Ciência Rural, Santa Maria, v.54:03, e20220257, 2024 http://doi.org/10.1590/0103-8478cr20220257

ISSNe 1678-4596
FORESTRY SCIENCE

Moisture content and temperature of storage in peach palm seed conservation

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ABSTRACT: The peach palm (*Bactris gasipaes*) is an important alternative for heart-of-palm extraction, showing precocity, rusticity and high tillering. The seeds of this species are considered recalcitrant making storage for long periods and production of seedlings difficulty. This identified a combination of moisture content of peach palm seeds and temperature during storage for longer seed longevity. Seeds with 35% and 45% of moisture content (wet basis - wb) were storage at 20 °C and 25 ºC during 180 days. The evaluations were carried out every 60 days by the germination test, emergence in sand, shoot length, diameter of stem, shoot dry matter, root dry matter and moisture content. It was observed that seeds with moisture content of 45% wb showed better performance during storage. The storage at 20 ºC provides higher seed quality maintenance. Peach palm seeds maintain their viability for 120 days when stored with moisture content of 45% wb at 20 ºC.
Key words: seed analysis, *Bactris gasipaes*, germination; plants initial growth, seeds vigour.

Teor de água e temperatura de armazenamento na conservação de sementes de pupunha

RESUMO: A pupunha *(Bactris gasipaes)* é uma importante alternativa para a extração de palmito, apresentando precocidade, rusticidade e alto grau de perfilhamento. As sementes desta espécie são consideradas recalcitrantes, dificultando o armazenamento por longos períodos e a produção de mudas. Neste trabalho objetivou-se identificar uma combinação de teor de água das sementes de pupunha e temperatura durante o armazenamento para maior longevidade das sementes. Foram utilizadas sementes com teor de água de 35% e 45% (base úmida – bu), armazenadas a 20 °C e 25 ºC por 180 dias. As avaliações foram realizadas a cada 60 dias, por meio do teste de germinação, emergência em areia, comprimento da parte aérea, diâmetro de coleto, massa de matéria seca de parte aérea, massa de matéria seca de raiz das plantas e teor de água das sementes. Observou-se que as sementes com teor de água de 45% tiveram desempenho superior durante o armazenamento. A temperatura de 20 ºC proporciona maior manutenção da qualidade das sementes. Sementes de pupunha mantêm sua viabilidade durante 120 dias, quando armazenadas com teor de água de 45% a 20 ºC.
Palavras-chave: análise de sementes, *Bactris gasipaes*, germinação, desenvolvimento inicial de plantas, vigor de sementes.

INTRODUCTION

Brazil is one of the largest producers and consumers of heart-of-palm in the world, with 30,000 hectares planted area with 20,000 hectares of peach palm (BRASIL, 2019).

Research with peach palm has been intensified due to the characteristics such as precocity (harvesting at 15-24 months after planting), high productivity, rusticity and quality heart-of-palm. Thus, this plant is an ecological and sustainable alternative for heart-of-palm production has been cultivated in different parts of the country (BRASIL, 2019), in addition, the sustainable management of peach palm in agroforestry systems could contribute to carbon sequestration, nutrient cycling and biodiversity conservation (GRAEFE et al., 2013). The peach palm is propagated via seeds or through tillers; however, seed propagation is most commonly used. The peach palm seeds are classified as recalcitrant, so, the seeds viability and longevity decrease when occur a reduction in their water content (BOVI et al., 2004; FERREIRA & SANTOS, 1992; RAMALHO et al., 2005b). As a consequence, recalcitrant seeds are generally short-lived (PARKER et al., 2008), thus, it is recommended to proceed sowing as soon as possible after harvesting the fruits (FONSECA & FREIRE, 2003).

Furthermore, peach palm seed germination is slow, occurring between 38 and 133 days after

Received 05.03.22 Approved 05.04.23 Returned by the author 07.10.23
CR-2022-0257.R2
Editors: Leandro Souza da Silva Marcos Meiado

sowing (BOVI et al., 1994), due to seed dormancy (NAZÁRIO et al., 2017). Such characteristics of peach palm seeds hinder the production of seedlings and make difficult the economic use of this plant (BETTENCOURT et al., 2016).

According to RAMALHO et al. (2005a), the seeds of *Euterpe* sp. and *Bactris* sp., stored in permeable packaging in laboratory conditions (25 ± 30ºC and 84 ± 3% relative humidity) after 30 to 45 days, the embryo is dry and the seed showed less germinative power. Morphological changes in peach palm seeds internal tissues and seed internal empty space increases were observed by X-rays during the seeds drying (PARMEJIANI, 2013). However, the maintenance of seeds during storage with high moisture content in impermeable packages induces germination, as verified for seeds of *Euterpe oleracea* (NASCIMENTO et al., 2010).

Between orthodox and recalcitrant seeds group there is different behaviors that difficulties development of seed conservation technologies (BARBEDO, 2018), and even the variability between ecotypes can involve to different responses to seed dehydration (MARTINS et al., 1999).

