SEED FEATURES OF IMPORTANT TIMBER SPECIES FROM THE FLOODPLAIN VÁRZEA FOREST: IMPLICATIONS FOR EX SITU CONSERVATION PROGRAMS IN THE AMAZON

CARACTERÍSTICAS DE SEMENTES DE ESPÉCIES ARBÓREAS DE IMPORTÂNCIA ECONÔMICA DA FLORESTA DE VÁRZEA: IMPLICAÇÕES PARA PROGRAMAS DE CONSERVAÇÃO EX SITU NA AMAZÔNIA.

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KEY WORDS:

Seed biometrics;

Floodplain forests;

Germination;

Orthodox seeds;

Recalcitrant seeds.

ABSTRACT

As an integral part of plant regeneration ecology, the ability of seeds to survive desiccation is an important functional feature. For the purpose of conservation, studies have investigated the responses of stored seeds to the desiccation process. In order to enhance the knowledge on seeds ecology of Amazonian floodplain trees, eight common tree species of the várzea floodplain forest with high economic value, were selected and their seeds classified according to their attributes. The selected species represent 80% of the number and total volume of the timber species selectively extracted from Mamirauá Sustainable Development Reserve, Central Amazon. Smaller seeds with lower water content (*Calycophyllum spruceanum* (Benth.) Hook. f ex K. Schum., *Hura crepitans* L. and *Piranhea trifoliata* Baill.), which remained viable and germinated after desiccation and storage, were classified as tolerant to desiccation. The species *Guarea guidonia* (L.) Sleumer., *Laetia corymbulosa* Spruce ex Benth., *Ocotea cymbarum* Kunth., *Tabebuia barbata* (E. Mey.) Sandwith, and *Sterculia apetala* (Jacq.) H. Karst., were classified as sensitive to desiccation because their seeds did not germinate in the same treatment and thus cannot be effectively stored. The average dry mass was ten times higher in desiccation-sensitive seeds (82.22 g) than in desiccation-tolerant (8.58 g) seeds. The study suggests that if there are mechanisms to protect floodplain seeds, these would be more efficient as a form of conferring greater tolerance to flooding. Therefore, methods of storage in moist conditions should be investigated to desiccation-sensitive seeds.

PALAVRAS - CHAVE:

Biometria de sementes;

Florestas inundáveis;

Germinação;

Sementes ortodoxas;

Sementes recalcitrantes.

RESUMO

Como parte integrante da ecologia da regeneração, a capacidade das sementes de sobreviver à dessecação é uma característica funcional importante. Com propósitos conservacionistas, estudos têm investigado as respostas de sementes armazenadas ao processo de dessecação. A fim de aumentar o conhecimento sobre a ecologia de sementes de árvores de várzea na Amazônia, oito espécies de árvores comuns da das florestas de várzea com alto valor econômico, foram selecionados e suas sementes classificadas de acordo com seus atributos. As espécies selecionadas representam 80 % do número e do volume total de madeira seletivamente extraídas na Reserva de Desenvolvimento Sustentável Mamirauá. Sementes menores e com os menores teores de água, *Calycophyllum spruceanum* (Benth.) Hook. f ex K. Schum., *Hura crepitans* L., e *Piranhea trifoliata* Baill., permaneceram viáveis e germinaram após o dessecamento e armazenamento, sendo classificadas como tolerantes à dessecação. As espécies *Guarea guidonia* (L.) Sleumer., *Laetia corymbulosa* Spruce ex Benth., *Ocotea cymbarum* Kunth., *Tabebuia barbata* (E. Mey.) Sandwith, e *Sterculia apetala* (Jacq.) H. Karst., foram classificadas como sensíveis a dessecação, suas sementes não germinaram nos mesmos tratamento, não podendo ser efetivamente armazenadas. A média da massa seca foi dez vezes maior nas sementes sensíveis à dessecação (82.22 g) do que nas tolerantes a dessecação (8.58g). O estudo sugere que se existem mecanismos de proteção nas sementes da várzea, estes seriam mais eficientes como forma de conferir maior tolerância a inundação, portanto, devem ser investigadas formas de armazenamento em meio úmido para sementes sensíveis ao dessecamento.

