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Efficiency of methods to overcome dormancy in seeds of *Delonix regia*

Eficiência de métodos de superação de dormência em sementes de Delonix regia

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Abstract
Seed dormancy is an important plant survival mechanism, but it is a limiting factor in seedling production. The aim of this study was to analyze methods of overcoming dormancy in flamboyant (*Delonix regia*) seeds. The seeds were subjected to mechanical scarification with

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120 grit sandpaper, cold stratification with sand (refrigerated at 8°C) for 18 hours, immersion in water at 100°C for five minutes, immersion in water at room temperature for 24 hours, as well as a control treatment (seeds without any treatment). The experiment consisted of five treatments and five replicates, with nine seeds in each replicate, totaling 45 seeds per treatment. The experimental design used for this experiment was completely randomized (DIC). The germination speed index (G.S.I.), average number of emerged seeds (N.M.S.E.) and germination percentage were analyzed. Mechanical scarification with 120 grit sandpaper and immersing the seeds in water at 100°C for five minutes are more efficient in overcoming the dormancy of *Delonix regia* and can be used in nurseries to produce flamboyant seedlings.

Keywords: mechanical scarification; cold stratification; hot water immersion; silviculture; seedling production.

Resumo

A dormência de sementes é um importante mecanismo de sobrevivência das plantas, entretanto é um fator limitante na produção de mudas. O objetivo deste estudo foi analisar métodos de superação de dormência em sementes de flamboyant (Delonix regia). As sementes foram submetidas aos métodos de escarificação mecânica com lixa d'água n° 120, estratificação a frio com areia (refrigeração a 8°C) por 18 horas, imersão em água a 100°C por cinco minutos, imersão em água à temperatura ambiente por 24 horas, além de contar com um tratamento testemunha (sementes sem nenhum tratamento). O experimento contou com cinco tratamentos e cinco repetições, sendo nove sementes em cada repetição, totalizando 45 sementes por tratamento. O delineamento experimental utilizado para esse experimento foi o inteiramente casualizado (DIC). Foram analisados o índice de velocidade de germinação (G.S.I.), o número médio de sementes emergidas (N.M.S.E.) e a porcentagem de germinação. A escarificação mecânica com lixa d'água n° 120 e a imersão das sementes em água a 100°C por cinco minutos são mais eficientes na superação da dormência de Delonix regia, podendo ser utilizados em viveiros para produção de mudas de flamboyant.

Palavras-chave*: escarificação mecânica; estratificação a frio; imersão em água quente; silvicultura; produção de mudas.*

INTRODUCTION

Delonix regia (Bojerex Hook.) Raf., popularly known as flamboyant, is a tree from the Fabaceae family, subfamily Caesalpionoideae (Lucena *et al*., 2006). This forest species is exotic, originally from Madagascar and adapted to tropical climate conditions (Babineau and Bruneau, 2017). The species is known for its showy and attractive flowers, which vary in color from red to orange (Rocha *et al*., 2021; Souza *et al*., 2023).

Flamboyant trees are important because of their ornamental potential and can be used for landscaping in cities and rural areas. In addition, its wood can be used to make canoes and light constructions, as well as the plant's medicinal potential (Venturoli *et al*., 2019, Khongkaew *et al*., 2020).

Flamboyant seedlings are mainly produced by seeds, but germination has its limitations (Myers and Vendrame, 2004). One of the main challenges to producing flamboyant seedlings is that the seeds of this species are physically dormant, as their tegument is impermeable to the entry of water and oxygen, restricting the development of the embryo (Carvalho and Nakagawa, 2000; Cossa, 2009; Ataíde *et al*., 2013). Dormancy is defined as the temporary suspension of growth of any part of the plant made up of meristems. It is a mechanism that helps plants to survive in places that make their development unfeasible, but it hinders the propagation of plants for cultivation and seedling production, as germination is uneven and slow (Smith *et al*., 2003; Lima *et al*., 2013).

The germination rate of seeds with impermeable teguments can be increased in the laboratory using methods to overcome dormancy. These methods aim to standardize and accelerate seed germination and seedling emergence, with a view to improving the production of forest seedlings (Silva *et al*., 2011). There are various methods for overcoming dormancy, with mechanical scarification, immersion in hot water and cold stratification being widely used in many forest species (Fowler and Bianchetti, 2000).