All these factors difficult the long periods seed storage because post-harvest technics commonly used for orthodox seeds storage, reduction of their moisture content and refrigeration, cause them low germination. However, the maintenance of high moisture contents during the storage period can contribute to development of harmful microorganisms and reduce germination (NASCIMENTO et al., 2010). Thus, knowing the desiccation tolerance degree, ideal temperatures and the longevity of these seeds is essential for planning, transporting and storing seeds.

Considering the possibility of reduction in seeds moisture content and the temperature of storage for greater longevity of the seeds, this research evaluated the viability, during storage, of *Bactris gasipaes* Kunth. (Arecaceae) seeds using different moisture content and temperature.

MATERIALS E METHODS

The peach palm seeds used were from a spineless cultivar from farmers in the Reca project, Amazonas region. The seeds were manually harvested, pulped and sent in plastic bags, showing uniformity in size and with no damage. The seeds moisture content was determinate according to the Rules for Seed Analysis - RAS (BRASIL, 2009) immediately after receiving the seeds lot. The seeds had an initial moisture content of 45% (wet basis - wb).

The treatments were two peach palm seed moisture content (45% and 35% wb), two temperatures of storage (20 ºC and 25 ºC) and four periods of storage (0, 60, 120 and 180 days), with four replicates.

The seeds were separated into two portions. One portion remained in the plastic package in which they were kept at 20 ºC (moisture content of 45% wb) and the other portion was dried until reaching moisture content of 35% wb. To dry the seeds, they were distributed in a single layer on paper towels in plastic trays, kept at room temperature until moisture content of 35% wb. The seed water loss was monitored by weight loss at regular intervals. Drying occurs in approximately seven days. The final mass of the samples corresponding to moisture content of 35% wb was determined using the equation of CROMARTY et al. (1985).

$$Mf = \frac{Mi(100 - Ui)}{100 - Uf}$$, where:

Mf = final mass (g) after dry; Mi = initial mass (g) before dry; Ui = initial moisture content (%) before dry; Uf = final moisture content (%) after dry.

Once the expected final mass was reached, the seed water was determined again according to RAS (BRASIL, 2009). The seeds with moisture content of 45% and 35% wb were divided into eight portions to be stored during 0 (zero), 60, 120 and 180 days at 20 °C and 25 °C. The seeds were packed in 0.2 mm thick plastic bags, sealed, and stored in chambers with controlled temperatures of 20 ºC and 25 ºC.

At the beginning of storage (time zero) and at 60, 120 and 180 days of storage, the seeds evaluations were performed by: a) Moisture content: two replicates of 10 seeds, per treatment, were placed in an oven at 105 ºC for 24 hours (BRASIL, 2009); b) Germination: the germination test was performed using eight replicates of 25 seeds for each treatment. The seeds were placed to germinate between three paper towels, moistened with water equivalent to 2.5 times the dry substrate mass. Paper rolls were placed in plastic bags and distributed in a germination chamber (BOD) with a photoperiod of 8 hours of light and 16 hours of darkness at 25 ºC. The evaluations were carried out after 30 days (BRASIL, 2009). Seed germination was defined as radicule protrusion. Results were expressed as percentage of germination.

After the germination test, all seeds and seedlings from the germination test were taken to a bed containing medium sand in four replicates of 50 seeds per treatment, at all evaluation periods (0, 60, 120 and 180 days of storage). The evaluation was carried out 60 days after sowing by: a) Emergence test: the seedlings that presented normal aerial part, emerged plumule more than 2 cm, were counted. Results expressed in percentage; b) Length of plants: using a ruler graduated in mm, the length of normal plants (with stem, leaves and apical meristem) was measured; c) Diameter of stem: the measurement was performed, in normal plants, with a digital paquimeter, at the base of the stem (close to the substrate); d) Shoot dry matter: the normal plants were cut closed to the substrate. The aerial part of the plants was placed in paper bags, taken to a ventilated oven at 70 ºC until reaching the equilibrium, when they were weighed; e) Root dry matter: the normal plants roots were cut, washed and placed in paper bags, taken to a ventilated oven at 70 ºC until reaching the equilibrium, when they were weighed.

The experimental design used was completely randomized with split plots, with the water contents in the plots and the temperatures and times of evaluation during storage in subplots. The data were subjected to the test of normality and homogeneity of variance and then to the analysis of variance (ANOVA). For the comparison between the averages of the temperature and water content treatments the results of the ANOVA were used considering it significant $P \leq 0.05$. It was used polynomial regression analysis to study the storage periods, when there were significant differences by ANOVA. For the significant interactions, the sliced factorial analysis was carried out.

RESULTS AND DISCUSSION

The moisture content of seeds has a great influence on the conservation of recalcitrant seeds during storage. In this work, there was a variation in the moisture content during storage from both treatments with 45% or 35% wb. This variation reached 5 percentage points, considering all treatments and all evaluation periods (Figure 1).

