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OVERCOMING DORMANCY IN *Bowdichia virgilioides* Kunth SEEDS

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ABSTRACT

Objective:The study aimed to evaluate the efficiency of methods for overcoming dormancy in *Bowdichia virgilioide*s Kunth (purple sucupira) seeds. The aim was to develop accessible and effective techniques for propagating the species, contributing to its conservation and sustainable use.

Theoretical Reference: The research addressed tegument dormancy in Fabaceae, exploring strategies such as thermal, chemical and mechanical scarification to optimise germination. The ecological, medicinal and economic relevance of *B. virgilioides* supports the importance of the study for its conservation.

Method: The experiment was carried out in the Hydraulic Irrigation and Hydrology Laboratory and in the experimental field of the UEMASUL Agricultural Sciences Centre. Four treatments were tested: control, mechanical scarification (sandpaper no. 180), thermal scarification (water at 80°C for 10 min) and chemical scarification (sulphuric acid for 10 min, followed by neutralisation with calcium carbonate). The data collected on the seed germination rate and speed.

Results and Discussion: Thermal scarification was the most effective method, resulting in 90 per cent germination, while chemical and mechanical scarification each achieved 70 per cent. These results validate the viability of safe and accessible techniques, although the limitations of handling chemical substances were considered.

Research Implications: The practical implications include applications in reforestation, nurseries and environmental recovery in the Cerrado. In addition, the study reinforces the importance of properly selecting dormancy overcoming methods for propagating native species.

Originality/Value: This study is a differentiator in that it compares practical and safe methods in a native and little-studied species. Its value lies in its potential for direct application in sustainable practices and in expanding knowledge about the propagation of *B. virgilioides* Kunth.

Keywords: Native Species, Scarification, Germination, Seedling Production.

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SUPERAÇÃO DE DORMÊNCIA EM SEMENTES DE *Bowdichia virgilioides Kunth*

RESUMO

Objetivo:O estudo objetivou avaliar a eficiência de métodos de superação de dormência em sementes de *Bowdichia virgilioides* Kunth (sucupira-roxa). O foco foi desenvolver técnicas acessíveis e eficazes para a propagação da espécie, contribuindo para sua conservação e uso sustentável.

Referencial Teórico:A pesquisa abordou a dormência tegumentar em Fabaceae, explorando estratégias como escarificação térmica, química e mecânica para otimizar a germinação. A relevância ecológica, medicinal e econômica da *B. virgilioides* sustenta a importância do estudo para sua conservação.

Método: O experimento foi realizado no Laboratório de Irrigação Hidráulica e Hidrologia e no campo experimental do Centro de Ciências Agrárias da UEMASUL. Foram testados quatro tratamentos: testemunha, escarificação mecânica (lixa nº 180), escarificação térmica (água a 80°C por 10 min) e escarificação química (ácido sulfúrico por 10 min, seguido de neutralização com carbonato de cálcio). A taxa e velocidade de germinação das sementes foram os dados coletados.

Resultados e Discussão:A escarificação térmica foi o método mais eficaz, resultando em 90% de germinação, enquanto a química e mecânica atingiram 70% cada. Esses resultados validam a viabilidade de técnicas seguras e acessíveis, embora as limitações do manuseio de substâncias químicas tenham sido consideradas.

Implicações da Pesquisa: As implicações práticas incluem aplicações em reflorestamento, viveiros e recuperação ambiental no Cerrado. Além disso, o estudo reforça a importância da seleção adequada de métodos de superação de dormência para propagação de espécies nativas.

Originalidade/Valor: Este estudo é um diferencial ao comparar métodos práticos e seguros em uma espécie nativa e pouco estudada. Seu valor reside no potencial de aplicação direta em práticas sustentáveis e na ampliação do conhecimento sobre a propagação de *B. virgilioides* Kunth**.**

Palavras-chave: Espécies Nativas, Escarificação, Germinação, Produção de Mudas.

