Anais da Academia Brasileira de Ciências (2013) 85(2): 799-811
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
www.scielo.br/aabc

Osmotic conditioning and shading on the germination and on the initial growth of *Myracrodruon urundeuva* Allemão seedlings

SILVANA P.Q. SCALON[1*], LEANDRO H.S. MOTA[2] and ROSILDA M. MUSSURY[3]

[1]Universidade Federal da Grande Dourados/ UFGD, Faculdade de Ciências Agrárias, Rodovia Dourados/Itahum, Km 12, 79804-970 Dourados, MS, Brasil
[2]Programa de Pós-Graduação em Agronomia-Produção Vegetal, Universidade Federal da Grande Dourados/ UFGD, Faculdade de Ciências Agrárias, Rodovia Dourados/Itahum, Km 12, 79804-970 Dourados, MS, Brasil
[3]Universidade Federal da Grande Dourados, Faculdade de Ciências Biológicas e Ambientais, Rodovia Dourados/Itahum, Km 12, 79804-970 Dourados,MS, Brasil

Manuscript received on July 13, 2012; accepted for publication on August 27, 2012

ABSTRACT

The present work aimed to evaluate the osmotic conditioning and shading on the germination and on the initial growth of aroeira seedlings. The seeds were pre-imbibed in solutions with different concentrations of PEG (polyethylene glycol) and KNO_3 and incubated at 10°C and 20°C temperatures, during 0 (control), 12 and 24 hours. After these periods, the seeds were dried until they reached the initial levels of humidity. After that, they were put for germinating in BOD (Biochemical Oxygen Demand) chambers, at alternated 20-30°C. The control treatment and the pre-conditionings that presented the best results in BOD germination were selected, PEG (-1.0 MPa) + KNO_3 (-1.0 MPa) and KNO_3 (-1.0 MPa), with pre-imbibition for 12h and incubated in BOD at 20°C. The seeds were sowed on trays and then they were transplanted, keeping under a net covered with 50% and 70% of shading and at sunlight. The osmotic conditioning did not change the seeds germination in BOD, but the highest aerial part size was observed in PEG -1.0 MPa + KNO_3-1.0 MPa treatment. The shading levels at 50% and 70% and the osmotic conditioning with PEG -1.0 MPa + KNO_3-1.0 MPa offered a higher emergence in a greenhouse condition; however, at sunlight the seeds presented a better index of quality on the 145th day.

Key words: "aroeira", Anacardiaceae, Cerrado, shading, PEG 6000 and KNO_3.

INTRODUCTION

The Brazilian cerrado has the biggest diversity of species when compared to other savannahs (Klink and Machado 2005) and it has presented a great human pressure, mainly due to mixed-farming activity. In Brazil, the area of cerrado covers around 1.8 million Km^2 (Aguiar et al. 2004), 13% is occupied with nature pastures, 23% with cultivated ones, 5% with agriculture, 18% with other kinds of use and 41% of this area is not cultivated (Sano et al. 2001).

With a quick rhythm of deforestation, the native areas have being degraded and gradually reduced as a consequence of the agriculture development, just as it occurred in Mato Grosso do Sul with soya cultivation. So, several vegetal species are limited to determined areas or are also being extinct (Martins and Silva 2001, Campos et al. cited by Vazzoler et al. 1997).

Correspondence to: Rosilda Mara Mussury
E-mail: maramussury@ufgd.edu.br
Bolsista/*CNPq

Therefore, studies about seeds production and domestication are necessary to support future projects for the composition and reforestation of the degraded areas. However, these studies depend on the seeds germination and on the initial development of the seedlings and they must approach the existing interaction among the natural necessities of each species and the environmental factors. But many native species present quiescence or a great heterogeneity on the germinative potential.

For getting around this heterogeneity, the technique of osmotic conditioning may be used since it propitiates higher germination uniformity and synchronization, an elevated index of emergence and seedlings development, even in soils with low contents of humidity and a higher growth index of the aerial part (Marcos Filho 2005). The technique of osmotic conditioning of the seeds consists in immersing the seeds in an osmotic solution under time and temperature previously determined. It is done with an increase on the osmotic pressure of the imbibed solution, adding inorganic osmotic agents such as NaCl, KNO_3 e $MgSO_4$ and organic ones, like polyethylene glycol (PEG 6000), mannitol and sucrose, which increase the solution concentration and thus, decrease the hydric potential (Roveri José et al. 1999).

However, the osmotic conditioning may be affected by environmental conditions such as temperature and brightness, microbial contamination, drying or non-drying of the seeds and oxygen availability (Rovieri José et al. 1999).

The acquaintance about the germination ecophysiology and the initial growth of the seedlings is essential for the success of the seedlings production activity with quality, vital for an outcome on the reforestation and planting activities in natural woods.

The light availability is fundamental for the plants, not only to supply energy for the photosynthesis but also to supply signals that adjust its development through receptors sensitive to different intensities and spectral quality (Gonçalves et al. 2006).

So changes in the light levels on which a species is adapted may limit different physiological responses in their biochemical, anatomical and growth characteristics (Atroch et al. 2001). As the process of the stomatal opening and closure is mainly related to the light intensity and condition of leaf hydration, the stomata functioning and the leaf area influence the vegetal productivity since they control the CO_2 absorption and the light interception (Marenco and Lopes 2005).

The success on the adaptation of a species in different conditions of radiation is related to the efficiency and quickness on which the patterns of biomass allocation and physiological behavior are adjusted. The lowest or the highest adaptive plasticity of the species to different conditions of solar radiation depends on the adaptation of its photosynthetic apparatus, which assures a higher efficiency when it converts radiant energy into carbohydrates and consequently offers a higher growth (Campos and Uchida 2002).

"Aroeira" (*Myracrodruon urundeuva* Allemão) presents a great pharmacological use. Carvalho (2003) observed in his revision that "aroeira" has anti-inflammatory, astringent, anti-allergic and healing properties and it is indicated for curing gastritis, throat's inflammation, breathing and urinary diseases and regulates periods. Besides this, its wood is considered the strongest one in Brazil due to its durability and difficulty in rot. It is used on civil construction for building lamp posts or beams for fences, for manufacturing luxurious furniture, flooring and adornments. Guedes et al. 2009 observed that due to its several properties, this species is widely used in a predatory way and this has caused a reduction on its natural population; therefore, it was included in IBAMA official list as an endangered species. In this sense, studies for the seedlings production are necessary in order to

make possible its sustainable usage. Dorneles et al. (2005) observed in their revision that "aroeira is a species which indicates a mesotrophic cerradão, in an area in Central Brazil, and the seeds germination is changeable and depends on its origin, presenting an average among 20 to 80%, so it is necessary studies to optimize and stimulate this germination.

