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Post-harvest fruit rest and storage of *Diospyros inconstans* Jacq. seeds

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ABSTRACT: This work aimed at evaluating the effect of drying and slow rewetting of seeds obtained from fruits kept in post-harvest rest on the physiological quality of the seeds before and during storage. This research was divided into two parts: in experiment 1, seeds obtained from fruits that had rested for seven days after harvest were used, separated into three maturation stages based on the fruit color (COLOR1/7, COLOR2/7 and COLOR3/7), dried at 36, 15 and 11% water content. In experiment 2, COLOR3/7 seeds were used, dried at 11% water content and stored in plastic bags in a refrigerator (8 ± 1 °C), for 90, 210, 270 and 360 days. The following was evaluated: water content, germination, germination speed index, average germination time, seedling formation and dry mass of seeds and seedlings. The speed and intensity of seedling growth are negatively affected components when evaluated in seeds obtained from fruits collected with a green epicarp, even if they remained in post-harvest rest. However, these components are favored when the water content of the seeds is reduced and the seeds are slowly rewetted (seven days) or stored. The dry mass contents of the seeds desiccated at 36, 15 and 11% water content did not differ between the color stages. However, there were differences with regard to seedling development. The seeds from fruits that had rested for seven days, called COLOR3/7 and dried at 11%, presented storage capacity for 360 days.

Index terms: drying, epicarp color, germination, slow rewetting.

RESUMO: Objetivou-se neste trabalho avaliar o efeito da secagem e do reumedecimento lento de sementes obtidas de frutos mantidos em repouso pós-colheita sobre a qualidade fisiológica das sementes antes e durante o armazenamento. Esta pesquisa foi dividida em duas partes: no experimento 1, utilizou-se sementes obtidas de frutos com repouso de sete dias pós-colheita, separadas em três estádios de maturação baseados na coloração dos frutos (COR1/7, COR2/7 e COR3/7), secas a 36, 15 e 11% de teor de água. No experimento 2, utilizou-se sementes de COR3/7, secas a 11% de teor de água e armazenadas em sacos de plástico em geladeira (8 ± 1 °C), durante 90, 210, 270 e 360 dias. Foram avaliados: o teor de água, germinação, índice de velocidade de germinação, tempo médio de germinação, formação de plântulas e massa seca das sementes e plântulas. A velocidade e a intensidade de crescimento das plântulas são componentes afetados negativamente quando avaliados em sementes obtidas de frutos coletados com epicarpo verde, mesmo permanecendo em repouso pós-colheita. Porém, estes componentes são favorecidos quando se reduz o teor de água das sementes e realiza-se o reumedecimento lento (sete dias) ou o armazenamento das sementes. Os conteúdos de massa seca das sementes dessecadas a 36, 15 e 11% de teor de água não apresentaram diferenças entre os estádios de coloração. Entretanto, houve diferenças em relação ao desenvolvimento das plântulas. Sementes de frutos com repouso de sete dias, denominados de COR3/7 e secas a 11% apresentam capacidade de armazenamento por 360 dias.

Termos para indexação: secagem, coloração do epicarpo, germinação, reumedecimento lento.

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INTRODUCTION

Diospyros inconstans Jacq. is popularly known in Brazil as *"cinzeiro"*, *"fruta-de-jacú-do-mato"*, *"fruta-de-jacú-macho"*, *"maria-preta"*, *"marmelinho"*, *"marmelinho-do-mato"*, and *"granadilo"* (Lorenzi, 2009). It is a shrub tree species that can reach up to 15 m height (Santos and Sano, 2007); it is native with a wide distribution, but not endemic to Brazil (Flora and Funga do Brasil, 2022). This species belongs to the Ebenaceae Gürke family (1891) and Ericales Bercht. & J. Presl order (1820) (APG IV, 2016). The *Diospyros* L. genus is the most representative of the family and several species of this genus are commercially important, especially for their edible fruits or wood.

This species is ecologically relevant, and it serves as a food source for local fauna. Its presence contributes to the maintenance of biodiversity with potential for use in reforestation programs, but its use is limited because of the lack of technical information on seed management. It presents uneven maturation, with fruits in different color stages on the same plant, and for this reason it becomes difficult to collect fruits and obtain seeds. It is a species that has fleshy fruits dispersed by animals, especially by birds, making the collection of ripe fruits difficult, since animals consume them even before the epicarp changes color.

Therefore, an alternative to collect completely ripe fruits from this species would be to collect them early. However, immature seeds can present great variations in behavior depending on the time and place of collection, for the same chronological age, these variations in the behavior of the seeds may be due to their degree of maturity at the time they are dispersed (Ribeiro et al., 2024). Therefore, studies on maturation are necessary, since many factors can interfere with maintaining the viability and preservation of seeds. It is known that seeds must reach a certain level of maturity before they are harvested and stored, and that this process may take from a few weeks to several months, depending on the species. However, early harvesting may result in lower physiological quality (Bewley and Black, 1994). On the other hand, the effects of a post-harvest rest period for fruits, before seed removal, have been shown to improve the quality of the seeds of different species (Barbedo et al., 1997; Ricci et al., 2013; Santos et al., 2019).

At the end of maturation, two types of behavior are observed: orthodox seeds, which tolerate desiccation and probably depend on this process to change their development activity to the germination mode; and recalcitrant seeds, which have limits of tolerance to desiccation and are independent of drying to acquire germination capacity (Kermode, 1990; Barbedo and Marcos-Filho, 1998). For Barbedo et al. (2013), the differences between orthodox and recalcitrant seeds seem to lie on the stage of maturity in which they are detached from the parental plant, the recalcitrant ones in a very immature stage.

Knowledge of fruit and seed maturation contributes to increase the availability of *D. inconstans* seeds for conservation purposes. This can be achieved by bringing forward fruit collection with post-harvest rest and by slow rewetting of the seeds, extending the harvest period under field conditions. In addition, the possibility of collecting fruits before they change color and are predated by animals can prevent the loss of viable seeds, extending the harvest period and contributing to their use in seedling production in a practical way, expanding their conservation and use in reforestation programs.

Thus, studies on maturation are crucial for the correct handling of the seeds and, also, when bringing forward fruit collection, knowledge of seed behavior in relation to the tolerated limits of water loss and storage to check their physiological quality. Given that, this work had the following aims: to evaluate the effect of drying and slow rewetting of seeds obtained from fruits with different stages of maturation characterized by the color of the epicarp after being kept in post-harvest rest on germination capacity and seedling development; and to evaluate the physiological quality of the seeds during storage.

MATERIAL AND METHODS

The fruits of *Diospyros inconstans* Jacq. were collected from six parental trees located in a pasture area (09º48’24,17’’ S and 55º49’5,24’’ W) in the municipality of Carlinda/MT, 750 km far from Cuiabá/MT, in June 2021. The botanical material was deposited in the Herbarium of Southern Amazon (HERBAM/UNEMAT) under registration number 26700. The fruits were randomly collected and transported to the Seed Laboratory of the Faculty of Agronomy and Animal Science (FAAZ) of the *Universidade Federal de Mato Grosso* (UFMT), Cuiabá campus, over a period of no more than two days.

