Sustainable techniques for overcoming seed dormancy in Flamboyant

ABSTRACT

Aims: The aim of this study is to evaluate methods of overcoming the dormancy of *Delonix regia* seeds, with an emphasis on sustainable techniques
Study design: The experimental design was entirely randomized, with five replicates of 20 seeds.
Place and Duration of Study: The study was conducted on the premises of the Instituto Federal do Tocantins, Câmpus Avançado Formoso do Araguaia, located in the municipality of Formoso do Araguaia, in the state of Tocantins, Brazil. Between September 2024 and October 2024
Methodology: The seeds were subjected to the following treatments: T1, untreated seeds (control); T2, chemical scarification with sulfuric acid for 3 minutes; T3, chemical scarification with sulfuric acid for 5 minutes; T4, immersion in water at 80°C for 3 minutes, followed by cooling to room temperature; T5, immersion in water at 80°C for 5 minutes, followed by cooling to room temperature; and T6, immersion in water at 80°C for 10 minutes, followed by cooling to room temperature. The analyses carried out included seedling emergence, the emergence speed index, the average emergence time and the emergence speed coefficient.

Results: The results of this study indicated that heat treatments with immersion in water at 80°C for 5 minutes (T5) were the most effective in overcoming the dormancy of *Delonix regia* seeds. This method resulted in the highest emergence rates and the highest emergence speed indexes (ESI), highlighting its potential as a sustainable and efficient alternative to chemical treatments.

Conclusion: It is concluded that the application of sustainable methods, such as heat treatments, represents a promising strategy for overcoming seed dormancy in tropical species, especially in contexts that demand ecologically responsible techniques suitable for large-scale operations.

Keywords: Delonix regia; seed dormancy; germination rate; overcoming dormancy; tropical species.

1. INTRODUCTION

Seed dormancy is a fundamental adaptive phenomenon that plays a crucial role in the survival of plants in variable environments. This evolutionary process confers an essential competitive advantage, especially in regions characterized by seasonal variations in climate and water availability (Lennon et al., 2021; Finch-Savage and Leubner-Metzger, 2006). The importance

of dormancy is particularly evident in tropical ecosystems, where competition for resources is intense and climatic conditions are highly unpredictable (Zhang et al., 2022).
In the context of tropical species, the flamboyant (*Delonix regia*) stands out as a tree widely recognized for its ornamental beauty and adaptability to different environments and is often used in reforestation and urban landscaping projects (Ataíde et al., 2013; Lima et al., 2013).
However, the low germination rate of its seeds, resulting from the impermeability of the integument, constitutes a significant obstacle to the large-scale propagation of the species (Mwase et al., 2015; Olatunji et al., 2017). Dormancy is influenced by several factors, including the characteristics of the integument, chemical exclusion and specific environmental requirements (Baskin and Baskin, 2014).
Various methods have been proposed to overcome the dormancy of flamboyant seeds. Techniques such as mechanical scarification, immersion in hot water and chemical treatments have proved effective in promoting germination (Lima et al., 2013; Míssio et al., 2011). Mechanical scarification, for example, consists of controlled abrasion of the seed coat, facilitating water absorption and the start of the germination process (Ataíde et al., 2013). Hot water immersion is considered a practical and efficient technique for overcoming the physical dormancy of seeds (Sorace et al., 2009).
Innovation in the application of these techniques is key to optimizing flamboyant propagation and promoting more sustainable agricultural practices. Adopting methods that eliminate the use of environmentally harmful chemicals not only improves germination rates, but also favors more ecological agriculture (Pausas and Lamont, 2022).
Furthermore, overcoming seed dormancy has significant implications for the recovery of degraded areas, contributing to the restoration of ecosystems and the conservation of biodiversity (Samarasinghe et al., 2022).
Recent studies highlight that understanding the mechanisms of dormancy and the techniques for overcoming it can promote significant advances in the propagation of native and exotic species (Zhang et al., 2022). Research into the effects of temperature and exposure time on different methods of overcoming dormancy is crucial for developing effective protocols for growing flamboyant and other species with similar characteristics (Míssio et al., 2011; Lima et al., 2013).
The aim of this study is to evaluate methods of overcoming the dormancy of *Delonix regia* seeds, with an emphasis on sustainable techniques such as hot water immersion and chemical treatments. The research aims to analyze the effects of specific factors, such as temperature and exposure time, to establish effective protocols for seed germination.