Variations in moisture content during storage were also observed by NASCIMENTO et al. (2010) and CARILLO et al. (2003).

These variations may occur due to seed deterioration and the presence of microorganisms (NASCIMENTO et al., 2010; BERJAK & PAMMENTER, 2008). According to FARRANT et al. (1988) the deterioration in recalcitrant seeds during drying occurs due changes in the metabolic and membrane systems. Thus, in general, recalcitrant seeds must be stored wet, but longevity is reduced by the proliferation of fungi and germination inside the package (PRITCHARD et al., 2014).

In this research, the beginning of the germination process was observed inside the package during storage, which may have caused a variation in the seed moisture content during storage, but the number of seeds that were in this situation was not verified and these were used in the tests.

Polyethylene packaging has been efficient to maintaining the seed peach palm moisture content during storage (MARTINS et al., 2009; NASCIMENTO et al., 2010), being observed its efficiency also in this research.

The temperature of the germination chambers (BOD's) was monitored with a variation of 2 ºC in relation to the desired temperature. The relative humidity of the storage environment was not monitored because the packaging used to storage the seeds difficulty water vapor exchange. The air relative humidity on indoor ambient for storage of peach palm seeds should be around 50% to 60%, however, this factor may have little influence on storage when packaging with low permeability to water vapor exchange is used (BELNIAKI et al., 2020).

It is observed that seeds stored with moisture content of 45% wb, showed higher germination at the two temperatures studied (Figure 2A and 2B). Peach palm seeds show high germination when the moisture content is between 47% and 38% and a drastic drop in the germination when the moisture content is reduced to 30% (BOVI et al., 2004).

The critical moisture content for peach palm seeds is between 36.4% (PARMEJIANI, 2013) and 30% (CARVALHO & MULLER, 1998), below which there is a decrease in germination and vigour. The ability to tolerate desiccation depends on genetic characteristics, but also on environmental conditions during seed formation and the methodology used in the study (BOVI et al., 2004; BARBEDO, 2018). Seeds stored with moisture content of 45% wb maintained germination above 70% up to 120 days of storage, with a small drop in germination power at 180 days of storage, at the two temperatures used. The storage of recalcitrant seeds with high moisture content implies greater metabolic activity and; consequently, higher respiratory rates, consumption of reserves and reduced viability (BARBEDO et al., 2013; ARAÚJO & BARBEDO, 2017). These results corroborated those obtained by NASCIMENTO et al. (2010) in which seeds of açaí palm (*Euterpe oleracea* Mart.), maintained germination for a period longer than 180 days, when stored with a moisture content higher than 40% wb. It is important to emphasize that for peach palm seeds stored at 25 ºC and with moisture content of 45% wb, there was a lower germination

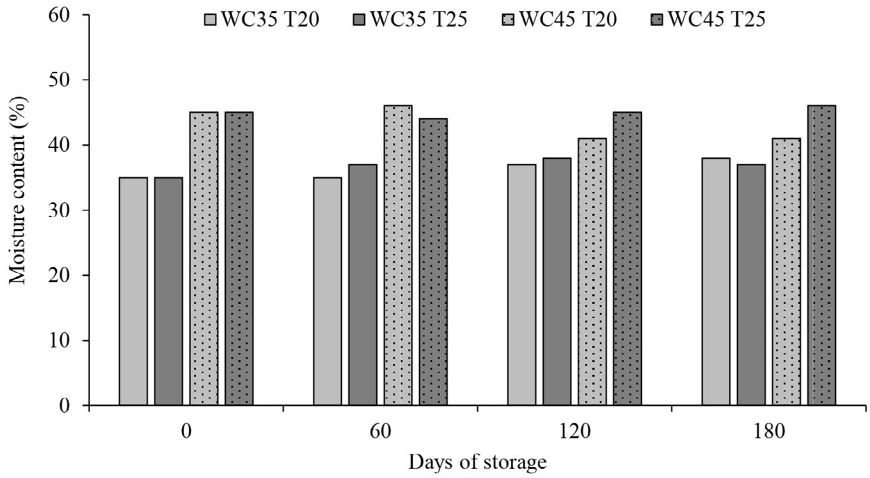

Figure 1 - Moisture content (%) of peach palm seeds in different temperatures (20 ºC - T20, and 25 ºC - T25) and initial moisture content (35% - WC35, and 45% - WC45) during storage.

rate at the beginning of storage, increasing by about 10 percentage points and remaining that way up to 120 days of storage (Figure 2A and 2B). These results demonstrated the importance of correct storage of peach palm seeds to maintain seed viability during storage. Palm seeds also have morphophysiological dormancy (BASKIN & BASKIN, 2013) and this may have contributed to this lower percentage of germination (NAZÁRIO et al., 2017).

