GERMINATION, VIGOR AND SEED BIOMETRICS OF *Licania kunthiana* Hook.f.

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Resumo
Germinação, vigor e biometria de sementes de Licania kunthiana Hook.f. Licania kunthiana, popularmente conhecida como fruta-de-morcego, apresenta porte arbóreo médio e é encontrada em áreas de Floresta Estacional na Amazônia, Caatinga, Cerrado e Mata Atlântica, com sua madeira utilizada na construção civil e confecção de mobiliário. Porém, a espécie carece de informações sobre às condições ideais de germinação e características biométricas de suas sementes. Desta maneira, objetivou-se avaliar o potencial germinativo, vigor (índice de velocidade de germinação – IVG e tempo médio de germinação - TMG), crescimento inicial (comprimento total) e biometria de sementes de *L. kunthiana*. Foram utilizadas temperaturas constantes de 20, 25, 30 e 35 °C e alternadas de 20-30 e 25-35 °C, em delineamento experimental inteiramente casualizado. As sementes possuem média de comprimento de 1,7 cm; diâmetro de 1,4 cm e peso de 1,4 g, com maior coeficiente de variação para comprimento. A espécie apresenta maior porcentagem de germinação e formação de plântulas normais nas temperaturas de 25 e 30 °C, com os resultados indicando que o vigor das sementes pode ser considerado alto (25 °C - 2,2 IVG e 6,1 TMG e, 30 °C - 1,9 IVG e 8,9 TMG). À frequência relativa de germinação indicou que ela não é perfeitamente sincronizada, com rápida germinação em curto espaço de tempo.
Palavras-chave: Sementes florestais; espécie nativa; Chrysobalanaceae; fruta-de-morcego.

Abstract
Licania kunthiana, popularly known as 'fruta-de-morcego', is a medium-size plant found in seasonal forest areas of the Amazon, Caatinga, Cerrado and the Atlantic Forest. The wood of the plant is used in civil construction and in the manufacture of furniture. However, the species lacks information concerning ideal conditions for germination and biometric characteristics of its seeds. In this manner, the current study aimed to investigate the germination potential, vigor (speed germination index - SGI and average germination time - AGT), initial growth (total length) and biometrics of *L. kunthiana* seeds. Constant (20, 25, 30 and 35 °C) and alternating (20-30 and 25-35 °C) temperatures were used, in a completely randomized design. The seeds had an average height of 1.7 cm, diameter of 1.4 cm and weight of 1.4 g, with a greater variation coefficient for length. The species shows better germination performance and formation of normal seedlings at temperatures of 25 and 30 °C, with results indicating that the vigor of the seeds can be considered high (25 °C - 2.2 SGI and 6.1 AGT; 30 °C - 1.9 SGI and 8.9 AGT). The relative frequency of germination indicated *L. kunthiana* seeds are not perfectly synchronized, displaying rapid germination over a short time period.
Keywords: Forest seeds; native species; Chrysobalanaceae; 'fruta-de-morcego'.

INTRODUCTION

Licania kunthiana Hook.f. (Chrysobalanaceae) is a tree species with pantropical distribution that is popularly known as 'caripé-de-cotia', bat fruit or 'rapadura'; the plant has a medium size (10 to 25 m) and can be found in seasonal forest areas of the Amazon, Caatinga, Cerrado and Atlantic Forest biomes (FORZZA *et al*., 2010; Gomes-Silva *et al*., 2018). Teixeira *et al*. (2014) classify the species as late secondary, with zoochoric dispersion and, according to Stefanello *et al*. (2010), Ribeiro *et al*. (2013) and Corrêa *et al*. (2015), the fruit and seeds of the species are of great ecological importance, being consumed by local fauna as well as possessing medicinal properties.

Several species of this family are used in traditional medicine for their antitumor and antimicrobial actions, or in treatments against diarrhea and malaria, for example, as mentioned by Carvalho and Costa (2009). *Licania kunthiana* wood is widely used in the manufacture of furniture and in the production of beams and slats in civil construction due to the good natural durability of the material and its resistance to insects, in addition to possible of use in the naval industry (Gonzaga, 2006; Ribeiro *et al*., 2013).

Despite its importance, basic information about the physiological qualities of *L. kunthiana* seeds, obtained through the germination test, remains scarce, which can be a limiting factor for the propagation of forest species of economic interest. Additionally, there are no data on the biometric characteristics of *L.*

kunthiana seeds collected in areas of the Cerrado biome. Leonhardt *et al*. (2008), Andrade *et al.* (2010) and Oliveira *et al.* (2011) write that knowledge about the biometric characteristics of seeds can be useful in the identification of species and is important in assisting the production of seedlings for restoration of degraded areas.