Guedes et al. (2009) observed the seeds are orthodox and tolerate the drying till 23%. Therefore, this work aimed to evaluate the osmotic conditioning and the shading on the germination and on the initial growth of "aroeira" seedlings.

MATERIALS AND METHODS

The "aroeira" seeds were collected from ten (10) trees, in Dourados, Mato Grosso do Sul, a city placed at 22° 14' 16" S and 54° 48' 02" W and 452 m of mean altitude, with a weather classified as Cwa and its annual mean rainfall is 1500 mm. The annual mean temperature is 22°C. The soil, primarily under savannah vegetation, has plane topography and is classified as Distroferric Red Latossol with a clayish texture (Mato Grosso do Sul 1990).

Effect of the Conditioning, Time and Temperature of Pre-Imbibition on the Germination

The seeds were put in a pre-imbibition condition, in transparent "gerbox" boxes lined with two sheets of filter paper, moistened with 15 mL of these respective test-solutions: 1) PEG 6000 (-0.5 MPa); 2) PEG 6000 (-1.0 MPa); 3) PEG 6000 (-0.5 MPa) + KNO_3 (-0.5 MPa); 4) PEG 6000 (-1.0 MPa) + KNO_3 (-1.0 MPa); 5) KNO_3 (-0.5 MPa); 6) KNO_3 (-1.0 MPa); and 7) control. The calculus for obtaining the PEG 6000 solution concentration was achieved according to Villela et al. (1991) and the concentration of KNO_3 solution was achieved with Van't Hoff equation (Hillel 1971). For the mixture of KNO_3 and PEG 6000, the interaction between both products was ignored.

The transparent 'gerbox' boxes were covered with a plastic film to prevent the evaporation and then, they were incubated in germination chambers (BOD) with a controlled temperature for 10°C and 20°C during 0 (control without pre-imbibition) and for 12 and 24h, both with direct light. After each period of pre-imbibition, the seeds were taken from the BOD, and washed in running water for removing the excess of solution then they were kept at the laboratory environment condition until they reached the initial weight presented before the osmotic conditioning, monitored through consecutive weightings.

After the drying, the seeds were sowed in 'gerbox' boxes, on two sheets of filter paper and kept in BOD at alternated 20-30°C temperature and at 8h dark and 16h light photoperiods and irrigated with water for keeping 2.5 of the paper weight during 14 days. The germination percentage, index of germination speed, size of the shoot, root/shoot ratio and dry mass of the seedlings were evaluated.

The statistical design was completely randomized in a factorial scheme with 7 pre-conditioning treatments x 3 pre-imbibition periods, with four replications of 25 seeds. All the results were submitted to the analysis of variance and the means were compared by Tukey test at 5% of probability, using the SANEST statistical program (Zonta et al. 1985).

Effect of shading and Osmotic Conditioning on the Emergence and Initial Growth of the Seedlings

The control treatment and the pre-conditioning ones which presented the best results of germination and vigor at the laboratory, in BOD, under alternate temperature and light, were sowed at 1 cm deep in cell trays containing the substratum Plantmax® + soil + sand + chicken litter semi-decomposed, at 1:1:1:0.5 (v:v). The chosen treatments were: PEG (-1.0 MPa) + KNO_3 (-1.0 MPa) and KNO_3 (-1.0 MPa), with a 12h imbibitions and incubated in BOD at 20°C. After the sowing, the trays were kept under a net covered with 50% and 70% of shading (black nylon nets were also used) and at sunlight. All treatments were daily watered by sprinkling

until they reached the field capacity. The emergence percentage (E) and the index of emergence speed [IES = ∑ (ni/ti)] were evaluated, according to Popinigis (1985). The experiment was achieved in a completely randomized design with three levels of shading and three pre-osmotic conditioning treatments, with four replications of 25 seeds.

At the 20th day after the emergence, the seedlings were transplanted to 20 x 12 cm polyethylene bags, containing as substratum: soil + sand + chicken litter, at 1:1:1 (v:v) volume proportions and they were kept in their respective shading places.

The evaluations of the growth and the quality of the "aroeira" seedlings were achieved on the 45th, 70th, 95th, 120th and 145th days of the seedling age and the total chlorophyll, transpiration, stomatic conductance and photosynthesis were also evaluated. The transpiration, stomatic conductance and the photosynthesis evaluations were achieved between 9 am and 10 am, on leaves completely outspread with the reinforcement of an LCi portable measurer of photosynthesis and the chlorophyll was measured with a SPAD 502 one.

For the evaluations of the growth and the quality of the seedlings, the following characteristics were determined: a) seedling height (cm) measured with a millimeter scale, from the stem until the apical bud; b) root length (cm) also measured with a millimeter scale, from the tip of the primary root until the stem; c) stem diameter (mm), measured with a caliper rule (0.01 mm); d) dry mass of the aerial part and of the roots (g) determined in a greenhouse condition, with air circulation at 60° ± 5°C, until the constant mass; e) HDR: plant height / stem diameter ratio; f) SRR: shoot dry mass / root dry mass ratio; g) DQI: Dickson quality index, obtained by the formula: DQI = [total dry mass /(HDR + SRR)] (Dickson et al. 1960).

The experiment was carried out in a completely randomized design, with four replications of 15 seedlings. The obtained results were submitted to the analysis of variance and as there was significance, the means of emergence percentage and the index of emergence speed were compared by Tukey test at 5% of probability and for the other characteristics, it was used the analysis of regression, using the SANEST (Zonta et al. 1985).

RESULTS AND DISCUSSION

On the first experiment percentage, index of germination speed of the seeds and the size of the aerial part of "aroeira" neither present a significant effect of the treatments and nor any interaction among them (Table I). However, it is verified for the size of the aerial part that the treatments of the pre-conditioning offered higher values, standing out the treatment PEG (-1.0 MPa) + KNO_3 (-1.0 MPa).

TABLE I
Germination percentage (%G), index of germination speed (IGS) and aerial part size (APS) of the *Myracrodruon urundeuva* Allemão seedlings due to different treatments of pre-osmotic conditioning and incubation at 20-30°C. UFGD, Dourados-MS, Brasil, 2009.