INTRODUCTION

The availability of seeds and micro-environments are the two main factors that can potentially limit the recruitment of plant populations (ERIKSSON; EHRLÉN, 1992). Therefore, studies involving the performance of seeds are vital to the understanding of plant community processes, such as recruitment and succession (KHURANA; SINGH, 2001).

The ability of seeds to survive desiccation is an important functional feature and integral part of plant regeneration ecology (TWEDDLE et al., 2003). Many studies focusing on conservation have investigated the response of stored seeds to desiccation (VÁZQUEZ-YANES; OROZCO-SEGOVIA, 1996; HONG; ELLIS, 1998; DICKIE; PRITCHARD, 2002; TWEEDLE et al., 2003; DAWS et al., 2006; BERJAK; PAMMENTER, 2008; HAMILTON et al., 2013), since this information can be used for the development of strategies for the conservation of biodiversity and the recovery of tropical forests. In this sense, seeds from native species are of major interest to attend these demands, which have gradually increased during recent years (CARVALHO et al. 2006).

Storage treatments must differ if the seeds are orthodox, i.e. tolerant to desiccation or recalcitrant, i.e. sensitive to desiccation (KHURANA; SINGH, 2001; ROBERTS, 1973). Although there are other categories or subdivisions in literature, such as intermediary seeds, with intermediate storage characteristics between orthodox and recalcitrant (HONG; ELLIS, 1996), from an ecological perspective, seeds classified as intermediate are essentially tolerant to desiccation (TWEDDLE et al., 2003). Thus, in this article, the terms tolerant to desiccation (TD) and sensitive to desiccation (SD) will be adopted to categorize the studied seeds.

The Amazonian flooded areas cover 14% of the Amazon basin (MELACK; HESS, 2010). The most conspicuous floodplains among this total are the "várzeas", associated with white water rivers, originated in the Andean and Pre-Andean regions, which cover 400.000 km^2 or 7% of the region (MELACK; HESS, 2010). They have comparatively high fertility, owing to the high concentrations of dissolved solids that are deposited annually along the margins of the alluvial plains (JUNK et al., 2011).

The expansion of agriculture, exploitation of forest resources and climate variability have become important disturbance agents in the Amazon basin (DAVIDSON et al., 2012). The várzeas are the most species rich floodplain forests of the world (WITTMANN et al., 2006), many of which are economically important and suffer intense exploitation by local populations (KVIST et al., 1995; JUNK et al., 2000; NEBEL et al., 2005; PINEDO-VASQUEZ; SEARS, 2011; LEONI, 2010; 2013).

Commercial exploitation of timber várzea forests is focused on few species. More than 67 species are used in sawmills as well as plywood and laminate industries in the State of Amazonas, with four species (louro inamuí -*Ocotea cymbarum*, assacu - *Hura crepitans*, muiratinga - *Maquira coriacea* and sumaúma - *Ceiba pentandra*), all from várzea areas, contributing more than 40% of total consumption of the commercially exploited species for wood in the Amazonas State (LIMA et al., 2005).

Thus, it is clear that a massive removal of adult trees can lead to the reduction of populations as a consequence of the extraction impacts on regenerative processes. On the other hand, to improve the success of sustainable management in tropical forests, effective maintenance of individuals in the regeneration phase is essential. However, there is a need for more information about the effects of management practices on the regeneration of species, especially for the Amazonian várzea forests (NEBEL et al., 2005).

The seed storage (FAO 1993) can be one of *ex situ* conservation strategies (Brasil 2000) important for maintenance of várzea forests biodiversity. Nevertheless, knowledge on the appropriated conditions for storage and the performance of seeds during this process is necessary in order to ensure seed germination, i.e. their viability, as well as the success of the conservation of seed lots (HONG; ELLIS, 1996).

The identification of the performance of seeds from species that constitute the forest base, i.e. species with potential for commercial exploitation, is of great importance and can indicate ways to maximize the capabilities of stored seeds under the sector's new sustainable development paradigm. Aiming to contribute to enhance this knowledge of great economic and ecological value to várzea forests, this study describes seeds morphological characteristics of eight species occurring in the floodplain of the Mamirauá Sustainable Development Reserve Mamirauá (MSDR), Central Amazon, Brazil. Additionally, experimental treatments allowed the classification of the seeds according to their tolerance to desiccation. The selected species constitute more than 80% of the number and total volume of timber species selectively extracted in the SDR Mamirauá (IDSM. 2002).

