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Original article

Pre-germination treatments in Phoenix canariensis seeds for urban forestry (Lima, Peru)

Tratamientos pregerminativos en semillas de Phoenix canariensis para la silvicultura urbana (Lima, Perú)

Tratamentos pré-germinativos em sementes de Phoenix canariensis para silvicultura urbana (Lima, Peru)

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ABSTRACT

The objective of the present study on the *Phoenix canariensis palm* Wildpret aimed to evaluate the effects of different pre-germination treatments on the seeds of this species for their subsequent use in urban forestry. Six pre-germination treatments were employed: scarification (T_{ES}), hot water (T_{CA}), cold water (T_{FR}), 9% hydrochloric acid for 15 minutes (T_{A15}), 9% hydrochloric acid for 30 minutes (T_{A30}), and a control treatment (T_{TE}). The germination percentage (PG) and the number of days required to reach maximum germination (energy period) were reported. The results showed that the most effective treatments were scarification (T_{ES}), with a germination percentage of 81.33% from day 22 to day 35 of the trial, and hot water (T_{CA}), with a germination percentage of 86.67% from day 32 to day 35 of the trial. These results show that the use of pre-germination treatments can be essential to overcome the physical dormancy of *Phoenix canariensis* seeds and promote their faster and more uniform germination, a key aspect for the production of plants intended for reforestation projects in urban forestry contexts.

Keywords: *Phoenix canariensis,* pre-germination treatments, seed propagation, urban forestry, palm trees.

RESUMEN

El objetivo del presente estudio sobre la palmera *Phoenix canariensis* Wildpret fue evaluar los efectos de diferentes tratamientos pregerminativos en las semillas de esta especie, para su posterior uso en la silvicultura urbana. Se emplearon seis tratamientos pregerminativos: Escarificación (T_{ES}), Agua caliente (T_{CA}), Agua fría (T_{FR}), Ácido clorhídrico de 9% por 15 minutos (T_{A15}), Ácido clorhídrico de 9% por 30 minutos (T_{A30}) y el tratamiento Testigo (T_{TE}). Se reportó el porcentaje de germinación (PG) y la cantidad de días requeridos para alcanzar el máximo de germinación (periodo de energía). Los resultados mostraron que los tratamientos más eficaces fueron el de Escarificación (T_{ES}) con un porcentaje de germinación de 81,33% desde el día 22 hasta el día 35 del ensayo y el tratamiento con Agua caliente (T_{CA}) con un porcentaje de germinación de 86,67% desde el día 32 hasta el día 35 que duró el ensayo. Estos resultados evidencian que el uso de tratamientos pregerminativos puede ser esencial para superar la latencia física de las

semillas de *Phoenix canariensis* y promover su germinación más rápida y uniforme, aspecto clave para la producción de plantas destinadas a proyectos de reforestación en contextos de silvicultura urbana.

Palabras clave: *Phoenix canariensis*, tratamientos pregerminativos, propagación de semillas, silvicultura urbana, palmeras.

RESUMO

O objetivo deste estudo com a palmeira Phoenix canariensis Wildpret foi avaliar os efeitos de diferentes tratamentos pré-germinativos em sementes desta espécie para posterior utilização em arborização urbana. Foram utilizados seis tratamentos pré-germinativos: escarificação (TES), tratamento com água quente (HWT), tratamento com água fria (CWT), ácido clorídrico a 9% por 15 minutos (HW15), ácido clorídrico a 9% por 30 minutos (HW30) e o tratamento controle (CTT). A porcentagem de germinação (GP) e o número de dias necessários para atingir a germinação máxima (Período de Energia) foram relatados. Os resultados mostraram que os tratamentos mais eficazes foram a escarificação (SST), com uma taxa de germinação de 81,33% do dia 22 ao dia 35 do ensaio, e o tratamento com água quente (HWT), com uma taxa de germinação de 86,67% do dia 32 ao dia 35 do ensaio. Esses resultados demonstram que o uso de tratamentos pré-germinativos pode ser essencial para superar a dormência física das sementes de Phoenix canariensis e promover uma germinação mais rápida e uniforme, aspecto fundamental para a produção de plantas para projetos de reflorestamento em contextos de silvicultura urbana.

Palavras-chave: Phoenix canariensis, tratamentos pré-germinativos, propagação de sementes, silvicultura urbana, palmeiras.

INTRODUCTION

From the Arecaceae family, the most important species for their ornamental use stand out: *Phoenix dactylifera* L., *Phoenix roebelenii* O'Brien, *Phoenix canariensis* Wildpret, *Phoenix theophrasti* Greuter, *Phoenix sylvestris* (L.) Roxb. and *Phoenix reclinata* Jacq. It is also reported that virtually all species have been cultivated by nursery growers, resulting in the wide diversity found in gardens worldwide (Martínez Rico 2017). This study will focus on *Phoenix canariensis*. Wildpret. This palm tree is native to the Canary Islands. It is large (approximately 20 m) and slender, with pinnate leaves whose segments lie in a single plane and whose lower leaflets are transformed into strong spines (Santa Cruz *et al*., 2021). It has a broad, leafy, and dense crown (Bulnes *et al*., 2017). Commonly known as the "Phoenix palm" or "Canary Island date palm," it is an introduced species in coastal cities (Lima, the capital of Peru) and in the highlands of Peru (cities of Palca, Tarma, Caraz, and Huaraz), where it is highly valued for its ornamental use in urban areas (Brack 1999).