Peach palm seeds are sensitive to dehydration and present high initial germination when seeds water content is between 47% and 38% (BOVI et al., 2004), and the viability is drastically reduced with 30% moisture content (FERREIRA & SANTOS, 1992). Thus, peach palm seeds are considered highly recalcitrant because even with high water content they present significant reduction in vigor and viability (BOVI et al., 2004), being very sensitive to low temperature storage (FARRANT et al, 1988). In general, recalcitrant seeds do not tolerate drying due to the nonexistence or inefficiency of protection mechanisms against desiccation (BERJAK & PAMMENTER, 2013).

When peach palm seeds were stored with moisture content of 35% wb, there was a reduction in germination in the initial evaluation, before storage, with an average of 38% germination. This reduction was accentuated during storage, mainly at 25 ºC storage condition (Figure 2A). Thus, it is observed that under inadequate conditions of temperature and moisture content of peach palm seeds, there is a rapid loss of germination potential during storage, emphasizing the importance of the environment for the conservation of recalcitrant seeds (NASCIMENTO et al., 2010). Also, CARVALHO & MÜLLER (1998) verified that the drying of peach palm seeds made the germination not uniform and slower.

At 20 ºC was observed better seed performance in all storage periods for seeds stored with 35% wb moisture content compared to seeds stored at 25 ºC (Figure 2B). The seeds stored with moisture content of 45% wb at 20 ºC showed higher percentage of germination at 180 days of storage. Similarly, NASCIMENTO et al. (2010) reported that the storage of açai seeds at 20 ºC had better results, especially when the seeds had moisture content of 43.4% wb. Temperatures between 15 and 18 °C were recommended by BELNIAKI et al. (2020) for the conservation of peach palm seeds. However, seeds with 45% wb moisture content stored at 25 ºC maintained higher germination potential than those stored at 20 ºC for up to 120 days of storage.

The seeds storage with high water content may germinate inside the packages during storage (NASCIMENTO et al., 2010). In this sense, the reduction in temperature and; consequently, the seeds metabolism restricts the embryonic axis growth and thus increase the longevity of recalcitrant seeds as long as the conditions keep water contents above the critical level (BARBEDO & MARCOS FILHO, 1998).

During storage, it was verified the germination of peach palm seed inside the packages in the two water contents and temperatures studied, being more frequent at 25 ºC, in the final storage period.

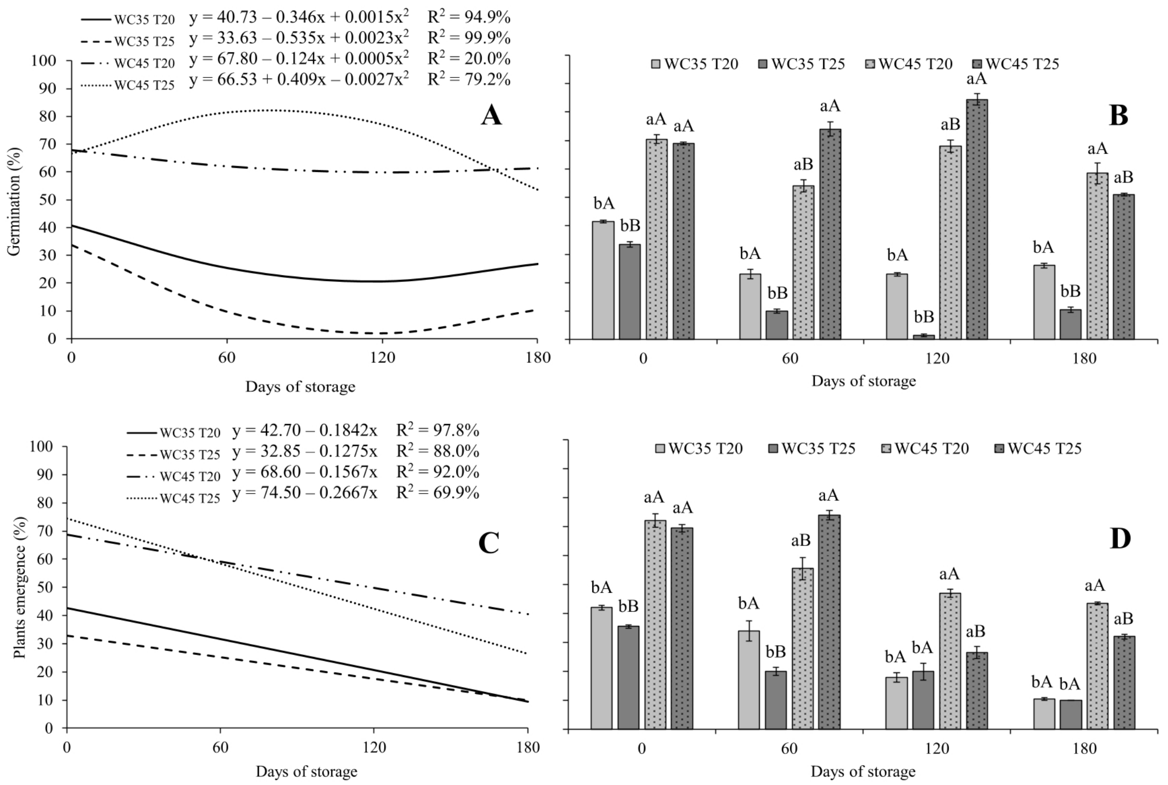

Figure 2 - Percentage of peach palm seeds germination and plant emergence (%) in different temperatures (20 ºC - T20, and 25 ºC - T25) and water content (35% - WC35, and 45% - WC45) during storage. Means followed by the same lowercase letter, comparing water contents, and capital letters, comparing temperatures, do not differ significantly for each other for each storage period.