MATERIAL AND METHODS

The diaspore collections were made between 2009 and 2012 using mother plants located next and inside the lake systems of the Mamirauá Sustainable Development Reserve - MSDR (2º 51´ S, 64º 55´ W), located 70 km NW of the city of Tefé – AM (Figure 1). The MSDR occupies 1.124.000 hectares, located between the Japurá, Solimões and Auati-Paraná rivers, and is characteristically composed of flooded várzea forests (IDSM, 2010). The mean flood amplitude in the study period was 13 m (Figure 2, IDSM, 2013), and the maximum and minimum monthly temperature means were 32.0ºC and 23.1ºC, respectively. The rainfall index was 1.730 mm (IDSM, 2013).

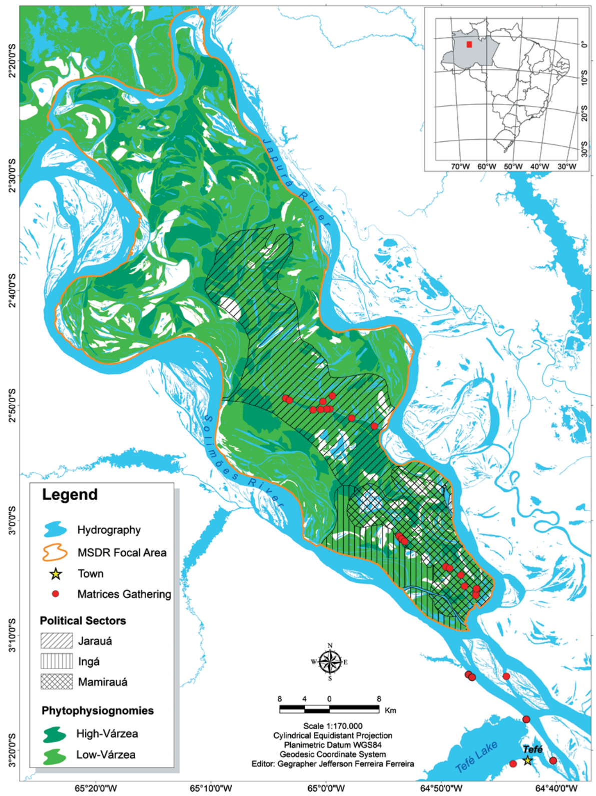

Figure 1 - Map of Mamirauá RDS, with the focus area of the study, highlighting the different phytophysionomies of the várzea forests (low várzea, high várzea) in which the mother plants were marked for the collection of diaspores. diaspores.

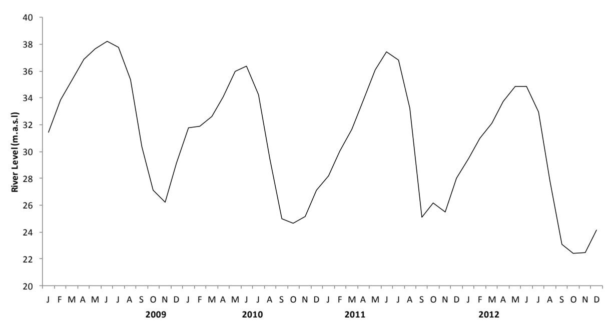

Figure 2 - Monthly variation in water level recorded daily between 2009 and 2012 in the Mamirauá RDS. Water level of the river measured in meters above sea level (m.a.s.l.) (Pluviometric database of the Mamirauá RDS, accesse:d on April 12, 2013 http://www.mamiraua.org.br/fluviometrico)