Additionally, biometric studies are important for understanding dispersion processes and establishing seedlings. However, Fonseca *et al*. (2013) and Pagliarini *et al*. (2014) claim that this form of research is still scarce in the literature for Brazilian species, when compared to the great biodiversity found in the country's biomes.

The germination process is characterized by the resumption of the metabolic processes of the seed following imbibition, such as respiratory activity, and is influenced by several factors, such as temperature, which significantly affects germination by acting on the speed of water absorption and biochemical reactions, changing the percentage and speed of germination (Bewley *et al*., 2013). The prior referenced study also mentions that there are cardinal temperatures (maximum, minimum and optimal), of which the minimum temperature is the lowest temperature at which the seed can germinate while the maximum temperature is the upper limit at which seeds will germinate; on the other hand, at the optimum temperature, the highest germination rate occurs.

However, there is no optimum and uniform temperature for all species. According to Brancalion *et al*. (2010), temperatures between 25 to 30 °C are the most favorable for the germination of most Brazilian tree forest species, depending on the biome and the region. Another factor that can affect the germination process is the degree of moisture present in the seeds during the dispersion period (Barbedo, 2018). According to Diniz *et al*. (2015), who evaluated the seeds of *L. rigida* Benth., another species of the same genus, the seeds have high water content and a yellowish white color that becomes dark (brownish) when water is lost, making germination unfeasible.

Given the above, the present study aimed to evaluate the biometric characteristics of seeds and the effect of different temperatures on the germination and formation of *L. kunthiana* seedlings.

MATERIAL AND METHODS

The fruits were collected in fragments of seasonal semideciduous forest in October 2016, shortly after dispersal, in the Taboco region, Corguinho municipality, Mato Grosso do Sul, Brazil. The region has an average altitude of 320 m and, according to Köppen & Geiger, the climate is tropical (Aw), with dry winters and rainy summers, with an average temperature of 24.8 °C and annual precipitation of 1,444 mm (Mato Grosso Do Sul, 1990).

Plant material was collected directly from the middle of the litter, underneath the canopies of 10 *L. kunthiana* matrix trees, packed in paper bags and transported to the Research Laboratory, Campo Grande, Mato Grosso do Sul. An exsiccata was assembled and incorporated into the collection of the herbarium, with registration number 2332.

After being removed from the fruits, the seeds were subjected to screening to separate those that had a brownish color, indicative of oxidation of their chemical composition (separate germination test). We then selected the seeds that did not show signs of predation and had a whitish color (yellowish white), which is indicative of physiological maturity of the seeds of some species of the genus *Licania* (Diniz *et al*., 2015).

According to the methodology adapted from Brasil (2009), a sample consisting of three repetitions of 10 seeds was used to evaluate the water content. Another sample, consisting of eight repetitions of 100 seeds, was used to obtain the weight of a thousand seeds (Brasil, 2009) as well as biometrics, including length (measurement carried out between the base and apex of the seed), diameter (measurement carried out in the median position of the seed using a digital caliper with a precision of 0.01 mm) and mass (analytical balance - scale of 0.001 g).

The smaller and larger seeds were subsequently discarded in order to standardize the size of the seeds used in the germination tests. The remaining seeds, which were between 12 and 14 mm in diameter and 15 and 18 mm in length, were used for the germination test, being superficially disinfected by immersion in sodium hypochlorite (2%) for three minutes and then washed in water current for one minute. The seeds were divided into six treatments comprising four repetitions of 25 seeds maintained at four constant temperatures (20, 25, 30 and 35 °C) and two alternating temperatures (20-30 and 25-35 °C), with a 12-hour photoperiod of white light for each temperature tested. A treatment group of brownish colored seeds was also prepared and maintained at a temperature of 30 °C in order to assess whether deterioration of the seed structure influences germination.

The seeds were placed in gerbox type boxes (11 x 11 x 3.5 cm) on vermiculite substrate (medium texture), with the substrate moistened 1.0 times its mass in water and replenished whenever necessary. The boxes were placed in germination chambers (four 20 W fluorescent lamps, ± 660 lux). The non-germinated seeds were submitted to the tetrazolium viability test (2,3,5 triphenyl chloride 1% in aqueous solution) (Brasil, 2009), being placed in dark plastic boxes between two sheets of germitest paper moistened with the solution and kept in the dark at 25 °C for 24 hours. Subsequently, the seeds were sectioned and evaluated using a stereomicroscope.

Germination was monitored every 24 hours for a period of 28 days; seeds that had a 2 mm primary root protrusion were considered to be germinated. The germination data were used to calculate the percentage of germination, average germination time (AGT) in days, speed germination index (SGI), frequency of germination and percentage of accumulated germination. For the evaluation of normal seedlings, the Seed Analysis Rules criterion was followed (Brasil, 2009).