The fruits were collected when the epicarp was predominantly green in color and remained in post-harvest rest in a laboratory environment (temperature 25 ± 2 °C and relative humidity around 58%) for 7 days before the seeds were extracted. Afterwards, they were separated according to the color of the epicarp. COLOR1/7: completely green epicarp (Figure 1A); COLOR2/7: green epicarp with approximately 20% of reddish spots (Figure 1B); COLOR3/7: epicarp with more than 50% of reddish spots or completely reddish (Figure 1C).

The seeds of the fruits of each maturation stage were extracted manually and immediately after that were processed, water content was determined, and the germination test was carried out in each stage of maturation, for the initial characterization of the seeds. This research was divided into two experiments:

Experiment 1

The seeds of each color class (COLOR1/7, COLOR2/7 and COLOR3/7) were dried at 36, 15 and 11% water content. Then, the seeds were divided into two groups. In the first group, the seeds of each color class were evaluated for water content and germination immediately after drying. In the second group, the seeds of each color class dried at 36, 15 and 11% were rewetted (seven days) and evaluated again for water content and germination.

Experiment 2

The seeds obtained from fruits of COLOR3/7 and dried at 11% water content, with and without rewetting, were used. The evaluations of the germination test, water content and priming were carried out at zero and after 90, 210, 270 and 360 days of storage in transparent plastic bags (six micron thick polythene) in a refrigerator at the temperature of 8 ± 1 °C.

The tests were equally carried out in both experiments, according to the methodologies described below.

Water content: the oven method was used, at 105 ± 3 °C for 24 hours (Brasil, 2009), with three replications of five seeds, and the results were expressed as a percentage based on the wet mass of the seeds.

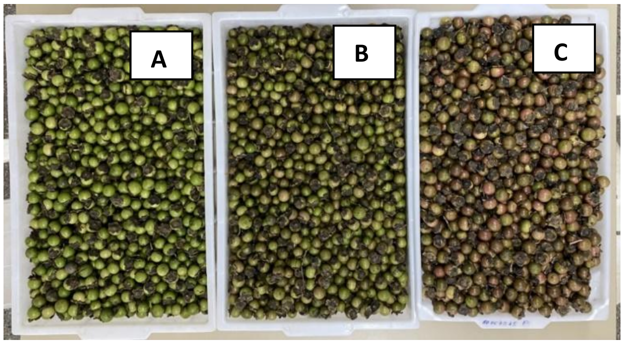

Figure 1. Maturation stages of the *D. inconstans* Jacq. fruits, based on the visual color of the epicarp, after a seven-day rest in a laboratory environment: COLOR1/7 (A), COLOR2/7 (B) and COLOR3/7 (C).

Germination test: the seeds were previously treated with fungincide Vitavax® - Thiram (Carboxin and Thiram, 200 $g.L^{-1}$ of active ingredient each). Each treatment consisted of 100 seeds with four replications of 25 on a germitest paper substrate in rolls; the seeds were placed on two sheets at the bottom and one for the cover, and moistened with water (2.5 times the mass of the dry paper). The rolls were placed in transparent plastic bags (polythene) Plasmel® (six microns thick, size 22 x 48 cm), completely sealed to prevent excessive water loss, and placed in an incubator chamber (BOD) at the temperature of 25 ± 0,5 °C, with a 12-hour photo period.

Rewetting: the seeds were placed on a stainless steel mesh attached to a plastic box of the "gerbox" type, containing 40 mL of water at the bottom (no direct contact between water and seeds). The boxes were sealed with PVC film and kept in a BOD incubator at the temperature of 25 ± 0,5 °C, with a 12-hour photo period, for seven days.

The following variables were analyzed: germination percentage, germination speed index (GSI), average germination time (AGT), seedling percentage, and dry mass of seeds and seedlings.

The counts of the germinated seeds were carried out daily, for 84 days. Germination was defined as the protrusion of at least 2 mm long of the primary root, and the seedlings were counted as soon as they presented all the structures complete. The content of dry mass of the seeds was determined gravimetrically, and randomly sampled seeds from each treatment were dried in an oven at 105 ± 3 °C for 24 hours (Brasil, 2009), using three replications of five seeds. The dry mass was expressed in $g.seed^{-1}$.

The average dry mass of the seedlings was calculated by using seedlings from each replication placed in kraft paper bags, identified and taken to dry in a forced-air circulation oven, at constant 60 ± 1 °C, for 48 hours. The maximum and minimum number of seedlings used in the evaluation of experiment 1 was from 3 to 24 seedlings, and of experiment 2, from 14 to 24 seedlings; this amount varied according to the number of seedlings developed in each treatment. Next, the samples were weighed on an analytical scale, the average dry mass was calculated, and the results were expressed in grams per seedling.

At the end of the germination test, the non-germinated seeds were cut to check the presence of larvae and, when found, they were disregarded from the total number of seeds from that replication. The procedure was carried out for the calculation of the germination percentage and seedling formation. Torrez et al. (2022) found that *Aniba rosaeodora* Ducke seeds, despite presenting losses in the cotyledon reserve due to predation, can still produce roots if the embryonic axis is not affected; however, the chances of producing the aerial part are drastically reduced as damage increases. This shows that the seeds with the presence of larvae, if considered in the total number of seeds, would be affecting the germination percentage, since the seed that did not germinate had been consumed by the larvae.

The design used was completely randomized, with four replications of 25 seeds for the germination test. For the initial characterization of the sample, three treatments were evaluated (COLOR1/7, COLOR2/7 and COLOR3/7). In experiment 1, the data were analyzed in a 3 x 3 x 2 factorial scheme (color x water content x priming). In experiment 2, in a 5 x 2 factorial scheme (storage times x priming). The data were subjected to the normality test (Shapiro-Wilk), analysis of variance (ANOVA) and, when significant, the averages were compared according to the Tukey test or regression at 5% probability, making use of package "ExpDes.pt" (Ferreira et al., 2021), program R Core Team (2021).

RESULTS AND DISCUSSION

The newly processed seeds presented high water content (49.43% COLOR1/7, 51.88% COLOR2/7 and 51.05% COLOR3/7). The germination percentage was lower in seeds obtained from fruits with color COLOR1/7 (34%) and the germination speed index increased with the advancement in the maturation/color stage of the fruits. Seedling formation was low, with a higher percentage for seeds from fruits in stage COLOR3/7 (39%) (Figure 2). This fact indicates that regardless of the stage of maturation or color of the skin achieved by the fruits after resting for seven days, the seeds had not yet reached the point of physiological maturity. This happened because, in research carried by Sanches et al. (2023), which used fruits harvested with the epicarp in different colors and with high water content (green fruits 48.46%, intermediate 55.19% and reddish 50.37%), obtained a high percentage of germination and seedling formation over 94% and 92% respectively, using the temperature of 25 °C.

In Experiment 1, the seeds of each maturation stage were desiccated at 36, 15 and 11% and showed small variations in the calculated water content in relation to what was expected (Table 1).

Maturation, related to fruit color, water content and seed priming, showed a significant triple interaction for germination percentage, seedling formation, speed index and average germination time.