Eight tree species common in floodplains, with high frequency of occurrence and significant economic value, were selected: *Calycophyllum spruceanum* (Benth.) Hook. f ex K. Schum. (Rubiaceae), a species classified as a várzea generalist that colonizes both the high and the low várzea areas (WITTMANN et al., 2012); *Piranhea trifoliata* Baill. (Euphorbiaceae) and *Tabebuia barbata* (E. Mey.) Sandwith (Bignoniaceae), classified as freshwater specialist; *Laetia corymbulosa* Spruce ex Benth. (Salicaceae), described as endemic from várzea (WITTMANN et al., 2012), which along with *Hura crepitans* L. (Euphorbiaceae), colonize low várzea areas; *Guarea guidonia* (L.) Sleumer (Meliaceae), *Ocotea cymbarum* Kunth (Lauraceae) and *Sterculia apetala* (Jacq.) H. Karst. (Malvaceae), which colonize high várzea areas. The classification used was based on the distribution of species along the flood topographical gradient (vertical distribution), which was divided into two classes according to height and duration of the flood period: low várzea, with average heights of flooding >3 m that remain flooded more than 50 days/year and high várzea, with average heights of flooding <3 m and flooded less than 50 days/year (WITTMANN et al.,2004; Wittmann et al., 2012).

Fruit sampling took place at the beginning and the peak of the flood season (between April and July of 2009, 2010 and 2012), period of maximum fructification for most várzea tree species (KUBITZKI; ZIBURSKI, 1994; PAROLIN et al., 2010), which corresponds to the average monthly rainfall of 169.46 $\pm$ 40.30 mm. At least five mother plants of each species were marked in three different areas, totaling 15 mother plants per species. Naturally mature fruits were collected, preserved in plastic bags, identified with date and place of sample, packed into a styrofoam box, and then transported to the IDSM Forest Ecology Laboratory for the removal and processing of seeds.

In the laboratory, seeds from different mother plants were mixed and homogenized to form a single lot, from which at least 400 seeds per species were sub-sampled to the germination tests. The remaining seeds of the lot were stored in a cold chamber between 18°C and 22°C, for a period of at least 4 months.

Biometric measures were taken (length, width and thickness) of samples of at least 30 seeds per species, using a digital caliper (Digimess 100.176 BL); the external morphology (contour shape and integument texture) of the seeds was also described.

The remaining lot of seeds was divided in three sub-samples used in experiments as follows: Sub-sample 1: was freshly weighed, dried and weighed again; the degree of moisture for each species was determined in whole seeds that were dried 24 hours at 105°C in an air circling/renovation oven, model SP-102/2000 (RAS 2009). Sub-sample 2: was left at room temperature until seeds have lost between 10-12% of moisture; subsequently seeds were sowed in trays using the floodplain soil as substrate, placed in greenhouse and left to germinate in order to classify them as tolerant to desiccation (TD) or sensitive to desiccation (SD). Sub-sample 3: freshly seeds were sowed in trays using the floodplain soil as substrate, placed in greenhouse and left to germinate without drying (Control). In accordance with RAS 2009, the results were expressed in grams of water per gram of dry matter, according to the following formula: Water weight/weight of Dry Matter = (g/g).

The relation between length and width of the seed and between seed size (use log of dry mass) and its water content were analyzed by linear and logarithmic regression. In the first analysis, the length was selected as a representative measure of seed size. In a second analysis, the seeds' dry weight was used as a measure of size. The analyses were used to test whether differences in size using the length or dry mass can be used as predictors of the seed storage behavior. Differences in the percentiles of seed germination of control and desiccated treatment were analyzed by a *t*-test.

RESULTS

The average seed size varied between 0.591±0.111 cm long and 0.072±0.024 cm wide for *Calycophyllum spruceanum* to 4.168±0.506 cm long and 2.105±0.197 cm wide for *Ocotea cymbarum* (Table 1). The measures of width were positively correlated with length (R^2= 0.76 Figure 3). The average seed size was positively correlated to the water content (R^2= 0.60 Figure 4) when length was used as a measure of seed size. However, when seeds' dry weight was used, the correlations between this parameter and the seeds' water content were not strongly significant (R^2= 0.43 Figure 5). Nevertheless, in both cases, seeds with smaller sizes and dispersed with lower water content, *Calycophyllum spruceanum*, *Hura crepitans* and *Piranhea trifoliata,* were those that remained viable and germinated after desiccation, and thus classified as tolerant to desiccation (Table 2). The average dry mass was 10 times greater in seeds sensitive to desiccation (82.22 g) than in desiccation-tolerant seeds (8.58g). The seeds of *Ocotea cymbarum* and *Piranhea trifoliata* were considered outlier, which may be explained by the huge variability of seed size of different species used in the same analysis.