After the established period (28 days), the germinated seeds were used in the growth evaluation; the total size (length in mm) of the seedlings was evaluated (average) for all individual samples in the germination tests with the aid of a digital caliper.

The experimental design used was completely randomized and the germination and seedling growth data were subjected to analysis of variance (ANOVA); when a significant difference was noted, the Tukey test was used at a 5% probability level. Statistical analyses were performed using BioEstat 5.0 software, with data subjected to the tests of normality and homogeneity of variances. There was a need for data transformation, according to the Shapiro-Wilk test for normality of ANOVA residues and the Levene test for homogeneity between variances. For ease of understanding the results, the data were presented without transformation.

RESULTS

Water content and seed biometrics

The freshly harvested seeds of *L. kunthiana* showed a water content of 26.2%. Regarding the average length, 74.7% of the seeds were between 15 and 18 mm (11-14 mm = 7.9%; 19-22 mm = 17.4%). Regarding the average diameter, 65.7% of the seeds were between 12 and 14 mm (9-11 mm = 11.5%; 15-17 mm = 22.5%). Results of the average wet mass measurements showed that 60.6% of the seeds weighed between 1.0 and 1.69 g (0.39-0.99 g = 16.6%; 1.7-3.94 g = 22.6%) (Table 1).

Table 1. Length, diameter and seed mass of *Licania kunthiana.*
Tabela 1. Comprimento, diâmetro e massa de sementes de *Licania kunthiana.*

Parameters	Mean	Variance	Coefficient of variation (%)	Standard deviation	Minimum	Maximum
Length (mm)	17.4	3.4	19.7	1.86	11.8	22.8
Diameter (mm)	13.9	2.2	16.4	1.59	9.0	19.5
Mass (g)	1.4	0.2	14.9	0.46	0.4	3.9

Germination

Regarding the relative frequency, seed germination was not perfectly synchronized, with a small distribution over time, mainly at 20 and 35 ° C (Figure 1).

At a temperature of 20 °C, germination started on the 12th day, with no seedlings forming at this temperature. In contrast, at a temperature of 25 °C or an alternating temperature of 20-30 °C, germination occurred on the third day. At a temperature of 30 °C, germination occured on the second day while, at a temperature of 35 °C germination occured on the seventh day. At an alternating temperature of 25-35 °C there was no germination (Figure 1; Figure 2).

