



CHEMICAL AND MECHANICAL SCARIFICATION AS TECHNIQUES FOR OVERCOMING DORMANCE IN RED TENT SEEDS (*Adenanthera pavonina* L.)

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ABSTRACT

Purpose: Evaluate chemical and mechanical scarification techniques, as methods for overcoming dormancy in red vine seeds.

Theoretical Framework: Based on scientific articles found on search engines and books in the field of seeds, types of forest seeds, types of dormancy in forest seeds and techniques for overcoming dormancy. In order to support the explanation of how techniques for overcoming dormancy are related to the rate and time of germination of red seed seeds, and how germination time can subsequently affect the quantity of seedlings produced, as well as their initial growth.

Method: The experiment was installed to test the following treatments: T0 – without scarification; T1 – mechanical scarification; T2 chemical scarification with 80% H₂SO₄ for half an hour; T3 – chemical scarification with 80% H₂SO₄ for one hour; T4 – chemical scarification with 0.4% KNO₃ for half an hour; T5 – chemical scarification with 0.4% KNO₃ for one hour. The design used was completely randomized, with six treatments, five replications and 20 seeds in each replication. At the end of 30 days, counting from the beginning of germination, the following variables were evaluated: germination speed index (IVG), average germination time (TMG), germination percentage (G) and germination speed index (IVG).

Results and Conclusion: The most efficient methods for germinating the red tent seeds were mechanical scarification with sandpaper and immersion in 0.4% KNO₃ for half an hour. However, mechanical scarification would be the most easily used and least expensive method for producing seedlings in nurseries.

Research Implications: These results indicate that the mechanical scarification technique is an efficient method for overcoming the dormancy of the red tent, which is integumentary. Understanding the most efficient and effective techniques for overcoming dormancy in seeds of species that present this characteristic is important to allow, within the nursery, germination to occur quickly and uniformly. Consequently, making it possible to obtain seedlings with more uniform sizes, even though these are produced from seeds.

Originality/Value: A high germination rate and uniform initial growth are important factors within the nursery, especially if it is of a commercial nature, but also for the restoration of areas, because it allows seedlings to be obtained in less time.

Keywords: Carolina Tent, Seedling Production, Acid Scarification, Saline Scarification.

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ESCARIFICAÇÃO QUÍMICA E MECÂNICA COMO TÉCNICAS PARA SUPERAÇÃO DE DORMÊNCIA EM SEMENTES DE TENTO VERMELHO (*Adenanthera pavonina* L.)

RESUMO

Objetivo: Avaliar técnicas de escarificações, química ou mecânica, como métodos para a superação da dormência de sementes de tento vermelho.

Referencial Teórico: Baseado em artigos científicos encontrados em sites de buscas e em livros da área de sementes, tipos de sementes florestais, tipos de dormências em sementes florestais e, técnicas em superação de dormência. A fim de embasar a explicação de como as técnicas de superação de dormência estão relacionadas com a taxa e tempo de germinação das sementes de tento vermelho, e como o tempo de germinação pode afetar, posteriormente, na quantidade de plântulas produzidas, bem como no seu crescimento inicial.

Método: O experimento foi instalado para testar os seguintes tratamentos: T0 – sem escarificação; T1 – escarificação mecânica; T2 escarificação química com H_2SO_4 80% por meia hora; T3 – escarificação química com H_2SO_4 80% por uma hora; T4 – escarificação química com KNO_3 0,4% por meia hora; T5 – escarificação química com KNO_3 0,4% por uma hora. O delineamento utilizado foi o inteiramente casualizado, com seis tratamentos, cinco repetições e 20 sementes em cada repetição. Ao final de 30 dias, a contar do começo das germinações, foram avaliadas as seguintes variáveis: índice de velocidade de germinação (IVG), o tempo médio de germinação (TMG), porcentagem de germinação (G) e o índice de velocidade de germinação (IVG).

Resultados e Conclusão: Os métodos mais eficientes para a germinação das sementes de tento vermelho foram a escarificação mecânica com lixa e a imersão em KNO_3 0,4% por meia hora. No entanto, a escarificação mecânica seria o método mais facilmente empregado e menos oneroso, para a produção de mudas em viveiros.