Treatments	% G	IGS	APS
Pre-imbibition 10°C	45.55 a	1.89 a	1.84 a
Pre-imbibition 20°C	47.49 a	1.98 a	1.78 a
0 h without pre-imbibition	44.67 a	1.83 a	1.73 a
12h Pre-imbibition	49.61 a	2.07 a	1.8 1a
24h Pre-imbibition	45.29 a	1.89 a	1.88 a
Control	46.89 a	1.95 a	1.67 b
KNO_3 -1.0 MPa	50.00 a	2.06 a	1.68 b
KNO_3 -0.5 MPa	42.67 a	1.76 a	1.86 ab
PEG -1.0 MPa + KNO_3 -1.0 MPa	48.89 a	2.02 a	2.06 a
PEG -0.5 MPa + KNO_3 -0.5 MPa	47.11 a	1.95 a	1.82 ab
PEG -1.0 MPa	46.78 a	2.01 a	1.74 ab
PEG -0.5 MPa	43.33 a	1.79 a	1.84 ab
VG%	26.73	26.18	20.28

Means followed by the same letter in the columns do not differ themselves by Tukey test at 5% of probability.

The results contradict those observed by D.M. Carvalho et al. (unpublished data) while evaluating the effect of the water stress on the germination and vigor of *Myracrodruon urundeuva* seeds stored at 20°C and 50% relative

humidity during five months after they were osmo-conditioned without endocarp. It was used a PEG solution at zero, -0.2, -0.4, -0.6, -0.8, -1.0, -1.2, -1.4 MPa, as well as and incubated in BOD at 25°C under constant light, verifying a reduction on the germination and on the germination speed, with a reduction on the osmotic potential.

However, even with the osmotic conditioning, the germination data observed in this present research are lower than those observed on literature for aroeira. The aroeira seeds treated with gibberelline, cytokynin, potassium nitrate and water did not present a significant difference on the germination, which presented values of 52.8 to 60% when sowed soon after the harvest (Dorneles et al. 2005).

The scarification of the seeds with a sandpaper number 60 and sowing two months after the harvest, at the alternate temperature, offered values that varied from 79 to 90% of germination when the sowing occurred over or between the paper or vermiculite and 25% over or among the sand (Pacheco et al. 2006). These authors observed an IGS higher than those ones from this present research, observing IGS of 5.05 and 3.19 when the sowing occurred among vermiculite and at alternate temperature of 20-27°C and 20-30°C respectively, compared to means of 2.49 and 0.89, when it was among the sand.

Guedes et al. (2009) observed a higher emergence of the seeds when they were scarified with sulfuric acid for 12 minutes (74% and IGS higher than 3) when compared to the control (lower than 20% and around 0.5 IGS) and with scarification of the seeds with a sandpaper number 80 at alternate temperatures followed by a KNO_3 imbibition for 24h, which was practically non-existant.

As for the germination of the "aroeira" seeds, the variable results may be due to the fact that intra specific and significant changes on the phenology of the species occur due to the period and the place, since the environmental factors and its interaction with the species genotype may influence on the growth and developmental responses (Larcher 2000).

For the dry mass, it was not observed any significant interaction among the treatments with average of 0.08 g. Seeds submitted to KNO_3 (-1.0 MPa) and PEG (-1.0 MPa) + KNO_3 (-1.0 MPa) treatments for 12h imbibition presented higher root/shoot ratios (Table II). In general, it is also observed a higher root/shoot ratio at 20°C, standing out PEG (-1.0 MPa) + KNO_3 (-1.0 MPa) treatment. On Kissmann et al. (2011) revision, it is observed that the mixture of salts contaning nitrate and phosphate may be more effective on the seeds conditioning than on the pure solutions of PEG 6000 and that the osmotic conditioning promotes organic solutes production resulting in a higher potential of the cell turgor during the seedlings rehydration, which would result on the emergence of the primary root in a lower time besides stimulating or synthesizing the enymes. This result may occur due to a reduction the osmotic potential of the cells from the radicular tissues, similar to the occurrence on the osmotic adjustment in situations of hydric deficit, taking to a higher entrance of water producing a higher emptiness and growth, so the plants tend to use more biomass on the radicular system, allowing higher roots growth and consequently, an increase on nutrients absorption capacity (Taiz and Zeiger 2008).

However, for carobinha (*Jacaranda decurrens* subsp.symmetrifoliolata Farias & Proença) a native species from Cerrado, the conditioning treatments tested did not differ themselves on any characteristics of viability and vigour evaluated (Kissmann et al. 2011).

On the second experiment, it was not observed any significant interaction among the treatments for emergence percentage and index of emergence speed, which were higher under shading. The seeds submitted to the osmotic conditioning presented emergence higher than the control seeds and the index of emergence speed did not differ statistically for the conditioning (Table III).

TABLE II
Shoot/root ratio (SRR) of *Myracrodruon urundeuva* Allemão seedlings due to different periods of imbibition, temperature and pre-osmotic conditioning treatments. UFGD, Dourados-MS, Brasil, 2009.

Treatments	0 h	12h	24h	10°C	20°C
Control	0.39 Aa	0.54 ABCa	0.49 Aa	0.40 Ab	0.54 ABa
KNO_3 -1.0 MPa	0.39 Ab	0.63 ABa	0.45 Aab	0.49 Aa	0.49 ABa
KNO_3 -0.5 MPa	0.39 Aa	0.50 ABCa	0.37 Aa	0.32 Ab	0.52 ABa
PEG -1.0 MPa+KNO_3 -1.0 MPa	0.39 Ab	0.70 Aa	0.39 Ab	0.32 Ab	0.66 Aa
PEG -0.5 MPa+KNO_3 -0.5 MPa	0.39 Aa	0.55 ABCa	0.47 Aa	0.45 Aa	0.49 ABa
PEG -1.0 MPa	0.38 Aa	0.36 BCa	0.33 Aa	0.32 Aa	0.40 Ba
PEG -0.5 MPa	0.39 Aa	0.30 Ca	0.50 Aa	0.37 Aa	0.42 Ba
VG%		34.78		34.78	

Means followed by the same capital letter in the columns and small ones on the line do not differ themselves by Tukey test at 5% of probability.

TABLE III
Emergence percentage (E) and index of emergence speed (IES) of *Myracrodruon urundeuva* Allemão seeds due to different levels of shading and different pre-osmotic conditioning treatments. UFGD, Dourados-MS, Brasil, 2009.

Treatments	E (%)	IES
70% of shading	49.67 a	1.97 a
50% of shading	46.67 b	1.90 a
Full sun	44.22 c	1.79 b
PEG -1.0 MPa+ KNO_3 -1.0 MPa	49.55 a	1.91 a
KNO_3 -1.0 MPa	46.89 b	1.89 a
Control	44.11 c	1.87 a
VG %	3.78	4.35

Means followed by the same letter in the columns do not differ themselves by Tukey test at 5% of probability.