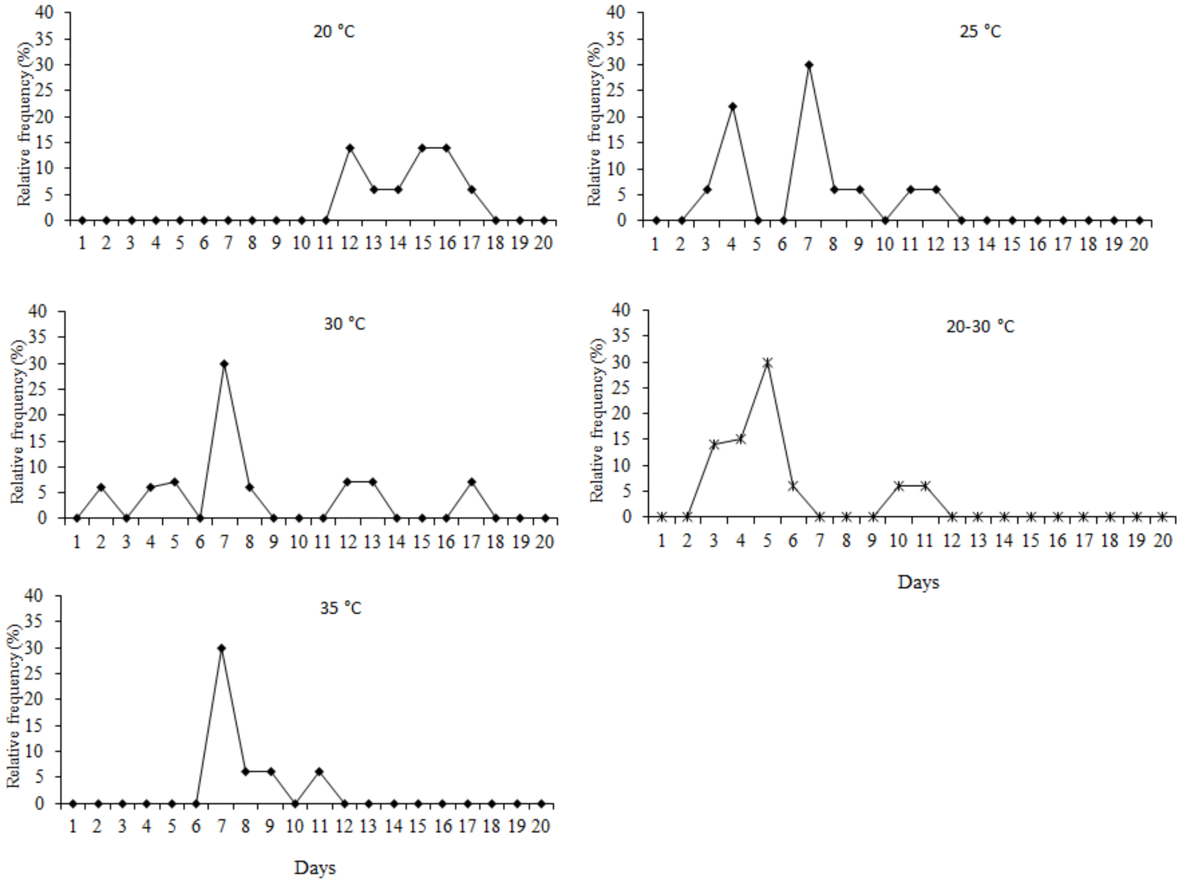

Figure 1. Relative frequency of seed germination of *Licania kunthiana* at five temperatures in germination chambers.
Figura 1. Frequência relativa da germinação de sementes de *Licania kunthiana* obtidas em cinco temperaturas em câmara de germinação.

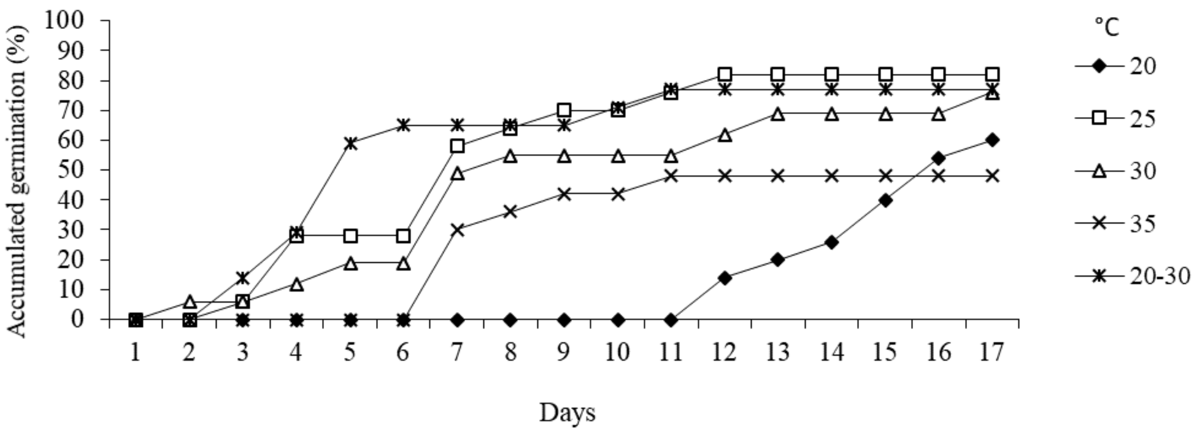

Figure 2. Accumulated germination of seeds of *Licania kunthiana* at five temperatures in germination chambers.
Figura 2. Germinação acumulada de sementes de *Licania kunthiana* em cinco temperaturas obtidas em câmara de germinação.

Temperatures of 25, 30 and 20-30 °C showed the best results in terms of germination (however 20-30 °C did not provide seedling formation) and vigor (IVG and TMG) (30 °C presented the second best TMG). The temperature of 20 °C reduced the germination speed, while a temperature of 35 °C negatively affected germination and the alternating temperature of 25-35 °C prevented germination (Table 2).

Table 2. Germination percentage, speed germination index (SGI), average germination time (AGT), seedling size and percentage of normal seedlings (cv - coefficient of variation) of *Licania kunthiana* after 28 days at various temperatures in germination chambers.

Tabela 2. Percentagem de germinação, índice de velocidade de germinação (IVG), tempo médio de germinação (TMG), tamanho de plântulas (cv – coeficiente de variação) e percentagem de plântulas normais de *Licania kunthiana* após 28 dias em diferentes temperaturas em câmara de germinação.

Temperature (°C)	Germination (%)	SGI	AGT (days)	Seedlings (mm)	Normal seedlings (%)
20	60 b	0.6 b	14.0 c	0 e	0
25	82 a	2.2 a	6.1 a	36 (cv-936) b	71 a
30	76 a	1.9 a	8 b	71.8 (cv-2960) a	69 a
35	48 c	0.9 b	7.8 b	14.7 (cv-362) c	39 b
20-30	77 a	2.2 a	5.2 a	0 e	0
25-35	0 d	0 c	0 d	0 e	0

*Averages in the same column that are followed by the same letter do not significantly differ by the Tukey test ($p < 0.05$).

