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Container volume and shading in *Parkia multijuga* Benth. propagation in nursery

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ABSTRACT - *Parkia multijuca* Benth. is one of the Forest species that occurs in the Amazon region. The aim of the this study was evaluate the development of seedlings of *Parkia multijuga* in differents shading and container volume in nursery. The experimental design was a randomized block design in 4 x 4 subplotplot (4 shadings and 4 containers volumes). The shading was 0, 30, 50 and 70% and containerv olumes 110, 180, 290 and 400 cm³. The diameter, root drymass, shootdrymass, total dry mass and the Dickson quality índex of the seedlings increased proportionally with container volume and with the availability of light. The conduction of the seedlings in full sun and container volume 400 cm³ favors the development of *P. multijuga* quality seedlings and 70% shading should not be used in nurseries to produce *P. multijuga* seedlings.

Keywords: IQD, light, native forest seedlings

RESUMO - Volume do recipiente e sombreamento na propagação em viveiro de *Parkia multijuga* Benth. *Parkia multijuca* Benth. é uma das espécies florestais que ocorre na região amazônica. O objetivo deste trabalho foi avaliar o desenvolvimento de mudas de *P. multijuga* em diferentes sombreamentos e volumes do recipiente. O delineamento experimental utilizado foi blocos ao acaso em esquema de parcelas subdividida 4 x 4 (4 sombreamentos e 4 volumes dorecipiente). O sombreamento foi 0, 30, 50 e 70% e os volumes 110, 180, 290 e 400 cm³. O diâmetro, a massa seca da raiz, a massa seca da parte aérea, a massa seca total e o índice de qualidade de Dickson das mudas aumentaram proporcionalmente com o volume do recipiente e com a disponibilidade de luz. A condução das mudas a pleno sol e o volume dorecipientede 400 cm³ proporcionaram mudas de qualidade de *P. multijuga* e 70% de sombreamento não deve ser utilizado em viveiros para produção de mudas de *P. multijuga*.

Palavras-chave: IQD, luz, mudas florestas nativas

INTRODUCTION

The North West Region of Mato Grosso is one of the last unexplored áreas of the State. It presents a great biological diversity, with fragile ecosystems, little studied and is part of the Arch of Deforestation that concentrates some of the most serious environmental problems, among them, unbridled deforestation (WWF 2012) and illegal logging (Silgueiro *et al.* 2018).

Parkia multijuca Benth. is one of the Forest species that occurs in Amazon region and it is distributed in the States of Amazonas, Para, Maranhão, Acre, Rondônia and Mato Grosso in áreas of forest in the phytogeographic domain of Amazonia (Oliveira & Hopkins 2018). The species belongs to the Fabaceae family, the largest trees reach dimensions close to 40 m in height and 100 cm of DAP (diameter at breash eight, measured at 1.30 m from the ground) in adult hood and classified as early secondary (Carvalho 2009). *P. multijuga* can also be used in landscaping, especially in urban arborization and public squares (Lorenzi 2008), besides being important for there covery of degraded áreas of permanente preservation, mainly due to its rapid growth (Carvalho 2009).

Native Forest species such as *P. multijuga* could be used in agroforestry systems, in there covery of areas and in the composition of commercial plantations, however, there is little scientific information about the production of forest seedlings in theregion, because despite the technological advances, the available information on native forest species is still scarce (Ribeiro *et al.* 2018).

In the processof nursery seedling production, the substrate and the volume available to the roots are fundamental, because it is in this environment that the planting of the seeds or the rooting of seedlings takes place, occurring the due sustentation to the plants, with the supply of water, nutrients and oxygen to the root system (Ribeiro *et al.* 2018).

Davide & Faria (2008) stated that pioneer forest species can usually be produced in smaller containers. Thus, it is interesting to study which container volume is most suitable

for each species, since the containers with larger volume capacity need more substrate and occupy more space in the nursery, which may contribute to increase the final cost of the seedling.

