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*Full Length Research Paper*

# Influence of the drying temperature on the emergence and vigor of Pequi seedlings (*Caryocar brasiliense* Camb), an important species of the Brazilian cerrado

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**The aim of this present study was to evaluate the influence of drying time and temperature on the physiological quality of pequi diaspores (*Caryocar brasiliense* Camb.). The diaspores were maintained in a forced-air circulation oven at 57±2 and 37±2°C for 0, 4, 8 and 12 days. The diaspores that were dehydrated at 37±2°C for up to 12 days showed a linear increase in the speed and percentage of emergence; however, the physiological quality of the diaspores was negatively affected when the dehydration was performed at 57±2°C. The drying of the diaspores at 37°C for up to 12 days both increased emergence and also resulted in seedlings with longer roots, a wider stem diameter and a greater number of leaves and leaf area. Drying at 37°C for up to 12 days promoted a greater emergence and initial growth of pequi seedlings, indicating that this is a possible orthodox behavior for seeds of this species.**

**Key words:** Native fruit plants, Cerrado, desiccation tolerance.

## INTRODUCTION

The Cerrado domain is currently one of the world's biodiversity hotspots for conservation. These hotspots are critical areas that have been rapidly transformed due to the advances of the agribusiness sector. The increase in degraded areas mainly occurs as a result of human interference that promotes the fragmentation of habitats, reduction of biodiversity and loss of territory and contributes directly to the imbalance of other ecosystems (Klink and Machado, 2005). Despite the rich biodiversity and maintenance of the Cerrado versus other biomes, this region has received less attention from the conservation community, and one approach for utilizing resources in threatened areas is to act those products, that can be used sustainably (Caldas et al., 2009).

Pequi *Caryocar brasiliense* (Camb) is a perennial species belonging to the family Caryocaraceae, comprising 25 species grouped into two genera, *Caryocar* and *Anthodiscus*, with *Caryocar* being the most common in the Central Plateau of Brazil and the Cerrado (Oliveira et al., 2008). The fruit of the pequi tree is characterized by its drupe shape, containing one to four hard endocarps surrounded by thorns; the exocarp represents the outermost portion and has a greenish color (Correa et al., 2008). The fruit is favored by the local population and is consumed raw or in the form of liqueurs, ice cream, juice and other products. In addition to the large amount of oil, vitamin A and proteins present in its pulp (Roesler et al., 2008), pequi is also known for its production of phenolic compounds, antioxidants, carotenoids and fatty acids (Lima et al., 2007) and is used both for cooking and as a source of nutrients.

Given the high consumption of pequi fruits for various purposes, the maximization of seedling development and optimization of fruit production becomes necessary, as one of the limiting factors for its commercialization and propagation is the short period of fruiting between

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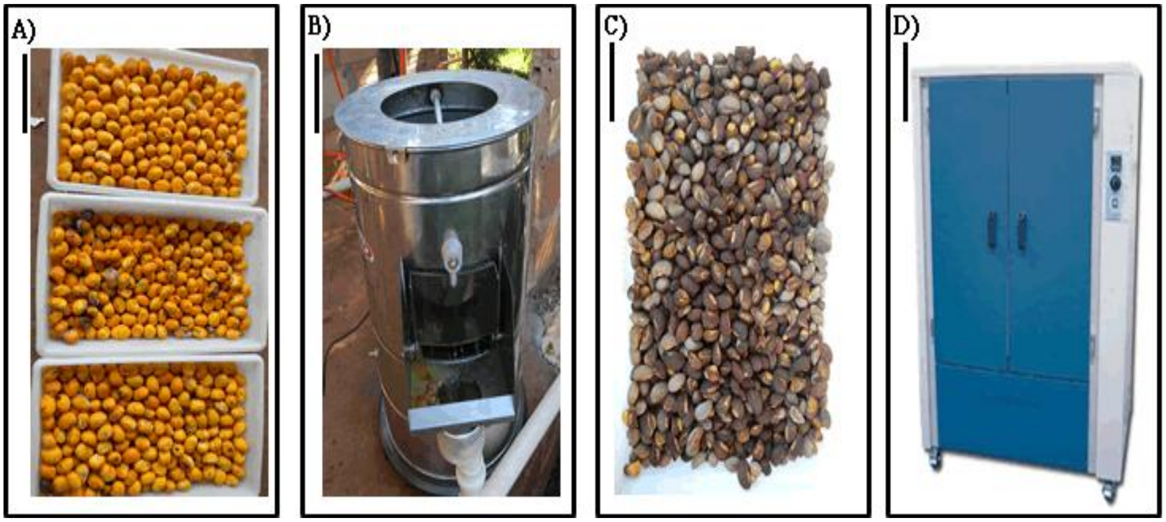