Initially, the COLOR1/7, COLOR2/7 and COLOR3/7 seeds showed germination of 34, 66 and 75%, respectively (Figure 2). With seed drying at water contents of 36, 15 and 11%, germinability increased, varying from 64 to 91% (non-rewetted seeds) and from 90.87 to 98.95% (rewetted seeds), for the different color stages (Table 2).

Germination and seedling formation varied according to the level of maturation/color of the seeds, with the beneficial effect of reducing the water content for seeds from fruits COLOR1/7 and COLOR2/7, showing that the seeds in COLOR3/7 were in a more advanced maturation stage, with no influence from the drying levels. However, when seeds were evaluated with or without rewetting, higher germination percentages were verified (above 90.87%) in rewetted seeds, which did not differ from those non-rewetted of COLOR1/7, dried at 11%, and COLOR3/7, at 15 and

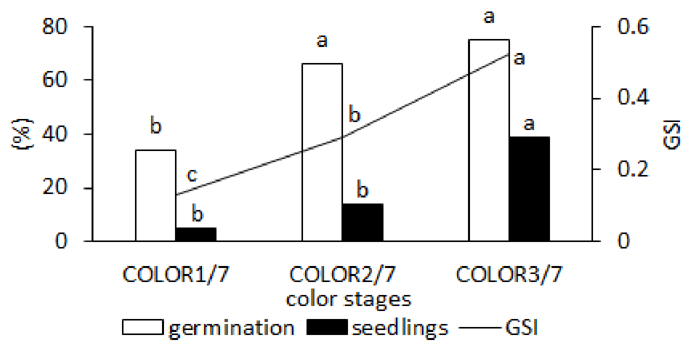

Figure 2. Initial germination (%), germination speed index (GSI) and seedling formation (%) of *D. inconstans* Jacq. seeds from fruits in different color stages. Averages followed by different lowercase letters, between the color stages, differ from each other according to the Tukey test (p<0.05).

Table 1. Water content (%) of *D. inconstans* Jacq. seeds obtained from fruits in three color stages, subjected to three drying levels, and rewetted or not for seven days.

Maturation stages	Water content (%)		
	Expected	After drying	After rewetting
COLOR1/7	36	36.1	41.31
	15	15.87	34.91
	11	11.13	35.01
COLOR2/7	36	36.34	41.14
	15	15.87	35.21
	11	11.14	35.79
COLOR3/7	36	36.1	41.44
	15	15.77	33.6
	11	11.22	33.46

11% (Table 2). For seedling formation, the rewetted seeds showed higher percentages, above 80.66% (Table 3). This shows that the slow rewetting of the seeds produced satisfactory results, allowing the seeds with lower physiological potential to reach the same or a very close level as the others, resulting in germination synchronization. Cunha et al. (2024) found that the germination potential of lentil seeds (*Lens culinaris* Medik) was similar at different maturation stages and that seeds obtained from yellow pods had greater vigor compared to those from green and brown pods.

The germination of seeds from COLOR1/7, COLOR2/7 and COLOR3/7 fruits without the drying process began at 29, 21 and 13 days, respectively (Figure 3) and the seeds from COLOR1/7 and COLOR2/7 showed a longer average germination time if compared to those from COLOR3/7. After drying, the non-rewetted seeds started to germinate from the 13th day after the germination tests were set up, varying according to the color stage of the fruits and water content of the seeds (Figure 3). Seeds from fruits in stages COLOR1/7 and COLOR2/7, dried at 11% moisture, reduced the time for germination (Figure 3).

Table 2. Germination (%) of *D. inconstans* Jacq. seeds obtained from fruits in three color stages, subjected to three drying levels, and rewetted or not for seven days.

Water content (%)	Color stages		
	COLOR1/7	COLOR2/7	COLOR3/7
		Non-rewetted	
36	68.00 Bb *B*	78.00 Aab *B*	87.00 Aa *B*
15	64.00 Bb *B*	71.37 Ab *B*	85.00 Aa *A*
11	91.00 Aa *A*	81.73 Aa *B*	90.00 Aa *A*
		Rewetted	
36	97.00 Aa *A*	94.00 Aa *A*	97.00 Aa *A*
15	98.95 Aa *A*	96.00 Aa *A*	90.87 Aa *A*
11	95.64 Aa *A*	97.87 Aa *A*	93.69 Aa *A*
CV = 6.84 %			

Averages followed by different letters (lowercase in the rows, between the color stages; and uppercase in the columns, between water contents; uppercase and italics between rewetting) differ from each other according to the Tukey test ($p<0.05$).

Table 3. Seedling formation (%) of *D. inconstans* Jacq. from seeds obtained from fruits in three color stages, subjected to three drying levels, and rewetted or not for seven days.

Water contents (%)	Color stages		
	COLOR1/7	COLOR2/7	COLOR3/7
		Non-rewetted	
36	19.00 Bc *B*	37.00 Bb *B*	60.00 Aa *B*
15	15.00 Bc *B*	33.79 Bb *B*	61.00 Aa *B*
11	66.00 Aab *B*	56.13 Ab *B*	70.00 Aa *B*
		Rewetted	
36	94.00 Aa *A*	93.00 Aa *A*	93.00 ABa *A*
15	94.87 Aa *A*	93.00 Aab *A*	80.66 Bb *A*
11	88.06 Aa *A*	93.00 Aa *A*	93.69 Aa *A*
CV= 10.62 %			

Averages followed by different letters (lowercase in the rows, between the color stages; and uppercase in the columns, between the water contents; uppercase and italics between rewetting) differ from each other according to the Tukey test ($p<0.05$).

