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Correlation between mass and vigor of *Pochota fendleri* (Malvaceae) seeds stored in different environments

Correlação entre massa e vigor de sementes de *Pochota fendleri* armazenadas em diferentes ambientes

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ABSTRACT

Pochota fendleri is an important native forest species that lacks considerable information in the literature regarding seed behavior during storage. The present study aimed to evaluate and correlate the germination and vigor of two classes of mass stored in different environments for 28 months. A completely randomized design was used with treatments arranged in a factorial scheme of 2x3x4 (2 classes of seeds x 3 environments x 4 storage periods) with four replications. During the storage period of 28 months, seed water content, percent of germination, and germination speed rate were assessed every six months. Large *P. fendleri* seeds placed in refrigeration presented percentages of at least 80%. *P.* seeds may stay in refrigeration (10 °C) for up to 28 months, and present high magnitude correlations with percentages of germination and vigor. Moreover, large seeds increase the values of physiological quality variables, and therefore, their use is highly recommended.

Keywords*:* viability; physiological quality; germination speed.

RESUMO

Pochota fendleri é uma importante espécie florestal tropical, que ainda carece de informações sobre o comportamento das sementes durante o armazenamento. O presente trabalho teve por objetivo avaliar e correlacionar a germinação e vigor das sementes de duas classes de massa, armazenadas em diferentes ambientes, durante 28 meses. O delineamento experimental utilizado foi o inteiramente casualizado, com os tratamentos arranjados em esquema fatorial 2x3x4 (2 classes de sementes x 3 ambientes x 4 períodos de armazenamento), com quatro repetições. As variáveis analisadas durante o período de armazenamento, a cada seis meses, foram: determinação do teor de água das sementes, percentagem de germinação, índice de velocidade de germinação durante 28 meses. As sementes de *P. fendleri* classificadas como grandes e acondicionadas a 10 °C durante até 28 meses apresentaram pelo menos 80% de germinação, valor minimo exigido para a comercialização de sementes. A massa das sementes de *P. fendleri* apresentou correlação significativamente elevada com a porcentagem de germinação e vigor, uma vez que sementes grandes aumentaram significativamente a qualidade das variáveis fisiológicas e por isso a utilização de sementes grandes é recomendada.

Palavras-chave: qualidade fisiológica; velocidade de germinação, viabilidade

INTRODUCTION

Pochota fendleri (Seem.) W.S. Alverson & M.C. Duarte is a tropical tree species of the Malvaceae family. It occurs naturally in latitudes of 14° N to 2° N, which covers Central America and a part of South America, in addition to being found throughout the Amazon. In Brazil, Roraima is the only state in which the species presents natural occurrence (Smiderle *et al*., 2017). It is present in the remaining

forests of the Cerrado and in the transition forest in the central part of the state. Notably, there have been records of its cultivation in agroforestry systems since 2006 (Halfeld-Vieira *et al*., 2007).

In spite of its importance in the Amazon, studies about seeds of native forest species are insufficient, especially as far as storage is concerned, since it aims to maintain seed viability for prolonged periods. According to Smiderle *et al*. (2016a), there are problems resulting from the irregularities of seed production, species diversity per area, low frequency per area and difficulty in accessing stock trees, which occasionally causes the lack of seeds. These kinds of difficulties hinder the use of these species in silvicultural programs.

However, in seedling production from seeds, it is necessary to know the influence of the seed mass on the physiological quality. Moreover, in the same lot, seeds classified as large, in general, have increased performance compared to their smaller counterparts due to higher amounts of nutrient reserves (Souza *et al*., 2016). Seeds must be stored in a safe and correct manner to maintain physiological quality throughout the storage period. Hence, the issues concerning the preservation of agricultural products are the subject of permanent study in order to increase the quality of the products stored (Lamarca *et al*., 2016). Storage success depends on the previous knowledge of physiological behavior in storage (Gonzalez-Castro *et al*., 2012). The behavior of the seeds during storage is a function of the factors affecting their conservation, such as temperature, air relative humidity, seed moisture content and the type of package utilized (Carneiro and Aguiar, 1993). Additionally, studies have revealed that seeds packed in impermeable packages can be stored in uncontrolled rooms (Carneiro and Aguiar, 1993).