The low percentage of the emerged seedlings and the index of emergence speed in full sun may occur due to the high temperature caused by a high light intensity present on this environment, making lower the availability of water and consequently, a lower imbibition. Another explanation could be based on Silva et al. (2002) observations, on which the seeds germinate in a higher percentage with the absence of light, but they may be considered as preferable negative photoblastic ones. The temperature increase and the decrease on the capacity for retaining water from the soil, in areas completely exposed, may speed up the seeds deterioration (Morris et al. 2000) and so, reducing the emergence index. According to Marcos Filho (2005), the red radiation (660 nm) penetrates till 2.5 cm of deep in the soil while the infrared radiation (730 nm) reaches a higher soil depth.

It was not observed any significant interaction among the treatments of shading, osmotic conditioning and seedlings age for height, total chlorophyll, transpiration, stomatic conductance, photosynthesis and HDR (height/stem diameter ratio). The osmotic conditioning treatments did not influence statistically any of the studied variables.

The seedlings height and the HDR were higher when submitted to 70% of shading (Table IV). The capacity of a fast growth on a shady environment is an important mechanism of the species adaptation, which constitutes a precious strategy for avoiding the conditions of a low availability of light (Moraes Neto et al. 2000). In this condition, the plants would try to assail on a higher quantity of photo assimilates on the shoot, besides the higher cellular elongation, which would contribute for a higher height of these species, under shady environments. The lowest growth of the seedlings kept in full sun may be assigned to some process of photo inhibition (Kitajima 1996).

TABLE IV
Height (H) and HDR of *Myracrodruon urundeuva* Allemão seedlings due o different levels of shading. HDR = height/stem diameter ratio. UFGD, Dourados-MS, Brasil, 2009.

Treatments	H (cm)	HDR
70% of shading	20.37 a	6.53 a
50% of shading	15.78 b	4.73 c
Full sun	14.80 b	5.24 b
VG (%)	14.22	17.45

Means followed by the same letter in the columns do not differ themselves by Tukey test at 5% of probability.

The shading also caused the highest growth in the height of other species, as it was observed by Scalon et al. (2003) in *Bombacopsis glabra* under 50% of shading, Rego and Possamai (2006) in *Cariniana legalis* Martius kept at 36% of shading and with Carvalho et al. (2006), with *Syagrus coronata* (Mart.) Becc. plants were kept at 70% of shading.

The height presented a quadratic growth, reaching at the final of the experiment values of 23.5 cm (Figure 1a). From the 70 days of age, the length of the seedling roots in full sun presented a higher growth and kept superior all along the evaluations (Figure 1b). This highest length of the root may be assigned due to the seedlings in full sun probably presented a higher loss of water by evapotranspiration, and therefore a lower availability of water in the soil, which unleashes a higher ABA synthesis on the cells of the radicular tissue and consequently a higher growth of these cells, leading to a higher radicular growth and favoring a higher area of soil to be explored (Taiz and Zeiger 2008).

The seedlings presented a higher stem diameter when submitted to the conditions in full sun (Figure 1c). The observed data confirmed those found in literature. In higher shading levels, there is a diminish of the assimilates and the growth regulators due to a decrease of the photosynthesis, reflecting on a lower development of the stem thickness. Rego and Possamai (2006) also observed a higher stem diameter in *Cariniana legalis* (Mart.) Kuntze submitted to a higher level of light. According to Larcher (2000), the diameter growth presents a direct relation with the liquid photosynthesis which depends on the carbohydrates and the auxins accumulated and on a favorable balance between liquid photosynthesis and respiration.

The higher dry mass of the shoot was observed in seedlings in full sun at the 145th day of their age (Figure 1d). Although it had been observed a higher length of the root on seedlings in full sun, seedlings at 70% of shading presented a higher dry mass of the root (Figure 1e).

These results observed for "aroeira" contradict those observed in literature, in which the proportion of dry mass led to the shoot is higher in shady plants and which the dry mass of the roots is higher in plants grew with greater light levels, as it was verified in *Syagrus coronata* (Mart.) Becc. (Carvalho et al. 2006), Cariniana legalis Martius (Rego and Possamai 2006) and *Clitoria fairchildiana* (Scalon et al. 2006). According to Welander and Ottosson (1997), the fact a lower dry mass of a root is observed in shady plants is due to the shading provided by the upper leaves on the stem basis, and so it occurs a lower production of assimilates from the lower leaves that are put in charge of tending the carbon demand on the roots. Seedlings with a higher root biomass probably have a better chance of surviving to the water stress on a dry season, when they are in natural environment (Kitajima 1996) and so, this characteristic is extremely important for the success of activities for the seedlings planting (Longman 2003).

The chlorophyll contents were higher in shady seedlings (Table V) and they kept a quadratic behavior during the evaluations (Figure 2a). The increase of the chlorophyll contents on leaves in shady condition, especially of chlorophyll b, increases the capacity of light absorbing on a different photosynthetic active radiation, just as with blue wave length, present in a great quantity in shady places (Taiz and Zeiger 2008).