Temperatures of 20 and 35 °C provided the lowest germination rates but produced alternative results when linked with other temperatures. A temperature of 35 °C alternating with 25 °C caused the death of all embryos, while a temperature of 20 °C alternating with 30 °C resulted in one of the best germination rates (Table 2).

The brown colored seed lot, which was maintained at 30 °C, did not show germination. All non-germinated seeds, according to the tetrazolium test, presented dead embryos with degradation of the cotyledons and produced a brownish color at the end of the test.

Seedling formation

At temperatures of 20, 20-30 and 25-35 °C, normal seedlings did not occur. At temperatures of 25, 30 and 35 °C, the number of abnormal seedlings did not exceed 20%. The highest temperature (35 °C), however, provided the lowest growth rate, while the best development was obtained at 30 °C, although this resulted in plants of various sizes with a high coefficient of variation (Table 2).

DISCUSSION

Water content and biometrics

According to Bewley *et al*. (2013), values between 5 and 20% water content are common for most species, although there is no "average" value for forest species, as this data depends on the physiological group (orthodox, intermediate or recalcitrant) and the percentages within each group are highly variable. A high water content (34.6%) has also been observed for *L. rigida* seeds, as reported by Diniz *et al*. (2015).

The results of previous experiments found that, for this genus, the behavior of recalcitrant seeds, in which the loss of water leads to a decrease in viability, produces deterioration of the seeds over a short time period (Barbedo, 2018). The brownish color identified in the cotyledons of part of the collected seeds, as well as in seeds kept in germination chambers at the end of the experiment (non-germinated seeds), may indicate loss of viability. However, as no subsequent viability tests were performed, it was not possible to confirm this assumption.

Diniz *et al*. (2015), studying *L. rigida* seeds, mention that the seeds, when high in water content, present a yellowish white color and become dark when water is lost; this behavior is allied to the oil oxidation process in the cotyledons in contact with air. For *L. kunthiana*, only seeds that showed a lighter (whitish) color of the cotyledons were viable; their darkening would be the result of water loss and oxidation, resulting in less viability, a situation similar to that found in *L. rigida*.

The biometric results, specifically coefficient values of variation for diameter, length and mass of *L. kunthiana* seeds, indicate homogeneous average values, taking into account that this coefficient is a relative measure that indicates variability, with lower values indicating more homogeneous results.

It should be noted that, seeds collected from many mother trees at different sites tend to have greater variation in their biometric characteristics, likely due to genetic variability of the plants and/or environmental factors, such as the soil, which is very heterogeneous in tropical forests. Despite these factors, most of the collected seeds showed a pattern in terms of size and weight, with lengths between 15 and 18 mm, diameters between 12 and 14 mm and a wet mass between 1.0 and 1.69 g. The average weight obtained from a thousand seeds was 14.12 g.

Differences in biometric characteristics of fruits and seeds have been observed for other species of the genus *Licania*, as reported by Monteiro *et al.* (2012) in studies with *L. tomentosa* (Benth.) Fritsch, which indicated seeds of length 4.1 ± 7.3 cm, with an average diameter of 18 ± 4.4 cm and weight of 12.7 ± 7.4 g. Diniz *et al*. (2015), studying *L. rigida* seeds, described a length of 3.1 to 5.0 cm and a diameter of 1.3 to 1.7 cm.

The results obtained for *L. kunthiana* seeds, according to the seed classification of Camargo *et al*. (2008), allow them to be classified as small in size, with an average weight between 0.2 and 2.0 g. Pereira *et al*. (2013) describe how small seeds can be a competitive advantage in the germination process, especially when water is restricted in the environment, as they germinate more quickly than larger seeds. However, this is not a fixed rule, as other factors can affect seed vigor and seedling formation. However, taking into account the region's climatic seasonality, perhaps a small seed size provides a competitive advantage.

Germination

The relative frequency indicated slightly heterogeneous germination for all treatments. The protrusion of the primary root demonstrated that speed in the germination process is strongly affected by different temperatures, with longer experiment times leading to a greater number of dead seeds at the end of the experiment. Diniz *et al.* (2015), in studies with *L. rigida*, confirmed that there is a rapid loss of viability of seeds of this genus, as they are recalcitrant seeds.

In terms of average germination time, Diniz *et al*. (2015) also reported irregular germination for *L. rigida*, approximately 8.5 days (AGT) in the best conditions. This situation was also observed for *L. kunthiana* in the present study. However, germination occurred in a more concentrated manner in the current study (AGT = 6.1 days, in the best conditions), possibly indicating that rapid establishment by seedlings in the area may occur during favorable conditions; other environmental variables may also interfere in this process, however.

Regarding the vigor of the seeds (SGI and AGT), low temperatures (20 °C) reduced the germination speed, a factor probably related to slower respiratory rates or increased rigidity of the cell membrane according to Bewley *et al*. (2013). Diniz *et al.* (2015), studying *L. rigida*, reported that a temperature of 20 °C negatively affects seed vigor, as do temperatures of 25 and 20-30 °C; these results differ from those obtained in the present study for *L. kunthiana* in regards to the final temperatures mentioned above (25 and 20-30 °C).