For long-term storage, conventional germplasm banks have utilized freezers at temperatures ranging from 18 to -20 ºC; however, even at such temperatures, seed metabolism is not completely interrupted.

The ecogeographic knowledge of seed storage behavior and of the relative longevity of seeds of other species of the same habitat is important to determine storage techniques. So, studies have shown that umburama seeds (*Amburana cearensis* (Allemão) A.C. Sm.), a native species of Amazonia, may be conserved efficiently in paper bag packages, cotton cloth bags, and aluminum foil in the laboratory (± 25 °C and 74.5% RU) and refrigerator environments (6 ± 2 °C and 38% ± 3 RU) for 90 days, and in aluminum packages and laboratory environments for 180 days (Guedes *et al*., 2010). Catanduva seeds (*Piptadenia moniliformis* Benth.), a native species of Northern Brazil, viability studies showed that catanduva seeds can be placed adequately both in glass containers and plastic bags for up to 210 days with controlled room (18-20 ºC, ± 60% RHR) (Benedito *et al*., 2011). According to Barbed *et al*. (2002) *Caesalpinia echinata* Lam., found in the threatened Atlantic Coastal Forest, under low temperatures (cold room at 7 ± 1 °C), seed viability was maintained for up to 18 months with seed germination superior to 80%. Nevertheless, the physiological quality was maintained for two years when the seeds were adequately placed in impermeable packages and in a cold room (Araújo Neto *et al*., 2005). Kissmann *et al*. (2009) concluded that when the seeds of *Albizia hasslerii* (Chod.) Burkart, native of Atlantic Forest of Southern Brazil, were evaluated under different storage conditions they can be stored for up to 90 days in a cold room, presenting germination above 50%.

Considering that and due to the scarcity of information on the behavior of *Pochota fendleri* (Jacq. W.S Alverson) seeds during storage, the present study evaluated and correlated the germination and vigor of seeds of two mass classes stored in different environments for 28 months.

MATERIALS AND METHODS

Seeds of the species *Pochota fendleri* (Seem.) W.S. Alverson & M.C. Duarte were collected in 10 year-old plants that grow in the Serra da Prata Experimental Field (Campo Experimental Serra da Prata). This field belongs to Embrapa Roraima and is located in the municipality of Mucajaí – RR (reference coordinates N 02°43'39.5" and W 06°51'35.4". *Datum*: WGS84), lies in the Tropical Climate Zone and has no extremely dry season or average monthly temperature below 18 °C. According to Köppen, the climate is tropical humid climate of the Aw type. It presents rainy tropical, warm and

humid climate. The rainy season is summer, and the driest month with rainfall below 60 mm. The average yearly rainfall is 1.750 mm, the average air temperature is 26.7 °C, and the air relative humidity 79% (Smiderle and Souza, 2016).

The fruits were suitably placed in raffia bags and taken to the Seed Analysis Laboratory, located at 02º45'28"N and 60º43'54"W and 90 m of altitude, in which they were placed onto trays for natural drying until the release of the seeds. The seeds were hand drawn, selected, and uniformed to the mass in small and large ones by utilizing metal sieves. The small seeds were those that passed through the 4 mm-diameter sieve, and the large ones those that the 4.5 mm sieve retained.

In order to determine seed water content in the seeds, two replications of 25 whole seeds were put into an oven at 105 ºC for 24-h, according to RAS (Brasil, 2009). Seed water content determination was performed at the onset of the experiment (seed moisture before storage) and at the end of the experiment at 28 months (moisture of the seeds stored in each environment).