Most palm seeds have a hard seed coat and are in a state of physical dormancy, so their germination requires specific conditions of humidity, temperature, aeration, light, and a prolonged period. Therefore, the use of pre-germination treatments that promote seed coat degradation is recommended (León and Saldaña, 2011). Regarding physical dormancy, Broschat *et al.* (2014) mention that, in the case of palms of the genus Phoenix, the increase in the percentage and speed of germination is due to the removal of the mesocarp (testa) when the fruit has reached maturity, exhibiting a red, orange, or brown coloration. For example, in the case of *Phoenix canariensis, immersion in warm water for 24 to 48 hours* has been previously reported as a pre-germination treatment for its seeds (Paladini 1992).

Urban forestry integrates the cultivation and management of trees and palms to ensure the well-being of the population living in urban areas, providing environmental services to cities (Huaman, *et al*., 2024). Among them, the contribution to urban biodiversity that provides habitat and shade for urban fauna promoting the ex-situ conservation of the species; the aesthetic and recreational value given that their presence in landscapes and public spaces beautifies with their shape and color which allows improving the quality of life of the inhabitants (Martínez Rico 2017).

It should be noted that urban forestry in Latin America still exhibits a simplistic approach due to the limited availability of public spaces, high population growth, the increasing number of homes, and the small group of species (trees and palms) used. Furthermore, research in this field is minimal compared to other regions of the world, despite the high levels of urbanization and biodiversity in the region (Ordóñez-Barona *et al.*, 2020).

In this context, it is important to document as much information as possible on tree and palm propagation techniques for their subsequent planting in avenues, parks, gardens, and public spaces in our cities. The Canary Island date palm *(Phoenix canariensis*) is adapted to the site conditions of various cities in Peru. However, there is a lack of knowledge about its ecology and silviculture, which limits a complete understanding of its behavior and management. Therefore, further research on seed germination is needed to achieve more effective management of this emblematic species in the urban landscape.

This study seeks to evaluate the effect of different pre-germination treatments on the germination percentage and the number of days required to reach maximum germination of the palm species *P. canariensis* with the aim of increasing its propagation in urban areas, obtaining plants at low cost and in the shortest possible time.

MATERIALS AND METHODS

Origin of the seeds

The fruit collection and seed processing of *Phoenix canariensis* took place at the end of the summer season (March and April). Fruits of this palm were collected manually on the campus of the National Agrarian University La Molina (UNALM) in the district of La Molina (department of Lima, Peru). Adult palm trees (between 5 and 7 individuals) taller than 3 m, free of pests and diseases, with straight trunks, were selected. Collection was carried out directly from standing palms, following the recommendations of Valera and Aparicio (2011).

For seed processing, the fruits were washed and soaked in clean water for 12 hours in the shade. The extracted seeds were then washed and cleaned (to remove any remaining pericarp). They were then naturally dried in a container in the shade and in a well-ventilated area. Finally, they were stored in plastic bags at the UNALM Forestry Laboratory until the germination trial, which involved applying pre-germination treatments to break physical dormancy.

Pre-germination treatments

In this study, six pre-germination treatments were carried out (Table 1), based on the work of Ramos-Huapaya (2015) and Zeberio and Pérez (2020). Seventy-five *Phoenix canariensis* seeds were used for each treatment, for a total of 450 seeds in the entire trial.

After the application of the pre-germination treatments, the seeds were exposed to air currents and treated with a powdered agricultural fungicide (50% technical grade benomyl). Sowing was carried out in a metal germination tray (0.40 m x 0.60 m) at a depth twice the size of the seeds (approximately 3 cm), using disinfected river sand as a substrate, as described by Ramos-Huapaya (2015). A completely randomized design (CRD) with three replicates per treatment was used for the sowing design (each replicate contained 25 seeds).

Table 1*Description of pre-germination treatments used in the trial*

Treatment		Description
T ES	Scarification	Sanding the end
T FR	Cold water	Soak in cold water for 24 hours and then wash with drinking water for 2 minutes
T CA	Hot water	Soak in hot water for 30 minutes and then wash with drinking water for 2 minutes
T A15	Hydrochloric acid for 15 minutes	Soak for 15 minutes in 9% hydrochloric acid and then wash with potable water for 5 minutes
T A30	Hydrochloric acid for 30 minutes	Soak for 30 minutes in 9% hydrochloric acid and then wash with potable water for 5 minutes
T TE	Witness	Seeds that did not receive any pre-germination treatment

Data logging

Germination recording (evidence of radicle emergence) was performed every 3 days during an evaluation period of 35 days (counted from the installation of the trial).

The count of the number of germinated seeds was transformed into a germination percentage, which was evaluated cumulatively as the germination percentage (PG) variable.