On the other hand, the higher temperature (35 °C) negatively affected germination, probably due to damage to the growing embryo resulting in death. These observed results are possibly due to enzymatic changes; for example, a modified speed of chemical reactions and/or increases in the consumption of nutritional reserves and the water absorption rate due to higher temperatures (Bewley *et al*., 2013).

Temperatures of 20 and 35 °C, which provided the lowest germination rates, produced different results when in combined with other temperatures. The alternating temperature of 25-35 °C was not propitious, preventing germination and again indicating that 35 °C is not adequate, together or alone. On the other hand, 20-30 °C generated the best germination rates, but did not allow the formation of normal seedlings.

Bewley *et al*. (2013) state that certain species have high germination rates at alternating temperatures due to the presence of specific enzymatic mechanisms that operate at various temperatures, a consequence of ecological adaptations. This statement is confirmed by Masin *et al*. (2017), who describe alternating temperatures as adequate for obtaining good germination rates, depending on the species. Bewley *et al.* (2013) also mention that the germination process is negatively affected by the use of inadequate temperatures, both lower and higher temperatures than the optimum, leading to a reduction in the percentage of germination and seed vigor due to longer exposure times to adverse factors.

The results related to null germination at an alternating temperature of 25-35 °C may be linked to the behavior of the seeds at different temperatures when associated with a certain type of substrate, as already verified by other works. Silva *et al.* (2017), evaluating the germination of *Parkia platycephala* Benth seeds on different substrates and at different temperatures, demonstrated that germination rates are directly affected by the variables tested and that at constant temperatures, for example 20 and 30 °C, germination rates can be high while, at alternating temperatures (20-30 °C), germination can be significantly less, depending on the substrate used. This situation occurs because the substrate influences the water holding capacity and, according to Seed Analysis Rules, 60% of the holding capacity is the appropriate value (Brasil, 2009). However, the seeds of the species have different requirements depending on their ecological and physiological characteristics (Brasil, 2009; BEWLEY *et al*., 2013).

At optimal temperatures for *L. kunthiana* seed germination, high seed vigor was observed (SGI between 1.9 and 2.2 and AGT 5.2 to 6.1). This factor is probably associated with adaptations to various regions, with soils with a fast infiltration rate (sandy) and average temperatures of 24 °C, combined with seasonal rains (summer), as is the case of the current study site, conditioning the species to synchronize its phenology for these periods, facilitating germination and seedling establishment over a short time period. It should be noted that, in addition to the environment, several other factors affect seed vigor, including genetics, seed maturity and mechanical or microorganism damage, among others.

As previously explained, there is no standard temperature established for germination of the species. Brancalion *et al.* (2010) indicate 25 °C as being the best for most species in the Cerrado biome, a result confirmed by this study, although the seeds of the species in question, *L. kunthiana*, also obtained good germination results at 30 °C, likely due to adaptations to the local environment; in addition to germination, there was good formation of normal seedlings at these two temperatures.

Data presented by Monteiro *et al*. (2012), working with *L. tomentosa*, note that nine days is necessary for protrusion of the primary root to begin in a greenhouse. Diniz *et al*. (2015) observed, in tests with *L. rigida*, that temperatures of 20, 25, 30 and 20-30 °C do not interfere with germination rates, although the best SGI and AGT were found at 30 °C, with high germination rates and the germination process starting 15 days after seeding.

The results by Monteiro *et al*. (2012) and Dinis *et al*. (2015) indicate that this genus has a high percentage of germination; however, in germination chamber conditions, SGI and AGT data were superior, with germination occurring in a short period. The results obtained for *L. kunthiana* are probably affected by the water content of the seeds, with greater water losses leading to lower germination rates; however, the results indicate that the collected seeds had good physiological quality, that is, their degree of physiological maturity at the time of collection was adequate.

Seedling formation

Seedling formation was strongly influenced by temperature, with uneven growth and high coefficient of variation values. This situation can indicate high genetic variability of the matrices or, according to Bewley *et al*. (2013), be a consequence of genetic and environmental factors that affect the plant structure. Among the mentioned environmental factors, we can note that the environment in which the seedlings were stored (gerbox) may have resulted in a lack of excess water and/or the incidence of fungi, despite daily surveys. In this way, an ideal follow-up experiment would be subsequent vegetation house evaluation, evaluating emergency.

Despite the great growth variability, the formation of normal seedlings was above 80%. On the other hand, temperatures of 20 °C, 20-30 or 25-35 °C either did not allow seedling formation or led to the formation of incomplete plants (without the presence of roots and/or the aerial part) that did not develop, dying in a short period of time under test conditions.