**Figure 1.** Methodology for obtaining and drying pequi seeds (*Caryocar brasiliense* Camb.). (A) Putamens. Bar = 20 cm. (B) Fruit and vegetable pulper. Bar = 20 cm. (C) Diaspores. Bar = 10 cm. (D) Forced-air circulation oven. Bar = 15 cm.

November and February (Alves et al., 2010). The mechanism for obtaining the fruit is extractivist, a practice that causes irregularities in seed dispersal, interfering with the genetic conditions, resulting from edaphoclimatic variations, and the relative age of the seedlings (Giordani et al., 2012).

Pequi trees are commonly propagated sexually; however, germination is slow and uneven due to seed dormancy, which is related to both the hard endocarp and imbalance of phytohormones that regulate germination. In this case, gibberellic acid has been used with satisfactory effects to promote seedling emergence (Souza et al., 2007).

Temperature is also an important factor for seed germination, even though this factor is related to the environmental conditions in which each individual plant develops; accordingly, there is no specific ideal temperature for all species. In the Cerrado, the temperature that allows for the best percent germination of seedlings is approximately 25°C, but temperature fluctuations in the embryo may occur as a result of the morphological characteristics of each seed and the climate particularities of the region (Brancalion et al., 2010).

Damage to the cell structure can occur during the process of seed drying, irreversibly affecting seedling development. In this regard, recalcitrant seeds do not tolerate excessive drying and become completely unviable (Berjak and Pammenter, 2000). Therefore, seeds that have undergone dehydration and do not exhibit complete germination are considered intolerant to water removal (Agbo and Nwosu, 2009).

The aim of this present study was to evaluate the effect of the drying time and temperature on the physiological quality of pequi diaspores.

## MATERIALS AND METHODS

The experiments were conducted at the Seed Laboratory of the Federal Institute of Goiás, Rio Verde Campus. Pequi fruits were collected from adult plants under natural conditions in November 2011, at the Gameleira Farm in the municipality of Montes Claros de Goiás – GO, located at 16° 07' S – 51º 18' W at an elevation of 592 m.

The fruits were kept on a bench for three days after collection until they achieved uniform ripening. The epicarp was then removed by hand, and the fruits were maintained in plastic trays (Figure 1A) for four days to soften the pulp and, consequently, facilitate the removal of the mesocarp. The fruits were pulped using an electric pulper for fruits and vegetables (Figure 1B) that contained an inner abrasive disk that allowed for the removal of the diaspores without the thorns (Figure 1C).

To assess the effect of the drying temperature, the diaspores were subjected to drying in a forced-air circulation oven at temperatures of 37±2°C and 57±2°C (Figure 1D) for 0, 4, 8 and 12 days; the water loss was monitored through the daily weighing of the samples. After each predetermined period, a batch of diaspores was removed from the oven and assessed for electrical conductivity, water content and emergence. The water content of the fruits at both temperatures was determined by adapting the method proposed by Brasil (2009) using an oven at 105±3°C until reaching a constant mass, with 4 replicates of 10 seeds each.