SUPERACIÓN DE LA LATENCIA EN LAS SEMILLAS DE *Bowdichia virgilioides* Kunth

RESUMEN

Objetivo: El estudio tuvo como objetivo evaluar la eficacia de los métodos para superar la latencia de las semillas de *Bowdichia virgilioides* Kunth (sucupira púrpura). El objetivo fue desarrollar técnicas accesibles y eficaces para propagar la especie, contribuyendo a su conservación y uso sostenible.

Referencia teórica: La investigación abordó la latencia tegumentaria en Fabaceae, explorando estrategias como la escarificación térmica, química y mecánica para optimizar la germinación. La relevancia ecológica, medicinal y económica de *B. virgilioides* avala la importancia del estudio para su conservación.

Método: El experimento se llevó a cabo en el Laboratorio de Riego Hidráulico e Hidrología y en el campo experimental del Centro de Ciencias Agrícolas de la UEMASUL. Se ensayaron cuatro tratamientos: testigo, escarificación mecánica (lija nº 180), escarificación térmica (agua a 80°C durante 10 min) y escarificación química (ácido sulfúrico durante 10 min, seguido de neutralización con carbonato cálcico). Los datos recogidos fueron el índice y la velocidad de germinación de las semillas.

Resultados y discusión: La escarificación térmica fue el método más eficaz, con un 90% de germinación, mientras que la escarificación química y la mecánica alcanzaron un 70% cada una. Estos resultados validan la viabilidad de técnicas seguras y accesibles, aunque se tuvieron en cuenta las limitaciones de la manipulación de sustancias químicas.

Implicaciones de la investigación:Las implicaciones prácticas incluyen aplicaciones en reforestación, viveros y recuperación medioambiental en el Cerrado. Además, el estudio refuerza la importancia de seleccionar adecuadamente los métodos de superación de la dormancia para la propagación de especies nativas.

Originalidad/Valor:Este estudio es diferenciador por comparar métodos prácticos y seguros en una especie nativa y poco estudiada. Su valor reside en su potencial de aplicación directa en prácticas sostenibles y en la ampliación del conocimiento sobre la propagación de *B. virgilioides* Kunth.

Palabras clave: Especie Nativa, Escarificación, Germinación, Producción de Plántulas.

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1 INTRODUCTION

The occurrence of dormant seeds is common among native forest species, even when exposed to environmental conditions favorable to germination. These seeds present a temporary physiological inhibition that prevents immediate germination, and are classified as dormant. According to Bewley (2013), dormancy is defined as a state in which the seed, despite being subjected to adequate extrinsic and intrinsic conditions, does not germinate. This condition can manifest itself in different ways, such as dormancy imposed by the seed coat, embryonic dormancy or caused by imbalances between substances that promote and inhibit germination.

Among the types of dormancy, that imposed by the tegument stands out in several species of the Fabaceae family. The impermeability of the tegument to water is a recurring characteristic, hindering water absorption and gas exchange, which are essential for germination (Carvalho & Nakagawa, 2000). For seedling producers, this barrier represents a challenge, as it delays the germination process and compromises production efficiency (Moussa *et al.* , 1998). In this context, scarification emerges as a viable technique to break or weaken the tegument and enable the beginning of germination (Mayer & Poljakoff-Mayber , 1989).

Several scarification techniques are used to overcome dormancy, and the choice of the appropriate method depends directly on the cause of dormancy and the characteristics of the species (Tavares *et al.*, 2015). Among the main methods, chemical, mechanical and thermal scarification stand out, whose effectiveness varies according to the intensity of dormancy, the origin and the time of collection of the seeds (Lima *et al.* , 2013).