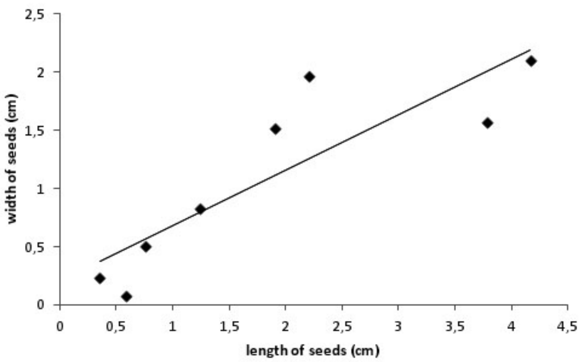

Figure 3 - Relationship between average width and length of seeds of várzea species studied (y= 0.477x + 0.203 R^2 = 0.76).

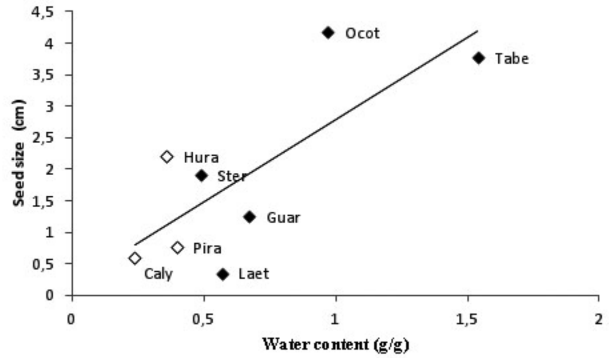

Figure 4 - Relationship between size (length in cm) and water content in the seeds of the várzea species studied (y= 2.6119x + 0.1648 R^2 = 0.58). Open diamond represent species tolerant to dessication (Caly - *Calycophyllum spruceanum*, Hura - *Hura crepitans*, Pira - *Piranhea trifoliata*), solid diamond represent species sensitive to dessication (Guar - *Guarea guidonia,* Laet - *Laetia corymbulosa,* Ocot - *Ocotea cymbarum,* Ster - *Sterculia apetala* and Tabe - *Tabebuia barbata).*

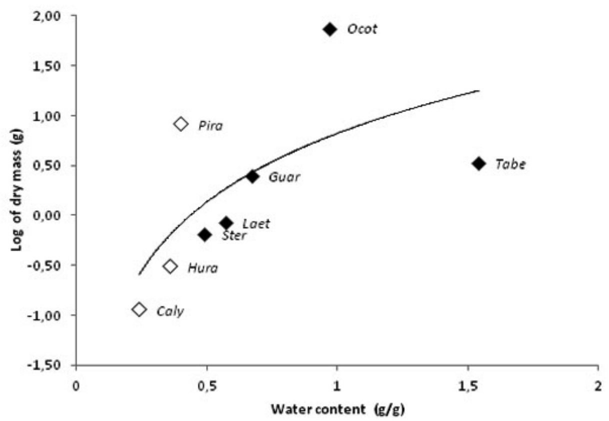

Figure 5 - Relationship between size (dry mass log) and water content in seeds of the várzea species studied (y = 0.9887 ln(x) + 0.8219 R^2 = 0.4285). Open diamond represent species tolerant to dessication (Caly - *Calycophyllum spruceanum*, Hura - *Hura crepitans*, Pira - *Piranhea trifoliata*), solid diamond represent species sensitive to dessication. (Guar - *Guarea guidonia,* Laet - *Laetia corymbulosa,* Ocot - *Ocotea cymbarum,* Ster - *Sterculia apetala* and Tabe - *Tabebuia barbata).*

The tolerance to desiccation was prevalent in the seeds that were flat or flattened, while spherical, oval or convex seeds were predominantly sensitive to desiccation, with the exception of *Piranhea trifoliata* and *Tabebuia barbata* (Table 1).

Table 1 - List of studied species, number of seeds per species, measurements of length, width and thickness (mean values followed by standard deviation). The format describes the external contour of the seeds.