The aim of this study was to analyze different methods of overcoming the dormancy of *Delonix regia* (flamboyant) seeds with a view to producing seedlings.

MATERIAL AND METHODS

The study was carried out in 2021 at the Forest Engineering Department of the Federal University of Santa Maria (*Universidade Federal de Santa Maria* - UFSM), Frederico Westphalen campus, Rio Grande do Sul (27º22’S, 53º25’W), whose region has a humid subtropical climate (Cfa) and an average temperature of 19.1°C (Alvares *et al*., 2013). The procedures followed the order described below.

Seed collection and selection: Flamboyant seeds were collected in Restinga Seca, Rio Grande do Sul, from eight adult trees with healthy characteristics (straight stem and no visible pests or diseases). Selection was based on seed health and length, and a washing process with water and detergent was carried out to eliminate pathogens.

Preparing and conducting the experiment: the experiment was conducted in an air-conditioned chamber with temperature (25 ± 2°C) and humidity (80 ± 5%) control, using an intermittent mist irrigation system. The seeds were planted in 110 cm^3 tubes in trays filled with Maxfertil® (vermiculite, pine and eucalyptus bark, coconut fiber and recycled paper).

Treatments to overcome dormancy: the seeds were subjected to five treatments to overcome dormancy, including: Mechanical scarification (MS): sanding of the area opposite the micropyle with 120 grit sandpaper. Cold stratification (REF 8°C 18 hours): storage of the seeds in washed sand in a plastic pot, refrigerated at 8°C for 18 hours. Immersion in water at 100°C for five minutes (H_2O 100°C 5 m): seeds immersed in an electric kettle at 100°C, with temperature monitored. Immersion in water at room temperature for 24 hours (H_2O 24 hours): Seeds kept in water at room temperature for 24 hours. Control (TEST): seeds without any previous treatment, sown directly into the tubes.

Experimental design and evaluations: The experimental design was entirely randomized (DIC), with five treatments and five replicates of nine seeds, totaling 45 seeds per treatment. Weekly evaluations were carried out until 17 days after sowing to measure the germination percentage and the average number of emerged seeds (N.M.S.E.).

Germination Speed Index (G.S.I.): The G.S.I. was calculated through daily counts, and in accordance with that proposed by Maguire (1962). The counts began 3 days after sowing and lasted until the 17th day. The results of the G.S.I. were expressed as a percentage of normal seedlings emerging at 17 days, as shown below:

G.S.I. = (G1/N1) + (G2/N2) + ... + (Gn/Nn), where:

G.S.I. = Germination Speed Index;

G = number of normal seedlings counted;

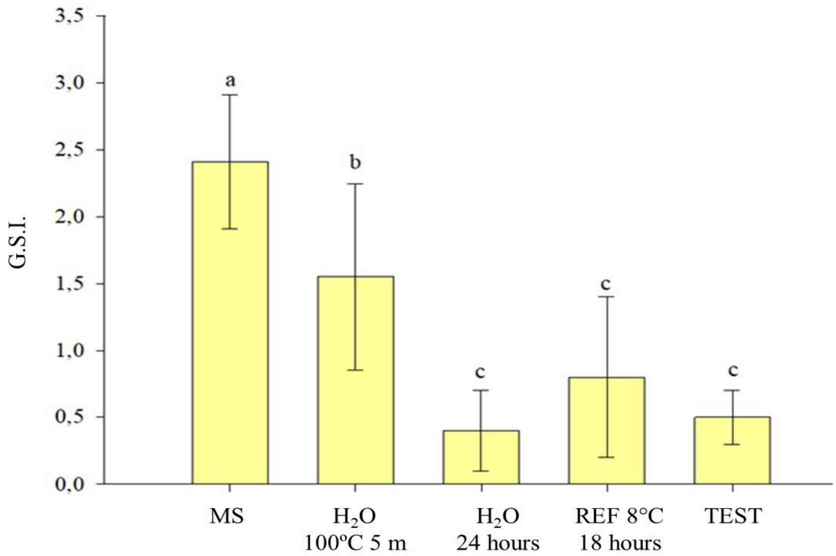
N = number of days from sowing to evaluation.