Chemical scarification with sulfuric acid is widely used, especially for its effectiveness in breaking thick integuments. However, its effectiveness depends on the exposure time and the sensitivity of the species. In *Adenanthera pavonina* L., for example, dormancy was overcome by immersion in sulfuric acid for 10 to 20 minutes (Neto *et al.* , 2012). Mechanical scarification, by abrasion with sandpaper or manual cutting, is a simple, safe and low-cost alternative, presenting good results in legumes (Fowler & Bianchetti, 2000), although excess can damage

the seeds (McDonald & Copeland, 1997). Immersion in hot water, a thermal method, is also widely used and consists of exposing the seeds to high temperatures for a controlled time, according to the specific requirements of each species.

Bowdichia stands out *virgilioides* Kunth , a tree species of the Fabaceae family, widely distributed in Brazil, with a greater occurrence in the Northeast, Central-West and Southeast regions. According to Brandão & Ferreira (1991) and Lorenzi (1992), it is a pioneer species, adapted to poor and dry soils, with moderate density wood and consolidated use in carpentry and civil construction. In addition to its economic importance, the species is also valued for its ecological role, being commonly used in reforestation programs and recovery of degraded areas (Albuquerque *et al.*, 2007; Campos Filho & Sartorelli, 2015).

Despite its relevance, *B. virgilioides* faces the threat of extinction due to predatory extractivism and the expansion of the agricultural frontier in the Cerrado. Added to this is the difficulty in producing seedlings, caused mainly by tegumentary dormancy, which results in low germination rates (Albuquerque *et al.* , 2007).

Given this scenario, it is essential to identify efficient and accessible methods to overcome dormancy and enable the propagation of this species. Thus, the present study aimed to evaluate the efficiency of different methods for overcoming dormancy in *Bowdichia seeds. virgilioides* Kunth , focusing on germination percentage and seed emergence speed index.

2 THEORETICAL FRAMEWORK

2.1 IMPORTANCE OF *Bowdichia virgilioides* (PURPLE SUCUPIRA)

The *Bowdichia virgilioides* Kunth , popularly known as black sucupira or purple sucupira, stands out for its multiple medicinal, ecological and economic applications, being a species of great relevance for different sectors. In the medicinal field, it is widely recognized for its anti-inflammatory, antimicrobial and anxiolytic properties, being traditionally used in the treatment of diseases such as arthritis, dermatological diseases and throat infections (Machado *et al.* , 2018; Leite *et al.* , 2014). These therapeutic effects are associated with its rich phytochemical composition, especially the presence of flavonoids and tannins, bioactive compounds responsible for its effectiveness in traditional medicine (Leite *et al.* , 2014).

In addition to its therapeutic value, the species plays a fundamental role in the ecological dynamics of the Cerrado biome. Its presence contributes to the maintenance of biodiversity and

the balance of local ecosystems, and it is considered a pioneer species with a high capacity to adapt to degraded environments (Esteves *et al.*, 2021). From an economic point of view, the wood of *B. virgilioides* is valued for its durability and is used in civil construction, carpentry, landscaping, and the manufacture of furniture and various artifacts (Rosa-Magri & Meneghin, 2014).

However, despite its widespread importance, the species faces serious risks to its conservation. The degradation of natural habitats, predatory extraction, and low germination rates hinder the natural regeneration and sustainable management of *B. virgilioides* (Esteves *et al.*, 2021; Rosa-Magri & Meneghin, 2014). These factors make it urgent to develop effective strategies for seedling production. Among these strategies, treatments to overcome tegumentary dormancy stand out, with an emphasis on chemical scarification, which have shown promise for increasing germination rates and ensuring the conservation of the species (Rosa-Magri & Meneghin, 2014).

2.2 TEGUMENTARY DORMANCY IN SPECIES OF THE FABACEAE FAMILY

Tegumentary dormancy is a common mechanism among species of the Fabaceae family and is associated with the impermeability of the tegument to water and gases, preventing immediate seed germination even under favorable environmental conditions. To overcome this physiological barrier, several methods have been adopted, among which heat treatments stand out for their effectiveness and operational simplicity.