Seed storage was carried out for 28 months (2014/2016) and put suitably into reutilized 0.5 L terephthalate polyethylene bottles (TPB), which were hygienized with water and neutral detergent and afterwards sanitized with a solution of 200 mL L^{-1} of active chlorine. Then, seeds were put into laboratory environment (24 °C and 56% of relative humidity), a cold room (15 °C and 45% of relative humidity) and refrigerator (10 °C and 60% of relative humidity).

A completely randomized experimental design was used with the treatments arranged in factorial scheme of 2x3x4 (2 classes of seeds x 3 environments x 4 storage periods) with four replications. Every six months of the storage period the variables were tested for seed germination and germination speed index (GSI).

Seed germination tests were carried out in a Mangelsdorf-type germinator with relative humidity near 100% and temperature of 25 °C. The gerbox (11x11x3.2 cm) was used as a container. It contained substrate paper (germitest®) moistened with distilled water 2.5 times the paper weight and it was kept in a germination chamber at 25 ± 2 °C under constant light. Germination testing was performed by daily counting until day 14, considering the number of seeds that emitted roots larger than 2 mm (Labouriau, 1983). From the data obtained in the germination test, the germination speed index was calculated according to the method recommended by Maguire (1962).

The means of the variables were submitted to the statistical analysis utilizing the software Sisvar (Ferreira, 2011), with variance analysis and the Tukey test ($p \leq 0.05\%$). The values of mass classes (large and small seeds), environment, storage, germination percentage and germination speed index, were submitted to the Pearson correlation analysis utilizing the software R Development (2008). The homogeneity and normality of the sampling distribution were surveyed by the Bartlett and Shapiro-Wilks tests.

RESULTS

Seed water content of *Pochota fendleri* regardless of the mass, oscillated according to the storage environment. Small and large seeds stored in a terephthalate polyethylene bottles (TPB), both in laboratory environment condition and a cold room, presented reduction in moisture content when compared to initial moisture content. Seeds of both mass classes of *P. fendleri* stored in the refrigerator environment maintained the water content of the seeds steady remaining close to those of the fresh seeds (Table 1).

Table 1 - Water content (%) of *Pochota fendleri* (Seem.) W.S. Alverson & M.C. Duarte seeds by different classes of mass, environments and storage periods

Environment	Seed classes	Months		Means
		4	28	
Refrigerator	Large	8.2	7.8	8.0
	Small	9.6	9.2	9.4
Laboratory	Large	8.0	7.8	7.9
	Small	9.8	9.0	9.4
Cold room	Large	8.0	7.8	7.9
	Small	9.8	9.5	9.6

By analyzing the curves adjusted for germination (Fig. 1A and B), a decrease with linear effect for

both classes of *P. fendleri* seeds conditioned in cold room and laboratory conditions was observed. The adjusted curves showed that *P. fendleri* seeds had a marked fall in germination in the laboratory environment condition, regardless of seed mass classes (Figure 1A and B). The germination values conditioned by the storage periods reached the value of zero at 28 months of storage.

Large *P. fendleri* seeds packaged in a refrigerator for up to 28 months presented seed germination percentage within minimum standards for commercialization as seeds in Brazil, which is at least 80%. Indeed, the combination of temperature with high air relative humidity provided more favorable conditions, which minimized the deterioration rate of the seeds. According to Felix *et al*. (2017), storage aims to maintain the seed in cryptobiosis, that is, in a state of no embryo growth, by reducing the active metabolism. Results obtained in the refrigerator condition showed that storage under these conditions maintained the seeds in state to germinate for longer periods, even at levels below the initial one.

As far as germination speed index is concerned, tendencies similar to seed germination percentage were observed (Figure 1A, B and 2A, B). Despite presenting similar behavior, the germination speed index for seeds classified as small presented lower indexes when compared to their larger counterparts. This finding suggests that the mass of *P. fendleri* seeds positively influences seed vigor.