From this value, the energy period was calculated (PE) and the day on which more than 50% of the evaluated seeds germinated (Table 2).

Table 2 *– Description of the variables evaluated.*

Variables	Description	Fountain
Germination percentage (PG)	Percentage of seeds that germinated based on the total number of seeds sown over 35 days.	Viveros *et al*. (2015)
Energy period (EP)	Number of days required to reach the maximum germination rate.	Pece *et al*. (2010)

Statistical tests

The Shapiro-Wilk test was performed, confirming that the data (number of germinated seeds and germination percentage) had a normal distribution. Analysis of variance was then conducted, and the following comparison tests were performed: Fisher's least significant difference (LSD) test and Tukey-Kramer multiple range test, both at a 95% confidence level (significance level of 0.05). Additionally, cluster analysis was performed to group the germination percentage (GP) variable according to a homogeneity criterion. The interpretation of the cluster analysis was carried out using a similarity dendrogram (Nolasco-Chumpitaz *et al.*, 2020). The software used for data analysis was *Infostat*. (2020 version), taking as references the work of Pece *et al.* (2010) and Zapata *et al*. (2017).

RESULTS AND DISCUSSION

Pre-germination treatments

Germination began on day 8 for four treatments (Scarification, Cold Water, Hot Water and Hydrochloric Acid for 15 minutes) and on day 10 for two treatments (Hydrochloric Acid for 30 minutes and Control) (Figure 1).

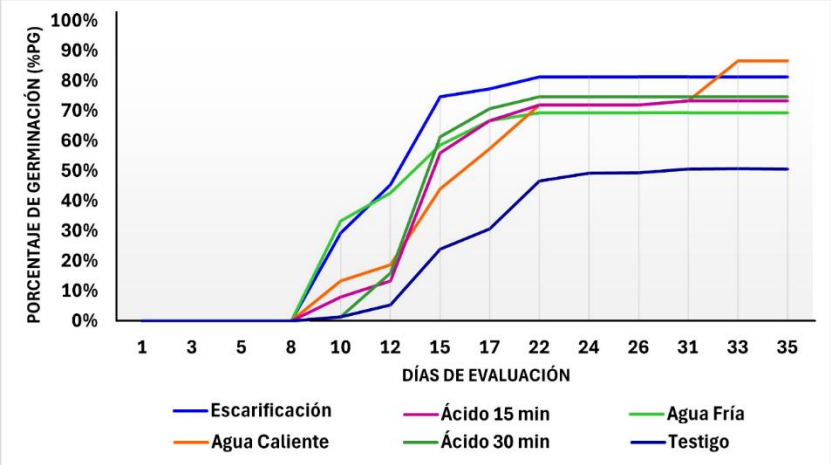

Figure 1*Germination percentage (PG) accumulated by pre-germination treatment*

The scarification treatment (T $_{ES}$) showed positive results by achieving high and homogeneous germination (Figure 1). Utello *et al.* (2023) indicate that manual sanding (scarification) achieves the best values for uniformity in seed germination, regardless of the seed type. In addition, Zapata *et al.* (2017) mention that mechanical scarification (sanding) reduces production costs and helps obtain uniform plants. This suggests that the abrasive action of sandpaper, used in the Scarification Treatment (T $_{ES}$), accelerated water penetration into the *Phoenix canariensis seeds* and the gas exchange necessary to trigger germination.

Of the six treatments, five exceeded 51% germination percentage (GP), while only the Control treatment (T $_{TE}$) did not. The two treatments with the highest mean germination percentage (GP) were Hot Water (T $_{CA}$ at 86.67% and Scarification (T $_{ES}$) at 81.33%. The Control treatment (T $_{TE}$) had the lowest mean germination percentage at 50.67% (Table 3).

The treatments that reached their energy period (number of days to reach maximum germination) in the shortest time were Scarification (T_{ES}), Cold Water (T_{FR}), and Hydrochloric Acid for 30 minutes (T_{A30}), requiring a total of 22 days. In contrast, the hot water treatment (T_{CA}) took the longest, reaching its energy period (EP) on day 32 (Table 3).

In the present trial, the day on which more than 50% of the seeds germinated was also evaluated, with the Scarification treatment (T_{ES}) the first of all to achieve it on day 12, in contrast to the Control treatment (T_{TE}) which was only able to achieve it on day 31. In the remaining four treatments more than 50% of their seeds germinated between days 15 and 17 of evaluation (Figure 1).