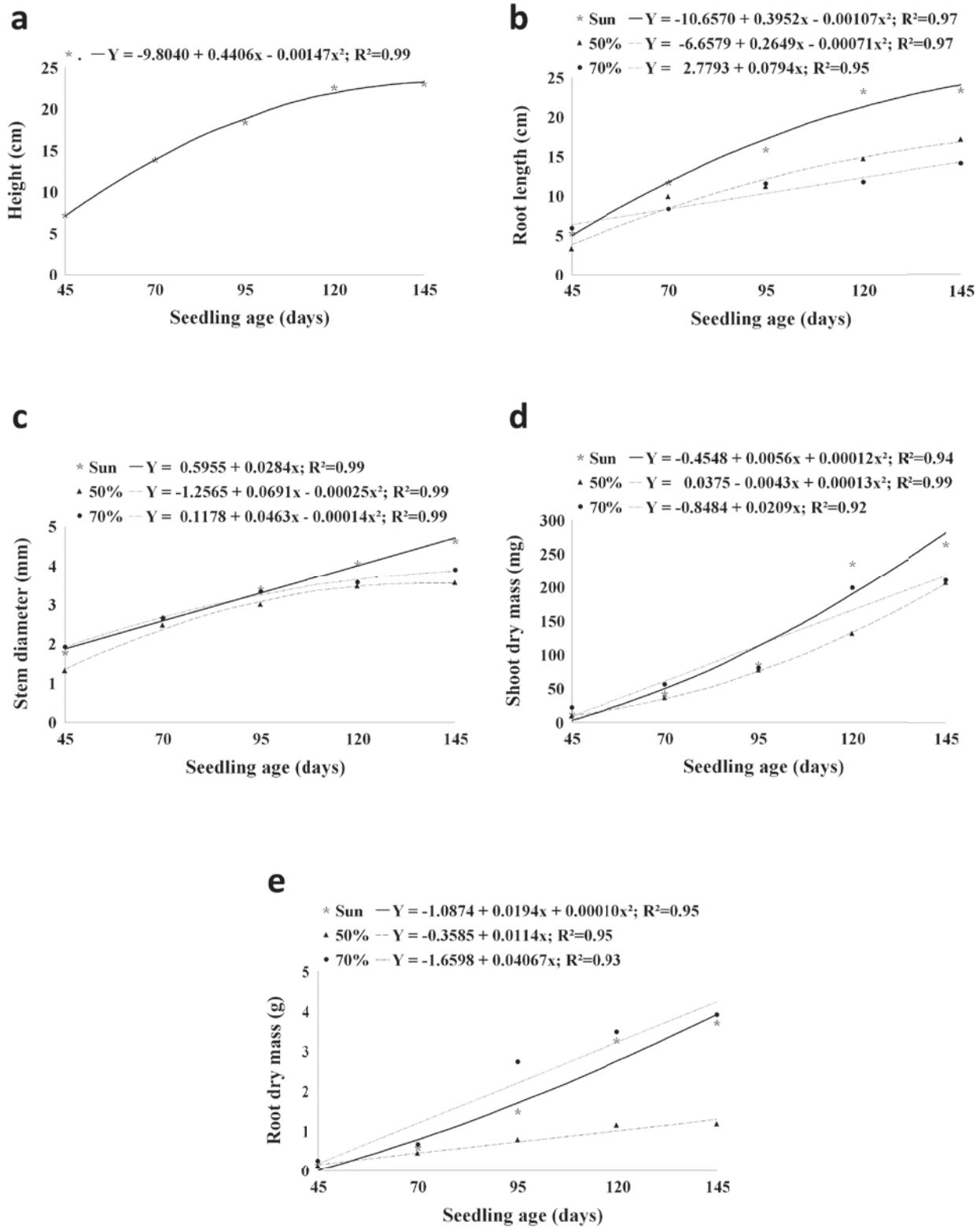

Figure 1 - Height **(a)**, root length **(b)**, stem diameter **(c)**, shoot dry mass **(d)** and root dry mass **(e)** of *Myracrodruon urundeuva* ALLEMÃO seedlings due to their age.

TABLE V
Total chlorophyll (TC), transpiration (E), stomatic conductance (Gs) and photosynthesis (F) of *Myracrodruon urundeuva* Allemão seedlings due to different levels of shading. UFGD, Dourados-MS, Brasil, 2009.

Treatments	TC	E	Gs	F
	µg.cm^{-2}	mmol.m^{-2}.s^{-1}	mol.m^{-2}.s^{-1}	µmol.m^{-2}.s^{-1}
70% of shading	50.59 a	1.61 b	0.20 b	7.81 c
50% of shading	46.76 b	1.81 a	0.20 b	9.34 b
Full sun	45.05 c	1.91 a	0.30 a	10.39 a
VG %	6.77	20.76	27.43	16.41

Means followed by the same letter in the columns do not differ themselves by Tukey test at 5% of probability.

Observing Table V, it is verified that the higher the luminous intensity was, the higher the transpiration, the stomatic conductance and the photosynthesis of the aroeira seedlings were. Similar results were observed by Lima Junior et al. (2006). Yet, the osmotic conditioning treatments did not influence statistically the contents of total chlorophyll, the transpiration, the stomatic conductance and the photosynthesis of the aroeira seedlings. Rice plants cultivated in a nutritional solution with polyrthyleneglycol presented a reduction on the CO_2 absorption, in the stomatic conductance and in the transpiration and, in general, after the interruption of the osmotic and hydric stress, the plants recovered the water tension on the 1st day of cultivation in a solution without PEG (Gomes et al. 1997). So, it is suggested that the PEG concentrations used in the seeds, during the imbibition period, did not cause any structural and metabolic damage on the cells and not interfere on the photossinthetic efficiency of the seedlings.

Palhares et al. (2010) observed on their revision that the relation complexity between climate and soil form Cerrado is related to the diversity of photosynthetic responses and the hydric relations on vegetal species adapted to this environment. Generally, the young plants from Cerrado must put up with shading, the water seasonal scarcity on the most superficial layers of the soil and the forest fires. During the dry season, there are species that depress the carbon assimilation rate up to 50% (mainly between midday and 2 pm, period of a higher solar radiation, higher temperature and lower relative air humidity), while other species maintain it unaltereted. There are also some species that present a reduction on carbon assimilation rates at midday, even during the rainy period. There are species that during the dry season maintain, depress or increase the rate of transpiration.

Analyzing the figures 2b, 2c and 2d, it may be observed that the values of transpiration, stomatic conductance and photosynthesis decreased during the evaluations. This behavior may be assigned to the falling on temperature, as a consequence of the end of the summer (34 ± 2°C) and the beginning of the autumn (24 ± 2°C).

It is observed in literature that the transpiration behavior of the seedlings in different light availabilities is variable. Welander and Ottosson (2000), while evaluating the growth of *Quercus robur* seedlings, also observed higher indexes of transpiration with the increase of irradiance.

Alvarenga et al. (2003), while evaluating the effect of different light levels on the initial growth of *Croton urucurana* Baill. seedlings, also noted that the highest photosynthetic indexes occurred on cultivated plants with the highest levels of irradiance.

A similar tendency related to the stomatic conductance was also observed for the *Carapa*