According to Ferreira and Novembre (2016), seed morphometric characteristics are also directly related to physiological quality, specifically greater vigor of seedlings. This situation is confirmed by Pagliarini *et al*. (2014), who recommend the use of larger jatobá seeds (*Hymeneae courbaril* L. var. *Stilbocarpa*) to obtain better germination rates and initial growth. As the *L. kunthiana* seeds used had the same pattern, their size must have had little influence on growth variability. Thus, the results indicate that the substrate and temperature influenced the growth of seedlings and that new substrates should be tested to obtain better conditions for germination.

CONCLUSIONS

- The freshly harvested seeds of *L. kunthiana* showed values of water content (26.2%) that indicate a behavior of recalcitrant seeds, similar to that found for other species of the same genus. The biometry of the seeds indicated that most of the seeds had an average length of 17.4 mm, an average diameter of 13.9 mm and an average wet mass of 1.4 g, with coefficients of variation showing average values of data homogeneity, that is, small variability.
- Under laboratory conditions, temperatures of 25 and 30 °C provided the highest germination and vigor rates in *L. kunthiana* seeds, in addition to the formation of normal seedlings. However, the greatest growth of plant structures was achieved at 30 °C.

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REFERENCES

ANDRADE, L. A.; BRUNO, R. L. A.; OLIVEIRA, L. S. B.; SILVA, H. T. F. Aspectos biométricos de frutos e sementes, grau de umidade e superação de dormência de jatobá. **Acta Scientiarum Agronomy**, Maringá, v. 32, n. 2, p. 293-299, 2010.

BARBEDO, C. J. Uma nova abordagem para as chamadas sementes recalcitrantes. **Journal of Seed Science**, Londrina, v. 40, n. 3, p. 221-236, 2018.

BEWLEY, J. D.; BRADFORD, K.; HILHORST, H.; NONOGAKI, H. **Seeds:** physiology of development, germination and dormency. 3ed. New York: Springer eBooks, 2013. 392 p.

BRANCALION, P. H. S.; NOVEMBRE, A. D. L. C.; RODRIGUES, R. R. Temperatura ótima de germinação de sementes de espécies arbóreas brasileiras. **Revista Brasileira de Sementes**, Londrina, v. 32, n. 4, p. 15-21, 2010.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Regras para análise de sementes.** Brasília: Secretaria de Defesa Agropecuária. Mapa/ACS, 2009. 395 p.

CAMARGO, J. L. C.; FERRAZ, I. D. K.; MESQUITA, M. R.; SANTOS, B. A.; BRUM, H. D. **Guia de propágulos e plântulas da Amazônia.** vol. 1. Manaus: INPA, 2008. 168 p.

CARVALHO, M. G.; COSTA, P. M. Outros constituintes isolados de *Licania arianeae* (Chrysobalanaceae). **Revista Brasileira de Farmacognosia,** Maringá, v. 19, n. 1B, p. 290-293, 2009.

CORRÊA, V. V.; GAMA, J. R. V.; RIBEIRO, R. B. S.; ALVES, A. F.; VIEIRA, D. S.; XIMENES, L. C. Estrutura e uso potencial de espécies arbóreas em floresta manejada, PA Moju, Santarém-Pará. **Cerne**, Viçosa, v. 21, n. 2, p. 293-300, 2015.

DINIZ, F. O.; MEDEIROS FILHO, S.; BEZERRA, A. M. E.; MOREIRA, F. J. C. Biometria e morfologia da semente e plântula de oiticica. **Revista Verde de Agroecologia e Desenvolvimento Sustentável**, Pombal, v. 10, n. 2, p. 183-187, 2015.

FERREIRA, R. L.; NOVEMBRE, A. D. L. C. Estimativa do vigor das sementes e das plântulas de *Bixa orellana* L. **Revista Ciência Agronômica**, Fortaleza, v. 47, n. 1, p. 101-107, 2016.

FONSECA, M. D. S.; FREITAS, T. A. S.; MENDONÇA, A. V. R.; SOUZA, L. S.; ABDALLA, S. D. Morfometria de sementes e plântulas e verificação da dormência da espécie *Plathymenia foliolosa* Benth. **Comunicata Scientiae,** Bom Jesus, v. 4, n. 4, p. 368-376, 2013.