Table 3.- *Germination Percentage (GP) Statistics at 35 days.*

Treatment	Germination Percentage (PG)				No. day to germinate more than 50% of seeds	Day number to arrive at PE*
	Average (%)	Standard Error (SE)	Standard Deviation (SD)	Coefficient of Variation (CV)		
Scarification (T_{ES})	81.33	3.53	6.11	7.51	12	22
Cold water (T_{FR})	69.33	4.81	8.33	12.01	15	22
Hot water (T_{CA})	86.67	5.81	10.07	11.62	17	32
Hydrochloric acid for 15 minutes (T_{A15})	73.33	4.81	8.33	11.35	15	29
Hydrochloric acid for 30 minutes (T_{A30})	74.67	1.33	2.34	3.09	15	22
Witness (T_{TE})	50.67	4.81	8.33	16.43	31	29

**PE (energy period): number of days required to reach the maximum germination rate.*

In general, the best germination responses were reported by the Hot Water treatment (T_{CA}) with an 86.67% Germination Percentage (GP) from day 32 to day 35 of the trial, followed by the Scarification treatment (T_{ES}), which reported the second highest Germination Percentage (GP) at 81.33%, but from day 22 to day 35 of the evaluation (Figure 2). Likewise, the scarification of *Phoenix canariensis* seeds It achieved a germination rate of over 80% in the fewest number of days (starting on day 22 of the

trial), indicating its validity for accelerating seed germination in this palm species (Figure 2). Broschat, for his part, *et al.* (2014) indicate that, in most palm trees, soaking the seeds in water for seven days increases the germination rate. However, the optimal soaking time and ideal water temperature have not yet been precisely determined.

Regarding the cold-water treatment (T $_{FR}$), it reported the second lowest Germination Percentage (GP) value at 69.33% (only higher than the control treatment). However, this type of treatment is widely used for palm seed germination. ARBORIZACIONES EIRL (2014) indicates that many ornamental palms exhibit Germination Percentage (GP) values between 65% and 80%, and recommends soaking the seeds in cold water for 48 hours as a pre-germination treatment. Ramón-Jiménez *et al*. (2004) indicate that the pre-germination treatments used for some palm species are soaking and/or immersion in water, from one hour to 21 days. Furthermore, Flores *et al*. (2020) indicate that the most effective pre-germination treatment for the seeds of the Amazonian palm *Euterpe precatoria* is soaking or immersion in water for 48 hours. Mart. (huasaí) was immersion in water at room temperature for 72 hours, resulting in a more uniform germination with 51%.

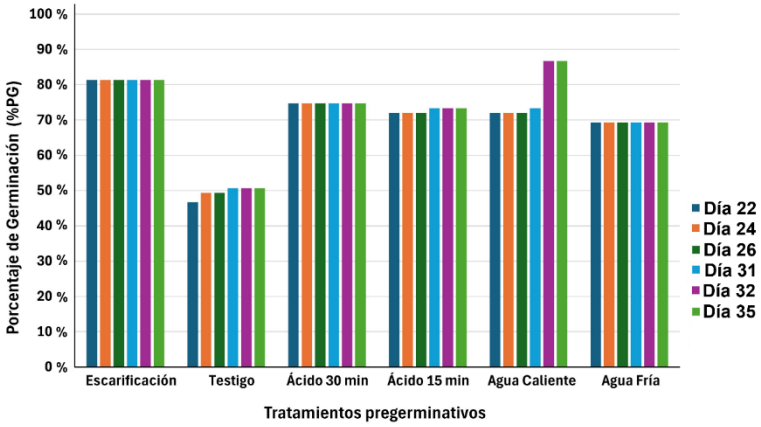

Figure 2- *Percentage of germination per treatment and day of evaluation*

The analysis of variance shows that the probability value is less than the significance level (α = 0.05) (Table 4), which determined that the pre-germination treatments (at least one) influenced the study variable of Germination Percentage (PG).

Table 4- *Analysis of variance*

Source of variability	Sum of squares	Degrees of freedom	Middle square	Test statistic	Probability value
Model	2312.00	5	462.40	7.88	0.0017
Treatment	2312.00	5	462.40	7.88	0.0017
Mistake	704.00	12	58.67		
Total	3016.00	17			

The analysis of variance (Table 4) and Fisher's LSD method (Table 5) were performed to evaluate the Germination Percentage (GP) in *Phoenix canariensis palm seeds Applying the* pre-germination treatments showed that there are statistically significant differences ($P < 0.05$) between the Control treatment (T_{TE}) and the five remaining treatments. However, it is important to mention that the average Germination Percentage (GP) of the Hot Water treatment (T_{CA}) was numerically higher than the other five treatments applied.

Table 5.- *Fisher's Least Significant Difference (LSD) Method*

Treatment	Socks	Number of repetitions	Homogeneous groups
T_{TE}	50.67	3	to
T_{FR}	69.33	3	b
T_{A15}	73.33	3	b, c
T_{A30}	74.67	3	b, c
T_{ES}	81.33	3	b, c
T_{CA}	86.67	3	c

Means with a common letter are not significantly different (P > 0.05).

The analysis of variance (Table 4) and the Tukey-Kramer multiple range test (Table 6) performed for the Germination Percentage (GP) variable showed no statistically significant differences ($P > 0.05$) among the treatments of Cold Water (T_{FR}), Hydrochloric Acid for 15 minutes (T_{A15}), Hydrochloric Acid for 30 minutes (T_{A30}), Scarification (T_{ES}), and Hot Water (T_{CA}). Similarly, the Scarification (T_{ES}) treatments and Hot Water (T_{CA}) They provided the highest Germination Percentage (GP) values between 80% and 87%.

