucalyptus plants (Table 3), with no significant effect on the stem diameter. However, there were no significant differences between the 50% and 70% shade treatments in relation to the aforementioned parameters, demonstrating that the seedlings can be produced at both levels of shade.

**Table 3** – Height (A), stem diameter (D), height/diameter ratio (HDR), absolute growth rate (AGR) and leaf area (LA) of *Microdesmia rigida* seedlings maintained in different shade levels.

| Shading (%) | A (cm) | D (mm) | RAD | TCA (cm day$^{-1}$) | AF (cm$^2$) |
|---|---|---|---|---|---|
| Full sun | 33,89 b | 7,93 a | 4,27 b | 0,34 b | 175,78 b |
| 50 | 81,93 a | 7,75 a | 10,57 a | 0,91 a | 239,40 a |
| 70 | 78,33 a | 7,70 a | 10,17 a | 0,87 a | 262,40 a |

Means followed by the same letter are not significantly different at $P < 0,05$.
Source: Silva et al. (2020).

It is noticed that subjecting the plants to 50% shade provided an increase of 142%, 147%, 167% and 36%, respectively, in the values of height, HDR, AGR and leaf area, in relation to plants kept in full sun. The increase in height of the shaded plants may constitute an escape strategy from the low light developed by some plants, promoting rapid growth in environments where light is a limiting factor (Moraes et al., 2000). In addition, it may be the result of the action of auxins, because when irradiance is limited, auxins are redistributed laterally towards the epidermis and cells cortices of the hypocotyl, resulting in the elongation of these tissues causing estiolation (Morelli & Ruberti, 2000).

Increased plant height in response to shading has also been reported in *Schizolobium parahyba* (Vell.) S. F. Blake. (Caron et al., 2010); *Copaifera langsolosffii* Desf. (Dutra et al., 2012) and *Enterolobium contortisiliquum* (Vell.) Morong (Souza et al., 2013).

The increase in the leaf area of plants when exposed to shading is an adaptation that allows them to invest in growth and elongation of the surface of the photosynthetic leaf, for greater efficiency in capturing photosynthetically active radiation (PAR) (Lenhard et al., 2013). In general, leaves exposed to sunnier environments are smaller, thicker compared to those kept in shade (Craven et al., 2010).

Regarding the dry mass production of the plants (Table 4), it appears that the shading provided an increase in all components, except for the R/PA ratio, which reduced. As with growth parameters, there was no significant difference between the 50% and 70% shade levels, but despite that, the values at 50% were higher than those obtained at the highest level of shading.

**Table 4 -** Stalk dry matter weight (PMSC), leaves (PMSF), roots (PMSR), aerial part (PMSPA), total (PMSTotal), root / aerial ratio (R/PA) and Quality index of Dickson (IQD) of seedlings maintained in different shade levels.

| Shading (%) | PMSC | PMSF | PMSPA (g) | PMSR | PMSTotal | R/PA | IQD |
|---|---|---|---|---|---|---|---|
| Full sun | 5,81b | 7,73 b | 13,54 b | 7,19 b | 20,74 b | 0,55 a | 0,41 b |
| 50 | 17,25 a | 22,37 a | 39,63 a | 15,84 a | 55,47 a | 0,41 b | 0,53 a |
| 70 | 16,14 a | 19,33 a | 35,47 a | 13,48 a | 48,95 a | 0,38 b | 0,46 b |

Means followed by the same letter are not significantly different at P < 0,05.
Source: Silva et al. (2020).

Shading 50% allowed increases of 197%, 189%, 193%, 120% and 167% in the dry mass of the stem, leaves, shoot, roots and total dry mass, respectively, in relation to the full sun treatment. The maintenance of the plants in the shaded condition may have caused photoinhibition due to the excess of light, resulting in losses in the capture of light and the performance of photosynthesis (Kitao et al., 2000), which may explain the fact that the plants in this condition have presented values so low in relation to the 50% shade treatment. This fact denotes the intolerance of the species to high levels of luminosity, in this initial stage of growth.

Positive responses of shading in the production of shoot and total dry matter were obtained in *Caesalpinia echinata* Lam. (Aguiar et al., 2011), *Piptadenia stipulacea* (Benth.) Ducke and *Anadenanthera colubrina* (Vell.) Brenan var. Cebil (Griseb.) Altshul (Ferreira et al., 2012) e *E.contortisiliquum* (Souza et al., 2013).

In contrast, these latter authors found a reduction in root dry matter with an increase in shading. Pinto et al. (2016), in *Tabebuia aurea* (Silva Manso) Benth & Hook. F ex S. Moore, observed that under full sun, the values of dry mass of leaves and aerial parts were higher than those of shaded plants (50% shade), at 63 days. However, the behavior was reversed at 105 and 126 days, with shading favoring these parameters, showing the plasticity of the species, which can be cultivated under the two conditions mentioned. Also in *T. aurea*, Oliveira & Perez (2012) found that the 100% light treatment allowed for greater growth and dry mass production in the plants, when compared with the plants at 30% and 45% shading.

However, Reis et al. (2016), in research with *C. langsdorffii*, a species from the Cerrado, observed that the production of photoassimilates can be impaired under light conditions at both ends. These authors verified that the seedlings did not present significant responses to shading in relation to the accumulation of dry matter of the roots, aerial part, total and root / aerial part ratio, despite the maximum productivity of both parameters occurring in 54% and 44% of shading respectively, as well as with 100% (0.43g) and 90% (0.91g) of luminosity tended to present the minimum production.

As for the Dickson Quality Index (DIQ) (Table 4), it is observed that the shading promoted an increase in values, with statistical equality between the levels of 50% and 70% of shading, despite the DIQ presented by the plants at 50% shadow is greater. The DIQ is considered one of the main seedling quality indicators, as it considers several important morphological factors simultaneously, such as the robustness and balance of the biomass distribution (Caldeira et al., 2005; Caldeira et al., 2007). Taking into account the values proposed by Gomes & Paiva (2011) and Hunt (1990) to determine the quality of the seedlings, which is the DIQ above 0.20, it was found that the seedlings produced were of excellent quality, being suitable for planting in the field.

Similar results to those verified in this study were obtained by Souza & Freire (2018), in *T. aurea*, who verified that the seedlings submitted to full sun had a reduction of 17% in the DIQ, and that the treatment with 50%, with a reduction in the level of shading imposed increased to 70%. In contrast, Santos et al. (2013), in a study with *Caesalpinia ferrea* Mart. ex Tull, obtained the best DIQ results in plants kept under full sun.

It is noted, then, the variability of the responses of the tree species to the luminosity, which are dependent on the successional class of the species evaluated. However, in agreement with the results obtained here, there are a large number of researchers recommending the maintenance of the species, during the nursery phase, at 50% shade, for providing greater growth and better quality of seedlings.

## 4. Final Considerations

Shading increases the photosynthetic capacity, internal concentration of $CO_2$, stomatal conductance and decreases the transpiration of the *Microdesmia rigida* seedlings.

Shading makes it possible to increase the concentrations of chlorophyll *b* and total, but keeping plants at 70% shade promotes a reduction in chlorophyll *a* synthesis.

The growth and production of dry mass of the *Microdesmia rigida* seedlings is favored by shading.

It is recommended to produce seedlings of *Microdesmia rigida* seedlings, during the nursery phase, under 50% shading, as this condition provides the achievement of better seedling quality indexes.

We suggest researches that associates shading with irrigation levels or intervals during seedlings production.

## Acknowledgments

The authors thanks to the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES - Brazil) for the scholarship to the first author.

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