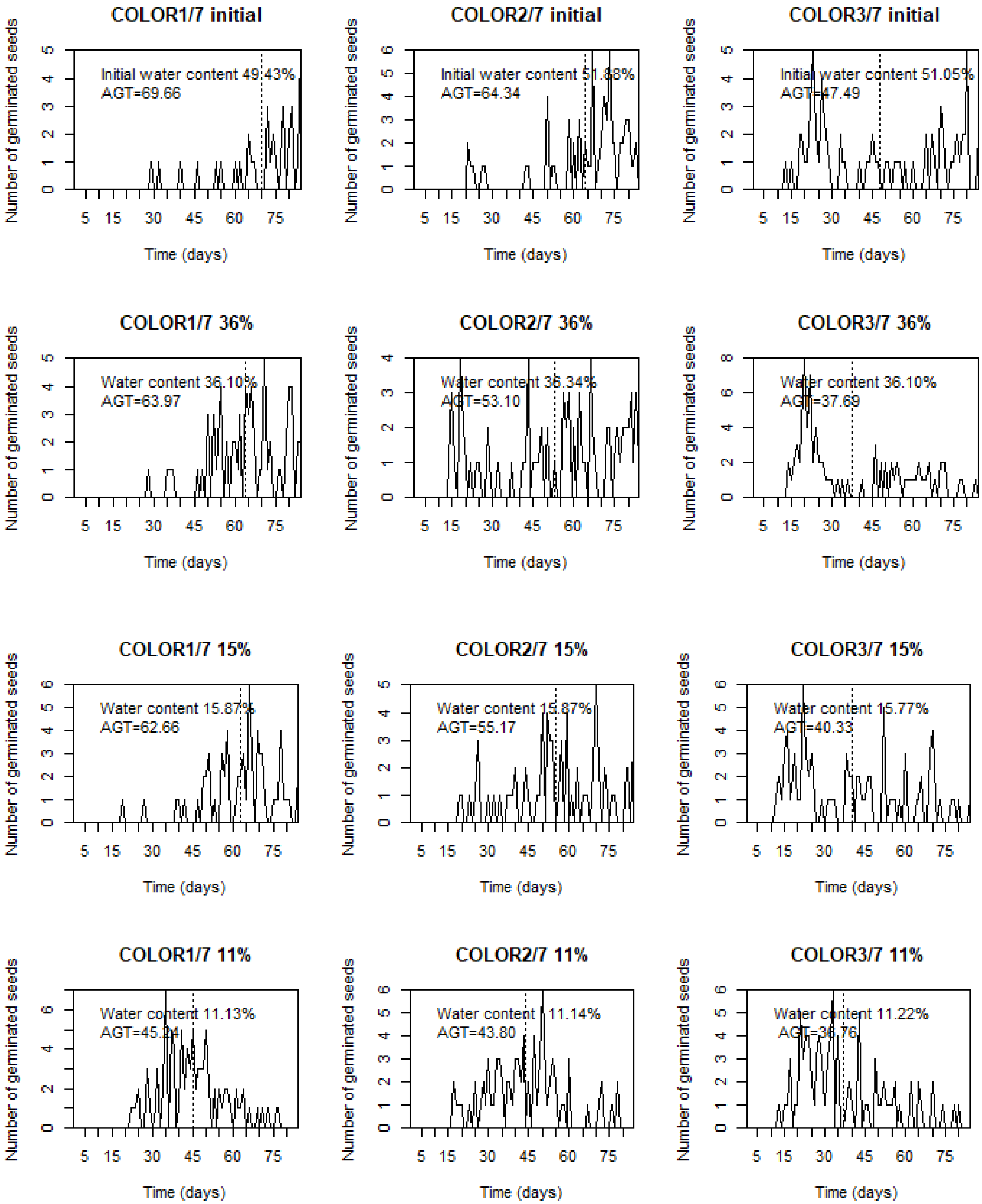

Figure 3. Germination behavior of seeds obtained from fruits in stages COLOR1/7, COLOR2/7 and COLOR3/7 of *D. inconstans* Jacq. with initial water contents of 36, 15 and 11%. The vertical bars represent the average germination time (AGT) of the seeds.

The rewetted seeds began to germinate from the ninth day onwards, varying according to the color stage of the fruits and the water content of the seeds. It was observed that rewetting promoted a better seed germination behavior, with concentration and reduction in the average germination time in the three color stages of the fruits (Figure 4).

Similar results were obtained by Carvalho et al. (2021), in which the germination of *D. inconstans* seeds obtained from ripe fruits (purple epicarp) with a water content of 25.8% and temperature of 25 °C, began at 10 days, but stabilized at 25 days, considering only the protrusion of the primary root with germination of around 90%. This shows that the early collection of fruits combined with post-harvest rest and the rewetting of seeds allowed for the obtainment of similar results to those of Carvalho et al. (2021) using ripe fruits.

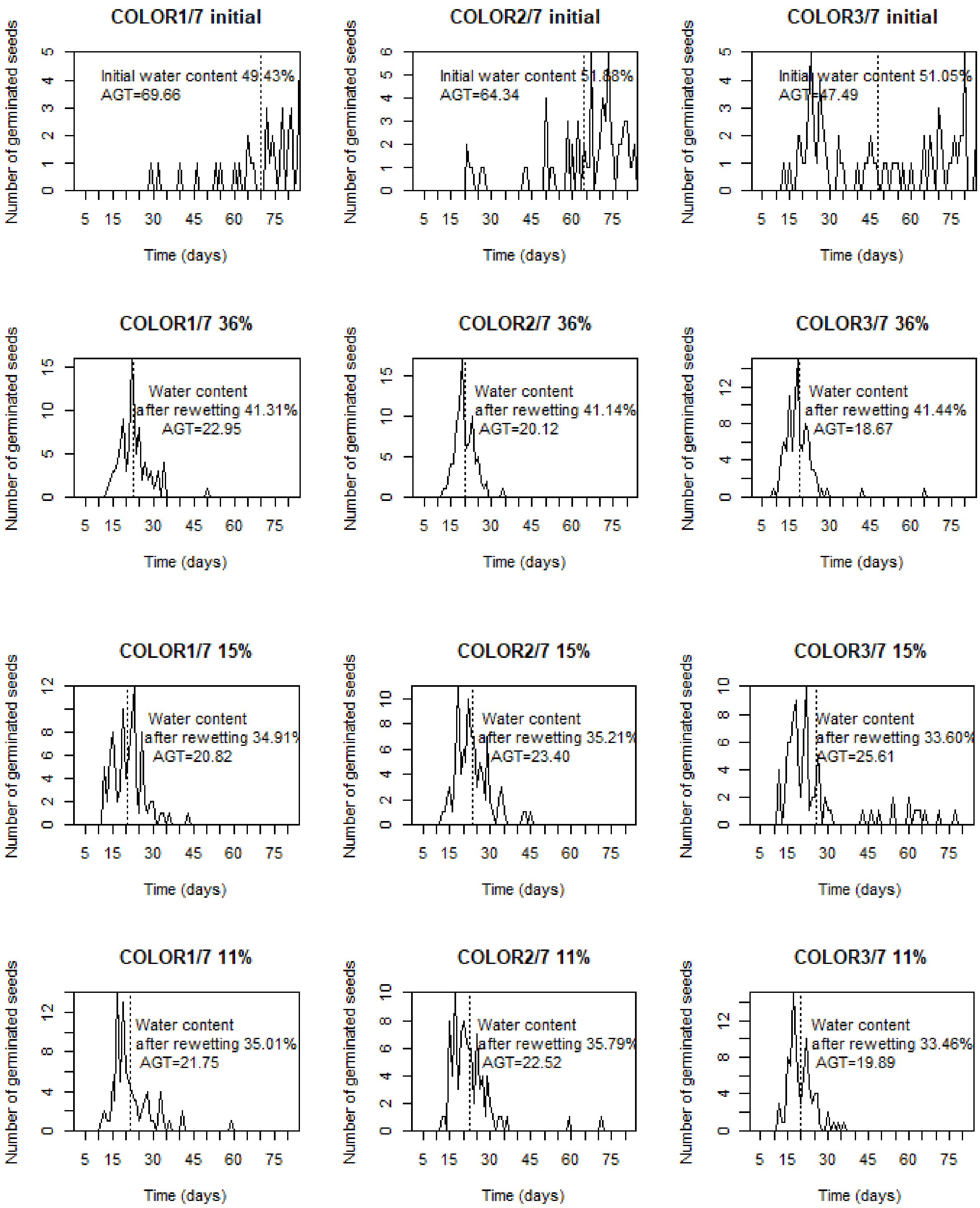

Figure 4. Germination behavior of seeds obtained from fruits in stages COLOR1/7, COLOR2/7 and COLOR3/7 of *D. inconstans* Jacq. with initial water content of 36, 15 and 11%, after rewetting. The vertical bars represent the average germination time (AGT) of the seeds.