The different light conditions generally cause morphological and physiological variations in theplant, and the degree of adaptation is dictated by its genetic characteristics in interaction with its environment. The consequences of these light intensity differences are more significant in the growth of the plant than in its quality, especially with respect to dry matter accumulation under natural conditions (Scalon *et al.* 2003).

The shading of seedlings in the nursery stage is also important and verifying the developmen of plants under controlled conditions with the use of artificial shading with screen allows to verify the tolerance of the species to the amount of light received (Borges *et al.* 2014). Plant species be have differently in relation to shading. *Tabebuia aurea* (Manso) Benth. & Hook. Seedlings were not influenced by the luminosity to which they were submitted (Pinto *et al.* 2016), whereas, *Caesalpinia ferrea* Mart. ex. Tul. var. *leiostachya* Benth. presented better growth rates when kept in na environment with 50% shading (Lenhard *et al.* 2013).

Parkia multijuga is a species threatened with extinction and of interest in planting by the producers in the North West of Mato Grosso. The seedlings of this species are expected to develop differently when subjected to light constraints and to increase the container volume. Thus, the present study aims to identify the best combinations of container volume and shading for the development of *P. multijuga* seedlings in nursery.

MATERIAL AND METHODS

The study was conducted at the Federal Institute of Education, Science and Technology of Mato Grosso (IFMT), located in the Municipality of Juína, Mato Grosso, at the geographic coordinates 11º26'48.9'' S and 58º43'22.0'' W, with altitude of 311 m. According to the classification of Köppen and Geiger, the climate of Juína is Aw, tropical with dry season in the winter. The mean temperature in 2016 and 2017 was 24.8 °C and the mean annual precipitation in the municipality was 1,850 mm (INMET 2018).

Parkia multijuga pods were collected in Five treeson February 2016 in the municipality of Juína at coordinates 11º22'09.5 "S and 58º45'27.6" W and the seeds were placed in plastic bags in the IFMT room under ambient conditions. In October 2016 the seeds were mechanically scarified with scissors of pruning on the opposite side of the radicle location tôo vercome dormancy, immersed in recipient with water for 3 periods of 6 hours, with a 30 minute interval of oxygenation.

These seeds, soaked in water, were transported to suspended germinators filled with sawdust powder substrate and covered with 1 cm of sawdust for 7-8 days. After this period, the integuments surrounding the seeds were removed manually the seeds were placed in plastic tube containers according to treatment, volumes of commercial substrate Plantmax Florestal®.

The experimental design was a randomized complete blockwith 4 x 4 subplotplot (4 light conditions and 4 volumes capacities of the containers) with 4 replicates of 20 plants. The light conditions were full sun, 30, 50 and 70% shading constituted the plots. The subplots were 110, 180, 290 and 400 cm^3 container volume.

At 180 days the evaluation of the seedlings was carried out with the measurement of diameter (with caliper at substrate level) and height (with millimeter ruler from base to apical bud), number o fleaves, and determination of the biomass. The plants were washed and dried for 48 hours at a temperature of 65 ºC in air circulation dryingstove, brandSolab, model SL - 102, in the IFMT. The dry mass of shoot and roots were obtained in na electronic digital scale, brandEdutec, model EJ-320 A tothenearest 0,01g.

The data obtained were used to calculate the morphophysiological parameters relation between shoot height and shoot diameter (H/D), relation between shoot height and dry hootmass (H/DSM), ratio between dry shoot mass and dry root mass (DSM/DRM), ratio between dry root ratio and dry shoot mass (DSR/DRM), and Dickson quality index (DQI), which is determined as a function of total dry mass, height (H), diameter (D), dry shoot mass (DSM) and dry root mass (DRM), by means of Equation (Dickson *et al.* 1960):

$$DQI = \frac{TDM(g)}{\left(\frac{H(cm)}{D(cm)}\right) + \left(\frac{DSM(g)}{DRM(g)}\right)}$$

The data were tested for variance analysis assumptions, analyzed, and the means were compared by the Scott Knott testat the 5% probability level using the SISVAR software (Ferreira 2014).