To test for electrical conductivity, the seeds were submerged in deionized water and incubated in a germinator at 30°C for 24 h. After this period, an electrical conductivity meter was used to obtain the data ($\mu Scm^{-1}$), with 4 replicates of 5 diaspores each.

The emergence test was performed with 4 replicates of 20 seeds treated with Vitavax-Thiram fungicide (30%). The seeds were sown in greenhouse plots containing washed sand as the substrate at an average temperature of 24.9±4°C and an average relative humidity of 76.0%. The seeds were placed 2.5 cm apart and 3.0 cm deep, in a vertical position relative to the substrate. Irrigation was performed 3 times a day for 30 min. Emergence was assessed daily after the emergence of the first seedling until 75 days after the initial emergence.

The lengths of the shoot and root were assessed after 75 days of

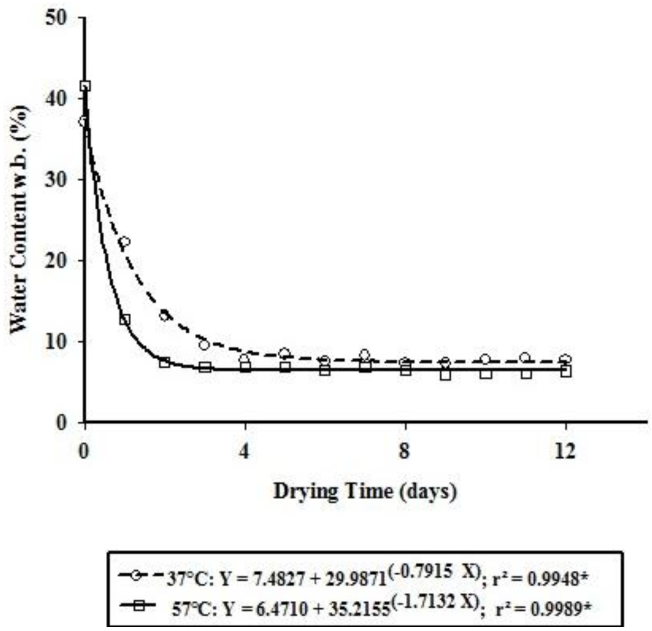


**Figure 2.** Water loss in pequi seeds (*C. brasiliense* Camb) subjected to drying for different durations at 37±2 and 57±2°C. *Significant at a 5% level.

cultivation, and the diameter at the collar and number of leaves per seedling was also evaluated. The dry mass of the root, stem and leaves were also obtained, and the leaf area was subsequently measured using Sigma Scan® software.

The experiment consisted of a completely randomized 4 (drying times) x 2 (drying temperatures) factorial design. Regression analysis was performed, and the means were compared using Tukey's test at a 5% significance level with assistance program statistical SISVAR.

## RESULTS AND DISCUSSION

The water content of the pequi diaspores recorded at the time of collection was 38.96% wet basis (w.b.), and the data obtained from the diaspores drying curve showed a gradual loss of water content. It was noted that the reduction in the water content occurred exponentially at both of the temperatures (Figure 2). However, there was an initial rapid release of water at 57°C, allowing for the seeds to remain in a hygroscopic balance after the 4th day of drying, with a water content of 6.4% (w.b.) recorded at the end of 12 days. The release of water was slower at 37°C, and a balance with the environment was only noted after the $10^{th}$ day of drying.

Pacheco et al. (2010) assessed the effect of temperature and substrate on the germination of *Dimorphandra mollis* Benth. and found the best results when combining temperatures of 30°C and 35°C with a paper towel substrate or vermiculite. The isolated effect of the temperature provided the best percent germination at 25°C.

A linear increase in the germination percentage was noted as the drying time increased for up to 12 days at a temperature of 37°C, reaching 57.4% emergence (Figure 3). Conversely, emergence was reduced when the diaspores were subjected to the drying temperature of 57°C, regardless of the time period assessed, reaching an average of 8.12%. The pequi seedlings began to emerge 28 days after sowing, a relatively short period compared to the literature, which showed that the seeds could remain in the process of germination for up to 1 year without treatments to overcome the dormancy. Pereira et al. (2004) found that the emergence of pequi seedlings began at 60 days after sowing, and the authors associated this fact to the impermeability of the integument (Figure 3A).