Similar result to germination test was observed in the emergence teste with seeds stored with moisture content of 45% wb that showed stand significantly superior to seeds with 35% wb throughout the storage period, at both temperatures studied (Figure 2C and 2D). These results corroborate those presented by FERREIRA & SANTOS (1993), in which the reduction of moisture content from 56% to 36% affected the germination and vigor of peach palm seeds. The seed drying can cause cell damage depending on the speed of the process and it is more evident in recalcitrant seeds because they do not have the protection mechanisms (BERJAK & PAMMENTER, 2013).

Drying of peach palm seeds accelerate deterioration. During the storage period there was a decrease in the plant emergence mainly in treatments with 35% wb moisture content.

In general, the temperature reduction to 20 ºC during storage showed higher percentage of plants in the emergence test (Figure 2D), corroborating the results observed in the germination test.

The seed with 45% wb moisture content had greater plant length than 35% wb at all evaluation times (Figure 3A and 3B and 3C). Regarding the initial evaluation of plant length, an increase is observed at 60 and 120 days of storage. This increase may be related to overcoming seed dormancy during storage, making germination faster and more uniform and, consequently, obtaining more vigorous plants. Seeds stored with a moisture content of 35% wb showed a low rate of initial germination (40%) compared to those kept with a 45% wb, with a drop in seed germination and vigor, resulting in shorter seedlings. Peach palm seeds are highly recalcitrant, so, the seeds moisture content should be kept as close as possible to the moisture content presented during harvest, and reductions in the moisture content of the seeds reduce their viability and vigour. Seeds that were stored at 20 ºC to present plants with greater length during storage (Figure 3B and 3C), indicating greater vigour of the seeds when stored in this condition. High vigour seeds have a faster and more uniform germination and consequently become plants more vigorous.

