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Seed dormancy and germination in *Psidium cattleyanum* Sabine (red and yellow araçá)

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Abstract: Araçá has economic potential due to its fruits for consumption *in natura* or as feedstock for the food industry in Brazil. Despite the economic interest, there are few works in the literature and they conflict regarding araçá seed dormancy and procedures to overcome it, which could be a necessary requisite for large-scale production of this species. This work aimed to verify the existence of seed dormancy in fresh-collected red and yellow araçá seeds and, if dormancy exists, determine a possible dormancy release procedure for this species. The applied seed dormancy release treatments were: chemical scarification with concentrated sulfuric acid, thermal shock with hot water, chemically induced germination with gibberellic acid, a combination of sulfuric acid and gibberellic acid treatments, a combination of hot water and gibberellic acid treatments, and a control. The seeds were kept incubated in a BOD incubator for 60 days at 25±2 °C and a photoperiod of 16 h light and 8 h dark. The percentage of germination and the germination speed index (GSI) were evaluated. The data underwent ANOVA, followed by Tukey's multiple range test at 5% probability. After 60 days of incubation, no treatment was statistically different from the controls for red and yellow araçá seeds. indicating that both red and yellow araçá fresh-collected seeds do not have dormancy. Thus, there is no need for dormancy overcoming treatment, saving time and costs in seedling production of this species.

Keywords: Myrtaceae, Native species, Dormancy release.

Resumo: *O araçá apresenta potencial econômico no Brasil devido aos seus frutos, que podem ser consumidos in natura ou empregados como matéria-prima para a indústria alimentícia. Apesar do interesse econômico, existem poucos estudos na literatura e que são conflitantes entre si em relação à presença de dormência em sementes de araçazeiro e os procedimentos para superá-la, um requisito necessário para produção desta espécie em larga escala. O objetivo deste trabalho foi verificar a existência de dormência em sementes de araçazeiro e, caso esta exista, determinar possíveis métodos de superação de dormência para as sementes desta espécie. Os tratamentos de superação de dormência empregados foram: escarificação química com ácido sulfúrico concentrado, choque térmico com água quente, indução química da germinação com ácido giberélico, uma combinação dos tratamentos com os ácidos sulfúrico e giberélico, uma combinação dos tratamentos com água quente e ácido giberélico e um controle. As sementes foram incubadas em uma estufa BOD por 60 dias a 25±2 °C e fotoperíodo de 16 h de luz e 8 h de escuro. Avaliou-se a porcentagem de germinação e o índice de velocidade de germinação (IVG). Os dados foram submetidos a ANOVA, seguido do teste de Tukey a 5% de probabilidade. Após 60 dias de incubação, nenhum tratamento que apresentou germinação diferiu estatisticamente dos controles para as sementes de araçazeiro vermelho e amarelo, indicando que as sementes recém-coletadas de araçazeiro vermelho e amarelo não apresentam dormência. Assim, não há a necessidade do uso de tratamentos para superação de dormência, economizando tempo e reduzindo custos na produção de mudas desta espécie.*

Palavras-Chaves: *Mirtáceas, Espécies nativas, Superação de dormência.*

1. INTRODUCTION

South Brazil has a great diversity of fruit species that can be used as food sources, both for wildlife and for human consumption. Many of these species belong to the Myrtaceae family [1]. The Myrtaceae family constitutes the eighth largest taxonomic family in the angiosperms, with 123 genera and approximately 5,500 species, whose climatic distribution in the planet is situated in tropical and subtropical zones [2].

Several native plant species of South Brazil and more specifically, the region of Rio Grande do Sul, belong to the Myrtaceae family. About 1,000 species, distributed in 23 genera, occur in the Brazilian territory [3-4], where approximately 100 species are native to the Rio Grande do Sul state [5].

Among the native fruit trees found in the Rio Grande do Sul state are the red and yellow araçás (*Psidium cattleyanum* Sabine), uvaia (*Eugenia pyriformis* Cambess), guamirim (*Calyptranthes concinna* DC), and pitanga (*Eugenia uniflora* L.), among others. Their use by local populations as a food source *in natura* and as an ingredient for candies and jams is part of the cultural and gastronomic richness of the region [6-7].