While analyzing the influence of temperature on the different species of the Cerrado, (Zaidan and Carreira, 2008), noted that the optimum temperature for seedling emergence ranged from 20 to 30°C. These authors also emphasized that the shrub species exhibit a dormancy that is derived from the integument; thus, the interference of other mechanisms that accelerate germination is required. Therefore, the temperature of 37°C promoted a satisfactory effect on the germination of the pequi diaspores.

At a temperature of 37°C, the time for seedling emergence decreased as the drying time was increased, reaching the least amount of time at 9.08 days of drying; so, the emergence speed began to decrease thereafter. The drying temperature of 57°C caused a reduction in the seedling vigor, regardless of the drying time (Figure 3B). Different drying temperatures and conditions were tested for the seeds of *Talisia subalbens* (Mart.) Radlk., with maximum vigor being achieved when the seeds were exposed to temperatures of 35°C, whereas 15°C and 25°C resulted in the least vigor, possibly due to a reduction in the enzyme activity (Oliveira et al., 2009).

No mathematical model could explain the behavior of the data for the length of the shoot of the seedling in relation to the drying times under assessment. The average length of the seedlings exposed to drying at 57°C did not exceed 4.93 cm, which was smaller than the average length of 9.74 cm for the seedlings dried at 37°C (Table 1).

The drying temperature of the diaspores did not affect the accumulation of the root dry mass, reaching an average of 0.043 and 0.019 g for 37 and 57°C, respectively, regardless of the drying time. It was noted that the leaching of exudate to the environment occurred at both 37 and 57°C. However, the average value reached at the temperature of 57°C was 251.05 $\mu Scm^{-1}$, which was greater than the average of 218.10 $\mu Scm^{-1}$ obtained at 37°C. This was likely due to the faster removal of water and to the damage caused to the membranes at the higher temperature, which decreased the percentage and speed of emergence observed for this temperature (Table 1).

Electrical conductivity tests do not always indicate the actual seed vigor, which may be related to the