Table 6*Tukey -Kramer multiple range test.*

Treatment	Socks	Number of repetitions	Homogeneous groups
T_{TE}	50.67	3	to
T_{FR}	69.33	3	a, b
T_{A15}	73.33	3	b
T_{A30}	74.67	3	b
T_{ES}	81.33	3	b
T_{CA}	86.67	3	b

Means with a common letter are not significantly different ($P > 0.05$).

Significant differences were observed between the control treatment (T_{TE}) and the other five treatments (Table 5 and Table 6), indicating that not using any pre-germination treatment delays the germination of *Phoenix canariensis seeds*. Of the five treatments, the hot water treatment (T_{CA}) yielded the highest average Germination Percentage (GP) values, thus validating its use. Luna and Fontana (2022) indicate that the pre-germination treatment of immersion in hot water (generally between 70 °C and 100 °C) followed by cooling to room temperature is widely used in tropical forest species, as it breaks dormancy and is an economical, easy, and safe method to apply. They also mention that its effectiveness depends not only on the soaking or immersion time in hot water and the water temperature range, but also on the species. Sánchez-Paz and Ramírez-Villalobos (2006), after working with thick-seeded forest seeds such as *Leucaena leucocephala* (Lam.) of Wit and *Prosopis juliflora* (Sw.) DC., suggest that pre-germination treatments with hot water are the most favorable, effective, easy, and safe to apply; therefore, they recommend their use. However, Broschat *et al.* (2014) indicate that

transient soaks (of one minute) in water at 100 ° C are lethal to the seeds of the *Phoenix reclinata palm tree* Jacq. and *Astrocaryum standleyanum* LH Bailey. Therefore, treatments involving immersion in hot water must allow the water to cool naturally to room temperature.

In summary, the combination of scarification (T_{ES}) and hot water (T_{CA}) pre-germination treatments could be beneficial for accelerating the germination processes of *Phoenix canariensis seeds*, as both were the most effective during the trial. Research on other forest and palm species highlights that combining pre-germination treatments with the application of thermal treatments or different temperature regimes can break seed dormancy (Valera and Aparicio 2011; Alizaga). *et al*., 2012; Gonçalves *et al*., 2024). For example, Pimenta *et al*. (2010) report that the use of *Phoenix canariensis seeds* from overripe (brown) fruits, along with temperature variations between 20 ° C and 30 ° C and a photoperiod of 8 hours of light for 40 days, positively influences the germination process, reaching a rate of 98 %, much higher than that recorded when applying constant temperatures (25 ° C, 30 ° C and 35 ° C). Similarly, Rodríguez (2019) points out in his literature review that *Phoenix canariensis seeds* increase their germination percentage by reducing the seed moisture content, going from 45 % to 35.2 %. This agrees with what Spennemann reported. *et al*. (2021) maintain that *Phoenix canariensis seeds* are tolerant to desiccation, allowing them to survive in arid or water-scarce environments. Furthermore, they acknowledge that aged seeds (from previous harvesting and processing seasons) have good preservation potential.

Furthermore, combining different treatments to improve germination has also been suggested, such as scarification along with hydration (by soaking in hot or cold water), stratification combined with scarification (Abril -Saltos *et al*., 2017; Luna and Fontana, 2022), or the application of thermal treatments that involve temperature variations during the germination process (Pimenta *et al*., 2010). Mayo-Mosqueda *et al.* (2017) suggest using freshly collected seeds and applying pretreatments with chemical substances combined with pericarp removal, which increased the Germination Percentage (GP) of *Calyptrogyne* palm seeds. *ghiesbreghtiana* (Linden & H. Wendl.) H. Wendl.

Cluster analysis

A cluster analysis was performed based on the similarity of their Germination Percentage values (with a Euclidean distance of 0.45), where 3 groups or clusters were formed. Group 1 (G1) consisted only of the Control treatment (T_{TE}), group 2 (G2) consisted of the Scarification (T_{ES}) and Hot Water (T_{CA}) treatments, and group 3 (G3) consisted of the Cold Water (T_{FR}), Hydrochloric Acid for 30 minutes (T_{A30}) and Hydrochloric Acid for 15 minutes (T_{A15}) treatments (Figure 3).