The germination speed index of non-rewetted seeds was higher when they were obtained from fruits of the COLOR3/7 color, with no differences between water contents; this showed that the germination speed of the seeds of this species is directly related to the color and possibly maturation of the fruits. However, the rewetting of the seeds promoted a higher germination speed, with the index varying from 1.05 to 1.39, while in non-rewetted seeds it varied from 0.27 to 0.75 (Table 4). This behavior might be associated with seed maturation, since premature drying is more harmful to the configuration of the membranes, causing disorganization and rapid imbibition, which may cause irreversible injuries and lead to cell death; this effect is more pronounced in seeds with low vigor, as membrane disorganization is more intense and slow rewetting minimizes damage during imbibition because it promotes membrane repair (Marcos-Filho, 2015). When the injuries are too extensive, either the seed is unable to mobilize energy or a long time is required for repair (Carvalho and Nakagawa, 2012).

The contents of dry mass of the seeds desiccated at 36, 15 and 11% water content did not differ between the color stages, varying between 0.1586 and 0.1692 $g.seed^{-1}$ (Figure 5). However, there were differences with regard to seedling development (Table 5).

Table 4. Germination speed index of *D. inconstans* Jacq. seeds obtained from fruits in different color stages, subjected to three drying levels, and rewetted or not for seven days.

Water contents (%)	Color stages		
	COLOR1/7	COLOR2/7	COLOR3/7
		Non-rewetted	
36	0.27 Bc *B*	0.48 ABb *B*	0.75 Aa *B*
15	0.27 Bb *B*	0.35 Bb *B*	0.71 Aa *B*
11	0.54 Ab *B*	0.51 Ab *B*	0.72 Aa *B*
		Rewetted	
36	1.11 Bb *A*	1.20 Ab *A*	1.39 Aa *A*
15	1.25 Aa *A*	1.09 Ab *A*	1.05 Cb *A*
11	1.10 Ba *A*	1.08 Aa *A*	1.20 Ba *A*
		CV= 9.05 %	

Averages followed by different letters (lowercase in the rows, between the color stages; and uppercase in the columns, between the water contents; uppercase and italics between rewetting) differ from each other according to the Tukey test ($p<0.05$).

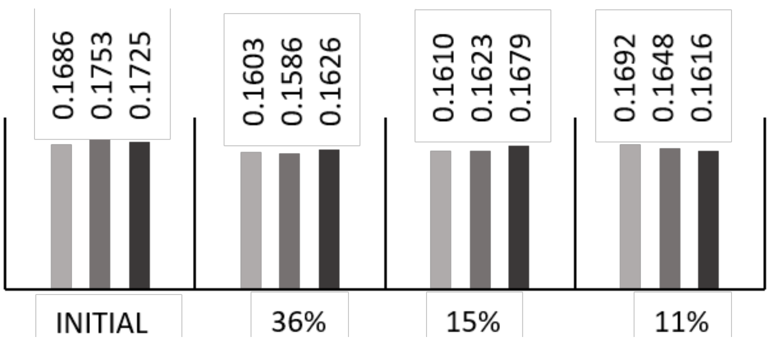

Figure 5. Dry mass of the *D. inconstans* Jacq. seeds obtained from fruits with the COLOR1/7, COLOR2/7 and COLOR3/7 color from the initial sample (without drying), dried at 36, 15 and 11% water content. (■ = COLOR1/7; ■ = COLOR2/7; ■ = COLOR3/7).

Table 5. Dry mass (g.seedling^{-1}) of *D. inconstans* Jacq. seedlings obtained from seeds from fruits in three color stages, subjected to three drying levels, rewetted or not for seven days.

Color stages	Dry mass (g.seedling^{-1})
COLOR1/7	0.0818 A
COLOR2/7	0.0764 B
COLOR3/7	0.0786 AB
Water content (%)	
36	0.0770 A
15	0.0800 A
11	0.0797 A
Priming	
Non-rewetted	0.0820 A
Rewetted	0.0758 B
CV = 7.31 %	

Averages followed by different uppercase letters in the columns differ from each other according to the Tukey test (p<0.05).

There was no relationship between the dry mass of the seeds and the dry mass of the seedlings, since the dry mass of the seeds did not differ between the color stages of the fruits. The dry mass of the seedlings did not differ when they were obtained from seeds dried at 36, 15 and 11%, and although the dry mass of the seedlings has shown a higher value for non-wetted seeds (Table 5), seedling formation was lower (Table 3). This fact may have occurred because of the germination speed of the seeds, since they present a higher germination speed when they are rewetted; this may have resulted in a shorter time, promoting less efficiency in mobilization and transfer of the dry mass of the reserve tissues to the embryonic axis, if compared to the non-rewetted seeds.

In view of the results, some possibilities can be raised. It can be seen that the reduction of water content had a beneficial effect on the germination of seeds from the COLOR1/7 fruits. Although the exact mechanisms may vary depending on the species and environmental conditions, seeds from immature fruits, when exposed to drying, may be unblocking physiological processes necessary for germination, such as the breaking of dormancy, hormonal activation and reserve mobilization. An example is the high-water content in immature seeds that might be associated with the presence of substances that inhibit germination or delay embryonic development. As water is reduced, these inhibitors may be removed or their activities may be reduced, promoting germination. The decrease in water content can help the mobilization of energy reserves in the seed, such as starch and lipids, which are necessary for germination and can also make it easier the transformation of these reserves into simpler substances and that are readily usable by the embryo during germination. It can also trigger the modulation of hormone concentration, such as the reduction in ABA and the increase in gibberellins, which makes germination possible.

In the Experiment 2, The water contents of *D. inconstans* seeds dried at 11% and determined during storage in plastic bags for 360 days remained practically constant, between, 10.58 and 13.16%, but, after rewetting, they varied from 31.25 to 35.43 (Figure 6).

Factors storage time and priming did not have a significant interaction for germination percentage, and so the simple effects were evaluated. The seeds showed a high germination percentage (91.84%) and maintained their germination capacity until 360 days of storage in plastic bags, varying from 92.34 to 96.87% (Figure 7A). The germination percentage showed no effect of rewetting, with 92.88% for the non-wetted ones and 95.47% for those wetted (Figure 7B).

Figure 8 shows the data of seedling formation, average time and germination speed index of the seeds. In the case of stored and non-rewetted seeds, it can be seen that, soon after storage, there was an increase in seedling formation from 70 to 88.74%, maintaining a high percentage (94.70%) until the end of the evaluations (Figure 8A). It can also be verified that the average germination time, initially 36.76 days, fell to 24.69 days, and remained with similar values during the entire storage period, with an average of 23.01 days at 360 days (Figure 8B). Higher germination speed indexes were observed in the stored seeds (from 0.99 to 1.07), if compared to those obtained before storage (0.72) (Figure 8C).