Implicações da Pesquisa: Esses resultados indicam que a técnica da escarificação mecânica é um método eficiente para a superação da dormência do tento vermelho, que é tegumentar. Entender sobre as técnicas mais eficientes e eficazes para a superação de dormência em sementes de espécies que apresentam essa característica é importante para permitir, dentro do viveiro, que a germinação seja de maneira rápida e uniforme. Consequentemente, possibilitando a obtenção de mudas com portes mais uniformes, mesmo essas sendo produzidas a partir de sementes.

Originalidade/Valor: A alta taxa de germinação e o crescimento inicial uniforme são fatores importantes dentro do viveiro, principalmente, se esse é de cunho comercial, mas também, para a recomposição de áreas, porque permite obter mudas em menos tempo.

Palavras-chave: Tento Carolina, Produção de Mudas, Escarificação Ácida, Escarificação Salina.

ESCARIFICACIÓN QUÍMICA Y MECÁNICA COMO TÉCNICAS PARA SUPERAR LA DORMICIÓN EN SEMILLAS DE CARPA ROJAS (*Adenanthera pavonina* L.)

RESUMEN

Propósito: Evaluar técnicas de escarificación química y mecánica, como métodos para superar la latencia en semillas de vid roja.

Marco Teórico: Basado en artículos científicos encontrados en motores de búsqueda y libros en el campo de semillas, tipos de semillas forestales, tipos de latencia en semillas forestales y técnicas para superar la latencia. Para apoyar la explicación de cómo las técnicas para superar la latencia están relacionadas con la tasa y el tiempo de germinación de las semillas rojas, y cómo el tiempo de germinación puede afectar posteriormente la cantidad de plántulas producidas, así como su crecimiento inicial.

Método: El experimento se instaló para probar los siguientes tratamientos: T0 – sin escarificación; T1 – escarificación mecánica; T2 escarificación química con 80% de H_2SO_4 durante media hora; T3 – escarificación química con 80% de H_2SO_4 durante una hora; T4 – escarificación química con 0,4% de KNO_3 durante media hora; T5 – escarificación química con 0,4% de KNO_3 durante una hora. El diseño utilizado fue completamente al azar, con seis tratamientos, cinco repeticiones y 20 semillas en cada replicación. Al final de 30 días, contando



desde el inicio de la germinación, se evaluaron las siguientes variables: índice de velocidad de germinación (IVG), tiempo medio de germinación (TMG), porcentaje de germinación (G) e índice de velocidad de germinación (IVG).

Resultados y Conclusión: Los métodos más eficientes para germinar las semillas de carpa roja fueron la escarificación mecánica con papel de lija y la inmersión en KNO₃ al 0,4% durante media hora. Sin embargo, la escarificación mecánica sería el método más fácil y menos costoso para producir plántulas en viveros.

Implicaciones de la Investigación: Estos resultados indican que la técnica de escarificación mecánica es un método eficiente para superar la latencia de la carpa roja, que es integumentaria. Es importante comprender las técnicas más eficientes y efectivas para superar la latencia en semillas de especies que presentan esta característica para permitir que, dentro del vivero, la germinación ocurra de manera rápida y uniforme. En consecuencia, lo que hace posible obtener plántulas con tamaños más uniformes, a pesar de que se producen a partir de semillas.

Originalidad/Valor: Una alta tasa de germinación y un crecimiento inicial uniforme son factores importantes dentro del vivero, especialmente si es de naturaleza comercial, pero también para la restauración de áreas, porque permite que las plántulas se obtengan en menos tiempo.

Palabras clave: Carpa Carolina, Producción de Plántulas, Escarificación Ácida, Escarificación Salina.

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1 INTRODUCTION

Adenanthera pavonina L. (red tento) is a tree species native to Africa and Asia, belonging to the Fabaceae family, subfamily Mimosoideae and which, currently, can be found in Brazil, in the States of Mato Grosso, Mato Grosso do Sul, cities in the interior of São Paulo, Minas Gerais and Northeast Region (Rodrigues et al., 2009). This species has ornamental purposes, in the afforestation of streets and squares, in the shading of areas, in crafts and in the production of medicines, since its seeds and wood can be used as phytotherapies (Kissmann et al., 2008).