A marked loss was verified in the viability of the seeds stored in the laboratory environment with null values for both classes of seed mass at 28 months of storage, as observed in Figure 2A. Among these characteristics, the Pearson correlation coefficients (r) that presented correlations of larger magnitudes (Table 2) involved the seed class (SC) with the percentage of seed germination (G). This result highlights that seed mass had a direct and positive correlation with the germination potential of the seeds evaluated by the germination test.

Table 2 - Pearson correlation coefficient matrix between storage (ST), seed mass classes (SMC), environments (ENV), percentage of germination (G), germination speed index (GSI) of *Pochota fendleri* (Seem.) W.S. Alverson & M.C. Duarte

Correlation	ST	SMC	ENV	G	GSI
SMC	0.85*	-	-	-	-
ENV	0.87*	0.91*	-	-	-
G	0.89*	0.99*	0.85*	-	-
GSI	0.88*	0.95*	0.83*	0.91*	-

Based on the coefficient of correlation between the variables (Table 2), seed mass had a positive and strong correlation, r ≥ 0.85 with all other variables evaluated.

The use of large seeds in the period of up to 28 months of storage is likely to ensure the adequate establishment of the best quality stand. Therefore,

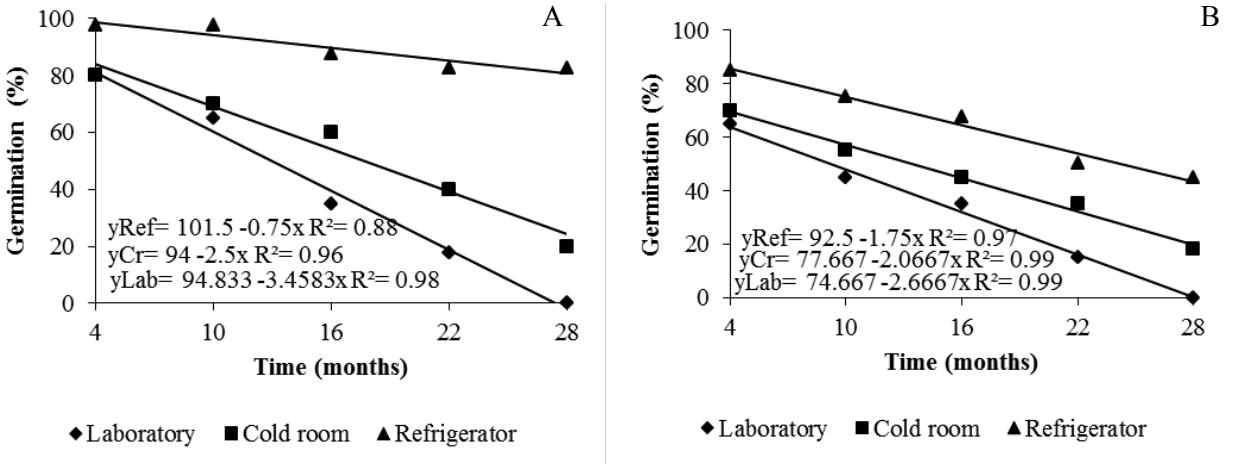

Figure 1 - Seed germination (%) of *Pochota fendleri* (Seem.) W.S. Alverson & M.C. Duarte, large (A) and small seeds (B), placed adequately in different environments along 28 months of storage.