The araçá (*Psidium cattleyanum* Sabine) occurs from Bahia state to Northern Uruguay. In general, it is found in the Atlantic forest, mainly in coastlands, and has great ecological importance to local fauna due to its fruits, which serve as food for animals [8-9].

The araçá plant has a medium size (shrub or small tree), generally reaching heights greater than 1.5 m. The white flowers develop in branches from October to November when the plant is in its natural habitat in South Brazil. When in cultivation, it has two main flowering periods; the first occurs between the end of September and October, and the second occurs in December [10]. The propagation of this plant is by seed dispersal; however, the literature has little information about procedures to promote germination, or even about seed dormancy or dormancy release procedures [8,11].

The araçá fruits correspond to berries and are somewhat globulous, with red or yellow epicarp (peel) and endocarp (pulp) with soft and juicy consistency, whose color can range between light yellow to white or even red, with numerous small seeds dispersed in the endocarp. The araçá seeds are of the orthodox kind, that is, the seed can be desiccated (dried) and posteriorly

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rehydrated without losing viability. The pulp has a sweet and acid taste and high ascorbic acid content (about three to four times the ascorbic acid content in citrus fruits), and phenolic compounds, whose economic potential for the food industry has already been acknowledged. The mature araçá fruit can be eaten *in natura* or as juice, jam, ice cream, and as liquor. The trunk bark has tannins and the root has antidiuretic properties [8-9,11-13].

For proper economic exploitation of araçá, the production of high-quality seedlings is necessary for planting by the farmers. The propagation attempts of this species have been unsuccessful due to their low rooting percentage. The araçá seed, though it has resistance to freezing and to dehydration (that is, the seed can be dried without the occurrence of embryo death), it also shows physiological dormancy; this hinders seed germination and seedling production [9,11].

The broad definition of seed dormancy corresponds to the hindering/blocking of the germination of a seed that is intact and viable, in conditions that are favorable for the seed to germinate. Therefore, the seed needs a post-maturation treatment (a dormancy release) for its development and germination to start. Despite the dormant (inactive) state, the seed has metabolic activity, even if it is reduced [14-16].

The dormancy mechanism generally varies among species and habitat and the dormancy phenomenon may be a set of two or more dormancy mechanisms that act together. It is necessary to know and understand the several dormancy mechanisms to determine the more adequate method to overcome it [14].

Seed dormancy can be divided into two groups: endogenous dormancy and exogenous dormancy. The dormancy from an endogenous origin is associated with the embryo, while in exogenous dormancy the phenomenon is associated with the external structures (tegument, endosperm), or barriers imposed by the fruit [15,17].

The seed dormancy can be also classified as primary (or natural) and secondary (or induced). Primary dormancy is a seed characteristic, developed when still on the mother plant, and remaining after dispersal. On the other hand, secondary dormancy is an induced dormancy mainly due to conditions unfavorable to germination in non-dormant seeds or in seeds whose primary dormancy has already been overcome [15-16].

Trevisan et al. [10], Hossel et al. [9,18], and Santos et al. [3] cited that araçá seeds present dormancy; the specific mechanism of this possible dormancy was not determined. Silva [19] cited that intertegumentary dormancy is the main dormancy mechanism for araçá. Santos et al. [3] commented that exposition of the dormant seeds to light might be enough to overcome the dormancy because the araçá seed is photoblastic positive.

However, Hossel et al. [9] cited that seed dormancy in araçá seeds may result from exposure to low temperatures; the authors also recommended against the use of stratification as a dormancy overcoming method for the seeds of this species. In other work [18], the same authors recommended the use of seed stratification at 5±1 °C, followed by soaking in indole-3-butyric acid (IBA) to increase the germination rate and reduce the germination time of the seedlings.