Statistical analysis: The data was tested for normality (Shapiro-Wilk) and homoscedasticity (Bartlett). When the data did not meet these criteria, the Kruskal-Wallis non-parametric analysis of variance was applied, followed by the Dunn test with Bonferroni correction at 5% probability, using the R software version 3.6.2 (R Development Core Team, 2020).

RESULTS AND DISCUSSION

The flamboyant seeds submitted to immersion in hot water at 100°C for five minutes and mechanical scarification with 120 grit sandpaper showed significantly higher germination speed indices (G.S.I.) (x^2= 19.49; G.L = 4, 20; *p*=<0.05) compared to the other treatments (Figure 1). These methods, with an average G.S.I. of 1.58 and 2.41, respectively, proved to be effective in overcoming the dormancy of *Delonix regia* seeds and speeding up the germination process, which can be of great value to nurseries looking to optimize seedling production.

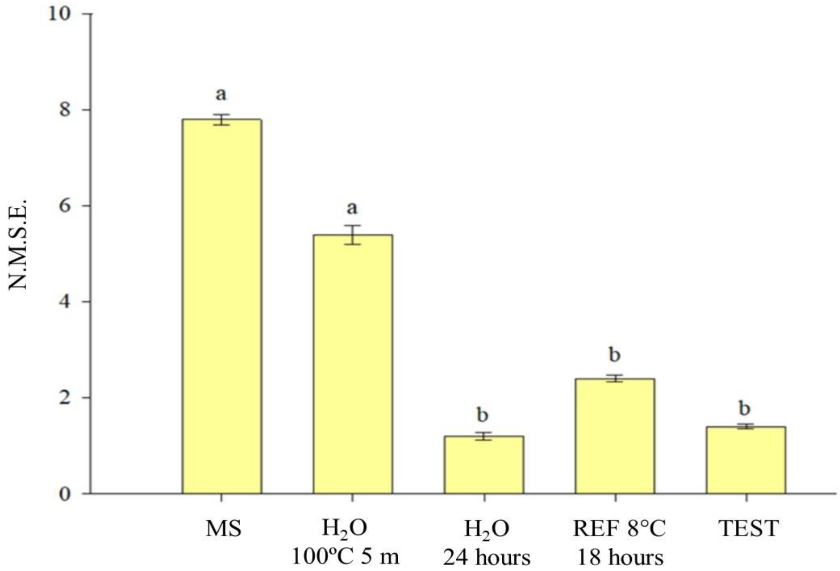
Figure 1 – Germination speed index (G.S.I.) of flamboyant seeds submitted to different treatments to overcome dormancy. Where: MS (mechanical scarification with 120 grit sandpaper); H_2O 100°C 5 m (immersion in water at 100°C for five minutes); H_2O 24 hours (immersion in water at room temperature for 24 hours); REF 8°C 18 hours (cold stratification with sand (refrigeration at 8°C for 18 hours) and TEST (control). Averages followed by different letters differ statistically by Dunn's test with Bonferroni correction at 5% probability. Vertical bars indicate the standard error.



Source: Authors (2025).

Mechanical scarification resulted in the highest average number of emerged seeds (7.8 seeds), followed by immersion in hot water at 100°C (5.4 seeds). Both treatments performed statistically better (x^2= 18.98; Gl: 4, 20; *p*=<0.05) than the other methods, which had lower emergence numbers and were close to the control (Figure 2). This result highlights mechanical scarification as the most efficient method for maximizing seedling emergence, while hot water immersion appears to be a practical and accessible alternative, especially useful in nurseries that need faster and simpler execution.