2. MATERIAL AND METHODS

2.1 Location of the study

The study was conducted on the premises of the Instituto Federal do Tocantins, Câmpus Avançado Formoso do Araguaia, located in the municipality of Formoso do Araguaia, in the state of Tocantins, Brazil (Fig. 1).
The climate of Formoso do Araguaia is characterized as tropical, humid and hot, with well-defined seasons: a rainy summer and a dry winter. The average annual temperature is approximately 24°C, ranging from lows of 15°C, usually recorded between May and June, to highs of 35°C, predominantly between September and October.
The region has low thermal amplitudes due to the topographical characteristics of the plain, which contribute to thermal stability. The predominant vegetation includes floodplains, savannahs and fields, making up an environment that is conducive to the development of agricultural and forestry experiments. These climatic and environmental conditions are especially relevant for the germination and growth of tropical species such as the flamboyant (*Delonix regia*), whose propagation can be influenced by local factors such as temperature and water regime.

Fig. 1. Location of the Federal Institute of Tocantins, Câmpus Avançado Formoso do Araguaia, municipality of Formoso do Araguaia, State of Tocantins, Brazil.

2.2 Description of the experiment

The seeds used in this study were collected from flamboyant plants (*Delonix regia*) located at the Formoso do Araguaia Advanced Campus (Fig. 2). The pods were then transported to the agriculture laboratory, where the seed processing process was carried out, including classification and the removal of deteriorated seeds. The seeds were then subjected to the following treatments:

T1: Untreated seeds (control).
T2: Chemical scarification with sulfuric acid for 3 minutes.
T3: Chemical scarification with sulfuric acid for 5 minutes.
T4: Immersion in water at 80°C for 3 minutes, followed by cooling to room temperature.
T5: Immersion in water at 80°C for 5 minutes, followed by cooling to room temperature.
T6: Immersion in water at 80°C for 10 minutes, followed by cooling to room temperature.

After treating the seeds, they were sown in 200-cell polypropylene trays. The trays were then placed in a screened nursery, where they remained throughout the evaluation period. The trays were irrigated twice a day.

Fig 2. Flamboyant tree (*Delonix regia*) located at the Advanced Campus of Formoso do Araguaia, Tocantins, used as a matrix for collecting the seeds used in the study.

2.3 Evaluations

2.3.1 Seedling emergence (SE): Evaluations were carried out by counting emerged seedlings with expanded cotyledon leaves up to the 21st day after sowing**.**

2.3.2 Emergence speed index (ESI): The test was conducted simultaneously with the emergence test. Daily counts were taken during the corresponding period, until the last count of the number of emergence seedlings. The emergence speed index was calculated according to Maguire's formula (1962).

2.3.3 Average emergence time (EMT): this was calculated according to the formula presented by LABOURIAU (1983).

2.3.4 Coefficient of speed of emergence (CSE): according to the formula proposed by ROOS and MOORE III (1975).

2.4 Statistical analysis

The experimental design was entirely randomized, with five replicates of 20 seeds. The data was tested for normality, homoscedasticity, analysis of variance using the F test and the means were compared using the Tukey test at 5% probability, using the GENES statistical program (Cruz, 2013). Graphs were generated using SigmaPlot software, version 14.

3. RESULTS AND DISCUSSION

The analysis of variance indicated that the treatments applied had statistically significant effects (*P=.01*) on the variables seedling emergence (SE) and emergence speed index (ESI), with F values of 28.31 and 27.11, respectively. These results suggest that the treatments were effective in directly influencing the germination process of *Delonix regia* seeds (Table 1.)

Table 1. Results of the analysis of variance for the characteristics seedling emergence (SE), emergence speed index (ESI), mean emergence time (MET) and emergence speed coefficient (ESC).