According to Dutra et al. (2017) many forest species belonging to the Fabaceae family have seeds with waterproof integument. One of these species is the red try. In this type of numbness, the tegument barrier prevents the entry of water and oxygen, thus limiting the growth of the embryo (Abreu et al., 2017; Castro et al., 2017). In natural environments this can be considered an advantage for the species, but when it comes to propagation for the production of seedlings, this becomes a problem.

Accordingly, it is necessary to study and to establish ways of treating the seeds of this species to speed up their germination and to assist in the process of the production of seedlings. For this reason, pregerminative treatments have been employed with the purpose of speeding up and standardizing this germinative process (Lopes et al., 2011). Methods to overcome



tegumentary numbness include mechanical scarification and chemistry (Dutra et al., 2012). For this purpose, sandpaper and sulfuric acid (H_2SO_4) can be used, respectively, as they are the techniques that often present the best results regarding germination rate in forest species (Araújo et al., 2017a). However, saline substances can also be used, as is the case with potassium nitrate (KNO_3).

There are several examples in the literature demonstrating the efficiency of sulfuric acid in overcoming dormancy of forest species. As the study by Pereira et al. (2016), where it is observed that the dormancy of *Stryphnodendron pulcherrimum* seeds can be overcome by immersion in sulfuric acid for 10 or 12 minutes. And Nascimento et al. (2018) who found that for *Sapindus saponaria* seeds, this soaking period should be 70 minutes.

However, work using KNO_3 to overcome tegumentary dormancy in forest species is rare. Generally, KNO_3 is used to overcome dormancy in brachiaria seeds, as in the case of the study by Carvalho et al. (2015); or herbaceous species (Parreira et al., 2012). An example within the forest area is the study by Souza et al. (2014), who employed KNO_3 to overcome the dormancy of *Cassia leptophylla*, however, without satisfactory results.

In the case of the red try, some works indicate that mechanical scarification is one of the most efficient techniques (Mantoan et al., 2012). As was verified by Rodrigues et al. (2009), who recommended sandpaper abrasion for 20 seconds to overcome dormancy of the tense; however, these authors also indicated sulfuric acid immersion for 22 minutes. Whereas, Costa et al. (2010) recommended sulfuric acid immersion for 5 or 10 minutes. However, other methods that allow a higher germination rate and/or faster germination should be studied so that they can be employed.

In view of this, the present study was carried out with the objective of evaluating techniques of scarification, chemistry and mechanics, as methods for overcoming the dormancy of seeds of red temper.

2 THEORETICAL FRAME

The theoretical reference was based on scientific articles and books published in the areas of forest seeds, types of forest seeds, types of dormancy in forest seeds and, techniques for overcoming dormancy. For better understanding, the theoretical framework for the study was divided into a few items: 2.1 *Adenanthera pavonina*; 2.2 Dormancy in forest species, focusing on tegumentary dormancy; 2.3 mechanical scarification as a technique for overcoming tegumentary dormancy; and 2.4 Chemical scarification as a technique for overcoming tegumentary dormancy.



2.1 ADENANTHERA PAVONINA

Adenanthera pavonina is a species of legume belonging to the family Fabaceae, subfamily Mimosoideae, popularly known as the red, caroline, dragon's-eye or tento. It is a tree legume, native to India and Malaysia, which was introduced in the Americas, including Brazil, for the composition of urban and rural afforestation (Lorenzi et al., 2003). It is not known for sure when the species was introduced in Brazil, however, according to Corrêa (1978), in 1978, its entry was already registered as "many years ago", so it is a species considered adapted and widely disseminated in all the states of the country.

The yellow inflorescences of this species are formed mainly in March-April, presenting long axillary or terminal peduncles, in short racemes. The fruits are in the form of narrow, flattened pods, brown, spiraled, when they open; exposing the globose, flattened, hard, bright red seeds. Seeds can vary in hue, shape and size, averaging 10 x 12 mm, and these have been widely used in the crafts and production of medicines, especially phytotherapies (seeds and wood), for the treatment of pulmonary infections and chronic ophthalmia (Kissmann et al., 2008).

According to Cardoso et al. (2005), the species produces large quantities of seeds, which are orthodox and require pre-germinative treatment due to dormancy due to the waterproofing of the integument. It is a semi deciduous species, reaching from 15 to 20 meters in height and has rapid growth, having a canopy suitable for shading herbaceous plants, shrubs and creepers, which do not tolerate high luminous intensities (Fonseca; Perez, 2001). Allied to the high adaptability throughout the country, its potential for use in the recovery of degraded areas has been observed, and its adaptation has been attested in several experiments (Kissmann et al., 2008).