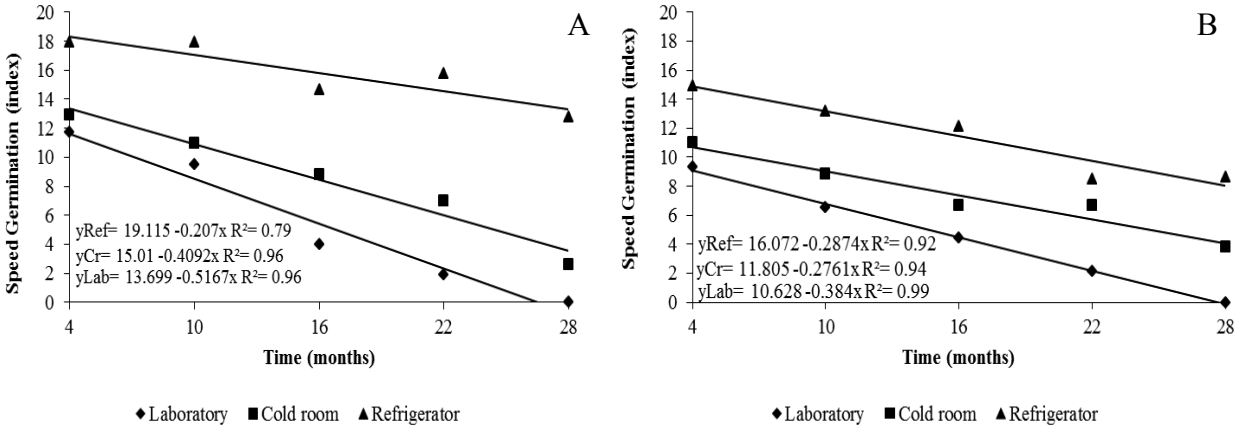

Figure 2 - Germination speed index of large (A) and small (B) *Pochota fendleri* (Seem.) W.S. Alverson & M.C. Duarte seeds placed suitably in three environments along 28 months of storage.

this is a sustainable alternative to decrease the production costs and time to be commercialized.

DISCUSSION

The use of large *Pochota fendleri* seeds, put suitably in refrigeration for a 28-month storage period, makes it possible to ensure the adequate establishment of the stand of best viability, being sustainable alternatives to encumber the production costs and time to be commercialized. The possibility of using seed mass as a guide to obtain more vigorous *P. fendleri* seeds allows the attainment of reliable results, which is one of the main aspects considered in the evaluation of seed quality of this species. The utilization of these seeds is allowed being used on a large scale, reducing the risks and costs when compared to low vigor seeds.

Therefore, the screening of *P. fendleri* seeds by size during post-harvest management is suggested, since it is a fast procedure that can be performed manually or with the use of a densimetric table. The use of seeds of higher mass gives the consumer or producer greater assurance as to the physiological quality of the material purchased and use in the production of *P. fendleri* seeds. Since seed quality plays a prominent role in the cultivation of stone fruit trees, it is possible to consider it one of the main bottlenecks in the production chain, especially in the field of seedling production.

Studies carried out by Oliveira and Bosco (2013) verified that vigor in *Copernicia hospita* seeds, which was measured by the average time of emergence, was directly proportional to seed size, and seeds classified as small presented less vigor, and corroborates our results. Under conditions similar to our study Pagliarini *et al*. (2014) verified that seeds classified as medium or large were more vigorous when compared to smaller seeds of jatobá (*courbaril*).

Oliveira *et al*. (2016) also stressed the need and importance of standardizing seeds by size in batch formation in order to obtain more adjusted results in tests that determine the physiological quality and, especially, vigor. According to Carvalho and Nakagawa (2000), seed vigor has important consequences in storage because the lower the vigor, the lower seed storage potential.

Donadon *et al*. (2015) reported that the loss of physiological quality of seeds stored under environmental conditions may be due to variation in moisture, environmental temperature and the proliferation of storage fungi; the action of these microorganisms, as long as there are conditions of humidity and temperature, may accelerate the rate of seed deterioration. These observations indicate that it is convenient to store the seeds of *P. fendleri* under refrigeration, probably due to the more favorable conditions of temperature and humidity found in this environment. These results are also

confirmed by Scalon *et al*. (2004) for *Eugenia uvalha* Cambess and Santana and Carvalho (2006) for *Baccharis trimera* (Less) DC. seeds.

CONCLUSIONS

The storage of *Pochota fendleri* seeds in a refrigerator is recommended for up to 28 months. The mass of the *P. fendleri* seeds possesses correlation of high magnitude with the germination percentage and vigor. Moreover, large seeds result in higher values for the variables of physiological quality, therefore more suitable for utilization.

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