Species	Seed Biometry (cm)				
Scientific name (number of seeds)	**Length**	**Width**	**Thickness**	**Shape**	**Classification**
Calycophyllum spruceanum (n = 100)	0.591 ± 0.111	0.072 ± 0.024	-	oblong/flat	TD*
Guarea guidonia(n = 100)	1.247 ± 0.367	0.827 ± 0.344	-	convex	SD**
Hura crepitans (n = 30)	2.202 ± 0.094	1.962 ± 0.063	0.600 ± 0.076	circular/flat	TD
Laetia corymbulosa (n = 100)	0.354 ± 0.047	0.237 ± 0.038	-	obovate	SD
Ocotea cymbarum (n = 30)	4.168 ± 0.506	2.105 ± 0.197	-	oblong	SD
Piranhea trifoliata (n = 100)	0.796 ± 0.057	0.526 ± 0.045	-	oblong	TD
Sterculia apetala (n = 30)	1.909 ± 0.197	1.515 ± 0.105	-	obovate	SD
Tabebuia barbata (n = 100)	3.779 ± 0.639	1.568 ± 0.110	0.401 ± 0.094	flat	SD

* Seeds Tolerant to Desiccation (TD) ** Seeds Sensitive to Desiccation (SD)

The seeds of species *Ocotea cymbarum* and *Tabebuia barbata* were completely oxidized after four months of storage, while those of *Guarea guidonia* were completely contaminated by fungi. In the other extreme, the seeds of species *Calycophyllum spruceanum*, *Hura crepitans* and *Piranhea trifoliata* survived dehydration during periods of 4 months to 1 year, when stored between temperatures of 18 ºC to 22ºC (Table 2).

Table 2 - Mean values of water content (g/g), germination percentage (G%) of seeds recently collected (Control treatment), dried (Dry seeds) and stored in a cold chamber for 4 months and 1 year (Stored Seeds). The number of seeds per repetition relates to the samples used to determine moisture content. For the germination test, 4 repetitions of 25 seeds for each species were conducted.

Species	**Water Content (g/g)**			**Germination (%)**				**Classification**
Scientifice Name (local common name)	**Control**	**Dry seed**	**Seeds / Repetition**	**Control**	**Dry seed**	**Stored Seeds 4 months**	**Stored Seeds 1 year**	
Calycophyllum spruceanum (mulateiro)	0.24	0.03	3000/ 3x1000	73	42	53	10	TD*
Guarea guidonia (Jitó)	0.67	0.30	100/ 10x10	72	0	0	0	SD**
Hura crepitans (assacú)	0.36	0.11	40/ 2x20	35	23	38	no lot	TD
Laetia corymbulosa (sardinheira)	0.57	0.34	500/ 5x100	28	0	0	no lot	SD
Ocotea cymbarum (louro-inamuí)	0.97	0.25	100/ 10x10	89	47	0	0	SD
Piranhea trifoliata (piranheira)	0.40	0.18	500/ 5x100	48	34	20	no lot	TD
Sterculia apetala (tacacazeiro)	0.49	0.18	100/ 10x10	48	3	0	no lot	SD
Tabebuia barbata (capitari)	1.54	0.18	300/ 3x100	29	10	0	0	SD

* Seeds Tolerant to Desiccation (TD) ** Seeds Sensitive to Desiccation (SD)

Calycophyllum spruceanum seeds germinated with 53% and 10% emergence, four months and one year after storage, respectively, while for *Hura crepitans* and *Piranhea trifoliata,* values of 38% and 20% emergence were recorded, respectively, after four months of storage (Figure 6). The seeds from the other species did not remain viable during the same period of storage, despite observing the following germination percentiles during the control treatment: 72% (*Guarea guidonia*), 28% (*Laetia corymbulosa*), 89% (*Ocotea cymbarum*), 48% (*Sterculia apétala*) and 29% (*Tabebuia barbata*) (Figure 6).