Treatments	SE	ESI	MET	CSE
F values	28.31 **	27.11**	1.43 NS	0.04 NS
Average	24.17	0.329	5.04	3.45

Significant effect 1% (**) and not significant (NS).

On the other hand, the variables mean emergence time (MET) and coefficient of speed of emergence (CSE) showed no significant differences between the treatments, with F values of 1.43 and 0.04, respectively. The lack of significance can be attributed to the homogeneity of the seedling emergence times, regardless of the treatment applied, indicating that although the treatments affected germination, there was no substantial difference in the speed of emergence.

However, the lack of significant effects on the MET and CSE variables suggests the need to adjust the conditions under which the treatments were applied, such as the exposure time and the intensity of the scarifying agent (Maguire,1962). This lack of significance may be associated with the relative uniformity in the response times of the seeds submitted to the treatments, suggesting that germination, although facilitated, was not sufficiently differentiated in terms of speed between the groups tested (Dutra et al., 2017).

The limited performance in some variables may be related to the specific characteristics of the seed coat, such as its thickness and impermeability, which act as physical barriers to germination (Carvalho and Nakagawa, 2012). In addition, treatments using high temperatures, such as immersion in hot water, may have generated variations in the results due to the risk of cell damage, as discussed by Shimizu et al. (2011).

Fig. 3 presents the emergence data of *Delonix regia* seedlings submitted to different dormancy overcoming treatments, with the means compared using the Tukey test. There was a significant difference between the treatments (*P=.01*), showing the different effectiveness of the methodologies evaluated.

Treatment T1, in which the seeds did not receive any type of intervention, resulted in an average emergence of just 6% (Fig. 3). This shows the presence of integumentary dormancy in *Delonix regia* seeds, a common characteristic in species of the Fabaceae family (Carvalho and Nakagawa, 2012). Without intervention, the impermeable tegument prevents adequate soaking, which is essential for activating the metabolism necessary for germination (Bewley et al., 2013).

Treatments T2 and T3, which involve chemical scarification with sulfuric acid for 3 and 5 minutes, respectively, also resulted in low emergence (Fig. 3). Although sulfuric acid is recognized as an effective method for breaking dormancy in seeds with hard teguments (Shimizu et al., 2011), the exposure time of less than 5 minutes may have been insufficient to significantly degrade the tegument, corroborating the findings of Kramer and Zonetti (2018), who highlight the need to optimize exposure time to maximize results.