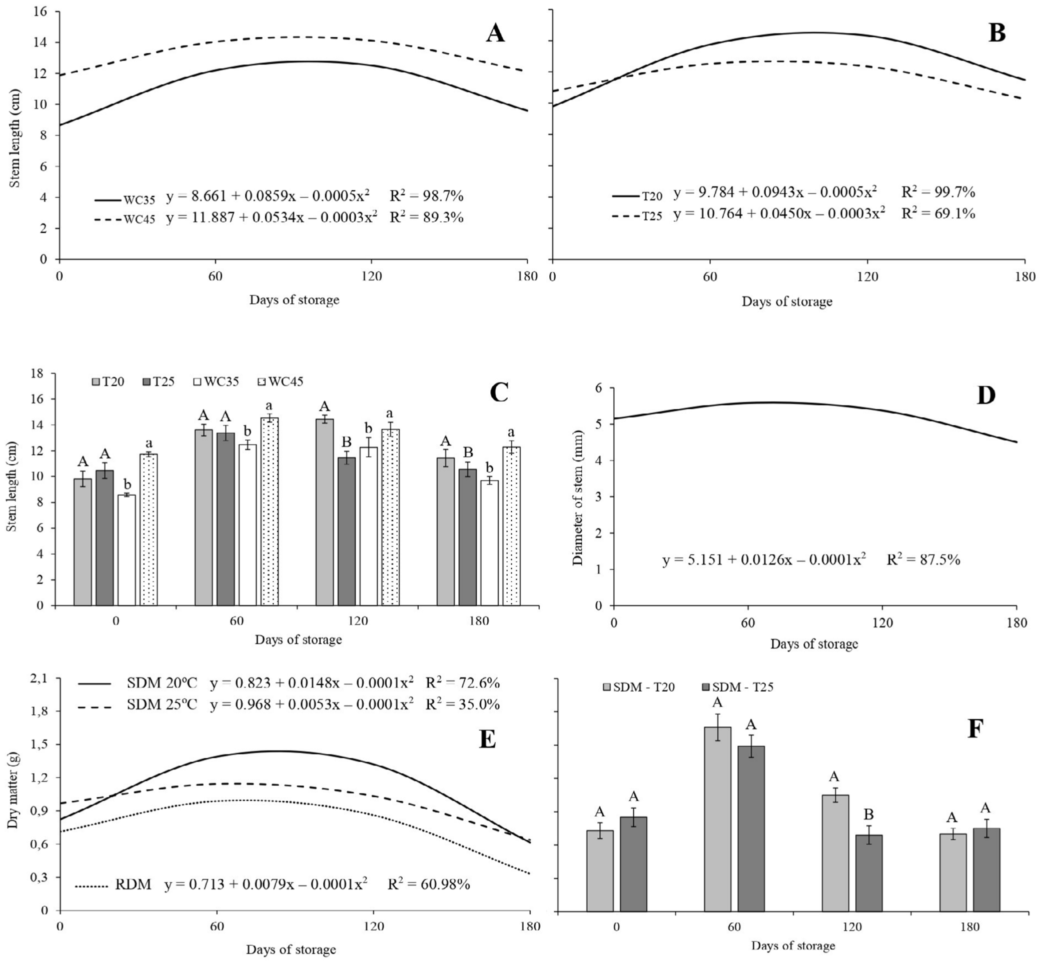

Figure 3 - Stem length, diameter of stem, shoot dry matter (SDM) and root dry matter (RDM) of plants from peach palm seeds in different temperatures (20 ºC - T20, and 25 ºC - T25) and water contents (35% - WC35, and 45% - WC45) during storage. Means followed by the same lowercase letter, when comparing water contents, and capital letters, when comparing temperatures, do not differ significantly from each other for each storage period.

There was a reduction in the diameter of the stem at the end of the storage period (Figure 3D). During storage, there was deterioration of the seeds, decreasing their vigor, which was observed in the performance of seedlings originated from. It was also observed that plants originated from seeds stored with 45% wb moisture content showed significantly better performance than those originated from seeds stored with moisture content of 35% wb. Stem diameter, as well as plant height and dry matter mass are efficient to evaluate plant performance of forest species, and the evaluation of these parameters is important because there is a correlation between seed vigour and plant development, mainly after seedling emergence (KIKUTI & MARCOS FILHO, 2007; TEKRONY & EGLI, 1991).

The shoot dry matter weight of plants originating from seeds stored with 45% wb moisture content was significantly higher than those originating from seeds stored with 35% wb moisture content, corroborating the results observed in the germination, stand and plant length test.

In the study of the interaction temperature and storage period, a tendency was observed for seeds stored at 20 ºC to present higher shoot dry matter weight, with a significant difference at 120 days of storage (Figure 3E and 3F).

Similar to observed for shoot dry matter, peach palm seeds stored with moisture content of 45% wb had higher root dry matter compared to storage at 35% wb. The dehydration of peach palm seeds reduces the vigor of the seeds, having a direct relationship with the formation of seedlings. In a work carried out by NASCIMENTO et al. (2010) it was observed that açai seeds had seedlings with lower dry matter during storage when the seeds were dried to moisture content of 37.4% wb. There was an increase in root dry matter at the beginning of storage, followed by a reduction at the end, regardless of temperature and water content (Figure 3E).

CONCLUSION

Drying reduces the viability of peach palm seeds, while decreasing temperature during storage support their longevity. Peach palm seeds stored with moisture content of 45% wb at 20 ºC show greater physiological potential. So, peach palm seeds should not be dried after harvesting and if storage is necessary, it should be carried out at 20 ºC for up to 120 days.

ACKNOWLEDGEMENTS

We thank PIBIC/IFTM (2017, 2018), IFTM Campus Uberlandia, for providing financial support. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

REFERENCES

ARAÚJO, A. C. F. B.; BARBEDO, C. J. Changes is desiccation tolerance and respiratory rates of immature *Caesalpinia echinata* Lam. seeds. **Journal of Seed Science**, v.39, n.2, p.123-132, 2017. Available from: <http://dx.doi.org/10.1590/2317-1545v39n2167788>. Accessed: Dec. 17, 2023. doi: 10.1590/2317-1545v39n2167788.

BARBEDO, C. J. A new approach towards so-called recalcitrant seeds. **Journal of Seed Science**, v.40, n.3, p.221-223, 2018. Available from: <https://doi.org/10.1590/2317-1545v40n3207201>. Accessed: Nov. 14, 2022. doi: 10.1590/2317-1545v40n3207201

BARBEDO, C. J.; et al. Do recalcitrant seeds really exist? **Hoehnea**, v.40, n.4, p.583-593, 2013. Available from: <https://doi.org/10.1590/S2236-89062013000400001>. Accessed: Dec. 17, 2023. doi: 10.1590/S2236-89062013000400001.

BARBEDO, C. J.; MARCOS FILHO, J. Desiccation tolerance on seeds. **Acta Botânica Brasileira**, v.12, n.2, p.145-164, 1998. Available from: <https://doi.org/10.1590/S0102-33061998000200005>. Accessed: Nov. 14, 2022. doi: 10.1590/S0102-33061998000200005.

BASKIN, J. M.; BASKIN, C. C. What kind of seed dormancy might palms have? **Seed Science Research**, n.1, p.17-22, 2013. Available from: <https://doi.org/10.1017/S0960258513000342>. Accessed: Nov. 14, 2022. doi: 10.1017/S0960258513000342.