2.2 NUMBNESS IN FOREST SPECIES, FOCUSING ON TEGUMENTARY NUMBNESS

Germination begins with the absorption of water by the seed and ends with the start of the elongation of the embryonic axis, identified by the protrusion of the root (Fonseca; Jacobi, 2011). However, most forest species produce seeds that have some type or degree of dormancy, making them unable to germinate even in a favorable environmental condition (Melo; Rodolfo Júnior, 2006).

According to Oliveira (2012) this adaptive process allows seeds to remain viable for long periods in the soil, until some favorable environmental condition acts on physiological



mechanisms and provides germination, however, this can be a problem for seedling production. The seeds that present dormancy make the planning and production of the species in nurseries difficult, due to the great variation in the uniformity of germination, making it indispensable to know the mechanism and method of overcoming dormancy (Silva et al., 2011).

This mechanism can occur due to an imposition made by the integument, due to the imbalance of substances that promote or inhibit germination, or because of the embryo (Araújo et al., 2017b). However, among these types of dormancy, tegumentary dormancy, also known as exogenous dormancy, is the most common in species in the Fabaceae family (Baskin; Baskin, 2014). These seeds, called hard, reach great longevity, and any procedure that allows breaking the seed integument (scarification), causing them to absorb water, promotes their germination and emergence of generally vigorous seedlings (Grus, 1990).

Therefore, the exogenous dormancy comes from the integument, pericarp, endocarp and floral extract, and in this case the embryo has no participation in overcoming it. The factors responsible for the occurrence of this numbness are impermeability, mechanical effect and inhibiting substances (Cardoso, 2004). Therefore, to begin the germination process, for these species, it will be necessary to promote the rupture of the impermeable layer. What can be done artificially, by mechanical scarification or with corrosive chemicals, such as acids (Rodrigues et al., 2021).

The various treatments used to overcome this type of numbness (hard integuments) are based on the principle of dissolving the waxy cuticular layer or forming streaks/perforations in the seed integument, because its rupture is immediately followed by soaking, which favors the beginning of the germinative process (Bianchetti; Ramos, 1981).

Fowler and Bianchetti (2000) add that, for this type of dormancy, the methods consist of acid scarification, with immersion of the seeds in acid for a certain time; immersion in water, both in hot water and at room temperature; and mechanical scarification, subjecting the seeds to abrasion. According to Silva et al. (2021) the effectiveness of each method will depend on the level and type of dormancy, the origin of the seeds and the time of exposure to the technique employed.

2.3 MECHANICAL SCARIFICATION AS A TECHNIQUE FOR OVERCOMING TEGUMENTARY NUMBNESS

In studies involving the overcoming of tegumentary dormancy of *Adenanthera pavonina*, some researchers have tested mechanical scarification and succeeded in this method



for the increase in the germination rate of the species. Ribeiro et al. (2009), for example, found that among the treatments performed, 15 and 30 minutes of immersion in sulfuric acid and mechanical scarification proved to be more efficient in promoting the overcoming of the dormancy of the seeds and, as a consequence, promoted an increase in the percentage of germination.

According to Mantoan et al. (2012) when compared with each other, to overcome the dormancy of seeds of *Adenanthera pavonina*, the techniques of mechanical and chemical scarification presented different results within the different works, but were always more efficient than unscarred seeds.

Silva et al. (2009) also obtained the best results with these methods. These authors concluded that mechanical scarification through the release of pliers and sandpaper friction and chemical scarification by immersion in sulfuric acid for 20 minutes were the most efficient for *Adenanthera pavonine*.

Another study was conducted by Pelazza et al. (2011) who found that treatments with mechanical scarification result in greater germination and in shorter time, there is no difference between the types of associated soaking, thus being indicated for breaking dormancy in seeds of *Adenanthera pavonina*. Corroborated by Freitas et al. (2019) which obtained more satisfactory results by using the method of mechanical scarification with sandpaper No. 120 to overcome the dormancy of seeds of this species.