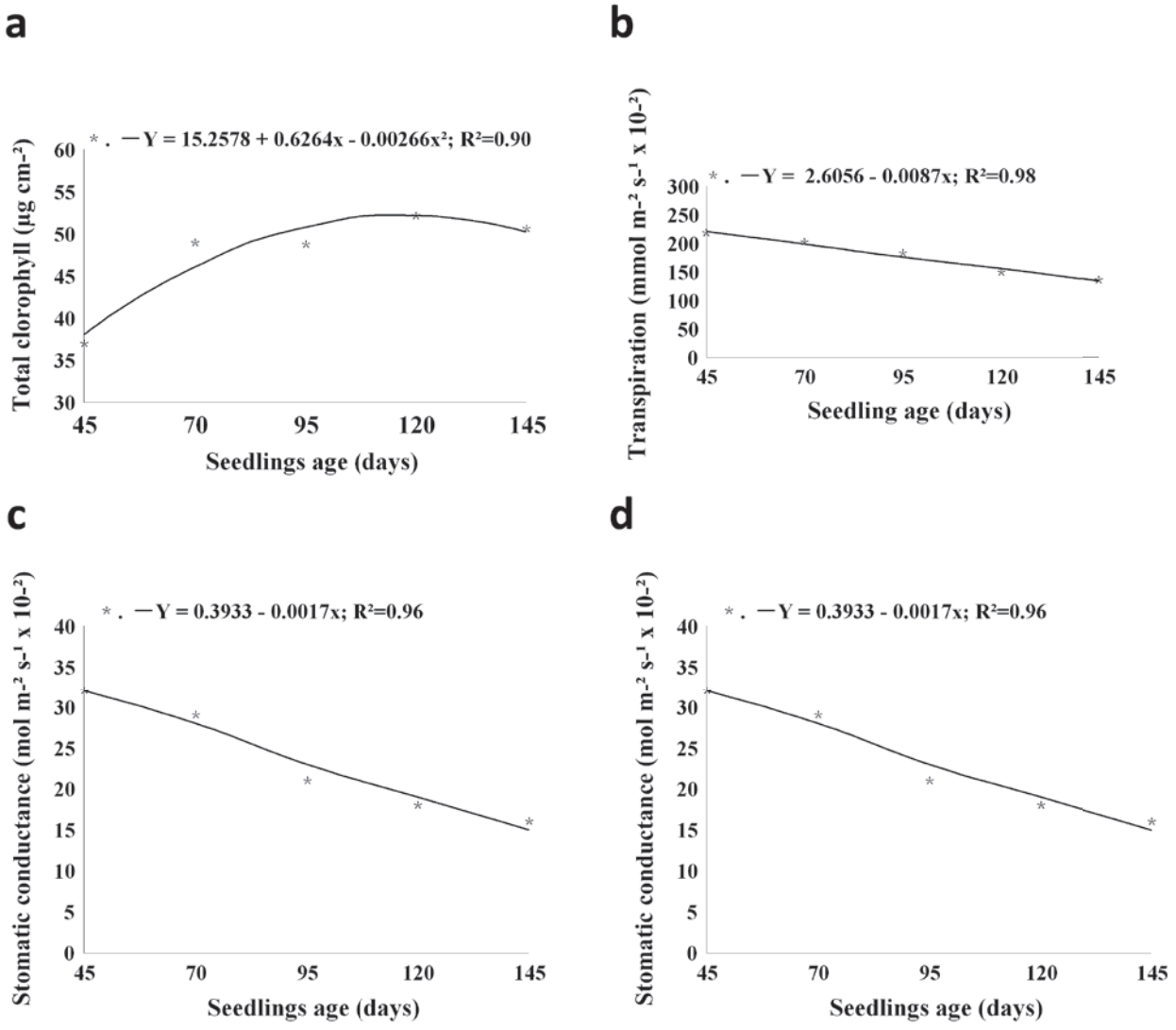

Figure 2 - Total chlorophyll **(a)**, transpiration **(b)**, photosynthesis **(c)** and stomatic conductance **(d)** of *Myracrodruon urundeuva* Allemão seedlings due to their age.

guianensis seedlings (Costa and Marrenco 2007), who also observed that the highest values of stomatic conductance occur when the solar radiation is maximum and the leaf hydric potential did not reach the minimum values, liable to lead to the stomatic closure.

Higher values of HDR were observed on the 120 days of the seedlings age (Figure 3a). The height/stem diameter ratio is a parameter that indicates the seedlings quality that will be taken to the field, since a development balance is waited, as etiolated seedlings have a higher probability of suffering a fall, resulting on a modification on the quality pattern of the adult plant. The etiolated characteristic of the plant on shady environments is a very common response that may be assigned to a higher investment on the cellular elongation, aiming to a higher search of light (King 1994).

The SRR parameter shows that the higher shoot dry mass/root dry mass ratio is, the lower the root development is, being the opposite for the shoot.

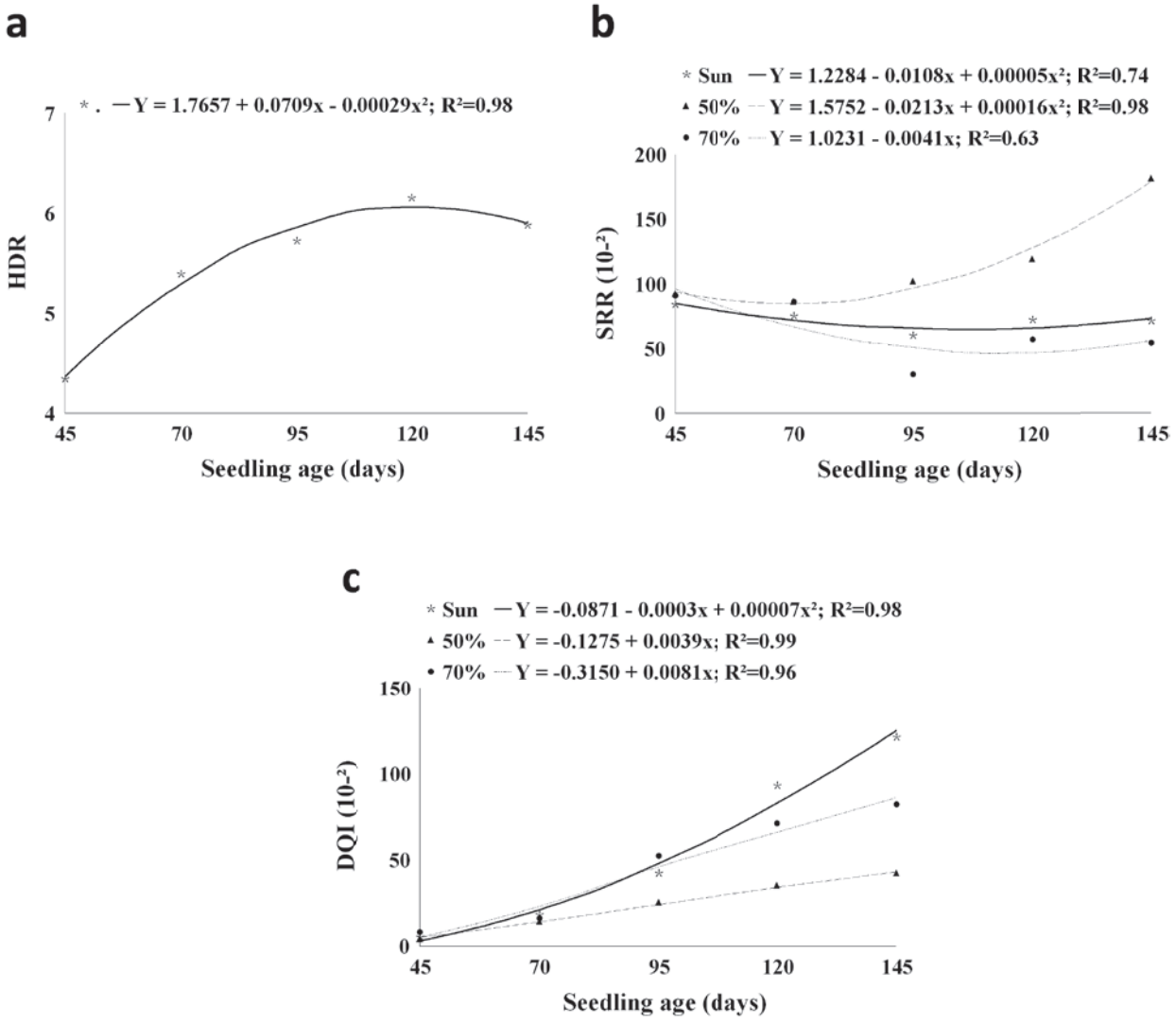

Figure 3 - HDR **(a)**, SRR **(b)** and DQI **(c)** of *Myracrodruon urundeuva* Allemão seedlings due to their age. HDR = height/stem diameter ratio. SRR = shoot dry mass/root dry mass ratio. DQI = Dickson quality index = [total dry mass / (HDR + SRR)].