On the other hand, Henz et al. [20], Porto et al. [13], and Lima et al. [21] suggested that araçá seeds may not have dormancy, and other factors relative to seed storage (storage temperature and humidity, time of storage) may act in the reduction of overall seed vigor other than dormancy mechanisms.

Tomaz et al. [11] and Barbiero et al. [8] cited the hard and impermeable tegument of araçá seed (more specifically the yellow araçá) as the main cause for seed dormancy and the difficulty for it to germinate, which makes araçá seed germination slow and erratic. However, the literature does not present concrete data about seed dormancy in red araçá [9]. Trevisan et al. [10] cited as procedures for overcoming seed dormancy in araçá the cold stratification technique or by using the phytoregulator IBA in the concentration of 2000 ppm to accelerate the germination process.

Gibberellic acid (GA), a member of the gibberellins, is widely used to induce seed germination. In general, the seeds are soaked in a GA solution for periods ranging from 24-72 h before sowing. Several works already reported the use of this phytohormone to induce/increase the germination of araçá seeds. Tomaz et al. [11] treated araçá seeds with a solution of 500 $mg \cdot L^{-1}$ of GA; the seeds were kept for 24 h in the solution. The GA-treated seeds presented a germination percentage of 80%, whereas the control (untreated seed) presented an average germination percentage of 90%. Porto et al. [22] reported the use of GA solution 300 $mg \cdot L^{-1}$ and cold stratification in the dormancy overcoming of yellow araçá seeds; the authors observed that the joint use of GA and stratification reduced the overall seed vigor. Nobrega et al. [23] used GA in the concentrations of 250 and 1,000 $mg \cdot L^{-1}$ as a seed treatment to overcome the dormancy of *Psidium guineense* Swartz; the authors reported no difference among the treatments and the control group.

Due to conflicting results reported in the literature regarding araçá seed dormancy and the dormancy release methods employed, this work aimed to verify the existence of seed dormancy in freshly collected red and yellow araçá seeds and, if dormancy exists, determine a possible efficient dormancy release procedure for this species.

2. MATERIALS AND METHODS

2.1. Obtainment of plant material

Mature red and yellow araçá fruits were collected in February 2019, in the Northeast Mountain Range of Rio Grande do Sul, in the municipality of Caxias do Sul, RS, at the geographical coordinates 29°10'48" S, 51°01'17" W, and an altitude of 748 m. The fruits were collected from a naturally grown local plant

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population composed of twelve red araçá plants and nine yellow araçá plants, in an approximate area of 2,000 m^2 (40x50 m); the fruits were collected from the plants only (not from the ground). The fruits were considered to be mature when presenting a uniform color (both yellow and red), being pulped immediately after collection.

2.2. Material cleanup and dormancy overcoming treatments

After fruit pulping, the obtained seeds were washed with tap water. Posteriorly, the seeds were disinfected by bathing in a sodium hypochlorite solution at 1% v/v for 5 min, according to the procedures described in the Instructions for the Analysis of Forest Species [24] and the Rules for Seed Analysis – RAS [25]. The seeds were washed with distilled water and dried away from sunlight at room temperature (20±3 °C) for 24 h, following the procedure described by Barbiero et al. [8]. The dormancy overcoming tests were carried out immediately after seed drying.

The following dormancy overcoming methods were used: T1 - chemical scarification by immersion in concentrated (98%) sulfuric acid (Labsynth, Brazil) for 15 s; T2 - thermal shock by immersion in hot water at 80 °C for 1 min; T3 - chemical germination induction by immersion in a 500 mg·L^{-1} aqueous solution of gibberellic acid (ProGibb®,10 wt.% of active ingredient, Sumitomo, Brazil) for 24 h; T4 - a combination of the sulfuric acid (T1) and gibberellic acid (T3) treatments; T5 - a combination of the hot water (T2) and gibberellic acid (T3) treatments; and T6 - control (seed without treatment). These treatments were based on the work of Barbiero et al. [8].