And yet, by Oliveira et al. (2020) who found that the treatment with the highest germination percentage was an association between mechanical scarification with sandpaper No. 80 for 20 seconds in the region opposite the hilum, followed by 20 minutes of soaking in water, obtaining 85% germination. E, por Silva et al. (2020) that recommended manual scarification with water sandpaper on both sides of the integument and opposite the hilum for *Adenanthera pavonina* seeds. This is the method that provided, in this study, higher percentage of emergence and rate of emergence and therefore recommended as pre-germinative treatment.

Other studies have been carried out and found the efficiency of mechanical scarification for overcoming the dormancy of seeds of forest species. For the seeds of *Cassia grandis*, Nascimento et al. (2021) recommended mechanical scarification with wood sandpaper number 100, in the region opposite the micropile; and chemical scarification with concentrated sulfuric acid, with a 30-minute immersion time. While, for *Cassia leptophylla*, Souza et al. (2014) indicated mechanical scarification by cutting.

Santos et al. (2022) tested methods for overcoming dormancy of *Parkia playcephala* seeds and recommended sandpaper for mass number 80 as the most efficient method. However,



when this method is not feasible, immersion in H_2SO_4 for 20 minutes may be used. Vasconcelos et al. (2022) indicated, for tegumentary numbness of *Mimosa caesalpinifolia* seeds, mechanical scarification or an association between mechanical scarification and immersion in water for 24 hours.

2.4 CHEMICAL SCARIFICATION AS A TECHNIQUE FOR OVERCOMING TEGUMENTARY NUMBNESS

Chemical or acid scarification is the method of submersion of the seeds in sulfuric acid (H_2SO_4), hydrochloric acid (HCl) or other type of acid for a certain time, varying according to the species, and is recommended for those with water- or gas-tight integuments (Moreira et al., 2017).

This method has also been tested for the overcoming of dormancy of the seeds of *Adenanthera pavonina*. Costa et al. (2010) they tested it and found that the use of concentrated sulfuric acid (98%), for five or 10 minutes, was the best method for the species, to the detriment of boiling and immersion in water. However, Mantoan et al. (2012) recommended longer immersion time. These authors recommended chemical scarification with H_2SO_4 for 30 minutes or scissor mechanics. Scissor scarification also gave the germination process greater speed.

Other studies have reported the efficiency of chemical scarification for overcoming dormancy of seeds of forest species. Ferreira et al. (2020) found that the use of sulfuric acid was efficient for overcoming dormancy in *Hymenaea stigonocarpa* seeds, proving to be the most efficient method and allowing the highest germination rate and in the shortest time.

For seeds of *Erythrina velutina*, Silva et al. (2021) recommended decay with sulfuric acid in immersion for 25 minutes, so that this causes ideal morphoanatomic changes in the integument strata, providing greater germination and vigor. However, Aguiar et al. (2021) warn that although treatment with sulfuric acid (99.9% p.a.) has shown good results for the breakdown of dormancy of *Dimorphandra mollis* seeds, this is extremely dangerous and costly, especially for people without training and ability to handle it.

The 0.2M HCl for two hours was efficient for the germination of *Senna pendula* seeds (Souza and Carrasco, 2021), and this method is indicated to accelerate the germination of these seeds, besides being easily reproduced in forest nurseries and having low cost.

Another product used is KNO_3 (although it is not an acid), due to its saline effect. According to Cordazzo and Hackbart (2009) KNO_3 can be used to overcome seed dormancy because it is a substance that tends to stimulate germination, however little is known about the



mechanism involved. This saline substance acts on positive photoblastic seeds, and its effect is related to the disinhibition of the pentose-phosphate cycle (Gupta, 2002).

Brito et al. (2016) found the efficiency of KNO_3 for *Acnistus arborescens*, as this method increased the rate of germination, being indicated to raise the vigor of the seeds. According to the authors, this result may be related to the fact that this substance increases the respiratory rate of the seed.

Santiago et al. (2019) also recommended the application of KNO_3 at 0.2%, for seeds of *Physalis angulata*, so that it is possible to achieve increment in germination and the rate of germination.

For *Buchenavia tomentosa* seeds, the recommendation is to pre-soak in KNO_3 0.2% for 20 minutes or KNO_3 30.3% for 30 minutes, which guarantees a germination rate of up to 85% (Vieira et al., 2021).