BELNIAKI, A. C. et al. **Sementes de pupunha: da colheita ao armazenamento**. Colombo: Embrapa. 2020, 11p. Available from: <https://ainfo.cnptia.embrapa.br/digital/bitstream/item/214558/1/CT-448-1773-final2.pdf>. Accessed: Nov. 14, 2022.

BERJAK, P.; PAMMENTER, N. W. From Avicennia to Zizania: Seed recalcitrance in perspective. **Annals of Botany**, v.101, n.2, p.213-228, 2008. Available from: <https://doi.org/10.1093/aob/mcm168>. Accessed: Nov. 14, 2022. doi: 10.1093/aob/mcm168.

BERJAK, P.; PAMMENTER, N. W. Implications of the lack of desiccation tolerance in recalcitrant seeds. **Frontiers in Plant Science**, v.22, p.1-9, 2013. Available from: <https://doi.org/10.3389/fpls.2013.00478>. Accessed: Nov. 14, 2022. doi: 10.3389/fpls.2013.00478.

BETTENCOURT, G. M. F. et al. Effect of carbon source on somatic embryogenesis of *Bactris gasipaes*. **Pesquisa Florestal Brasileira**, Colombo, v.36, n.86, p.179-183, 2016. Available from: <https://doi.org/10.4336/2016.pfb.36.86.809>. Accessed: Nov. 14, 2022. doi: 10.4336/2016.pfb.36.86.809.

BOVI, M. L. A. et al. Dehydration effects on germination and vigor of four pejibaye seed lots. **Horticultura Brasileira**, v.22, n.1, p.109-112, 2004. Available from: <https://doi.org/10.1590/S0102-05362004000100023>. Accessed: Nov. 14, 2022. doi: 10.1590/S0102-05362004000100023.

BOVI, M. L. A. et al. Seed germination of progênies of *Bactris gasipaes*: percentage, speed and duration. **Acta Horticulturae**, v.360, p.283-289, 1994. Available from: <284251079_SEED_GERMINATION_OF_PROGENIES_OF_BACTRIS_GASIPAES_PERCENTAGE_SPEED_AND_DURATION>. Accessed: Nov. 14, 2022. doi: 10.17660/ActaHortic.1994.360.20.

BRASIL. Ministério da Agricultura Pecuária e Abastecimento. **Regras para análise de sementes**. Brasília: MAPA/ACS, 2009. 399p. Available from: <https://www.gov.br/agricultura/pt-br/assuntos/insumos-agropecuarios/arquivos-publicacoes-insumos/2946_regras_analise__sementes.pdf>. Accessed: Nov. 14, 2022.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Palmeira pupunha se destaca como matéria-prima do palmito e na preservação de árvores nativas. **Notícias Agrícolas**. 2019. Available from: <https://www.gov.br/agricultura/pt-br/assuntos/noticias/palmeira-pupunha-se-destaca-como-materia-prima-do-palmito-e-na-preservacao-de-arvores-nativas>. Accessed: Nov. 14, 2022.

CARILLO, V. P. et al. A refrigerated storage of seeds of *Araucaria angustifolia* (Bert.) O. Kuntze over a period of 24 months. **Seed Science and Technology**, v.31, n.2, p.411-429, 2003. Available from: <https://doi.org/10.15258/sst.2003.31.2.18>. Accessed: Nov. 14, 2022. doi: 10.15258/sst.2003.31.2.18.

CARVALHO, J. E.; MÜLLER, C. H. Tolerance and lethal levels of moisture content in peach palm (*Bactris gasipaes*) seeds. **Revista Brasileira de Fruticultura**, Cruz das Almas, v.20, n.3, p.283-289, 1998. Available from: <https://ainfo.cnptia.embrapa.br/digital/bitstream/item/113320/1/p283.pdf>. Accessed: Nov. 14, 2022.

CROMARTY, A. S. et al. **Design of seed storage facilities for genetic conservation**. Rome: IPGRI, 1985. 100p. Available from: <https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/The_design_of_seed_storage_facilities_for_genetic_conservation_281.pdf>. Accessed: Nov. 14, 2022.

FARRANT, J. M. et al. Recalcitrance – a current assessment. **Seed Science and Technology**, v.16, n.1, p.155-166, 1988. Available from: <https://www.researchgate.net/publication/225303590_Recalcitrance_-_A_current_assessment>. Accessed: Nov. 14, 2022.

FERREIRA, S. A. N.; SANTOS, L. A. Viabilidade de sementes de pupunha (*Bactris gasipaes* Kunth). **Acta Amazônica**, v.22, n.3, p.303-307. 1992. Available from: <https://doi.org/10.1590/1809-43921992223307>. Accessed: Nov. 14, 2022. doi: 10.1590/1809-43921992223307.