2.3. Germination tests

The treatments were divided into four replicates of 50 seeds per replicate, totaling 200 seeds for each treatment. The replicates were put in a transparent plastic gerbox with three sheets of blotting paper moistened with distilled water. All materials were sterilized before the tests. The seeds were incubated in a CT-705.330 BOD incubator (Cientec, Brazil) for 60 days at 25±2 °C and a photoperiod of 8 h of light and 16 h of dark[8 [14]. The evaluations were carried out every 15 days up to 60 days (four evaluations). The germination percentage was calculated using Equation 1.

$$Germination\ (\%) = 100x\ \frac{G_n}{T} \qquad (1)$$

Being 'Gn' the number of seeds that germinated in the 'n'-th evaluation, and 'T' the total number of seeds in the replicate (50 seeds). The germination speed index (GSI) was calculated according to the formula proposed by Maguire [26], presented in Equation 2.

$$IVG = \frac{G_1}{N_1} + \frac{G_2}{N_2} + \frac{G_3}{N_3} + \ldots + \frac{G_n}{N_n} \qquad (2)$$

Being 'Gx' the number of normal seedlings counted in the 'x'-th evaluation and 'Nx' the number of days since the seeds were sowed relative to the 'x'-th evaluation. The seeds were considered as germinated when the radicle presented a length greater than 2 mm. A visual evaluation for the presence of growing fungi and/or bacteria was carried out along with the germination evaluations.

The germination and GSI data underwent Levene's test to evaluate the homogeneity of variances, followed by analysis of variance (ANOVA); the means were compared by Tukey's range test at 5% probability. The statistical analysis was carried out using the Agrostat® software. The seed samples were registered in SISGEN (Sistema Nacional de Gestão do Patrimônio Genético e do Conhecimento Tradicional Associado) system under the protocol AFA0168.

3. RESULTS AND DISCUSSION

The treatments of thermal shock (T2) and thermal shock plus chemical germination induction (T5) have not presented any seed that germinated, in either red or yellow araçá. Table 1 compiles the germination percentages for red and yellow araçá as function of incubation time.

Table 1 - Germination percentage for red and yellow araçá seeds in each evaluation during 60 days of incubation.

Treatment	Germination (%) – red araçá			
	15	30	45	60
T1	21.33 ab	65.33 a	66.67 a	66.67 a
T2	0.00 b	0.00 b	0.00 b	0.00 b
T3	46.67 a	68.00 a	69.33 a	69.33 a
T4	34.67 a	64.00 a	66.67 a	66.67 a
T5	0.00 b	0.00 b	0.00 b	0.00 b
T6	0.00 b	72.00 a	78.67 a	80.00 a
CV (%)	58.05	13.29	14.07	13.51
F-value	12.64*	102.64*	92.20*	97.66*
p-value	0.0002	<0.0001	<0.0001	<0.0001
Treatment	Germination (%) – yellow araçá			
	15	30	45	60
T1	25.33 a	73.33 a	82.67 a	84.00 a
T2	0.00 b	0.00 b	0.00 b	0.00 b
T3	17.33 a	81.33 a	84.00 a	85.33 a
T4	17.33 a	69.33 a	82.67 a	84.00 a
T5	0.00 b	0.00 b	0.00 b	0.00 b
T6	2.67 b	64.00 a	84.00 a	84.00 a
CV (%)	39.35	16.67	8.87	7.03
F-value	21.15*	61.06*	212.69*	339.02*
p-value	<0.0001	<0.0001	<0.0001	<0.0001

Means followed by the same letter in column do not present statistical difference by Tukey's range test at 5% probability (α = 0.05). T1 - chemical scarification by immersion in concentrated (98%) sulfuric acid for 15 s; T2 - thermal shock by immersion in hot water at 80 °C for 1 min; T3 - chemical germination induction by immersion in a 500 mg·L^{-1} aqueous solution of gibberellic acid for 24 h; T4 - a combination of the sulfuric acid (T1) and gibberellic acid (T3) treatments; T5 - a combination of the hot water (T2) and gibberellic acid (T3) treatments; and T6 - control; CV – coefficient of variation. * - Significant at the probability level.