3 METHOD

The experiment was carried out at the plant house of the Faculty of Agronomy of the University of Cuiabá (UNIC), located on the campus Beira Rio I, in Cuiabá - MT, at the coordinates 15°37'28"S and 56°05'11"O. The predominant climate of the region is tropical savanna, according to Köppen classification.

Red-tasted seeds were collected, on the ground, under randomly chosen mother trees, located at the Federal University of Mato Grosso, Cuiabá campus, at 15°36'36"S and 56°03'57"O. The collections of these seeds took place over seven days, from seeds not attacked by pests, found under the same mother trees. After collection, the seeds were washed, packed, identified and kept in a refrigerated environment until use.

For treatments where KNO_3 and H_2SO_4 were used for overcoming dormancy, the seeds were placed in a beaker with a capacity of 500 mL, filled with KNO_3 or with H_2SO_4 , and kept immersed for the period tested in each treatment, then were placed to germinate. For the treatment with mechanical scarification, the side referring to the hilum was scarified, with water sandpaper No. 80. Then the treatments were installed.

The treatments tested were: T0 - no scarification; T1 - mechanical scarification; T2 - chemical scarification with H_2SO_4 80% for half an hour; T3 - chemical scarification with H_2SO_4 80% for one hour; T4 - chemical scarification with KNO_3 0.4% for half an hour; T5 - chemical scarification with KNO_3 0.4% for one hour. The experimental design used was entirely casualized, having five repetitions and 20 seeds in each repetition.



After the dormancy treatment, the seeds were placed in plastic bags 10x20 cm, filled with approximately 500 grams of Basaplant® commercial substrate. According to the supplier, this substrate is composed of pine bark, coconut fiber, fibrous peat, vermiculite, NPK and micronutrients.

The first germinations were observed 15 days after the treatments, and the evaluations performed in the study were initiated at that time. To indicate a seed with the status of "germinated", the seedling was considered with the cotyledons totally detached from the integument. We evaluated: the germination rate index (IVG), calculated by Maguire's formula (1962): $IVG = G1/N1 + G2/N2 + \dots + Gn/Nn$ Where IVG = sprouting rate index; G1, G2, ... Gn = number of normal seedlings sprouted each day; N1, N2, ... Nn = number of days from sowing at first, second to last count.

The average germination time (GMT) was calculated using the formula: $GMT = (\sum n_i t_i) / \sum n_i$. Where: n_i = number of seeds sprouted per day; t_i = incubation time; $i = 1 \rightarrow 44$ days. The germination (G) was given by the formula: $G (\%) = (N/100) \times 100$, where: N = number of seeds germinated at the end of the test. E, the mean germination rate (VMG), with the formula $VMG = 1/t$ where: t = mean germination time.

The data were interpreted by means of the analysis of variance and the comparison of means was carried out by the Tukey method at the level of 5% probability of error using the SISVAR statistical program, after verification of the normality of the data.

4 RESULTS AND DISCUSSIONS

The effects of the different methods for overcoming the dormancy of red-temper seeds are presented in Table 1. It appears that all the characteristics assessed presented significant responses.



Table 1

Sprouting rate index (IVG), mean sprouting time (GMT, in days), mean sprouting rate (GMV) and sprouting rate (G, in %), after dormancy overcoming test with scarification types

Treatment	IVG	GMT	VMG	G
T0	0.21c	22.0 to	0.04 d	10.0 d
Q1	12.02 to	3.14 c	0.32a	70.25 to
Q2	0.97c	14.67 b	0.07 c	15.0 c
Q3	1.14c	22.0 to	0.04 d	10.0 d
Q4	11.49 to	3.14 c	0.32a	70.25 to
Q5	10.0 b	3.38c	0.29b	65.0 b
CV (%)	9.65	14.34	4.13	3.40

T0 - no scarification; T1 - mechanical scarification; T2 - chemical scarification with H₂SO₄ 80% for half an hour; T3 - chemical scarification with H₂SO₄ 80% for one hour; T4 - chemical scarification with KNO₃ 0.4% for half an hour; T5 - chemical scarification with KNO₃ 0.4% for one hour. The following averages of the same letter do not differ significantly, by the Tukey test at 5% probability.