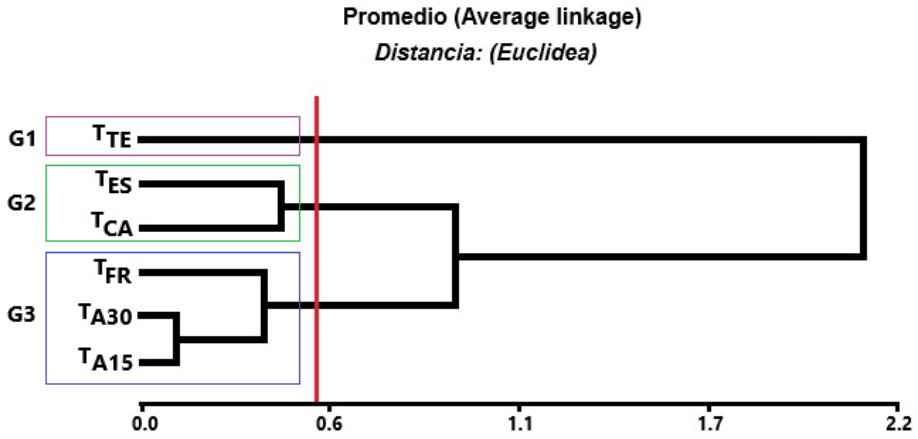

Figure 3*Cluster analysis of the six pre -germination treatments*

Group 1 consists solely of the Control treatment (T_{TE}), an independent group that exhibited the lowest average germination percentage (50.67%), significantly different from the other treatments. Group 2, comprised of the Scarification (T_{ES}) and Hot Water (T_{CA}) treatments, is characterized by the fact that both treatments presented the highest germination percentage rates (between 80% and 87%), making them the two most effective treatments for germinating *Phoenix canariensis seeds*.

Group 3, consisting of the treatments Cold Water (T_{FR}), Hydrochloric Acid for 30 minutes (T_{A30}) and Hydrochloric Acid for 15 minutes (T_{A15}), is characterized by Germination Percentage (PG) values between 69% and 75%. It should be mentioned that within group 3, a subgroup was formed consisting of the two treatments that applied hydrochloric acid, and these were the ones that showed the greatest similarity to each other, with a Germination Percentage (PG) between 73% and 75%.

Final considerations

Despite being an introduced species in Lima and several coastal and Andean cities of Peru, the Canary Island date palm (*Phoenix canariensis*) has adapted very well to the urban environment. In Metropolitan Lima, its abundance and excellent growth are noteworthy (Santa Cruz *et al.*, 2021), and it is present in many parks, green areas, avenues, private gardens, and urban forests located in different districts of Metropolitan Lima (Santa Cruz *et al.*, 2021; Huaman *et al.*, 2024). Due to its physical characteristics, resilience, and wide ecological range, which allows it to thrive in both humid and arid zones and at different altitudes, *Phoenix canariensis* can be considered an emblematic species of the urban landscape in Peru (Martínez Rico 2017). Therefore, its propagation is important for subsequent planting in different coastal areas, as it grows and adapts well in large parks, median strips of avenues, and seawalls because it tolerates sea breezes very well (Bulnes *et al.*, 2017).

In this research, it is recommended to propagate *Phoenix canariensis* using the pre-germination treatments of Scarification (TES) and Hot Water (TCA), which agrees with the results of León and Saldaña (2011), who, in research with seeds of another palm (*Euterpe precatoria*), obtained up to 100% germination by applying the treatments of immersion in hot water (50°C) for 3 minutes and partial mechanical abrasion of the seed coat with sandpaper (scarification).

Previous research mentioned in this study highlights the effectiveness of pre-germination treatments in overcoming physical dormancy and improving seedling establishment in nurseries. While no significant differences were found (LSD and Tukey-Kramer tests) between the Scarification (TES) and Hot Water (TCA) treatments, scarification stands out due to its high Germination Percentage (GP) values, associated with a shorter germination time (22 days to reach maximum germination). Therefore, the application of the Scarification (TES) and Hot Water (TCA) treatments is recommended over the other treatments applied in this study, in order to achieve the highest production of *Phoenix canariensis* seedlings for use in urban forestry.

The findings of this research indicate that to stimulate germination and overcome the physical dormancy of seeds, it is necessary to carry out pre-germination treatments in order to optimize production processes in nurseries and reduce costs. This type of strategy is especially relevant in urban contexts such as Lima, where the demand for seedlings for tree planting and public space recovery projects is increasing. Having efficient propagation protocols allows for a constant and economical supply of adapted species, which facilitates the planning, implementation and maintenance of sustainable green areas in arid and densely populated urban environments (Santa Cruz *et al.*, 2021).

CONCLUSIONS

pre-germination treatments that showed the best results in *Phoenix canariensis* seeds the most successful methods were Scarification (T_{ES}) and Hot Water (T_{CA}), with a Germination Percentage (PG) of 81.33% and 86.67% respectively, so it is recommended to use them in the nursery propagation of this palm species.

The correct propagation of *Phoenix canariensis* It will help to encourage the planting of this palm species in urban areas, especially in coastal cities.

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REFERENCES

ABRIL SALTOS, R.V., RUIZ VÁSQUEZ, T.E., ALONSO LAZO, J. y CABRERA MURILLO, G.M., 2017. Germinación, diámetro de semilla y tratamientos pregerminativos en especies con diferentes finalidades de uso. Agronomía Mesoamericana [en línea], pp. 703-717. [consulta: 3 septiembre 2025]. ISSN 2215-

3608. DOI 10.15517/ma.v28i3.26205. Disponible en: https://archivo.revistas.ucr.ac.cr/index.php/agromeso/article/view/26205.

ALIZAGA, R., HERRERA, J. y ALVARADO, A., 2012. Germinación de semillas de palma aceitera (Elaeis guineensis): almacenamiento previo y posterior al tratamiento de calor para romper el reposo. Oil Palm Papers [en línea], no. 38, Disponible en: https://cigras.ucr.ac.cr/phocadownload/Semillas/Binder1.pdf.