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chemical scarification (T1), gibberellic acid (T3), and the joint treatment (T4) induced a higher germination percentage (17.33-25.33% for yellow araçá and 21.33-46.67% for red araçá) in the early days of the experiment (first evaluation, 15 days after incubation) (Table 1). After the second evaluation onwards, these treatments have not differed from the control (T6). This could have occurred due to the stimulant effect of gibberellic acid (T3 and T4) on the seed embryo, which caused it to germinate earlier relative to the control (T6). The effect of acid on tegument (T1 and T4) also may have played a role in facilitating the water absorption by the seed tissues, fostering the germination. However, by verifying the behavior of the control treatment, which germinated later but have not differed from the other treatments after 30 days, despite the later germination, no impact on the overall seed vigor was observed.

It is noteworthy the complete absence of germination of the treatments that used thermal shock (T2 and T5), for both seeds. The use of hot water, which was the common procedure in both treatments T2 and T5, may have rendered the seeds non-viable due to excessive heating (80 °C for 1 min). Since the araçá seed is small, in a small amount of time its inside temperature might have reached values above the threshold of protein denaturation (45-50 °C), killing the embryo, as observed by Barbiero et al. [8] applying a similar treatment on araçá seeds.

According to Table 1, in the present work, the germination percentage of red araçá was smaller than for yellow araçá. The yellow araçá seeds tended to have higher germination percentages relative to the red araçá seeds, except for the control treatments (non-treated seeds). According to Tomaz et al. [11], yellow araçá seeds tend to have higher germination percentages and vigor than the red araçá seeds.

No treatment differed statistically from the control after 60 days of incubation, considering both red and yellow araçá. These results indicated that fresh-collected red and yellow araçá seeds very probably do not have primary dormancy. These results diverged from Trevisan et al. [10], who suggested that araçá seeds have primary dormancy. However, Floriano [27], Barbiero et al. [8], and Hossel et al. [9] also suggested that araçá seeds do not have primary dormancy. Tomaz et al. [11], who studied storage conditions of araçá seeds, suggested that a secondary dormancy might arise, especially if the seed is dried when in a refrigerated or dry chamber; the loss of water probably may trigger a secondary dormancy of the seeds until better conditions arise for the seed to germinate.

Barbiero et al. [8], who also worked with araçá *(P. cattleyanum*) seed germination, reported that the thermal shock treatment using hot water also resulted in zero germination; however, the joint treatment of hot water and gibberellic acid presented a germination percentage ranging from 62 to 70%. On the other hand, Tomaz et al. [11] reported a germination percentage of 90% for araçá seeds stored in a cold chamber and later treated with hot water at 80 °C for 25 s. The high temperature of the water (80 °C), or the excessive immersion time (60 s) probably led to the death of the embryo by protein denaturation. It is also important to highlight that both Barbiero et al. [8] and Tomaz et al. [11] stored the seeds in low temperatures before the germination tests, unlike the present work, in which the seeds were collected and underwent the dormancy overcoming and germination test; the differences in the storage condition may influence greatly both seed vigor and physiology [10].

Considering the treatments used, all of them had a similar performance relative to the control (T6) in both red and yellow araçá; this indicates that the treatments were ineffective in overcoming seed dormancy or this was a result of the seeds not presenting dormancy, at least not when fresh-collected from the mother plant, a question previously arisen by other studies.

Hossel et al. [9] reported, for red araçá, a germination percentage range of 3.52 to 59.60%; the higher germination percentage occurred at 25 °C. Tomaz et al. [11] reported a germination percentage of 67% for fresh-collected, untreated red araçá seeds; the same authors also reported a germination percentage of 77% for fresh-collected, untreated yellow araçá seeds. Lima et al. [28] reported a germination percentage range between 72.8 and 90.4%; the average emergence time of the seedlings ranged from 25.3 to 31.8 days. Porto et al. [13] reported a germination percentage of 51.34% and an average emergence time of 31.0 days for fresh-collected and untreated yellow araçá seeds.