Stored and rewetted seeds did not differ in terms of the percentage of seedlings formed and average germination time (Figures 8A and 8B). In this case, the percentage of seedlings remained practically constant and above 90.82% during the storage period, with average germination time from 19.89 to 23.15 days. The germination speed index presented a cubic behavior, with a reduction after storage for 90 days (1.20 to 0.97), and a subsequent increase (1.16) (Figure 8C). After drying, seeds require a certain time for a better performance, which may be related to the need to reactivate the physiological processes, recover cell integrity, and make metabolic and hormonal adjustments. During this period, the seed adapts to a new physiological stage that prepares it to germinate efficiently when conditions are favorable.

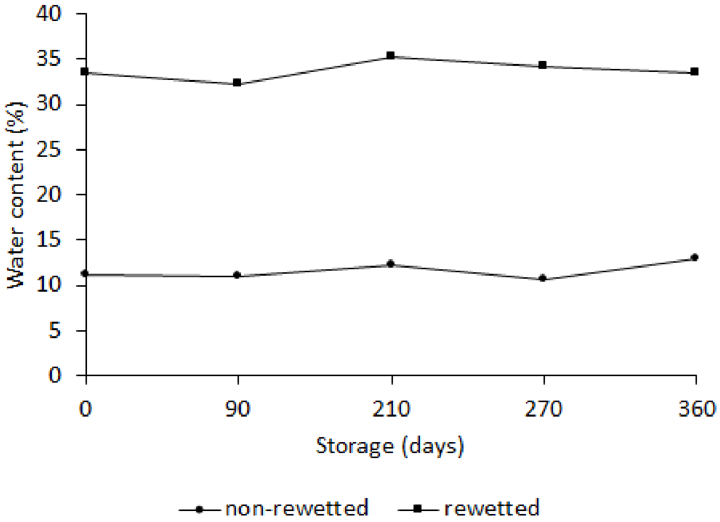

Figure 6. Water contents of seeds obtained from fruits of the COLOR3/7 color of *D. inconstans* Jacq. stored in plastic bags for 360 days in refrigerator conditions (8 °C), followed or not by rewetting (seven days).

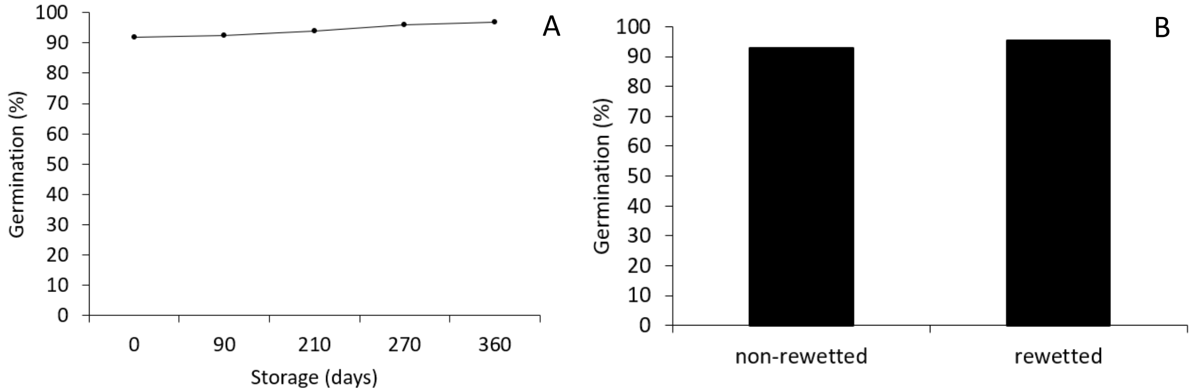

Figure 7. Germination of seeds obtained from fruits of the COLOR3/7 color of *D. inconstans* Jacq. stored in plastic bags for 360 days in a refrigerator environment (8 °C) (A), followed or not by rewetting (seven days) (B).

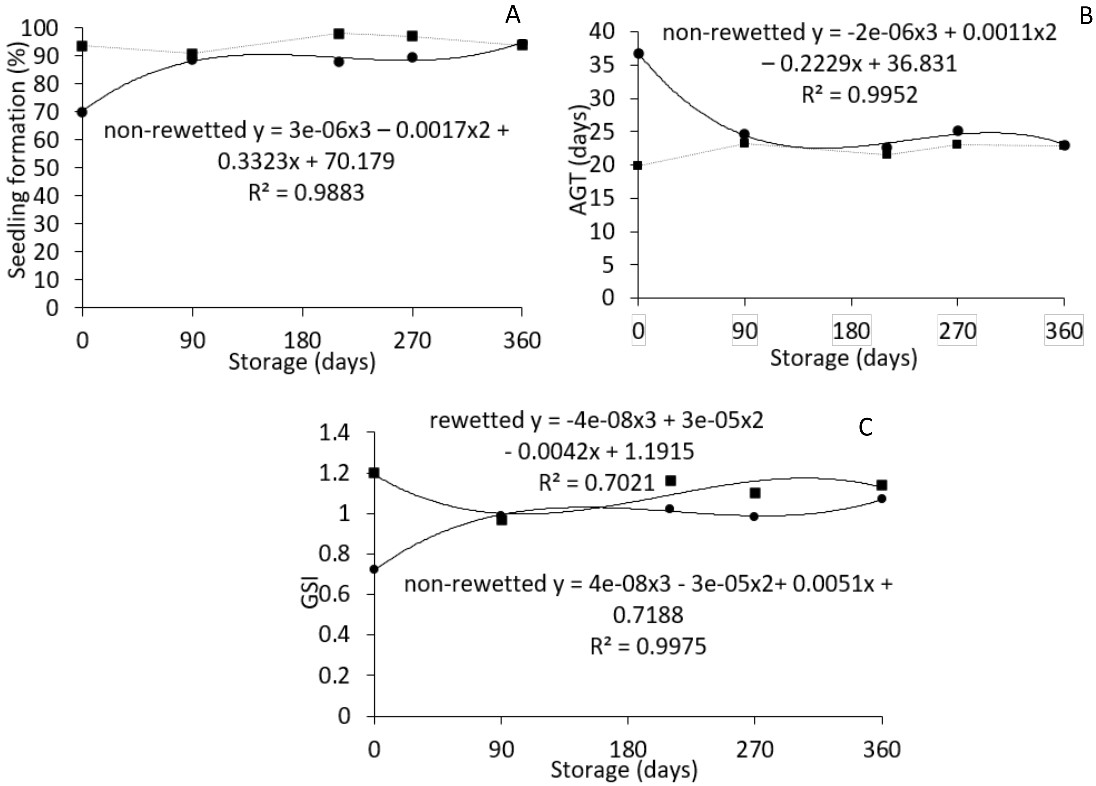

Figure 8. Seedlings (%), average germination time - AGT (days) and germination speed index - GSI of seeds obtained from fruits with the COLOR3/7 color of *D. inconstans* Jacq. stored in plastic bags (A, B and C) for 360 days in a refrigerator (8 °C), followed or not by rewetting (seven days). (● = non-rewetted; ■ = rewetted).