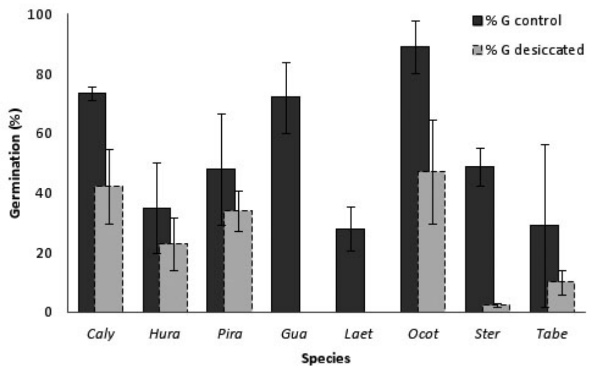

Figure 6. Percentage of germination in seeds of eight of the *várzea* species (Caly - *Calycophyllum spruceanum*, Hura - *Hura crepitans*, Pira - *Piranhea trifoliata,* Guar - *Guarea guidonia,* Laet - *Laetia corymbulosa,* Ocot - *Ocotea cymbarum,* Ster - *Sterculia apetala* and Tabe - *Tabebuia barbata*), in the dried seeds and in the control treatment.

DISCUSSION

Seeds of the five studied species that were classified as sensitive to desiccation (*Guarea guidonia*, *Laetia corymbulosa*, *Ocotea cymbarum*, *Sterculia apetala*, *Tabebuia barbata*) were bigger and dispersed with moisture contents above 33%, and the mean emergence time of these seedlings varied between 3 and 55 days (CONSERVA et. al., in press). This result confirms what has already been described by other authors for tropical forest species, who reported that fresh seeds, sensitive to desiccation, are generally dispersed with high moisture content (between 36% and 90%) (HONG; ELLIS, 1996). This occurs because, during their development, the recalcitrant seeds do not dry out at the end of maturation, as the orthodox seeds do, and are dispersed with a high content of moisture, remaining metabolically active, being therefore able to germinate right after dispersion (FARRANT et. al., 1988; KIKUTI, 2000; ROBERTS; KING, 1980). This tendency of larger seeds to be sensitive to desiccation was also verified in a large number of species from tropical forests in Costa Rica (DAWS et. al., 2005) and Australia (HAMILTON et. al., 2013). This supporting evidences suggesting that provenance is a pivotal factor in determining the degree of recalcitrant behavior exhibited by seeds of individual species (BERJAK; PAMMENTER, 2008).

The flat or compressed seeds studied (*Calycophyllum spruceanum* and *Hura crepitans*) were tolerant to desiccation, which is in accordance with other studies reporting the trend of tolerance to desiccation in most of the seeds with flat formats (HONG; ELLIS, 1998; HAMILTON et al., 2013). The authors support that the thin flat shape helps in the ripening and drying of natural seeds. Nevertheless, in the context of the current study, seed shape was not the best feature to be used as predictor of the seeds storage behavior. For instance, the species *Piranhea trifoliata,* despite having an oblong shape, remained viable for up to four months and was thus classified as tolerant to desiccation; and *Tabebuia barbata*, species that, despite having a flat shape, was sensitive to desiccation.

General observations of seed performance during storage have suggested that chemical composition is an important factor in longevity. For example, seeds with high starch content are more suitable for storage than oily seeds (BONNER, 2008). Substances, such as proteins and carbohydrates, are more hygroscopic than lipids, and these differences are reflected in the balance of moisture during storage. Thus, seeds with high starch content are more capable of balancing their moisture content than oleaginous seeds (BONNER, 2008). Comparing the percentage of oil in the seeds of *Hura crepitans,* tolerant to desiccation, a value of 34% of seed weight was recorded, while for *Sterculia apetala,* sensitive to desiccation, it was 66% of seed weight (PESCE, 2009). Thus, the importance and need for more studies to describe the chemical composition of floodplain seeds and fruits is imperative.

Desiccation sensitivity of seeds can be considered high risk regeneration strategy for plants. The occurrence of one prolonged drought at the time of seed fall can result in the death of the entire annual cohort of seedlings (PRITCHARD et. al., 2004). However, Pritchard et al. (2004b) and Daws et al. (2005) have noted a number of characteristics of tropical recalcitrant seeds that may confer advantages. As observed in the várzea forest species studied, seeds are generally larger than their co-occurring orthodox counterparts, germinate more rapidly and invest less in protection against predators. In addition, large seeds produce bigger seedlings, less susceptible to the risks of establishment conditions (CONSERVA, 2007; ZANNE, 2005; BARALOTO; FORGET 2007; MUSCARELLA et. al., 2013).