FORZZA, R. C.; BAUMGRATZ, J. F. A.; BICUDO, C. E. M.; CANHOS, D. A. L.; CARVALHO JR., A. A.; COSTA, A. F.; COSTA, D. P.; HOPKINS, M.; LEITMAN, P. M.; LOHMANN, L. G.; NICLUGHADHA, E.; MAIA, L. C.; MARTINELLI, G.; MENEZES, M.; MORIM, M. P.; COELHO, M. A. N.; PEIXOTO, A. L.; PIRANI, J. R.; PRADO, J.; QUEIROZ, L. P.; SOUZA, S.; SOUZA, V. C.; STEHMANN, J. R.; SYLVESTRE, L. S.; WALTER, B. M. T.; ZAPPI, D. (Coordenadores). **Catálogo de plantas e fungos do Brasil.** vol. 1. Rio de Janeiro: Instituto de Pesquisas Jardim Botânico do Rio de Janeiro, 2010. 871 p.

GOMES-SILVA, F.; MACEDO, A.; PESSOA, E.; ALVES, M. Flora da Usina São José, Igarassu, Pernambuco: Chrysobalanaceae, Humiriaceae, Lacistemataceae e Trigoniaceae. **Rodriguésia**, Rio de Janeiro, v. 69, n. 4, p. 1799-1811, 2018.

GONZAGA, A. L. **Madeira:** uso e conservação. Brasília: IPHAN/MONUMENTA. Caderno Técnico, 2006. 246 p.

LEONHARDT, C.; BUENO, O. L.; CALIL, A.C.; BUSNELLO, A.; ROSA, R. Morfologia e desenvolvimento de plântulas de 29 espécies arbóreas nativas da área da Bacia Hidrográfica do Guaíba, Rio Grande do Sul, Brasil. **Iheringia - Série Botânica,** Porto Alegre, v. 63, n. 1, p. 5-14, 2008.

MASIN, R.; ONOFRI, A.; GASPARINI, V.; ZANIN. G. Can alternating temperatures be used to estimate base temperature for seed germination? **Weed Research**, Wiley, v. 57, n. 6, p. 390-398, 2017.

MATO GROSSO DO SUL. Secretaria de Planejamento e Coordenação Geral de Mato Grosso do Sul. **Atlas multirreferencial. Mapas**. Governo do Estado do Mato Grosso do Sul, Campo Grande, 1990. 28 p.

MONTEIRO, K. L.; OLIVEIRA, C.; SILVA, B. M. S.; MORO, F. V.; CARVALHO, D. A. Caracterização morfológica de frutos, de sementes e do desenvolvimento pósseminal de *Licania tomentosa* (Benth.) Fritsch. **Ciência Rural**, Santa Maria, v. 42, n. 1, p. 90-97, 2012.

OLIVEIRA, M. T. R.; BERBERT, P. A.; PEREIRA, R. C.; VIEIRA, H. D.; CARLESSO, V. O. Características biométricas e físicoquímicas do fruto, morfologia da semente e da plântula de *Averrhoa carambola* L. (Oxalidaceae). **Revista Brasileira de Sementes**, Londrina, v. 33, n. 2, p. 251-260, 2011.

PAGLIARINI, M. K.; NASSER, M. D.; NASSER, F. A. C. M.; CAVICHIOLI, J. C.; CASTILHO, R. M. M. Influência do tamanho de sementes e substratos na germinação e biometria de plântulas de jatobá. **Tecnologia Ciência Agropecuária**, João Pessoa, v. 8, n. 5, p. 33-38, 2014.

PEREIRA, W. A.; PEREIRA, S. M. A.; DIAS, D. C. F. S. Influence of seed size and water restriction on germination of soybean seeds and on early development of seedlings. **Journal of Seed Science**, Londrina, v. 35, n. 3, p. 316-322, 2013.

RIBEIRO, R. B. S.; GAMA, J. R. V.; MARTINS, S. V.; MORAES, A.; SANTOS, C. A. A. CARVALHO, A. N. Estrutura florestal em projeto de assentamento, comunidade São Mateus, município de Placas, Pará, Brasil. **Rev. Ceres**, Viçosa, v. 60, n. 5, p. 610-620, 2013.

STEFANELLO, D.; IVANAUSKAS, N. M.; MARTINS, S. V.; SILVA, E.; KUNZ, S. H. Síndromes de dispersão de diásporos das espécies de trechos de vegetação ciliar do rio das Pacas, Querência – MT. **Acta Amazonica**, Manaus, v. 40, n. 1, p. 141 – 150, 2010.

SILVA, R. B.; MATOS, V. P.; FARIAS, S. G. G.; SENA, L. H. M.; SILVA, D. Y. B. O. Germinação e vigor de plântulas de *Parkia platycephala* Benth. em diferentes substratos e temperaturas. **Revista Ciência Agronômica**, Fortaleza, v. 48, n. 1, p. 142-150, 2017.

TEIXEIRA, G. M.; FIGUEIREDO, P. H. A.; VALCARCEL, R.; AMORIM, T. A. Regeneração de floresta atlântica sob níveis diferenciados de perturbação antrópica: implicações para restauração. **Scientia Forestalis**, Piracicaba, v. 42, n. 104, p. 543-554, 2014.