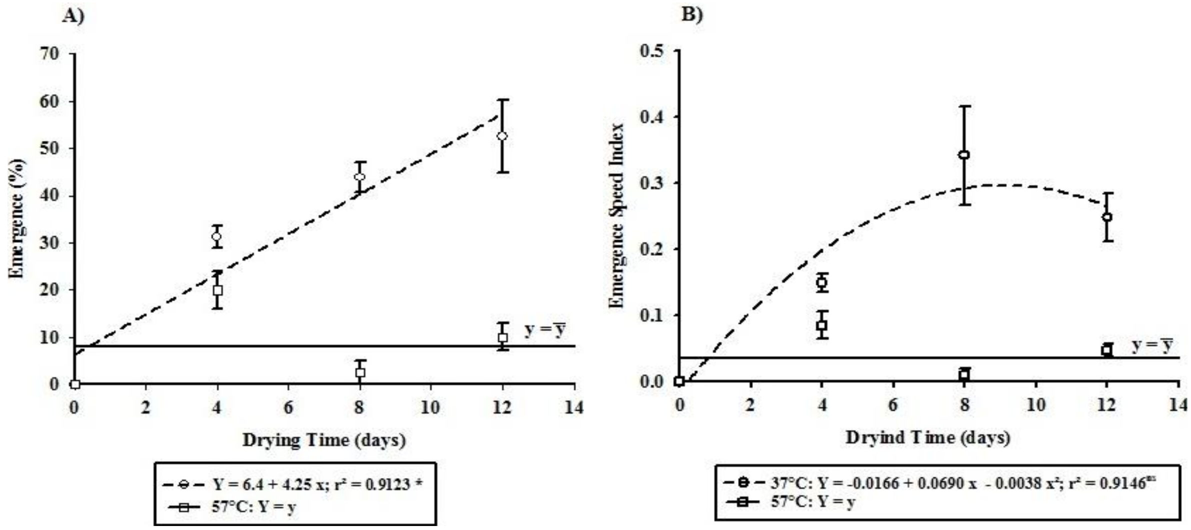


**Figure 3**. (A) Percent emergence and emergence speed index (ESI) of pequi diaspores (*C. brasiliense* CAMB.) (B) Exposed to different drying times and temperatures. nsNot significant; *Significant at a 5% level.

**Table 1.** Electrical conductivity (EC) of pequi diaspores (*C. brasiliense* CAMB.) dried at different temperatures.

| Temperature (°C) | RDM (g) | SL (cm) | EC (µS $cm^{-1}$) |
|---|---|---|---|
| 37± 2 | 0.043ns | 9.74* | 218.10* |
| 57± 2 | 0.019 | 4.93 | 251.05 |

The average root dry mass (RDM) and shoot length (SL) of pequi seedlings obtained from diaspores dried at different temperatures. nsNot significant. *Significant at a 5% level.

restructuring of cell membranes (Panobianco et al., 2007). In this regard, the pequi diaspores were able to endure a temperature of 37°C. The greater the stress experienced by the seeds, the greater the degree of their deterioration, thus decreasing their viability and, consequently, the speed of emergence (Binnotti et al., 2008). Silva and Martins (2009), reported a reduction in seedling emergence when performing electrical conductivity tests on castor bean seeds (*Ricinus communis* L.) after accelerated aging.

The average length of the roots was found to respond positively to the increase in the drying time of the seeds at 37°C, reaching a maximum point at 10.69 days; after this period, the average length of the roots was reduced observed for the diaspores dried at 37°C, which reached an average length of 4.17 cm.

A similar result was observed for the diameter at the collar, whereby the thickness of the stem was greater. At a temperature of 57°C, the average length of the roots remained constant and was lower than the lengths when the diaspores had been dried at 37°C, concomitant to the increase in the drying time, reaching the maximum diameter at 8.7 days. The stem development at 57°C did not exceed 1.74 mm in diameter, which may have interfered with the length of the shoot of the seedlings (Figure 4B). Larger diameters at the collar may also be obtained with the use of fertilizers, as highlighted by Duboc et al. (2009).

The number of leaves on the seedlings obtained from the diaspores dried at a temperature of 37°C attained the best results at 8.8 days of drying, corresponding to approximately 7 leaves per seedling. The seedlings obtained from the diaspores dried at 57°C had fewer leaves, reaching an average of 3.14 leaves at the d ifferent drying times (Figure 5A).

The leaf area of the pequi seedlings obtained from the diaspores dried at 37°C reached its maximum value of 81.34 $cm^2$ at 8.64 days of drying. The drying of the pequi seeds at 57°C impaired the development of the seedlings. Therefore, the average leaf area at this temperature did not exceed 27.18 $cm^2$, which was lower than that obtained for the seeds dried at 37°C (Figure 5B).

The accumulation of shoot dry mass (stem) (Figure 6A) occurred exponentially, reaching a maximum of 0.12 g at 6 days of drying at a temperature of 37°C. The drying time at 57°C did not affect the accumulation of shoot dry mass, displaying an average dry mass of 0.035 g, which was lower than that obtained for the drying at 37°C.