BRACK EGG, A., 1999. Diccionario enciclopédico de plantas útiles del Perú [en línea]. Perú: Centro de Estudios Regionales Andinos Bartolomé de las Casas. ISBN 978-9972-691-21-8. Disponible en: https://books.google.com.cu/books/about/Diccionario_enciclop%C3%A9dico_de_plantas_%C3%BA.html?id=e2pgAAAAMAAJ&hl=en&redir_esc=y.

BROSCHAT, T. k., ELLIOTT, M. l. y HODEL, D. r., 2014. Ornamental Palms: Biology and Horticulture. Horticultural Reviews: Volume 42 [en línea]. Estados Unidos: John Wiley & Sons, Ltd, pp. 1-120. [consulta: 3 septiembre 2025]. ISBN 978-1-118-91682-7. Disponible en: https://onlinelibrary.wiley.com/doi/abs/10.1002/9781118916827.ch01.

BULNES, F., ORREGO, M. y TERÁN, A., 2017. Árboles y palmeras del vivero forestal [en línea]. Perú: Universidad Nacional Agraria La Molina. Disponible en: https://www.todocoleccion.net/libros-segunda-mano-ciencias/arboles-palmeras-vivero-forestal-universidad-nacional-agraria-molina-lima-peru~x467707207.

FLORES ROMAYNA, M.A., ORTEGA CHÁVEZ, W. y ORTEGA MALLQUI, A., 2020. Evaluación de tratamientos pregerminativos en semillas de Euterpe precatoria Mart. (Huasaí) en la ciudad de Pucallpa-Perú. Revista Cubana de Ciencias Forestales [en línea], vol. 8, no. 1, pp. 88-103. [consulta: 3 septiembre 2025]. ISSN 2310-3469. Disponible en: https://cfores.upr.edu.cu/index.php/cfores/article/view/490.

GONÇALVES DOS SANTOS, J., NASCIMENTO FERREIRA, S.A. do y OLIVEIRA GENTIL, D.F. de, 2024. Germination and emergence of Astrocaryum murumuru Mart. under stratification in different temperature regimes. Journal of Seed Science [en línea], vol. 46, pp. e202446038. [consulta: 3 septiembre 2025]. ISSN 2317-1537, 2317-1545. DOI https://doi.org/10.1590/2317-1545v46288523. Disponible en: https://www.scielo.br/j/jss/a/N3zHBtVyn7sdcLMRVzvpgny/?lang=en.

HUAMAN, R., GIACOMOTTI, J. y CALIXTO, A., 2024. Evaluación de los servicios ambientales del bosque urbano "Caja de Agua" (Lima, Perú) mediante i-Tree Eco y i-Tree Canopy. Revista Forestal del Perú [en línea], vol. 39, no. 1, pp. 166-186. [consulta: 3 septiembre 2025]. ISSN 2523-1855. DOI 10.21704/rfp.v39i1.2174. Disponible en: https://revistas.lamolina.edu.pe/index.php/rfp/article/view/2174.

LEÓN FLORES, J. y SALDAÑA ROJAS, J.S., 2011. Tratamientos pregerminativos de las semillas de Euterpe precatoria Mart. en Santo Tomas, Loreto-Perú. Pittieria [en línea], vol. 35, pp. 63-70. [consulta: 4 septiembre 2025]. Disponible en: https://www.researchgate.net/publication/267868588_TRATAMIENTOS_PREGERMINATIVOS_DE_LAS_SEMILLAS_DE_Euterpe_precatoria_Mart_EN_SANTO_TOMAS_LORETO-PERU.

LUNA, C.V. y FONTANA, M.L., 2022. Caracterización morfo-fisiológica y respuesta germinativa de semillas de Delonix regia (Bojer) raf. sometidas a diferentes tratamientos pregerminativos. Revista Cubana de Ciencias Forestales [en línea], vol. 10, no. 1, pp. 59-73. [consulta: 4 septiembre 2025]. ISSN 2310-3469. Disponible en: https://cfores.upr.edu.cu/index.php/cfores/article/view/730.

MAYO MOSQUEDA, A., ESPINOSA MORENO, J., CENTURIÓN HIDALGO, D. y CAZARES CAMERO, J.G., 2017. Estrategias para mejorar la germinación de semillas de Calyptrogyne ghiesbreghtiana (Linden & H. Wendland). Polibotánica [en línea], no. 43, pp. 246-254. [consulta: 4 septiembre 2025]. ISSN 1405-2768. DOI 10.18387/polibotanica.43.11. Disponible en:

http://www.scielo.org.mx/scielo.php?script=sci_abstract&pid=S1405-27682017000100246&lng=es&nrm=iso&tlng=es.

NOLASCO CHUMPITAZ, J., CCOYLLO LLACSA, P., KOC SÁNCHEZ, G. y MEDINA MORALES, P., 2020. Collection and morphological characterization of 149 accessions of achiote (Bixa orellana L.) from seven departments in Perú. Peruvian Journal of Agronomy [en línea], vol. 4, no. 3, pp. 93-103. [consulta: 5 septiembre 2025]. ISSN 2616-4477. DOI 10.21704/pja.v4i3.1341. Disponible en: https://revistas.lamolina.edu.pe/index.php/jpagronomy/article/view/1341.