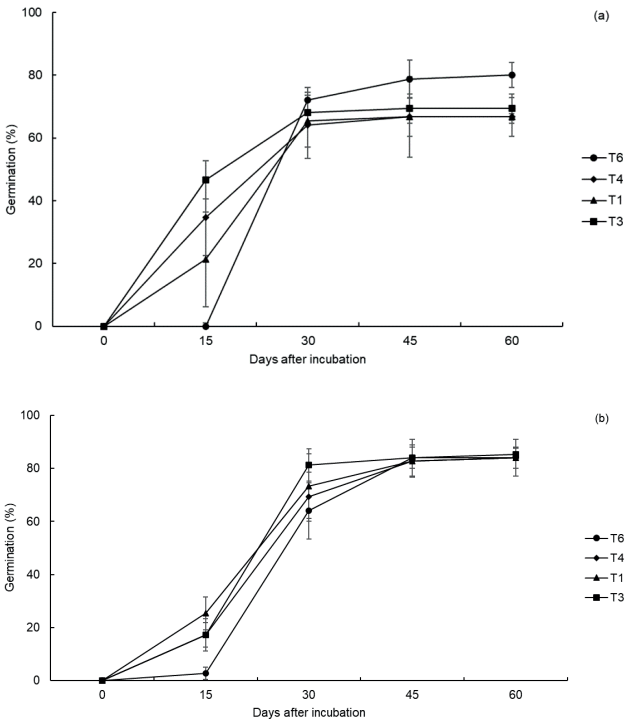

Figure 1 - Germination percentage of red (a) and yellow (b) araçá seeds for the dormancy release tests on each measurement. T1 – chemical scarification by immersion in concentrated sulfuric acid; T3 – immersion in gibberellic acid 500 mg·L^{-1} for 24 h; T4 – sulfuric acid and gibberellic acid treatments combined; T6 – control.

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By analyzing Figure 1, it is possible to observe that red araçá seeds germinated earlier, especially the seeds treated with gibberellic acid (T3 – 46.67%; and T4 – 34.67%), whereas the control (T6) seeds have not germinated until 15-30 days. Between 15 and 30 days, 65.33% of the seeds of control treatment germinated. This phenomenon was less pronounced in yellow araçá seeds, with similar germination percentages for both chemical scarification (T1 – 25.33%), gibberellic acid (T3 – 17.33%), and the joint treatment (T4 – 17.33%). An expressive portion (73.33%) of the control seeds for the yellow araçá also germinated in the range of 15-30 days after incubation, a higher germination percentage than red araçá seeds.

For red araçá, the control presented the highest germination percentage (80.00%), whereas the dormancy release methods had lower germination percentages (from 66.66 to 69.33%). It is unclear if the dormancy release methods reduced the vigor of the seeds or if it induced some degree of secondary dormancy. Another possibility is that the dormancy releasing treatments may have damaged the seeds, reducing their vigor, hindering their germination, or even rendering the seeds non-viable. However, there was no statistical difference between the germination percentage of the dormancy release methods and the control.

On the other hand, for yellow araçá after 60 days after incubation, the germination percentages for the control and the dormancy release methods were practically equal (a difference of only 1.33%), indicating that the methods used may have not had any effect, neither positive nor negative, on the seeds.

The fact that yellow araçá seeds have higher vigor than the red araçá [11] may explain the lower germination percentages in red araçá for the treated seeds. Floriano [27] and Trevisan et al. [10] stated that araçá seeds are mainly produced by apomixis, generating seeds with low genetic variability; the small population that originated the seeds may also explain the small differences in germination percentages, especially regarding yellow araçá.

Table 2 - Germination Speed Index (GSI) results for red and yellow araçá seeds in each evaluation during 60 days of incubation.