A quadratic behavior was observed for the values of leaf dry mass in the seedlings obtained from the diaspores dried at 37°C, with a peak at 9.86 days of drying, a time point when the seedlings had achieved.78 g of dry mass. The drying of the diaspores at 57°C promoted a linear accumulation of leaf dry mass on the seedlings. Therefore, an increase in the accumulation of leaf dry mass was noted with an increase in the drying time of the diaspores of 0.0328 g per day until a weight

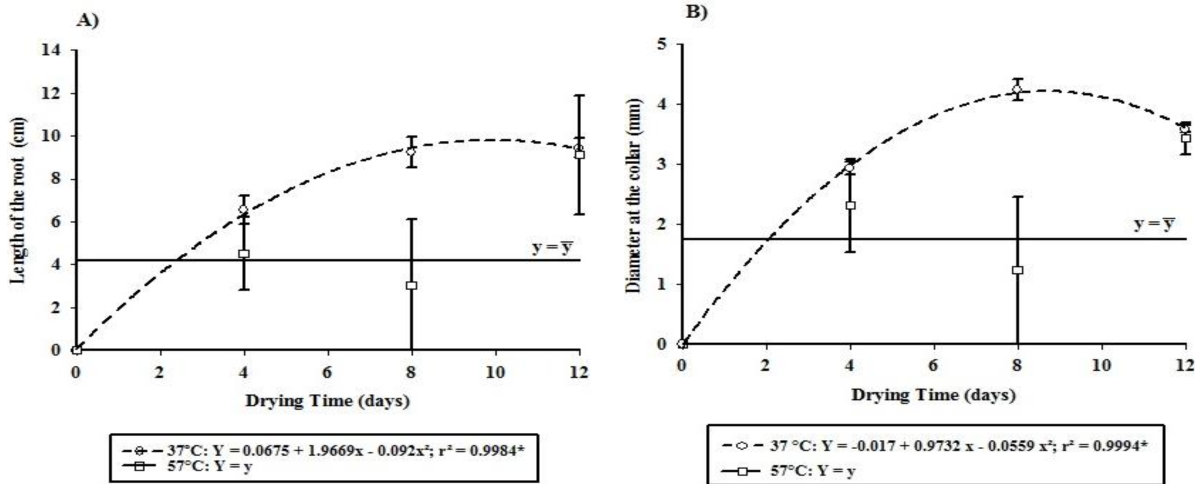


**Figure 4.** Length of the root (A) and diameter at the collar (B) in the seedlings of pequi diaspores (*C. brasiliense* Camb.) subjected to different drying times and temperatures. *Significant at a 5% level.

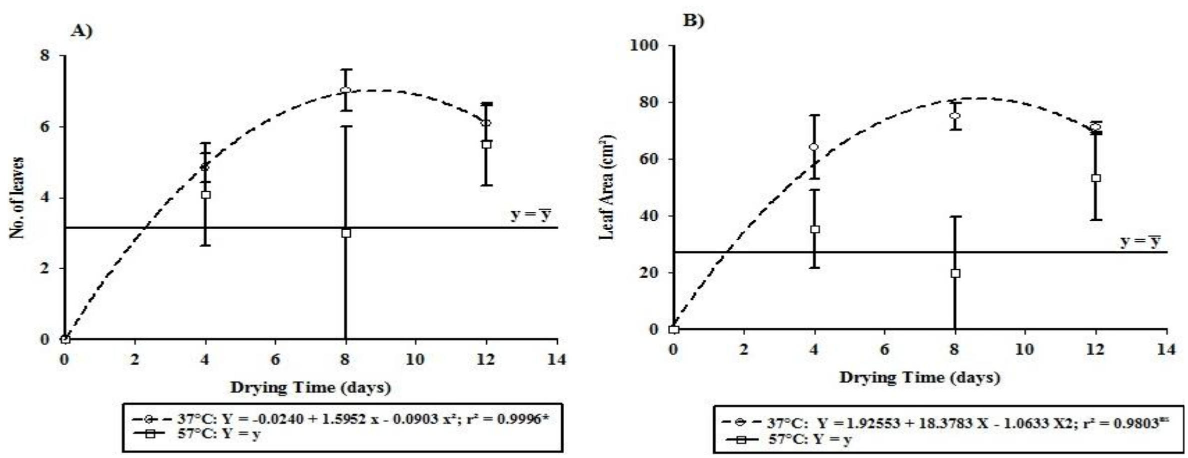


**Figure 5.** Number of leaves (A) and leaf area (B) of pequi seedlings (*C. brasiliense* Camb.) derived from diaspores exposed to different drying times and temperatures. $^{ns}$Not significant *Significant at a 5% level.