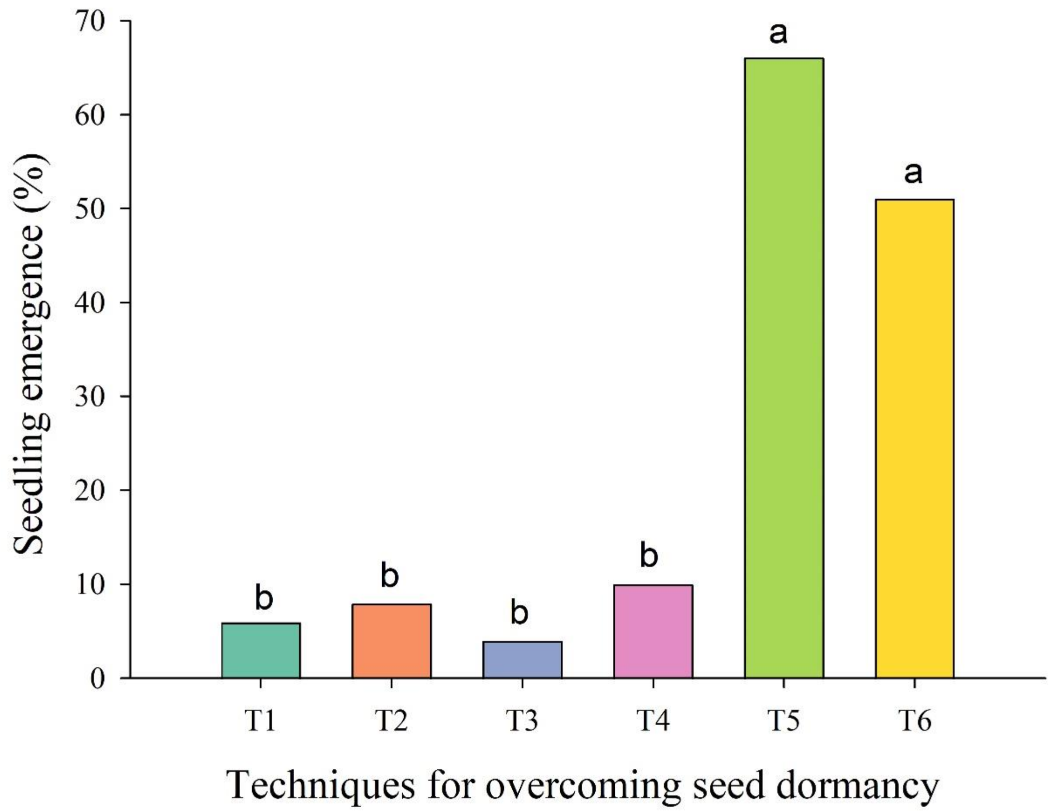

Fig 3. Emergence data of *Delonix regia* seedlings submitted to different dormancy overcoming treatments, with means compared by Tukey's test at 1% probability.

Treatments T4, T5 and T6, which used immersion in water at 80°C followed by cooling, were the most effective, with average emergences of 10%, 66% and 51%, respectively. Treatments T5 and T6 stood out, being statistically superior to the other treatments evaluated (Fig. 3). The greater efficiency of these treatments can be attributed to the combination of heat shock and exposure time (5 minutes), which promoted changes in the permeability of the tegument without damaging the embryo, as suggested by Dutra et al. (2017).

Treatment T6 (immersion in water at 80°C for 10 minutes) showed reduced emergence compared to T5, suggesting that prolonged exposure to heat can cause thermal damage to the embryo or tegument cells, compromising germination (Bewley et al., 2013).

When comparing the treatments, the application of water at 80°C for 5 minutes (T5) was the most effective method, significantly outperforming both the control and the sulfuric acid treatments. This reinforces the idea that thermal methods can be a more sustainable and safer alternative for overcoming dormancy in *Delonix regia* seeds, especially in situations where the use of chemical agents is limited by environmental or safety issues (Dutra et al., 2017).

These results highlight the importance of aligning the effectiveness of treatments with ecologically responsible practices, as proposed by Carvalho et al. (2019). The application of thermal treatments, such as the one used in T5, also shows potential for large-scale operations, offering lower risks compared to treatments involving the use of aggressive chemicals.

Fig. 4 presents the results of the Emergence Speed Index (ESI) of *Delonix regia* seeds submitted to different treatments to overcome dormancy, with the data analyzed using the

Tukey test at 1% probability. The results showed a significant difference between the treatments, demonstrating the effectiveness of some methods in promoting faster seedling emergence.