RESULTS

The analysis of variance showed that there was a significant difference for the effects isolated light conditions and container volume, but there was no difference for the interaction between these.

Container volume effects

The diameter of the seedling was larger in the largest container (400 cm^3) and the largesth eight and number of leaves occurred in the container volume of 290 cm^3 (Tab.1).

Dry root mass, shootmass, and total dry mass of *P. multijuga* increased with increasing container volume, so the largest biomass occurred with 400 cm^3 container volume (Tab. 1).

Table 1. Diameter (D), plant height (PH) and number of leaves (NL), dry root mass (DRM), dry shoot mass (DSM) and total dry mass (TDM) of *Parkia multijuga* seedlings in different container volume. Juína-MT, 2018

Container volume (cm^3)	D (mm)	PH (cm)	LN	DRM (g)	DSM (g)	TDM (g)
110	8.16 c	42.59 b	3.90 c	17.05 c	45.05 d	62.10 d
180	8.79 b	43.51 b	4.08 b	19.31 b	52.58 c	71.89 c
290	8.70 b	45.68 a	4.63 a	20.89 b	56.34 b	77.24 b
400	9.36 a	41.53 b	4.20 b	24.03 a	64.82 a	88.85 a

Minor letters equals in the column indicate the means do not differ significantly according to Scott Knott's test at 5% probability.

The smallest relations hip between height and diameter (H/D) and height and dry shoot mass (H/DSM) occurred with the largest container (400 cm^3). There was no difference between the means in the DRM/DSM and DSM/DRM ratios, whilethe QDI was higher in the largest recipient (400 cm^3) (Tab. 2).

Shading effects

The diameter of the plant was inversely proportional to the shading, the high plant height were verified with 70% of shading and there was no difference between the mean number of leaves in the light conditions and as the shading of the seedlings increased, the biomass values of root, shoot and total biomass decreased (Tab. 3).

Regarding the H/D, H/DSM and DSM/DRM ratios, *P. multijuga* plants presented higher values in 70% shading and the lowest averages under full Sun treatment, and inverse behavior, higher values in full Sun were observed for the DRM/DSM and DQI ratios (Tab. 4).

Table 2. Relationship between height and diameter (H/D), height and dry mass (H/DSM), root dry mass and dry shoot mass (DRM/DSM), dry shoot mass and root dry mass (DSM/DRM) and Dickson quality index (QDI) of *P. multijuga* seedlings under different container volume. Juína-MT, 2018

Container volume (cm^3)	H/D	H/DSM	DRM/DSM	DSM/DRM	QDI
110	5.29 a	0.98 a	0.37 a	2.81 a	15.18 b
180	5.00 a	0.84 b	0.37 a	2.83 a	17.88 b
290	5.33 a	0.82 b	0.37 a	2.87 a	18.10 b
400	4.47 b	0.64 c	0.37 a	2.84 a	23.17 a

Minor letters equals in the column indicate the means do not differ significantly according to Scott Knott's test at 5% probability.

Table 3. Diameter (D), plant height (PH) and number of leaves (NL), dry root mass (DRM), dry shoot mass (DSM) and total dry mass (TDM) of *Parkia multijuga* Benth. seedlings in different shading conditions. Juína-MT, 2018

Shading conditions (%)	D (mm)	PH (cm)	NL	DRM (g)	DSM (g)	TDM (g)
0	9.46 a	39.09 d	4.18 a	26.32 a	59.02 a	85.34 a
30	8.93 b	44.11 c	4.37 a	21.15 b	56.64 a	77.79 b
50	8.78 b	42.44 b	4.06 a	19.54 c	54.83 a	74.37 b
70	7.85 c	47.66 a	4.19 a	14.27 d	48.30 b	62.57 c

Minor letters equals in the column indicate the means do not differ significantly according to Scott Knott's test at 5% probability.