Treatment	GSI – red araçá			
	15	30	45	60
T1	0.356 ab	0.722 a	0.730 a	0.730 a
T2	0.000 b	0.000 b	0.000 b	0.000 b
T3	0.778 a	0.844 a	0.852 a	0.852 a
T4	0.578 a	0.755 a	0.770 a	0.770 a
T5	0.000 b	0.000 b	0.000 b	0.000 b
T6	0.000 b	0.600 a	0.637 a	0.643 a
CV (%)	58.02	36.32	35.81	35.62
F-value	12.63*	14.24*	14.49*	14.46*
p-value	0.0002	<0.0001	<0.0001	<0.0001
Treatment	GSI – yellow araçá			
	15	30	45	60
T1	0.422 a	0.767 a	0.819 a	0.826 a
T2	0.000 b	0.000 c	0.000 b	0.000 b
T3	0.289 a	0.778 a	0.793 a	0.794 a
T4	0.289 a	0.722 ab	0.885 a	0.865 a
T5	0.000 b	0.000 c	0.000 b	0.000 b
T6	0.000 b	0.567 b	0.715 a	0.715 a
CV (%)	39.33	14.32	15.47	16.44
F-value	21.14*	85.46*	71.94*	63.48*
p-value	<0.0001	<0.0001	<0.0001	<0.0001

Means followed by the same letter in column do not present statistical difference by Tukey's range test at 5% probability ($\alpha = 0.05$). T1 - chemical scarification by immersion in concentrated (98%) sulfuric acid for 15 s; T2 - thermal shock by immersion in hot water at 80 °C for 1 min; T3 - chemical germination induction by immersion in a 500 $mg \cdot L^{-1}$ aqueous solution of gibberellic acid for 24 h; T4 - a combination of the sulfuric acid (T1) and gibberellic acid (T3) treatments; T5 - a combination of the hot water (T2) and gibberellic acid (T3) treatments; and T6 - control; CV – coefficient of variation. * - Significant at the probability level.

Following a similar trend of the germination results, the GSI values for red araçá seeds were higher for the treatments that employed gibberellic acid (T3, and T4); the chemical scarification (T1) has not differed from the other treatments and the control (T6). From 30 days on, all treatments (with exception of the ones that employed thermal shock (T2 and T5) were statistically equal to the control.

For the yellow araçá, the treatments T1, T3, and T4 differed from the control (T6) in the first evaluation (15 days). In the second evaluation, the joint treatment (T4) performed similarly to the control, also not differing from the chemical scarification (T1) and gibberellic acid (T3). These two treatments differed from the control. From the third evaluation, all treatments were similar, not presenting statistical differences among themselves.

The GSI values for the yellow araçá seeds were lower than the ones for the red araçá in the first evaluation; the trend reversed from the second evaluation onwards. However, not all treatments followed this pattern. The GSI values varied from 0.643 to 0.852 for red araçá and from 0.715 to 0.865 for yellow araçá after 60 days of incubation.

Although following a similar pattern of the germination tests, the GSI results had distinct behaviors relative to the days after sowing. Despite the greater GSI values after 30 days for T1 and T3 in yellow araçá, it eventually had the same performance as the other treatments, including the control (T6) after 60 days, indicating that, in the long run, the treatments were ineffective in hastening seed germination, at least in greater periods of time than 30 days.

Hossel et al. [9] reported GSI values ranging between 0.07 and 1.31 for red araçá seeds. Barbiero et al. [8] reported GSI values for araçá seeds ranging from 0.09 to 1.10. For yellow araçá seeds, Lima et al. [28] reported GSI values ranging between 0.587 and 0.906, and Porto et al. [13] reported a GSI of 1.83, both for fresh-collected and untreated seeds. The differences among the

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values may be the result of genetic variability, especially if the mother plants compose different populations [10].

Figure 2 presents the GSI values for each dormancy release treatment at each measurement.