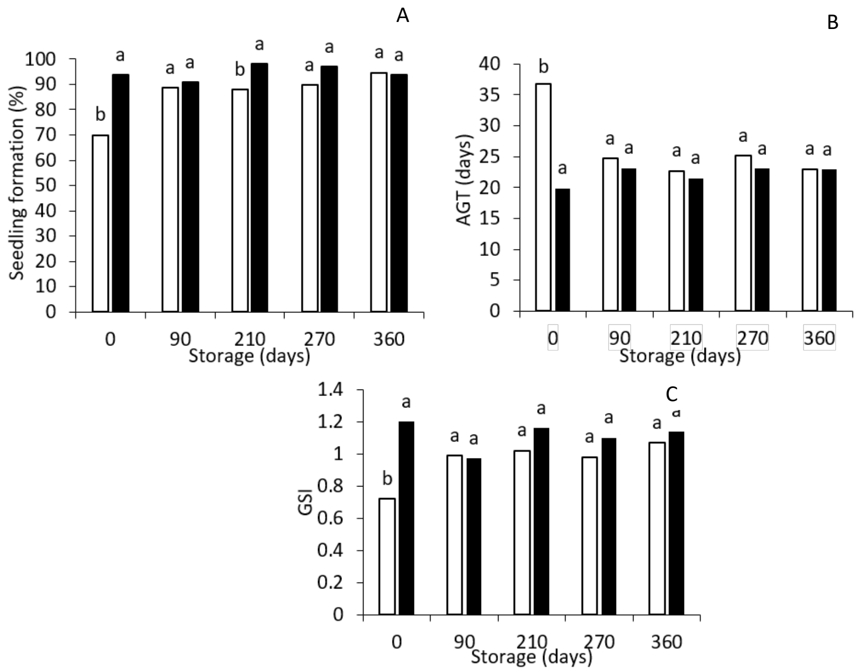

Figure 9. Seedling formation (%), average germination time - AGT (days) and germination speed index - GSI of seeds obtained from fruits of the COLOR3/7 color of *D. inconstans* Jacq. stored in plastic bags (A, B and C) for 360 in a refrigerator (8 °C), followed or not by rewetting (seven days). (□ = non - rewetted; ■ = rewetted). Averages followed by different letters (lowercase, between priming) differ from each other according to the Tukey test ($p<0.05$).

When comparing priming within each storage period (Figure 9), it is observed that it provided a higher percentage of seedling formation only in the evaluation at 210 days. Generally speaking, the average time for germination of the non-rewetted seeds after storage varied from 22.70 to 25.10 days (Figure 10), and with rewetting, from 21.49 to 23.15 days (Figure 11). There were no differences with regard to the dry mass of the seedlings (Table 6).

The results obtained indicate that the main effects on the conservation capacity of the physiological potential of the seeds were caused by the slow rewetting of the seeds when used immediately after processing and drying, and also by the reduction in water content. It is evident that the seeds from COLOR3/7, dried at 11% when stored, do not need slow rewetting. When water loss is gradual, it allows protective changes to take place, but this does not happen when drying is fast, which may cause considerable disruption to cell membranes and internal structures (Kermode,

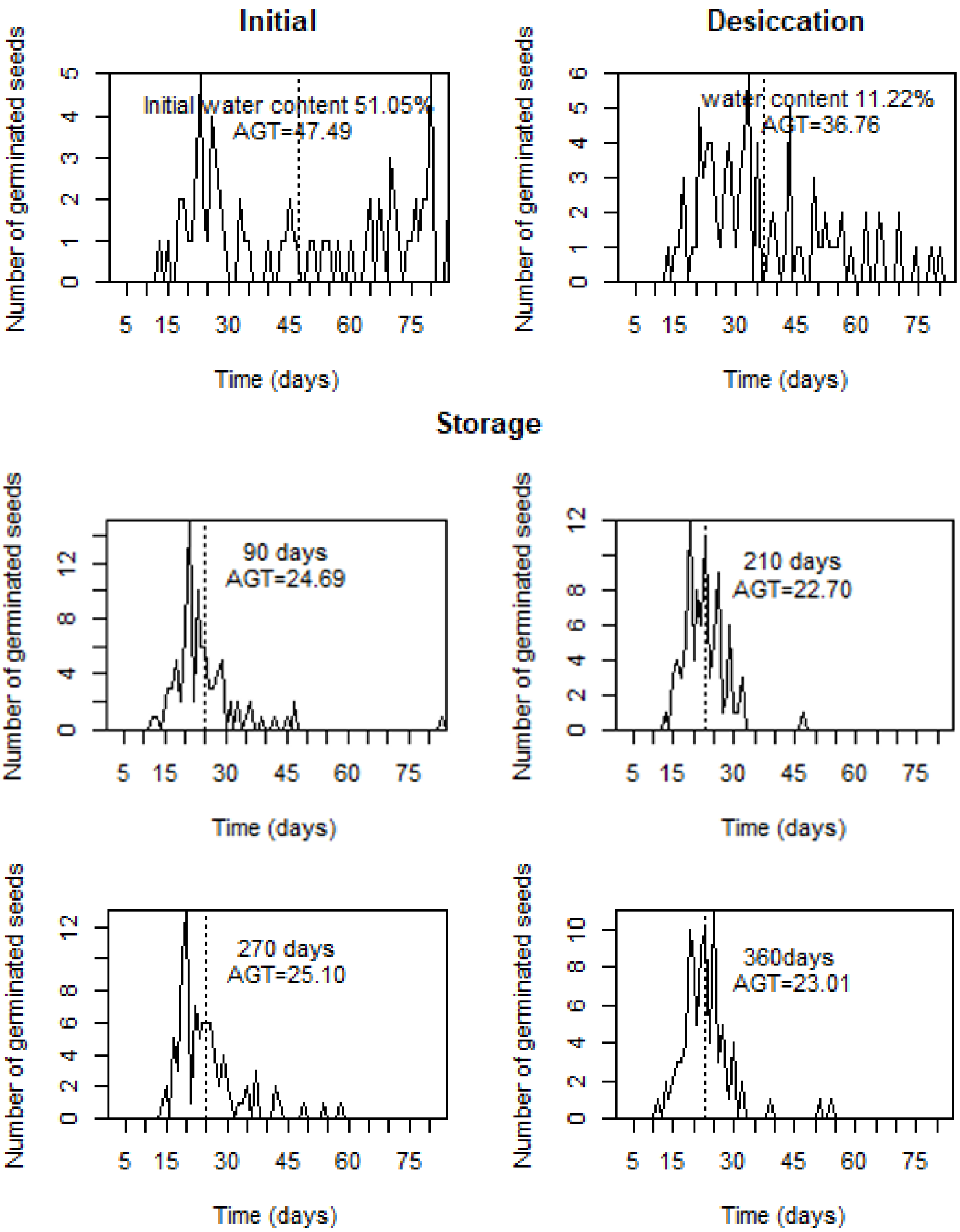

Figure 10. Germination behavior of seeds obtained from fruits of the COLOR3/7 color of *D. inconstans* Jacq. stored in plastic bags for 360, in a refrigerator (8 °C).