According to Júnior *et al. (2023), the exposure of Enterolobium* seeds *contortisiliquum* at 70 °C for 45 to 60 minutes resulted in a significant increase in the germination rate and favored the initial development of seedlings. Paula *et al. (2012) observed similar results with Cassia leptophylla* seeds , which, when subjected to 50 °C, presented efficient rupture of the tegument, allowing water absorption.

Among the scarification methods, chemical scarification with concentrated sulfuric acid (98%) has been widely used, especially for species with hard tegument. Cipriani *et al.* (2019) demonstrated the effectiveness of this method in *Chloroleucon acacioides* and *Senna macranthera* , with a significant increase in the germination rate. In a complementary manner, *Cassia grandis* also responded positively to chemical scarification, showing superior germination after immersion in sulfuric acid for 30 minutes (Nascimento *et al.*, 2020).

Mechanical scarification, on the other hand, has stood out as a practical, safe and low-cost alternative. Techniques such as manual abrasion with sandpaper have proven effective,

especially in *Cassia grandis seeds* , where the method was considered one of the most efficient in breaking dormancy (Nascimento *et al.*, 2020).

2.3 METHODS FOR OVERCOMING DORMANCY IN FOREST SEEDS

Several methods have been used to overcome physical dormancy in forest seeds, with emphasis on mechanical and chemical scarification and heat treatments. Mechanical scarification with sandpaper is one of the most widely used techniques, promoting controlled abrasion of the seed coat. Studies with *Adenanthera seeds pavonina* demonstrated the effectiveness of this method, reflected in higher germination rates (Vieira *et al.*, 2024). Another promising mechanical technique is chiselling, which consists of making a precise incision in the seed coat. This approach has proven effective in *Acacia mearnsii* , providing high germination rates (Alberti *et al.* , 2020).

Chemical scarification with acids, mainly concentrated sulfuric acid (H_2SO_4), has also been widely used in seeds with pronounced dormancy. In *Myrciaria glomerata* , immersion in H_2SO_4 demonstrated good results, with the exposure time being a determining factor for the success of the treatment (Santos *et al.* , 2021). In addition, the use of gibberellic acid (GA_3), a plant regulator, has contributed to increasing the germination rate and seedling vigor, as long as it is used in adequate concentrations (Santos *et al.* , 2021).

Heat treatments by immersion in hot water represent an efficient alternative. In *Acacia mearnsii* , immersing the seeds in water at 90 °C, for a controlled time, was sufficient to break the tegumentary dormancy, providing high germination (Alberti *et al.* , 2020). These results reinforce the importance of choosing the appropriate method according to the species and the nature of dormancy, especially in forest seedling conservation and production programs.

3 METHODOLOGY

The research was conducted between December 2023 and January 2024, at the Irrigation, Hydraulics and Hydrology Laboratory (LIHH) and at the experimental field of the Center for Agricultural Sciences (CCA) of the State University of the Tocantina Region of Maranhão (UEMASUL), located in the municipality of Imperatriz, Maranhão. According to the Köppen climate classification, the municipality has an Aw climate type , characterized by a dry

season in winter, average annual precipitation of approximately 1220 mm and average annual temperature of 26 °C (Alvares *et al.* , 2013).

The seeds used, in excellent phytosanitary condition, were purchased from specialized producers. For the initial treatment, the fruits were manually opened with the aid of pliers to extract the seeds, which were subsequently disinfected in a 2% sodium hypochlorite solution for three minutes, followed by washing in distilled water for one minute.

The seeds were subjected to the following treatments:

- **T1**: Control (no treatment);
- **T2**: Mechanical scarification with 180 grit sandpaper on the side opposite the hilum, until the surface of the cotyledons is exposed;
- **T3**: Incision in the tegument with forceps on the side opposite to the hilum, followed by soaking in distilled water for 24 hours;
- **T4**: Thermal scarification by immersion in distilled water heated to 80 °C for 10 minutes;
- **T5**: Chemical scarification in concentrated sulfuric acid (98% H_2SO_4) for 10 minutes, followed by neutralization in calcium carbonate ($CaCO_3$) for three minutes.