Table 4. Relationship between height and diameter (H/D), shoot height and dry mass (H/DSM), root dry mass and dry shoot mass (DRM/DSM), dry shoot mass and root dry mass (DSM/DRM) and Dickson quality index (DQI) of *P. multijuga* Benth. seedlings under different shading conditions. Juína-MT, 2018

Shadding conditions (%)	H/D	H/DSM	DRM/DSM	DSM/DRM	DQI
0	4.14 c	0.67 c	0.45 a	2.29 c	23.10 a
30	4.97 b	0.79 b	0.37 b	2.73 b	18.73 b
50	4.86 b	0.78 b	0.36 b	2.89 b	18.46 b
70	6.12 a	1.03 a	0.29 c	3.43 a	14.04 c

Minor letters equals in the column indicate the means do not differ significantly according to Scott Knott's test at 5% probability.

DISCUSSION

Container volume effects

In general, the quality standard of the seedlings has a high correlation with the diameter, generating higher rates of survival and growth in the field (Puértolas *et al.* 2012), hence the importance of seedlings with larger diameter. Greater substrate volume can mean greater development of the root system and quality seedlings as verified by Melo *et al.* (2018) in *Mimosa caesalpiniifolia* Benth. plants produced in 110, 180 and 280 cm^3 volumes that presented higher quality morphological values in nursery when compared to the seedlings produced in 30 and 55 cm^3 volumes. The diameter of *Toona ciliata* M. Roem. var. *australis* seedlings had the highest values at 280 cm^3 substrate volume and the lowest values at 110 cm^3 substrate volume (Lisboa *et al.* 2012). *Schizolobium parahyba* (Vell.) S. F. Blake. seedlings in the nursery had the diameter increased with the largest substrate volume (300 cm^3) (Figueiró *et al.* 2017).

Hence the importance of larger container volume to obtain larger diameter seedlings as observed in the present study. In relation to the effect of container volume at number of leaves, there agree with Viana *et al.* (2008) that studying the production of seedlings of *Bauhinia forficata* Link. And verified that the larger container volume positively influenced the number of leaves.

Studies aiming to evaluate the influence of container volume on the growth of forest seedlings have shown that the use of larger containers form larger seedlings and considered of better morphological quality (Antoniazzi *et al.* 2013, Baldin *et al.* 2015, Melo *et al.* 2018). This fact was also verified in the present study in which the largest biomasses (DSM, DRM and DMT) occurred proportionally with the increase of the container volume (Tab. 2), possibly because it provided higher nutrient availability. Biomass production hás been considere done of the Best parameters to characterize the quality of seedlings, but it hás the disadvantage that its determination in many nurseries is not feasible, mainly because it involves the complete destruction of seedlings and the use of greenhouses (Eloy *et al.* 2013).

The height/diameter ratio expresses the idea of robustness of the plant (low value) in contrast to the thin aspect (high value), verified when cultivated at high densities, due to estiolation. Thus, it expresses the growth balance of the seedling, considering that smaller relationships indicate greater capacity of the seedlings to survive and settle in the field (Gomes & Paiva 2012). According to Rossa *et al.* (2013), based on the literature, seedlings with H/D ratio lowest than 10 are considered of excellent quality, which would minimize mortality in the Field after planting. Gasparin *et al.* (2014) verified H/D of 3.22 in seedlings of *Cabralea canjerana* (Vell.) Mart. in the 280 cm^3 tube, lower than that observed in this study, due to the lower growth of the shoot. However, this relations should not be considered in isolation, and all morphophysiological parameters must be considered in order to choose the conditions that provide quality changes.

The DSM/DRM and DRM/DSM relations outline how the distribution of assimilate between the parts of the plant (partthat transpiring x partthat absorbs water). The absence of significant difference between DSM/DRM and DRM/DSM ratios indicates that the seedlings presented the same pattern of dry matter distribution between the two organs, regard less of the container volume.