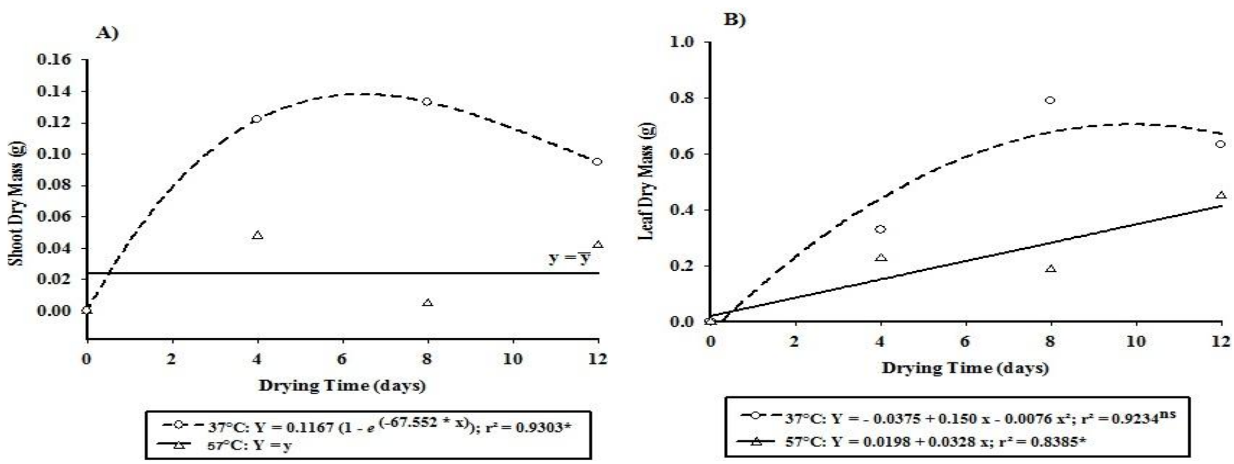


**Figure 6.** Shoot dry mass (A) and leaf dry mass (B) of pequi seedlings (*C. brasiliense* Camb.) obtained from diaspores dried at different times and temperatures. $^{ns}$Not significant *Significant at a 5% level.

of 0.41 g was reached at 12 days. This value was lower than that obtained for the same drying time at 37°C (Figure 6B).

## Conclusion

The drying of pequi seeds at 37°C for up to 10 days increased the speed and percent emergence of the seedlings, whereas drying at 57°C prevented the emergence. To attain pequi seedlings with a better root length, stem diameter, number of leaves, leaf area and dry mass characteristics, it is recommended that the seeds be dried at 37°C for up to 10 days.

## REFERENCES


Alves CCO, Resende JV, Prado MET, Cruvinel RSR (2010). The effects of added sugar and alcohols on the induction of crystallization and the stability of the freeze-dried peki (*Caryocar brasiliense* CAMB.) fruit pulps. Food Sci. Technol. 43:934–941.

Agbo CU, Nwosu PU (2009). The influence of seed processing and dryingtechniques at varying maturity stages of *Solanum melongena* fruits on their germination and dormancy. Afr. J. Biotechnol. 8(18):4529–4538.

Berjak P, Pammenter N (2000). What ultrastructure has told us about recalcitrant seeds. R. Bras. de Fisiol. Veg. 12:22-55.

Binnotti FFS, Haga KI, Cardoso ED, Alves CZ, Sá ME, Arf O (2008). Efeito do período de envelhecimento acelerado no teste de condutividade elétrica e na qualidade fisiológica de sementes de feijão. Acta Sci. Agron. 30(2):347-254.