The experimental design adopted was completely randomized (CRD), with five replicates of 10 seeds per treatment. The seeds were sown in polyethylene pots with a capacity of 1.7 liters, filled with plant substrate, and kept in a greenhouse. Irrigation was performed according to the water demand observed throughout the experiment.

Germination was monitored daily for 30 days, considering seeds germinated when the seedling emerged breaking the surface of the substrate. The parameters evaluated were the germination percentage (G%) and the emergence speed index (ESI).

The data were organized in electronic spreadsheets. The germination percentage was calculated using Equation 1:

$$G = \frac{N}{A} \cdot 100 (1)$$

where:

G= germination percentage;
N = number of seeds germinated at the end of the test;
A= total sample number.

The emergency speed index was determined according to Maguire's methodology (1962), expressed in Equation 2:

$$IVE = \left(\frac{G_1}{N_1}\right) + \left(\frac{G_2}{N_2}\right) + \ldots \left(\frac{G_n}{N_n}\right) (2)$$

where:

IVE = emergency speed index;
G = Number of compacted normal seedlings;
N = Number of days since sowing.

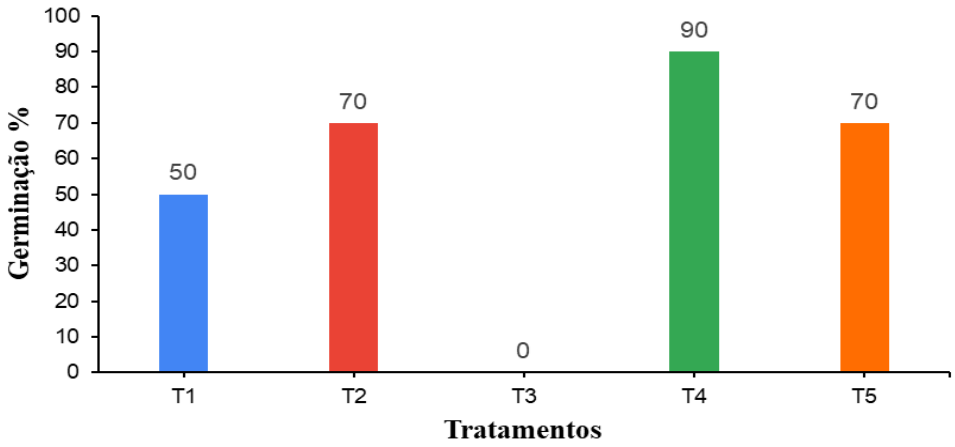
Additionally, the minimum and maximum air temperatures and relative humidity were recorded daily, between 8:00 am and 10:00 am, using a digital thermo-hygrometer.

4 RESULTS AND DISCUSSIONS

The results regarding the germination percentage of *Bowdichia seeds virgilioides* Kunth are presented in Figure 1.

Figure 1

Bowdichia Seed Germination Percentage virgilioides Kunth *subjected to different treatments.*



Legend: T1 – control; T2 – mechanical scarification performed on the side opposite to the hilum, using sandpaper no. 180 until the surface of the cotyledons is exposed; T3 – scarification by cutting the tegument with pliers followed by soaking in distilled water for 24 hours; T4 – immersion in distilled water heated to 80°C for 10 minutes; and T5 – chemical scarification in concentrated sulfuric acid (98% H_2SO_4) for 10 minutes, followed by neutralization with calcium carbonate ($CaCO_3$) for 3 minutes.

It is observed that the treatment that resulted in the highest germination rate was immersion in distilled water heated to 80 °C for 10 minutes (T4), with 90% germination. This result is in line with studies by Alberti *et al.* (2020) and Martins- Cander *et al.* (1999), who also observed high germination rates in similar thermal treatments, highlighting the effectiveness of thermal scarification within this temperature and time range. Coêlho *et al.* (2019) reported 64% germination for the same species subjected to 5 minutes of immersion in water at 80 °C, indicating that longer times, such as those adopted in this study, enhance the results.