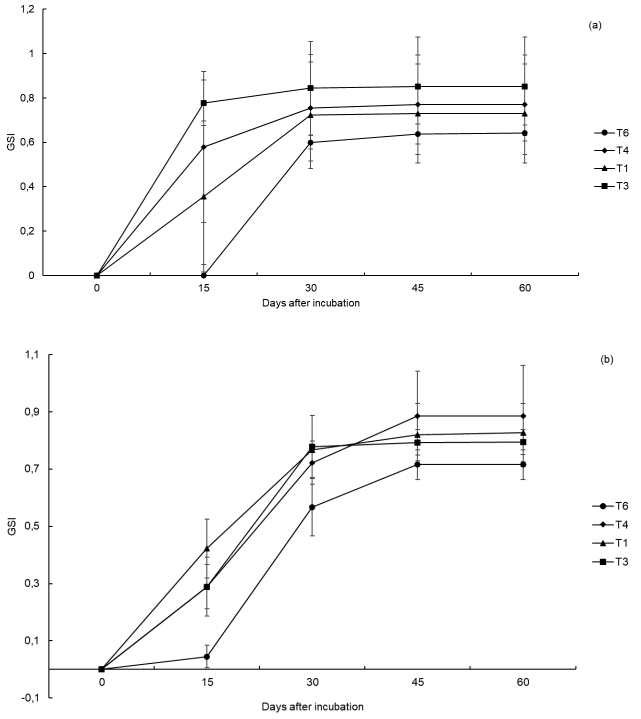

Figure 2 - Germination speed index (GSI) values of red (a) and yellow (b) araçá treated seeds in each evaluation. T1 – chemical scarification by immersion in concentrated sulfuric acid; T3 – immersion in gibberellic acid 500 mg·L^{-1} for 24 h; T4 – sulfuric acid and gibberellic acid treatments combined; T6 – control.

The GSI is an important parameter to verify the emergence speed of the seedling; higher GSI values indicate an earlier emergence, which may be interesting in seedling production [10]. The GSI value for gibberellic acid treatment (T3) was higher (0.778-0.852) in all measurements for red araçá; in yellow araçá, there was not a clear trend, as in the first 30 days, the chemical scarification (T1) presented a higher GSI (0.422 and 0.767) and, after the joint treatment of chemical scarification and gibberellic acid (T4) presented a higher GSI (0.793 and 0.794).

From figures 1 and 2, despite not increasing significantly the GSI and germination percentage, the dormancy release methods that employed gibberellic acid (T3 and T4) induced earlier germination when compared to the control (T6). This earlier germination is very probably the effect of gibberellic acid, which is a germination stimulant. Likely, these treatments (T3 and T4) accelerated seed germination, especially for red araçá. Compared to the controls, the red araçá germinated 15 days earlier, and yellow araçá germinated between 7 and 15 days earlier. Since it is reported that the average germination time for araçá is about 30 days [13,28], there was a reduction by about 25 to 50% in the germination time of the araçá seeds.

Although gibberellic acid treatment induced a higher GSI value in red araçá, and the chemical scarification and chemical scarification and gibberellic acid treatments induced a higher GSI value in yellow araçá, it is clear the increases were small. This indicates that the applied dormancy release methods were ineffective in increasing the germination percentage (indeed, the treatments reduced red araçá germination), but they may be used to accelerate the germination process of fresh-collected seeds.

It was observed the presence of infection in the non-germinated seeds (both red and yellow) by fungi, probably *Aspergillus* sp.. This was due to a saprophytic effect since the presence of fungi only occurred in the seeds whose dormancy release procedures had zero germination (hot water – T2 – and hot water plus gibberellic acid – T5), despite the prior disinfection treatment. This means that the presence of fungi has not caused the death of the seeds, on the contrary, the infection only occurred because the seeds were already non-viable (dead). Andrade and Ferreira [29], who worked with uvaia (*Eugenia pyriformis*) seed, cited a similar phenomenon, and stated that the fungi infection may be associated with, or is indicative of non-viability of the seed (dead seed).

4. CONCLUSIONS

For the conditions of the experiment, there was no statistical difference among the treatments regarding the germination percentage or the germination speed index (GSI) values, indicating that both red and yellow araçá fresh-collected seeds do not have dormancy. Excessive water temperature or immersion time in the hot water treatment rendered the seeds non-viable. According to the observed results, fresh-collected red and yellow araçá seeds do not have dormancy; therefore, there is no need for seed treatment to overcome it, saving time and reducing costs in seedling production.

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