This present work shows that on the 145th day of the seedlings age at 50% of shading presented higher values of SRR (Figure 3b).

The highest values of DQI were gotten in seedlings kept in full sun, on the 145 days of the seedlings age (Figure 3c), and the DQI is a good indicator of the seedlings quality, since its estimate the vigor and the balance of biomass distribution are taken into consideration, which are good parameters to be used on the quality evaluation (Fonseca et al. 2002). According to these authors, on the system for the seedlings production, the evaluation of the seedling quality may be a good instrument to identify if the planting is being carried out on an adequate manner, i.e., if the seedlings are healthy, with a maximum potential for the survival and later for the development in the field. The morphological parameters and the relations used for evaluating the seedlings quality do not have to be used isolated, so that it does not hazard to select the highest seedlings but the weak ones, discarding the lowest ones with more vigor.

CONCLUSIONS

The osmotic conditioning did not change the seedlings germination in BOD, but the highest APS was observed on PEG -1.0 MPa + KNO_3 -1.0 MPa treatment. The shading levels at 50% and 70% and the osmotic conditioning with PEG -1.0 MPa + KNO_3 -1.0 MPa offered a higher emergence in greenhouse condition. However, in full sun, the seedlings presented a better quality index on the 145th day of age.

ACKNOWLEDGMENTS

The authors thank to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and to Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT), for the financial support and the scholarships.

RESUMO

O presente trabalho objetivou avaliar o condicionamento osmótico e o sombreamento na germinação e no crescimento inicial de mudas de aroeira. As sementes foram pré-embebidas em soluções de diferentes concentrações de PEG (Polietilenoglicol) e KNO_3 e incubadas em temperatura de 10°C e 20°C durante 0 (controle), 12 e 24 horas. Após estes períodos as sementes foram secas até atingirem os níveis iniciais de umidade. Posteriormente elas foram colocadas para germinar em BOD (Demanda Bioquímica de Oxigênio) na temperatura de 20-30°C. O tratamento controle e os pré-condicionamentos que apresentaram os melhores resultados de germinação em BOD foram selecionados, sendo PEG (-1,0 MPa) + KNO_3 (-1,0 MPa) e KNO_3 (-1,0 MPa), com pré-embebição por 12 horas e incubados em BOD a 20°C. As sementes foram semeadas em bandejas e posteriormente transplantadas, permanecendo sob telado coberto com sombrite de 50% e 70% de sombreamento e a pleno sol. O condicionamento osmótico não alterou a germinação das sementes em BOD, porém o maior tamanho de parte aérea foi observado no tratamento PEG-1,0 MPa+KNO_3 -1,0 MPa. Os níveis de sombreamento de 50 e 70% e o condicionamento osmótico com PEG-1,0 MPa+KNO_3-1,0 MPa proporcionaram maior emergência em casa de vegetação, entretanto a pleno sol as mudas apresentaram melhor índice de qualidade aos 145 dias.

Palavras-chave: aroeira, Anacardiaceae, Cerrado, sombra, PEG 6000 e KNO_3.

REFERENCES

Aguiar LMS de, Machado RB and Marinho-Filho JA. 2004. A diversidade biológica do Cerrado. In: AGUIAR LM de and CAMARGO AJA (Org). Cerrado: ecologia e caracterização, Brasília: Embrapa Informação Tecnológica; Planaltina: Embrapa Cerrados, p.17-40.

Alvarenga AA, Castro EM, Lima Junior EC and Magalhães MM. 2003. Effects of different light level on the initial growth and phothosynthesis of Croton urucurana Baill. In. southeastern Brazil. Rev Árvore 27: 53-57.

Atroch EMAC, Soares AM, Alvarenga AA and Castro EM. 2001. Crescimento, teor de clorofila, distribuição de biomassa e características anatômicas de plantas jovens de *Bauhinia forficata* Link submetidos à diferentes condições de sombreamento. Ciênc Agrotec 25: 853-862.

Campos MAA and Uchida T. 2002. Influência do sombreamento no crescimento de mudas de três espécies amazônicas. Pesq Agropec Bras 37: 281-288.

Carvalho NOS, Pelacani CR, Rodrigues MOC and Crepald IC. 2006. Crescimento inicial de plantas de licuri (*Syagrus coronata* (Mart.) Becc.) em diferentes níveis de luminosidade. Rev Árvore 30: 351-357.

Carvalho PER. 2003. Espécies Árbóreas Brasileiras. Brasília: Embrapa Informação Tecnológica; Colombo: Embrapa Florestas 1: 1039.

Costa GF and Marenco RA. 2007. Fotossíntese, condutância estomática e potencial hídrico foliar em árvores jovens de andiroba (*Carapa guianensis*). Acta Amaz 37: 229-234.

Dickson A, Leaf AL and Hosner JF. 1960. Quality apprasial of withe spruce and White pine seedling stock in nurseries. Forest Chron 36: 10-13.

Dorneles MC, Renal MA and Santana DG. 2005. Germinação de diásporos recém-colhidos de *Myracrodruon urundeuva* Allemão (Anacardiácea) ocorrendo no cerrado do Brasil Central. Rev Bra Bot 28: 399-408.

Fonseca EP, Valeri SV, Miglioranҫa E, Fonseca NAN and Couto L. 2002. Padrão de qualidade de mudas de *Trema micrantha* (L.) Blume, produzidas sob diferentes períodos de sombreamento. Rev Árvore 26: 515-523.

Gomes MMA, Lagoa AMMA, Machado EC and Furlan PR. 1997. Trocas gasosas e quantificação do ácido abscísico em duas cultivares de arroz de sequeiro submetidas à deficiência hídrica. Rev Bras Fisiol Veg 9: 177-183.