Despite the effectiveness of heat treatments, they may not be ideal for all seeds, as indicated by Clemens *et al.* (1976) and José *et al.* (2019), who highlight the potential of mechanical scarification to increase germination, reinforcing the need for methods adapted to the specific characteristics of each species.

In the present study, treatments T2 (mechanical scarification) and T5 (chemical scarification) showed similar germination rates, both around 70% (Figure 1). Mechanical scarification promotes microlesions in the seed coat, facilitating the penetration of water and oxygen and the initiation of germination (Kim *et al.* , 2013). Chemical scarification acts by thinning the outer layer of the seed, increasing its permeability and overcoming physical dormancy (Madke *et al.* , 2017; Side *et al.* , 2021). Thus, both techniques proved effective in stimulating the germination of *B. virgilioides* .

The effectiveness of these methods in overcoming physical dormancy is widely corroborated in the literature. Aguiar *et al.* (2021) obtained 75% germination in *Pterodon seeds emarginatus* using mechanical scarification with sandpaper No. 60, results similar to those reported by Albuquerque *et al.* (2007). Silva *et al.* (2020) observed 80% germination in *Enterolobium contortisiliquum* , which reinforces the applicability of these techniques in forest species.

In contrast, treatment T3, which consisted of cutting the seed coat followed by prolonged soaking , did not show germination. This result can be attributed to excessive damage to the embryo, compromising seed viability. Costa *et al.* (2017) obtained 50% germination for *Hymenaea courbaril* by cutting, suggesting that this method may not be suitable for *B. virgilioides* , highlighting the need for specific evaluation for each species.

Regarding chemical scarification, Albuquerque *et al.* (2007) demonstrated that exposure periods between 4 and 12 minutes to concentrated sulfuric acid result in rates above 70%, corroborating the results obtained here. Coêlho *et al.* (2020) reported 82% germination for *B. virgilioides* subjected to similar treatment. On the other hand, Alberti *et al. (2020) found significantly lower rates for Acacia* seeds *mearnsii* subjected to chemical scarification for 3 and

10 minutes, indicating that the exposure time is a critical factor for the effectiveness of the method.

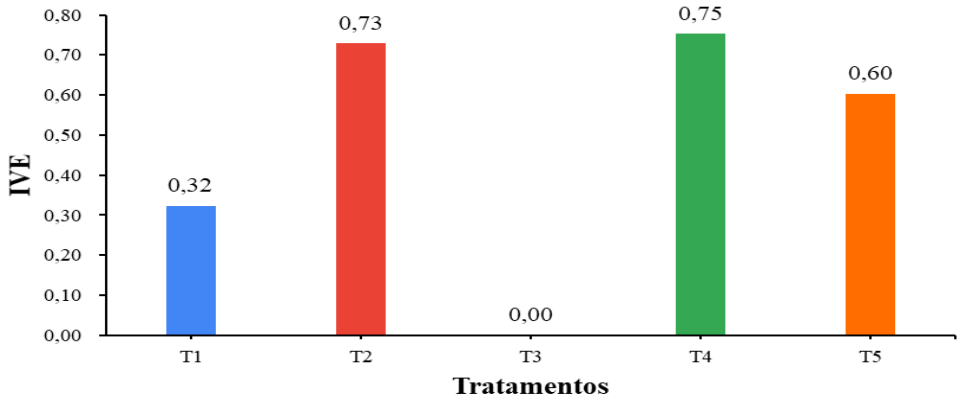
The control treatment (T1) showed a relatively high germination rate (50%) compared to the literature, which reports values between 0% and 10% in the absence of treatment (Alberti *et al.* , 2020; Silva *et al.* , 2020). This discrepancy can be explained by the environmental conditions during the experiment, where the average maximum temperature recorded was 31.8 °C, the minimum was 31.5 °C, and the relative humidity was 70.2%. Carvalho and Nakagawa (2000) emphasize that temperatures outside the ideal range can reduce the germination speed, while Albuquerque and Guimarães (2007) indicate ideal conditions for *B. virgilioides* around 25 °C or an alternating regime between 20-30 °C.