FERREIRA, S. A. N.; SANTOS, L. A. Effect of drying velocity over germination and vigour of peach palm (*Bactris gasipaes* Kunth) seeds. **Acta Amazônica**, v.23, n.1, p.3-8, 1993. Available from: <https://doi.org/10.1590/1809-43921993231008>. Accessed: Nov. 14, 2022. doi: 10.1590/1809-43921993231008.

FONSECA, S. C. L.; FREIRE, H. B. Recalcitrants seeds: post-harvest problems. **Bragantia**, v.62, n.2, p.297-303, 2003. Available from: <https://doi.org/10.1590/S0006-87052003000200016>. Accessed: Nov. 14, 2022. doi: 10.1590/S0006-87052003000200016.

GRAEFE, S. et al. Peach palm (*Bactris gasipaes*) in tropical Latin America: implications for biodiversity conservation, natural resource management and human nutrition. **Biodiversity and Conservation**, v.22, p.269-300, 2013. Available from: <https://link.springer.com/article/10.1007/s10531-012-0402-3>. Accessed: Nov. 14, 2022. doi: 10.1007/s10531-012-0402-3.

KIKUTI, A. L. P.; MARCOS FILHO, J. Cauliflower seeds physiological potential and plant field performance. **Revista Brasileira de Sementes**, v.29, n.1, p.107-113, 2007. Available from: <https://doi.org/10.1590/S0101-31222007000100015>. Accessed: Nov. 14, 2022. doi: 10.1590/S0101-31222007000100015.

MARTINS, C. C. et al. Drying and storage of *Euterpe edulis* seeds. **Revista Árvore**, Viçosa, v.33, n.4, p.635-642. 2009. Available from: <https://doi.org/10.1590/S0100-67622009000400006>. Accessed: Nov. 14, 2022. doi: 10.1590/S0100-67622009000400006.

MARTINS, C. C. et al. Desiccation tolerance of four seed lots from *Euterpe edulis* Mart. **Seed Science and Technology**, v.28, n.1, p.1-13, 1999. Available from: <https://www.cabdirect.org/cabdirect/abstract/20000310674>. Accessed: Nov. 14, 2022.

NASCIMENTO, W. M. O. et al. Conservation of *Euterpe oleracea* seeds. **Revista Brasileira de Sementes**, v.32, n.1, p.24-33. 2010. Available from: <https://doi.org/10.1590/S0101-31222010000100003>. Accessed: Nov. 14, 2022. doi: 10.1590/S0101-31222010000100003.

NAZÁRIO, P. et al. Embryonic dormancy in seeds of *Bactris gasipaes* Kunth (peach-palm). **Journal of Seed Science**, v.39, n.2, p.106-113, 2017. Available from: <https://doi.org/10.1590/2317-1545v39n2163507>. Accessed: Nov. 14, 2022. doi: 10.1590/2317-1545v39n2163507.

PARKER, V. T. et al. The seedling in an ecological and evolutionary context. In: LECK, M.A. **Seed Ecology and Evolution**. Cambridge: Cambridge University Press, 2008. p.373-389.

PARMEJIANI, R. S. **Avaliação da sensibilidade de pupunha à dessecação**. 2013. 48f. Dissertação (Mestrado em Fitotecnia) - Escola Superior de Agricultura Luiz de Queiroz, Piracicaba. Available from: <https://www.teses.usp.br/teses/disponiveis/11/11136/tde-29052013-165224/publico/Rene_Suaiden_Parmejiani.pdf>. Accessed: Nov. 14, 2022.

PRITCHARD, H. W. et al. Innovative Approaches to the preservation of forest trees. **Forest Ecology and Management**, v.333, p.88-98, 2014. Available from: <https://doi.org/10.1016/j.foreco.2014.08.012>. Accessed: Nov. 14, 2022. doi: 10.1016/j.foreco.2014.08.012.

RAMALHO, A. R. et al. **Caracteres quantitativos e condicionantes da germinação em sementes de pupunheira (raça Pampa Hermosa)**. Porto Velho: Embrapa Rondônia, 2005a. 15p. (Boletim de pesquisa e desenvolvimento 24). Available from: <https://www.infoteca.cnptia.embrapa.br/infoteca/bitstream/doc/901348/1/bpd24pupunha.pdf>. Accessed: Nov. 14, 2022.

RAMALHO, A. R. et al. **Metodização em produção, análise e conservação de sementes de pupunheira cultivada**. Porto Velho: Embrapa Rondônia, 2005b. 6p. (Comunicado Técnico 294). Available from: <https://www.infoteca.cnptia.embrapa.br/bitstream/doc/901483/1/Cot294pupunha.pdf>. Accessed: Nov. 14, 2022.

TEKRONY, D. M.; EGLI, D. B. Relationship of seed vigor to crop yeld: a review. **Crop Science**, v.31, n.3, p.816-822. 1991. Available from: <https://doi.org/10.2135/cropsci1991.0011183X003100030054x>. Accessed: Nov. 14, 2022. doi: 10.2135/cropsci1991.0011183X003100030054x.