Gasparin *et al.* (2014) did not find difference in the DQI means in *Cabralea canjerana* (Vell.) Mart. seedlings in tubes of 100 and 280 cm^3, while Gonzaga *et al.* (2016) verifiedin *Hymenaea courbaril* L. seedlings, DQI of 0.44 in 110 cm^3 tubes and 0.76 in plastic bag.The mean values of DQI in *P. multijuga* seedlings ranged from 15,18to 23.17 (Tab. 3) and the higest value were in largest container volume (400 cm^3). The root restriction influenced the total production and thedistribution of the drybiomass, consequently, influenced reduction of the DQI of the seedlings produced in thetreatments with smaller substrate volume. There fore well above the minimum valueof 0.2 established in studies for quality seedlings (Gomes & Paiva 2012), possibly because of the great development of the seedling found at 180 days of nursery.

Shading effects

Differently that observed in the present study, *Dalbergia nigra* (Vell.) Allemão ex. Benth. seedlings had greater diameter in treatments with shading of 50, 70 and 84% and the species hás characteristics of shadow tolerance and more advanced stages of succession, approaching from late secondary species to climax (Pacheco *et al.* 2013). However, *P. multijuga* is a species classified in the initial secondary succession stadium (Carvalho 2009) and possibly requires greater light at the beginning of development in nursery as observed in the presente study.

The result of higher height in treatments with shading is similar to that found in *Dalbergia nigra* (Vell.) Allemão ex. Benth. seedlings that was highest increase in height, in the treatments with 70 and 84% of shading, and height was reduced when the seedlings were cultivated under low levels of shading (Pacheco *et al.* 2013). In relation to the characteristics such as diameter and height of the plant, it is recommended that a seedling considered of quality should have a height between 20 and 35 cm and a diameter between 3 and 10 mm (Gomes & Paiva 2012). In the present study this diameter condition was satisfied in all treatments, but the seedling height values were over 39 cm (Tab. 4).

There was positive effect of light on the number of leaves of *Caesalpinia ferrea* Mart. ex Tul. (Lima *et al.* 2008) and on the other hand, Azevedo *et al.* (2010) and Reis *et al.*(2016) verified that the highest number of leaves occurred in the condition of greater shading. This shows that plants of diferente species can present adjustments to

light availability as observed in the present study where there was no difference in leaf number.

Freitas *et al.* (2012) observed higher dry mass in *Sclerolobium paniculatum* Vogel. seedlings in full sun. According to Pacheco *et al.* (2013) *Chorisia speciosa* A. St.-Hil. seedlings, there was a significant increase in full Sun treatments (0%) and shade treatments (20 and 50%). This species, according to their searchers, had characteristics of heliophytes species in the initial stages of succession, approaching Pioneer plants to early secondary, such as *P. multijuga*.

The shading of the seedlings also influenced the relations between shoo theight and dry mass (H/DSM), with values increasing proportionally with greater light restriction, corroborating with the results obtained by De Marco *et al.* (2014) in *Toonaciliata* M. Roem. var. *australis* (F. Muell.) Bahadur), Reis *et al.* (2015) with *Dilodendron bipinnatum* Radkl. and Reis *et al.* (2016) in *Copaifera langsdorffii* Desf. The lower values of the H/D and H/DSM ratios provide greater seedling robustness and better survival capacity after planting (Dutra *et al.* 2013). Thus, in this studytheseedlingsdeveloped in full sun are better (Tab.4). Increased exposure to photo synthetic radiation increases the assimilate partition to the root system by decreasing the ratio values. The reduction of the root weight under shading is due to the water restriction of the seedlings in full sun, which induces the accumulation of dry mass in the root system, to the detriment of the accumulation of assimilates in the aerial part.

The quality index of Dickson is a important indicator of the quality of the seedlings and the higher the value of this index, the more vigorous Will be the plant because in its calculation are considered the robustness and the balance of the biomass distribution in the plant (Gomes & Paiva 2012). Thus, the Best treatments were those with the great estavailability of light, as they provided the highest DQI (Table 4). There is a need to complement research at the Field level so that planting of quality seedlings can be indicated, with a high rate of survival and growth.

The conduction of the seedlings in full sun and container volume 400 cm³ favors the development of *P. multijuga* quality seedlings and 70% shading should not be used in nurseries to produce *P. multijuga* seedlings.

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