Brancalion PHS, Novembre ADLC, Rodrigues RR (2010). Temperatura ótima de germinação de espécies arbóreas brasileiras. Rev. Bras. Sementes. 32(4):15–21.

Brasil, Ministério da Agricultura, Pecuária e Abastecimento (2009). Regras para análise de sementes. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária. Brasília, DF: Mapa/ACS. p.399.

Caldas LS, Machado LL, Caldas SC, Campos ML, Caldas JÁ, Pharis RP, Neto ABP (2009). Growth-active gibberellins overcome the very slow shoot growth of *Hancornia speciosa*, an important fruit tree from the Brazilian “Cerrado”. Trees 23(6):1229-1235.

Correa GC, Naves RV, Rocha MR, Chaves LJ, Borges JD (2008). Determinações físicas em frutos e sementes de baru (*Dipteryxalata* Vog.), cajuzinho (*Anacardiumothonianum* Rizz.) e pequi (*Caryocar brasiliense* Camb.), visando ao melhoramento genético. Biosci. J. 24(4):42-47.

Duboc E, França LV, Paulo A, Oliveira LS (2009). Efeito de doses de fertilizante de liberação controlada em mudas de pequi (*Cariocar brasiliense* CAMB.). Bol. pesqui./ Embrapa Cerrados. 1ª Ed. pp. 1-18

Giordani SCO, Fernandes JSC, Titon M, Santana RC (2012). Parâmetros genéticos para caracteres de crescimento em pequizeiro em estádio precoce**.** Rev. Cienc. Agron. 43(1):146–153.

Klink CA, Machado RB (2005). Conservation of the Brazilian Cerrado. Conserv. Biol. 19(3):707-713.

Lima A, Silva AMO, Trindade RA, Torres RP, Filho JM (2007). Composição química e compostos bioativos presentes na polpa e na amêndoa do pequi (*Caryocar brasiliense*, CAMB.). Rev. Brás. Frutic. 29(3):695–698.

Oliveira HM, Nery FC, Alvarenga AA, Barbosa JPD, Carvalho DDC (2009). Comportamento germinativo de sementes de *Talisia subalbens* (MART.) Radlk. (Sapindaceae) submetidas a diferentes temperaturas e condições de secagem. Cienc. Agrotec.33(2):391–396.

Oliveira MEB, Guerra NB, Barros LM, Alves RE (2008). Aspectos Agronômicos e de Qualidade de Pequi. Embrapa Agroind. Trop. 1ª ed. pp.1-33.

Pacheco MV, Mattei VL, Matos VP, Sena LHM (2010). Germination and vigor of *Dimorphandra mollis* BENTH. Seeds under diferents temperatures and substrates. Rev. arvore. 34(2):205-213.

Panobianco M, Vieira RD, Perecin D (2007). Electrical conductivity as an indicator of pea seed aging of stored at different temperatures. Sci. Agric. 64(2):119-124.

Pereira AV, Pereira EBC, Silva DB, Gomes AC, Silva JCS (2004). Quebra de dormência de sementes de pequi. *Bol. pesqui./ Embrapa Cerrados*. 1ª ed. pp. 1-15.

Roesler R, Catharino RR, Malta LG, Eberlin MN, Pastore G (2008). Antioxidant activity of *Caryocar brasiliense* CAMB. (pequi) and characterization of components by electrospray ionization mass spectrometry. Food Chem. 110:711–717.

Silva LB, Martins CC (2009). Teste de condutividade elétrica para sementes de mamoneira. Semin., Cienc. Agrar. 30(1): 1043–1050.

Souza AO, Nascimento JL, Naves RV, Borges JD (2007). Propagação sexuada de pequizeiro (*Caryocar brasiliense* Camb.): efeito da procedência de frutos e do ácido giberélico na emergência de plântulas. Pesqui. Agropecu. Trop. 37(3):131-136.

Zaidan LBP, Carreira RC (2008). Seed gemination in Cerrado species. Braz. J. Plant Physiol. 20(3):167-181.