Another factor that may have contributed to germination in the control treatment was the prior immersion of the seeds in 2% sodium hypochlorite for three minutes, which possibly promoted the softening of the tegument and facilitated water absorption, accelerating the germination process (Jesus *et al.* , 2017; Hesami *et al.* , 2017).

Figure 2 shows the average values of the Emergence Speed Index (ESI), an indicator of seedling emergence speed.

Figure 2

Mean values of emergence speed index (ESI) of Bowdichia seeds virgilioides Kunth , subjected to different treatments to overcome dormancy.



Legend: T1 – control; T2 – mechanical scarification performed on the side opposite to the hilum, using sandpaper no. 180 until the surface of the cotyledons is exposed;; T3 – scarification by cutting the tegument with pliers followed by soaking in distilled water for 24 hours; T4 – immersion in distilled water heated to 80 °C for 10 minutes; and T5 – chemical scarification in concentrated sulfuric acid (98% H_2SO_4) for 10 minutes, followed by neutralization with calcium carbonate ($CaCO_3$) for 3 minutes.

Treatments T4, T2 and T5 presented the highest IVE values (0.75; 0.73; and 0.60, respectively), indicating faster emergence compared to the other treatments. Silva *et al* . (2020)

observed IVE of 0.64 for *Dimorphandra seeds mollis* subjected to chemical scarification, but reported values higher than 3.0 for mechanically scarified seeds, highlighting variations caused by differences in experimental protocols and in the morphophysiological characteristics of the species.

Mechanical scarification (T2) stands out for its practical feasibility, low cost and large-scale applicability, especially compared to methods that require heating (T4). Madke *et al.* (2016) reported that this method can increase germination from 3% to almost 69%, in addition to reducing the percentage of hard seeds from 87% to about 19%, using simple equipment.

These results confirm that mechanical scarification is an efficient, safe and economically viable alternative to overcome dormancy, being particularly suitable for large-scale production (Fernandes *et al* ., 2000).

Although the control treatment achieved 50% germination, its IVE was significantly lower (0.32), indicating a slower and less synchronized germination process, which may compromise the uniformity and vigor of seedlings in the field. Uneven emergence may result in plants with different stages of development, making management difficult and reducing production potential (Lavallee *et al* ., 2021; From Ron *et al.*, 2016).

Finally, the T3 treatment presented zero IVE, suggesting that cutting associated with prolonged imbibition may have caused structural damage or deterioration of the seeds. Takahashi *et al.* (2009) demonstrated that excessive periods of imbibition can impair germination, corroborating this hypothesis.

Additionally, discrepancies between studies, such as those reported by Costa *et al.* (2017) for *Hymenaea courbaril* , highlight the importance of adjusting scarification methods to the particularities of each species to optimize seedling emergence.

5 CONCLUSION

Thermal scarification, through immersion in distilled water at 80 ºC for 10 minutes, proved to be the most efficient method for overcoming dormancy in *Bowdichia seeds virgilioides* Kunth , achieving the highest germination rate (90%) and the highest emergence speed index. Mechanical and chemical scarification treatments also demonstrated significant efficacy, both with germination rates close to 70%, in addition to presenting good emergence speed indexes, confirming their usefulness as pre -germinative techniques.

However, although chemical scarification has shown good results, its use is not recommended due to the risks inherent in handling concentrated sulfuric acid, as well as the

potential environmental impact resulting from its improper disposal. In contrast, mechanical and thermal methods stand out as safer, more economical and environmentally sustainable alternatives, and are indicated for practical application on a large scale.

Thus, the choice of scarification method should consider not only the effectiveness in overcoming dormancy, but also aspects related to operational safety and environmental viability, positioning thermal and mechanical scarification as the most suitable options for the pretreatment of *B. virgilioides seeds.* Kunth .

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