Furthermore, large seeds are targets of much predation and selection is to germinate soon, which probably interferes with the evolution of mechanisms of protection against desiccation. As exposure to drought can also lead to death of the seed, selection should be for the rapid germination, thus avoiding the two causes of mortality (BARALOTO; FORGET 2007; BERJAK; PAMMENTER, 2008).

Although several metabolic mechanisms interfere in seed germination processes, their moisture content is the most important factor in maintaining viability during storage, since moisture assumes primary control of all vital metabolic activities (PAMMENTER; BERJAK, 1999).

According to the results described in the literature, most várzea species are dispersed during the aquatic phase of the hydrological cycle (PAROLIN et. al., 2010), with high rainfall indexes (169 mm per month) and high relative air humidity, above 80% (LEOPOLDO et al., 1987). For two of the studied species classified as sensitive to desiccation, *Laetia corymbulosa* and *Tabebuia barbata*, it was verified that, under immersion conditions where the seeds are submersed in water, there was no loss of viability. Their seeds had 10% to 30% emergence after 120 and 90 immersion days, respectively (CONSERVA, 2007). This suggests that these seeds can be stored in moist conditions, and this condition of storage must be investigated. Similar results were found for other species from floodplain areas with seeds preserved in water (PAROLIN, 2001; OLIVEIRA-WITTMANN, 2007).

Tweddle et. al. (2003) postulate that species of tropical and subtropical areas present higher proportion of seeds sensitive to desiccation, since these areas represent comparatively more humid habitats with little seasonality in temperature. This rule was compatible for five out of the eight species that were studied, even though the group of investigated plants did not allow for the confirmation of this tendency as characteristic of lowland várzea forests, where species richness is very high (WITTMANN et. al., 2006). However, when placed in the context of number of species commercially exploited from floodplain areas, this report describes about 20% of the total.

Pritchard et al. (2004b) examined seeds produced by some tropical African dryland trees and showed that shedding in months of high rainfall contributed to maintenance of high water content and successful germination and seedling establishment. Instead of desiccation tolerance, which presumably has costs, an alternative strategy could be a combination of physical characteristics that reduce the rate of water loss, with rapid germination when water is available.

Studies of tree species of the flora around the world have investigated the sensitivity of seeds to desiccation based on plant ecology and morphological traits, including seed mass (HONG; ELLIS 1998; DICKIE; PRITCHARD, 2002; PRITCHARD ET. AL., 2004), seed shape (TOMPSETT, 1984; 1987; HONG, ELLIS, 1997), and moisture content in the seeds at dispersion time (HONG; ELLIS, 1998), in order to find predictors of seed storage behavior, primarily with a view to their conservation (HAMILTON et. al., 2013). To the eight evaluated species from the várzea forest, the moisture content was the best predictors. The results suggest that, if there are protection mechanisms for seeds in várzea areas, these could be more efficient in increasing the tolerance of these species to flooding, since the majority of seeds completely lost their viability after four months of dry storage. However, when stored with water contact, the longevity of the seeds was enhanced. As recommend by Berjak and Pammenter (2008), in short to medium term, recalcitrant seeds should be stored in as hydrated condition as when they are shed. But, such hydrated storage has related problems of potential fungal proliferation. In conclusion, greater attention should be paid to the investigation of alternative storage options which do not affect seed quality in order to achieve the success of programs of recolonization of impacted areas among others depending on seeds availability. So far, one may say that is still an ongoing and fundamental need for the investigation of the performance of seeds and germination ecology.

CONCLUSION

The evaluation of moisture content and germination test performed showed that five out of the eight evaluated species can be classified as sensitive to desiccation: *Guarea guidonia*, *Laetia corymbulosa*, *Ocotea cymbarum*, *Tabebuia barbata* and *Sterculia apetala*. As the recommendations of the International Institute for Plant Genetic Resources (IPGRI) regarding the protocol to determine the storage behavior of seeds were not appropriated to apply of várzea forest seeds, this study can be considered a preliminary effort for classification and viability of seeds of these species, which were identified as being highly susceptible to desiccation. Considering the pressure of exploitation of these várzea species, as well as the várzea ecosystems himself, the results point out to the urgent need of studies on alternative forms of storage and their efficiency in accordance to the physiological characteristics of seeds of the Amazon várzea floodplains.

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