1990). According to the same author, seeds require time for metabolic readjustment (that is, repair) after fast drying. This cannot occur during drying itself because they reach a critical (and quiescent) dry state before the repair processes can begin. This repair is prevented after imbibition because of a very rapid water influx that cannot be accommodated by the (presumably) weakened or damaged structural components of the cell. For this reason, slow rewetting has a positive effect only after seed drying, since water absorption without direct contact and more slowly (for seven days without direct contact between water and seeds) allows more time for metabolic readjustment, which also occurs when the seeds are stored (where they remain for a prolonged period).

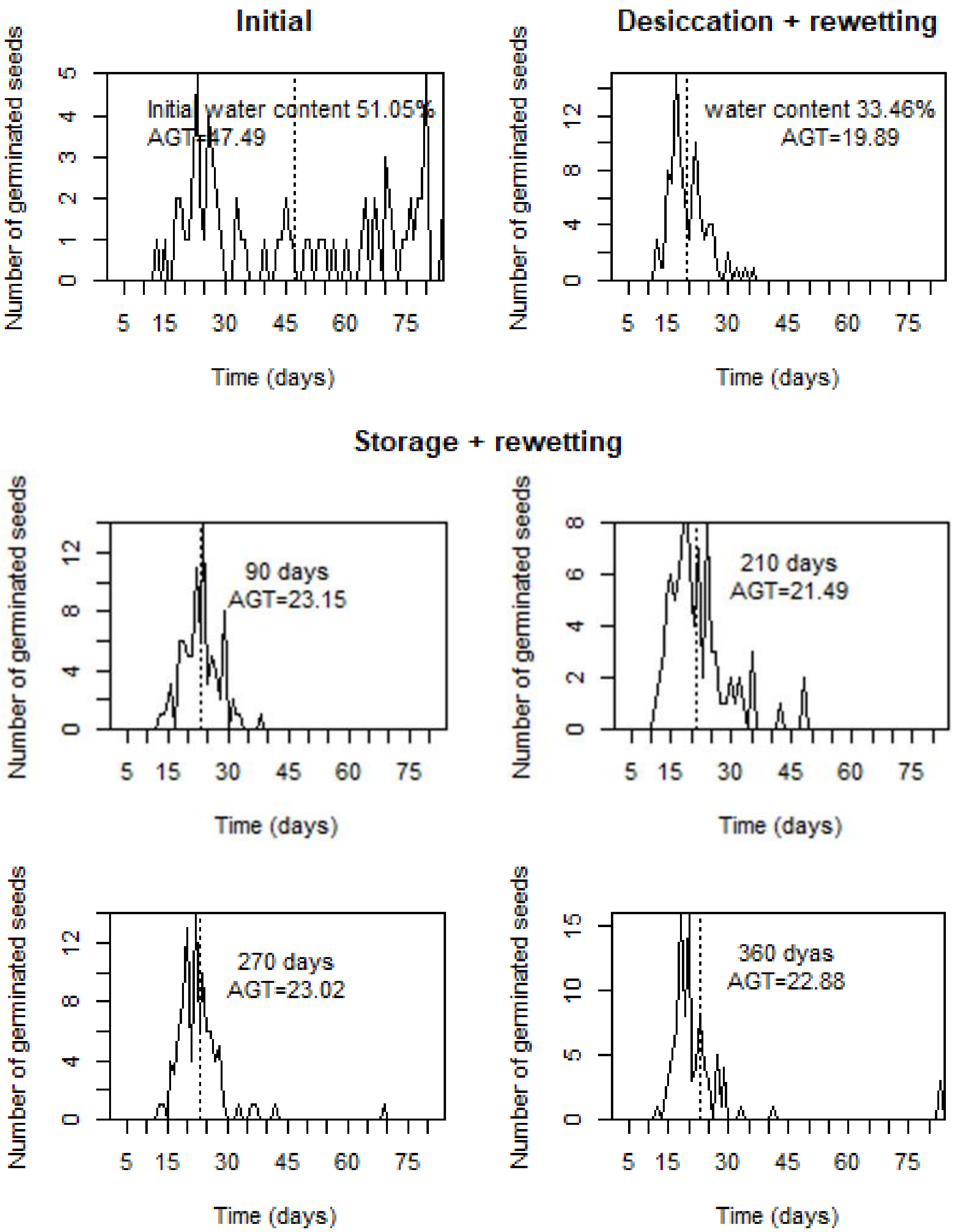

Figure 11. Germination behavior of seeds obtained from fruits with the COLOR3/7 color of *D. inconstans* Jacq. stored in plastic bags for 360 days, in a refrigerator (8 °C), followed by rewetting.

Table 6. Dry mass (g.seedling^{-1}) of seedlings obtained from seeds from fruits with the COLOR3/7 color of *D. inconstans* Jacq. stored at 11% water content in plastic bags for 360 days, in a refrigerator (8 °C).

Storage time (days)	Dry mass (g.seedling^{-1})
0	0.0786 A
90	0.0766 A
210	0.0791 A
270	0.0740 A
360	0.0728 A
Priming	
Non-rewetted	0.0771 A
Rewetted	0.0754 A
CV = 6.76%	

Averages followed by different letters in the columns differ from each other according to the Tukey test ($p<0.05$).

Drying and low temperature in seed storage are beneficial for many species and important to control the proliferation of fungi (Oliveira et al., 2011; Parisi et al., 2013). Seeds of *Caesalpinia echinata* Lam. (Brazilian redwood tree), for example, are considered to be orthodox, but lose their germination capacity within a month when they are stored at room temperature; however, after desiccation and storage at 8 °C, these seeds maintain viability for up to 18 months (Barbedo et al., 2002).

The seeds of the species under study behave like orthodox seeds, because when they were stored in plastic packaging and in a refrigerator environment, they maintained their capacity to germinate and produce seedlings. These data confirm that the change of the epicarp color is an indication of the physiological quality of the seeds, when they are obtained from fruits that have rested after harvest. When studying the germination of *D. inconstans* seeds from a population of the State of Mato Grosso, Cipriani et al. (2017) obtained a low percentage of germination (37%) at the temperatures of 25 and 30 °C. This reinforces the importance of research that evaluates the maturation stage and drying of the seeds at the time they are collected.

CONCLUSIONS

D. inconstans seeds, after fruit rest, germinate, but show differences in their physiological quality according to their color/maturation stage.

The speed and intensity of seedling growth are components affected in seeds obtained from fruits collected when their epicarp is still green, even if they remained in post-harvest rest. However, they are increased when water content is reduced and slow rewetting (seven days) or seed storage is carried out, providing uniformization in germination. This allows the harvest period to be extended and brought forward.

Seeds from fruits with the COLOR3/7 color, with a seven-day rest and dried at 11%, have the capacity to be stored for 360 in a refrigerator (8 °C).

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AUTHORS' CONTRIBUTION

Laura Araujo Sanches contribution with idealization of the work, implementation and methodological development of all stages of the work, data collection, analysis of results and writing of the manuscript; Aline Bueno Ramalho contribution with data collection and analysis of results; Elisangela Clarete Camili contribution with guidance, idealization of the work, analysis of results, guidance on writing the manuscript, review of the manuscript.

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