Source: Prepared by the authors (2024).

The rate of germination velocity (IVG) was higher in treatments with mechanical scarification (T1) and with chemical scarification with KNO₃ 0.4% per half hour (T4). In T1, the mean was higher in 98.3% and in T4 in 98.2%, in relation to the control treatment. Indicating that, there is a need to carry out treatments for overcoming the dormancy of this species, should there be an interest in producing cuttings. In general, scarifications with KNO₃ to 0.4% showed more satisfactory results for the red try. Treatment 5 (scarification with KNO₃ for one hour) was also outstanding in relation to the witness and H₂SO₄ treatments. Scarification with H₂SO₄ was not efficient, at least for the period during which it was carried out in this experiment, which may have been superior to that tolerated by the species, causing degradation of the integument and entry of acid to the embryo, damaging it.

This information is of great technical importance, since the IVG and the TMG are tools for the evaluation of the vigor and germination capacity of the seeds, besides serving as indicative of a shorter or longer stay of the seedlings in the nursery (Dutra et al., 2017). It is considered here, that other experiments with different periods could present more favorable results, because these can be obtained according to the hardness of the integument of the seeds of this species.

For other forest species, immersion in H₂SO₄ was also not efficient for overcoming seed dormancy. As in the cases of *Bauhinia forficata* (Ronchi et al., 2016); *Schizolobium parahyba* (Candido e Oliveira, 2018); of *Acacia mangium* (Fernandes et al., 2018); and of *Schizolobium amazonicum* (Carvalho et al., 2019).

However, among the evaluated treatments, H₂SO₄ is the most commonly used in red-tent germination tests and has been shown to be highly efficient for overcoming the dormancy



of its seeds (Mantoan et al., 2012), however, not for the period employed in the present study. According to Araújo Neto et al. (2012), the immersion treatments of red-tent seeds to H_2SO_4 promoted considerable increases in the percentage of emergence at first count (seed vigor), highlighting the immersions for 10 and 20 minutes, with an average of 83% with immersion for 10 minutes. In addition, Costa et al. (2010) found that the seeds of this species, submitted to treatments with concentrated H_2SO_4 , for different exposure times completed the germination process in only one day. This acid scarification, depending on the time of immersion, did not cause damage to the cells that make up the embryo. Proving that there is a need to promote specific methods for overcoming dormancy and that probably the times tested in this study, for the soaking of seeds in H_2SO_4 , were not adequate.

Mantoan et al. (2012) add that the dormancy in this case is tegumentary because of the impermeable elements in the integument, however, emphasize that the time of immersion to H_2SO_4 will vary according to the plant and the place of cultivation, as these factors influence the thickness of the seed integument.

Another characteristic evaluated was the average germination time (GMT), for which lower averages were obtained in the treatments with the best results for the IVG, which is expected since, if the seed germinates faster, it means that it takes less days (time) for this to occur. In this case, the first germinations occurred 15 days after being sown, in T1, T4 and T5, therefore, these were the most efficient, since with less time to germinate it is possible to produce more seedlings suitable for planting in the field. This being favorable for a commercial nursery or for when it is intended to have cuttings as soon as possible, for reforestation to take place. For this characteristic, it was verified that the seeds in the treatment witness presented average that was 85.7% higher in relation to treatments 1 and 4 and 84.6% higher in relation to treatment 5. Corroborating with what was discussed earlier when reporting that chemical scarification with KNO_3 is more efficient for this species.

The mean germination rate (GMV) was higher for T1 and T4 seeds, with averages that were 87.5% higher than in the control treatment. This is favorable for the production of seedlings of this species. In treatment 5, the mean was 86.2% higher than in the control treatment. Results that are directly related to those obtained and discussed previously. Possibly, because these treatments allowed for a greater wear in the integument of the seeds, without thereby damaging the embryo. This occurs because, according to Silva et al. (2020), manual scarification by providing tegument ruptures, favors increased water soaking, this being the main step for the start of the germinative process.



The positive effects of immersion of seeds of forest species in KNO_3 to overcome dormancy were also observed by Brito et al. (2016) for the germination of *Acnistus arborescens*; and by Matias et al. (2018) for the germination of *Annona cf. montana*.