Gonçalves FG, Gomes SS and Guilherme AL. 2006. Efeito da luz na germinação de sementes de *Guatteria gomeziana* (*Unonopsis lindmanii* R. E. FR.). Rev Cient Eletr Eng Fl 8: 11-17.

GUEDES RS, ALVES DA EU, GONÇALVES EP, COLARES PNQ, MEDEIROS MS AND SILVA KB. 2009. Tratamentos pré-germinativos em sementes de *Myracrodruon urundeuva* Freire Allemão. Rev Árvore 33: 997-1003.

HILLEL D. 1971. Soil and Water: physical principles and process. New York: Academic Press, 288 p.

KING D. 1994. Influence of light level on the growth and morphology of saplings in a Panamanian forest. Am J Bot 81: 948-957.

KISSMANN C, SCALON SPQ, SCALON FILHO H AND VIEIRA MC. 2011. Biorregulador e pré-condicionamento osmótico na germinação de sementes e no crescimento inicial da muda de carobinha (*Jacaranda decurrens* subsp. symmetrifoliolata Farias & Proença) – Bignoniaceae. Rev Bras Pl Med 13: 58-67.

KITAJIMA K. 1996. Ecophysiology of tropical tree seedlings. In: MULKEY SS, CHAZDON RL AND SMITH AP (Eds), Tropical forest plant ecophysiology. New York: Chapman & Hall, p. 559-597.

KLINK CA AND MACHADO RB. 2005. A conservação do Cerrado brasileiro. Megadiversidade 1: 147-155.

LARCHER W. 2000. Ecofisiologia vegetal. São Carlos: Rima Artes e Textos, 531 p.

LIMA JUNIOR EC, ALVARENGA AA DE, CASTRO EM, VIEIRA CV AND BARBOSA JPRAD. 2006. Aspectos fisioanatômicos de plantas jovens de *Cupania vernalis* Camb. submetidas a diferentes níveis de sombreamento. Rev Árvore 30: 33-41.

LONGMAN KA. 2003. Raising seedlings of tropical trees. Londres: Commonwealth Science Council, 156 p.

MARCOS FILHO J. 2005. Fisiologia de sementes de plantas cultivadas. Piracicaba: Fealq, 495 p.

MARENCO RA AND LOPES NF. 2005. Fisiologia Vegetal: Fotossíntese, respiração, relações hídricas e nutrição mineral. Viçosa: UFV, 451 p.

MARTINS SV AND SILVA NRS. 2001. Considerações sobre conservação e restauração de fragmentos florestais. Folha Florestal - Departamento de Engenharia Florestal da UFV, Viçosa 99: 7-8.

MATO GROSSO DO SUL. 1990. Atlas Multireferencial. Campo Grande: Secretaria de Planejamento e Coordenação Geral.

MORAES NETO SP, GONÇALVES JL DE M, TAKAKI M, CENCI S AND GONÇALVES JC. 2000. Crescimento de mudas de algumas espécies arbóreas que ocorrem na mata atlântica em função do nível de luminosidade. Rev Árvore 24: 35-45.

MORRIS M, NEGREROS-CASTILLO P AND MIZE CW. 2000. Sowing date, shade, and irrigation affect big-leaf mahogany (*Swietenia macrophylla* King). For Ecol Manage 132: 173-181.

PACHECO MV, MATOS VP, FERREIRA RLC, FELICIANO ALP AND PINTO KMS. 2006. Efeito de temperatura e substrato na germinação de sementes de *Myracrodruon urundeuva* Fr. All. (Anacardiácea). Rev Árvore 30: 359-367.

PALHARES D, FRANCO AC AND ZAIDAN LBP. 2010. Respostas fotossintéticas de plantas de cerrado nas estações seca e chuvosa. R Bras Bioci 8: 213-220.

POPINIGIS F. 1985. Fisiologia da semente. Brasília: Agiplan, 289 p.

REGO GM AND POSSAMAI E. 2006. Efeito do Sombreamento sobre o Teor de Clorofila e Crescimento Inicial do Jequitibá-rosa. Bol Pesq Florestal Embrapa Floresta 53: 179-194.

ROVIERI JOSÉ SCB, VIEIRA MGGC, GUIMARÃES RM AND RODRIGUES R. 1999. Alterações fisiológicas e bioquímicas de sementes de pimentão submetidas ao condicionamento osmótico, utilizando diferentes agentes osmóticos e meios de embebição. Rev Bras Sementes 21: 217-223.

SANO EE, JESUS ET AND BEZERRA HS. 2001. Uso de um sistema de informações geográficas para quantificação de áreas remanescentes do Cerrado. Planaltina: Embrapa Cerrados, 4 p. (Comunicado Técnico, 62).

SCALON SPQ, MUSSURY RM, SCALON FILHO H AND FRANCELINO CSF. 2006. Desenvolvimento de mudas de Aroeira (Schinus terebinthifolius) e sombreiro (Clitoria fairchildiana) sob condições de sombreamento. Ciênc Agrotec 30: 166-169.

SCALON SPQ, MUSSURY RM AND VERALDO F. 2003. Crescimento inicial de mudas de *Bombacopsis glabra* (Pasq.) A. Robyns sob condição de sombreamento. Rev Árvore 27: 753-758.

SILVA LMM, RODRIGUES TJD AND AGUIAR IB. 2002. Efeito da luz da temperatura na germinação de sementes de aroeira (*Myracrodruon urundeuva* Allemão) Rev Árvore 26: 691-697.

TAIZ L AND ZEIGER E. 2008. Fisiologia vegetal. 4ª ed., Porto Alegre: Artmed, 820 p.

VAZZOLER AEAM, AGOSTINHO AA AND HAHN NS. 1997. A Planície de Inundação do Alto rio Paraná: aspectos físicos, biológicos e sócios econômicos. Maringá: UEM, 460 p.

VILLELA FA, DONI-FILHO L AND SEQUEIRA EL. 1991. Tabela de potenciais osmóticos em função da concentração de polietilenoglicol 6000 e da temperatura. Pesq Agropec Bras 26: 1957-1968.

WELANDER NT AND OTTOSSON B. 1997. Influence of photosynthetic photon flux on growth and transpiration in seedlings of *Fagus sylvatica*. Tree Physiol 17: 133-140.

WELANDER NT AND OTTOSSON B. 2000. The influence of low light, droughtand fertilization on transpiration and growt in young seedllings of *Quercus robur*. For Ecol Manage 127: 139-151.

ZONTA EF, MACHADO AA AND AILVEIRA JUNIOR P. 1985. Sistema de análise estatística (SANEST) para microcomputador (versão 1. 0). In: Simpósio de estatística aplicada à experimentação agronômica, Piracicaba, p. 74-90.