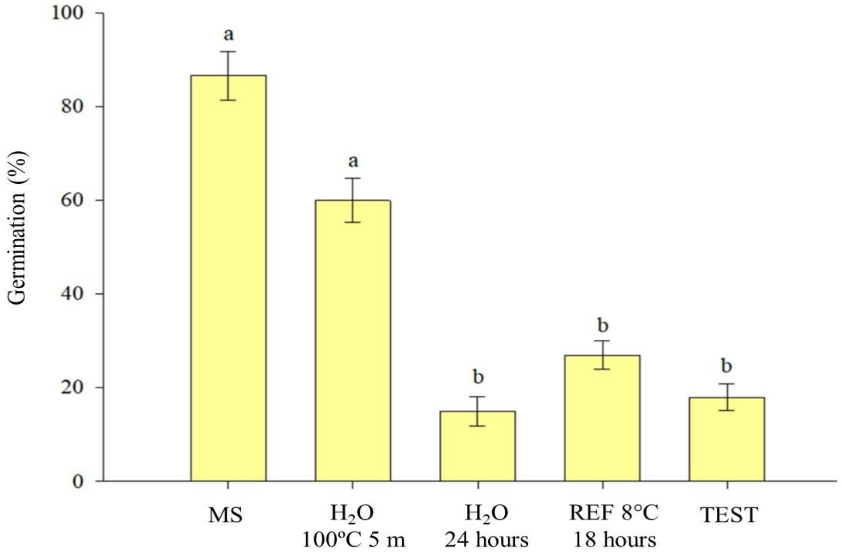
Figure 2 – Average number of emerged flamboyant seeds (N.M.S.E.) submitted to different treatments to overcome dormancy. Where: MS (mechanical scarification with 120 grit sandpaper); H_2O 100°C 5 m (immersion in water at 100°C for five minutes); H_2O 24 hours (immersion in water at room temperature for 24 hours); REF 8°C 18 hours (cold stratification with sand (refrigeration at 8°C for 18 hours) and TEST (control). Averages followed by different letters differ statistically by Dunn's test with Bonferroni correction at 5% probability. Vertical bars indicate the standard error.



Source: Authors (2025).

In terms of germination percentage, both mechanical scarification (86.66%) and hot water immersion (60%) stood out as superior methods for overcoming dormancy, significantly increasing (x^2 = 18.91, Gl = 4, 20; p=<0.05) the germination rate compared to the control and other treatments (Figure 3). These results indicate that, in practice, mechanical scarification is the most effective method for obtaining high germination rates, while hot water immersion represents a viable option in situations where access to scarification equipment may be limited.

Figure 3 – Germination percentage of flamboyant seeds submitted to different treatments to overcome dormancy. Where: MS (mechanical scarification with 120 grit sandpaper); H_2O 100°C 5 m (immersion in water at 100°C for five minutes); H_2O 24 hours (immersion in water at room temperature for 24 hours); REF 8°C 18 hours (cold stratification with sand (refrigeration at 8°C for 18 hours) and TEST (control). Averages followed by different letters differ statistically by Dunn's test with Bonferroni correction at 5% probability. Vertical bars indicate the standard error.



Source: Authors (2025).

In practice, mechanical scarification and immersion in hot water stand out as promising methods for producing flamboyant seedlings. By causing small cracks in the seed coat, mechanical scarification increases its permeability, facilitating water absorption and the start of the metabolic processes essential for germination (Franke and Baseggio, 1998; Lima *et al*., 2013). According to Lorenzi *et al*. (2003), this technique is widely recognized as one of the most effective methods for overcoming the dormancy of seeds with integumentary dormancy, as it directly favors soaking and subsequent germination.

These results are also supported by Oliveira *et al*. (2018), who observed that flamboyant seeds subjected to mechanical scarification and hot water immersion showed better germination rates compared to other methods. This alignment reinforces the consistency of the methods used and suggests that both can be widely applied under commercial conditions. Rocha *et al*. (2021) also pointed out that *Delonix regia* seeds submitted to mechanical scarification with sandpaper had higher germination rates, corroborating the findings of the present study and highlighting mechanical scarification as a reliable and high-performance method.

Hot water immersion, on the other hand, is advantageous due to its simplicity and low cost, as well as being a safe method for workers (Martins *et al*., 2008). Although it has not achieved the same levels of germination as mechanical scarification, hot water immersion allows a greater number of seeds to be treated simultaneously, making it an interesting alternative for large-scale nurseries. This method is especially practical in medium and large nurseries, where resources may be limited and simple management is essential (Perez, 2004).

Furthermore, according to Zaidan and Barbedo (2004), when dormancy is caused by the impermeability of the tegument, methods that promote soaking, such as scarification and the use of hot water, should be prioritized. Thus, the use of hot water for flamboyant seeds offers a practical and efficient solution for increasing germination, even if it does not reach the maximum performance of mechanical scarification, while still offering a robust and economically viable germination rate.

FINAL CONSIDERATIONS

Mechanical scarification with water sandpaper No. 120 and immersing the seeds in water at 100 °C for five minutes are more efficient in overcoming the dormancy of *Delonix regia* and can be used in nurseries to produce flamboyant seedlings.

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