This influenced the result presented for the germination percentage (G), which was the same for treatments 1 and 4, reaching an average of 70%, followed by treatment 5, with 65% germination. Results corroborated by Mantoan et al. (2012), which recommended chemical scarification with H_2SO_4 for a period of 30 minutes and mechanical scarification with scissors, averaging up to 65% and 61% respectively of germination. Values that were similar to those observed in the present case. While, in the control treatment, germination was 10%, similar to that observed for treatment with H_2SO_4 for one hour. Indicating that H_2SO_4 was not efficient for germination of tentative seeds, considering the time when they remained immersed in this acid.

However, new experiments could be performed, with chemical scarification with KNO_3 and H_2SO_4 , with concentrations and even new periods of immersion, to verify in greater detail the efficiencies of these methods in overcoming red-tent dormancy. Since, in other studies, it was found that the percentage of germination for this species may be higher and that the use of H_2SO_4 is one of the most promising methods. For example, Kissmann et al. (2008) who found that the best method for overcoming dormancy of red-tent seeds was immersion in H_2SO_4 for 10 minutes, with average germination of 83%. E, Costa et al. (2010) that recommended the soaking of the seeds in H_2SO_4 for 5 and 10 minutes, guaranteeing an average percentage of 85% germination.

While, in some studies, the method of mechanical scarification also proved to be efficient for the red try. For example, Ribeiro et al. (2009) found that immersion treatments in H_2SO_4 for 15 to 30 minutes and mechanical scarification proved to be the most efficient for overcoming dormancy of this species, reaching 95% and 100%, respectively. These authors recommended immersion in H_2SO_4 for 22 minutes or abrasion by sandpaper for 20 seconds, as these provided averages greater than 80% and 90% germination, respectively.

Pelazza et al. (2011) tested and proved the highest efficiency of mechanical scarification of red-tent seeds and the association with soaking in distilled water for 24 hours; or soaking in solution with KNO_3 (0.2%) for 24 hours; or soaking in giberelic acid solution - GA_3 (10%) for 24 hours. These treatments presented germination performance between 83% and 88%. According to the authors, these methods are safe and low-cost. Therefore, they should be preferred over the use of H_2SO_4 . Whereas, Silva et al. (2020) recommended the use of manual



scarification with water sandpaper on both sides of the integument and opposite the hilum as pre-germinative treatment, which may allow 83.7% of emergency percentage.

Whereas, in a nursery for the production of seedlings, in general, the least onerous, fastest and most practical method is chosen, the most recommended, for the present case, would be mechanical scarification. Other authors have also verified, for other forest species, the efficiency of this method.

Mariano et al. (2016) found that this was the method with the best performance in the number of seeds germinated and in the emergency speed index, and can thus be indicated for dormancy breaking of seeds of *Leucaena leucocephala*, with more than 95% germination. Coelho and Ribeiro (2018) found that mechanical scarification was the best option for overcoming dormancy of *Hymenaea courbaril* seeds, with an average of 95% germination. In another study, Oliveira et al. (2018) noted that mechanical scarification with sandpaper No 120 provided high germination percentage (72%) and high IVG (39) for *Delonix regia* seeds. The efficiency of this method is also reported for *Schizolobium parahyba* (Figueiró et al., 2017); *Caesalpinia ferrea* (Oliveira et al., 2017); *Sapindus saponaria* (Diniz et al., 2018) and *Cassia leptophylla* (Padilha et al., 2018).

5 FINAL CONSIDERATIONS

The methods for overcoming dormancy showed efficiency in the germination process of the red-tent seeds.

The most efficient methods for the germination of the seeds with red tent were mechanical scarification with water sandpaper n.80 and immersion in KNO₃ 0.4% for half an hour, both presenting similar results for the characteristics analyzed.

In this case, mechanical scarification would be the most easily employed and least costly method.

Results such as these may stimulate further studies on dormant overcoming techniques, with the same species or not. It is always important to search for methods that are more efficient, easier, faster and with less cost to be employed, and that, at the same time, guarantee ever higher germination rates and with quality.

Other work should be developed if the objective is testing with other species, other techniques, and other times of submission to salt or acid scarification. Knowing that this kind of knowledge is primordial for the production of quality seedlings within the nursery, since the



right technique and employed in a correct manner, guarantees a higher germination rate, more seedlings being formed and in less time.

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