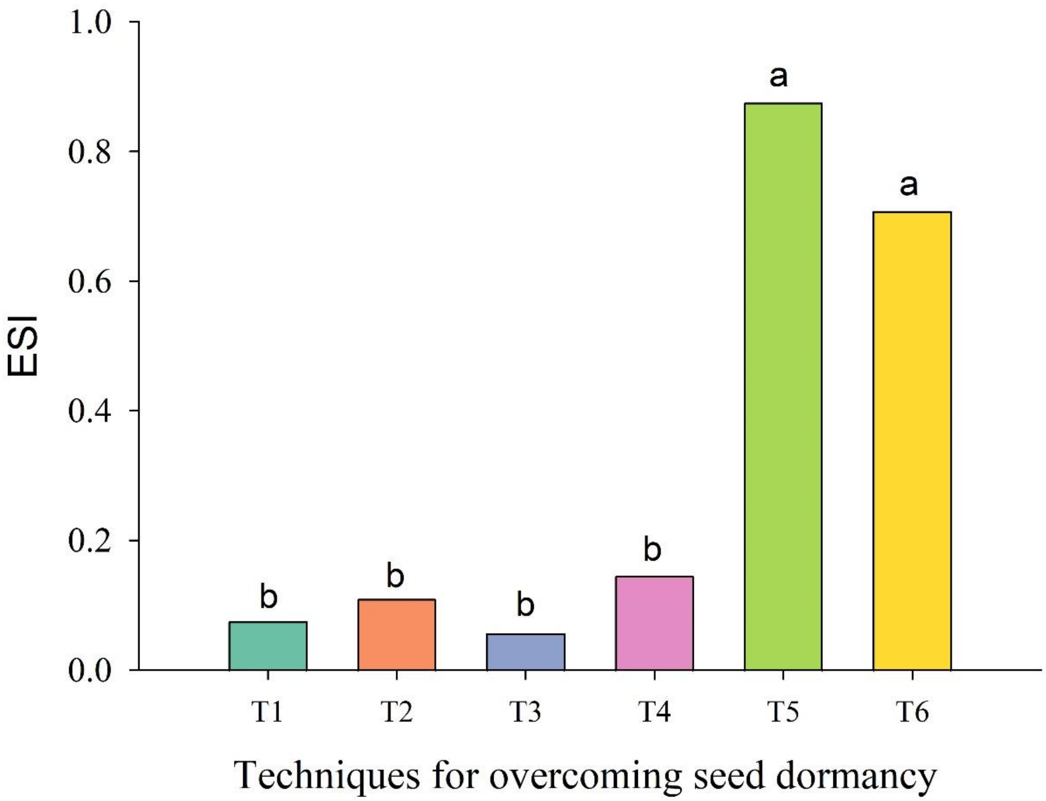

Fig. 4. Emergence speed index (ESI) data of *Delonix regia* seedlings submitted to different dormancy overcoming treatments, with means compared by Tukey's test at 1% probability.

Treatments T5 and T6, which involve immersion in water at 80°C for 5 and 10 minutes, respectively, showed the highest ESI values (Fig. 4). These treatments highlight the superiority of moderate heat shock in accelerating seed germination. Exposure to high temperatures for an appropriate length of time facilitates the rupture of the tegument without damaging the embryo, promoting more efficient seedling emergence, as observed by Shimizu et al. (2011). The efficiency of these techniques corroborates studies that point to heat treatments as promising for overcoming dormancy in Fabaceae seeds (Kramer and Zonetti, 2018).

On the other hand, treatments T1, T2, T3 and T4, which involved chemical scarification with sulfuric acid for different exposure times and immersion in water at 80°C for 3 minutes, showed considerably lower EVI values (Fig. 4). These results indicate that, although the action of sulfuric acid is widely recognized in overcoming dormancy (Bewley et al., 2013), the duration of exposure in treatments T2 to T4 was insufficient to promote the effective breaking of the integument, resulting in slower emergence. These data corroborate the findings of Kramer and Zonetti (2018), who highlight the need to optimize the time of exposure to acid in order to obtain better results in ESI.

The higher emergence speed indices (ESI) observed in treatments T5 and T6 can be explained by the combination of temperature and time, which favored faster hydration of the

seeds and more efficient activation of the metabolic processes involved in germination. The increase in the speed of emergence observed with these treatments is consistent with the literature, which highlights the importance of integrating factors such as temperature and time for efficiency in breaking tegument dormancy (Carvalho and Nakagawa, 2012).
The data suggests that, for *Delonix regia*, heat treatments with exposure times of 5 to 10 minutes are the most suitable for promoting not only greater emergence, but also better initial seedling vigor, as evidenced by the high ESI values. In addition, the adoption of more sustainable methods, such as heat treatments, may be preferable to the use of chemical acids, minimizing environmental and safety risks (Dutra et al., 2017).

4. CONCLUSION

It is concluded that the application of sustainable methods, such as heat treatments, represents a promising strategy for overcoming seed dormancy in tropical species, especially in contexts that demand ecologically responsible techniques suitable for large-scale operations. The results of this study also highlight the importance of understanding the factors that influence dormancy in order to develop efficient protocols, contributing to the propagation of species with high ornamental and ecological value, such as the flamboyant (*Delonix regia*).

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