ORDÓÑEZ BARONA, C., DEVISSCHER, T., DOBBS, C., AGUILAR, L.O., BAPTISTA, M.D., NAVARRO, N.M., FERREIRA DA SILVA FILHO, D. y ESCOBEDO, F.J., 2020. Trends in Urban Forestry Research in Latin America & The Caribbean: A Systematic Literature Review and Synthesis. Urban Forestry & Urban Greening [en línea], vol. 47, pp. 126544. [consulta: 5 septiembre 2025]. ISSN 1618-8667. DOI 10.1016/j.ufug.2019.126544. Disponible en: https://www.sciencedirect.com/science/article/pii/S1618866719303619.

PALADINI, E.F., 1992. Observaciones culturales en vivero de árboles forestales en Mendoza. Multequina, vol. 1, pp. 123-146.

PECE, M., GAILLARD, C., ACOSTA, M., BRUNO, C. y SAAVEDRA, S., 2010. Tratamientos pregerminativos para tipa colorada (Pterogyne nitens Tul.). Foresta Veracruzana [en línea], vol. 12, no. 1, pp. 17-25. [consulta: 5 septiembre 2025]. ISSN 1405-7247,. Disponible en: https://www.redalyc.org/articulo.oa?id=49720264003.

RAMÓN JIMÉNEZ, V., VELÁZQUEZ MARTÍNEZ, A., JASSO MATA, J. y MUSALEM, M.Á., 2020. Efecto de tratamientos en la germinación de semillas de palma camedor (Chamaedorea elegans Mart.). Revista Mexicana de Ciencias Forestales [en línea], vol. 27, no. 92, pp. 95-103. [consulta: 5 septiembre 2025]. ISSN 2448-6671. Disponible en: https://cienciasforestales.inifap.gob.mx/index.php/forestales/article/view/904.

RAMOS HUAPAYA, A.E., 2015. Efectos de los tratamientos pregerminativos en semillas de irapay (Lepidocaryum tenue Mart.). Xilema [en línea], vol. 28, [consulta: 5 septiembre 2025]. Disponible en: https://www.researchgate.net/publication/358281562_Efectos_de_los_tratamientos_pregerminativos_en_semillas_de_irapay_Lepidocaryum_tenue_Mart.

RODRÍGUEZ ESTRELLA, R., 2019. Servicios de consultoría para la elaboración de análisis de riesgo detallados para especies invasoras de alto riesgo para México: Análisis de riesgo de cinco especies de palmas con potencial invasor en México. Informe final. Proyecto 00089333 "Aumentar las capacidades nacionales para el manejo de las especies exóticas invasoras (EEI) a través de la implementación de la Estrategia Nacional de EEI" [en línea]. 2019. S.l.: CONABIO. Disponible en: https://www.biodiversidad.gob.mx/media/1/especies/Invasoras/files/comp1/Informe_y_analisis_de_riesgo_palmas.pdf.

SÁNCHEZ PAZ, Y. y RAMÍREZ VILLALOBOS, M., 2006. Tratamientos pregerminativos en semillas de Leucaena leucocephala (Lam.) de Wit. y Prosopis juliflora (Sw.) DC. Revista de la Facultad de Agronomía [en línea], vol. 23, no. 3, pp. 257-272. [consulta: 5 septiembre 2025]. ISSN 0378-7818. Disponible en: http://ve.scielo.org/scielo.php?script=sci_abstract&pid=S0378-78182006000300001&lng=es&nrm=iso&tlng=es.

SANTA CRUZ CERVERA, L., PINTAUD, J.C., CAMPOS DE LA CRUZ, J. y RODRÍGUEZ RODRÍGUEZ, E.F., 2021. Inventario de las palmeras ornamentales cultivadas en Lima Metropolitana, región Lima, Perú. Revista del Museo de Historia Natural. Arnaldoa [en línea], vol. 28, no. 3, pp. 531-556. [consulta: 5 septiembre 2025]. ISSN 2413-3299, 1815-8242. Disponible en: https://dialnet.unirioja.es/servlet/articulo?codigo=9477311.

SOARES PIMENTA, R., BAPTISTA DA LUZ, P., FERNANDES LOPES PIVETTA, K., CASTRO, A. de y UNGER CÉSAR PIZETTA, P., 2010. Efeito da maturação e temperatura na germinação de sementes de Phoenix canariensis hort. ex Chabaud - Arecaceae. Revista Árvore [en línea], vol. 34, no. 1, pp. 31-38. [consulta: 5 septiembre 2025]. ISSN 0100-6762, 1806-9088. DOI

https://doi.org/10.1590/S0100-67622010000100004. Disponible en: https://www.scielo.br/j/rarv/a/qL9zSmPfVbsgJL6RYSBr8Gp/?lang=pt.

SPENNEMANN, D.H., PIKE, M. y ROBINSON, W., 2020. Germination rates of old and fresh seeds and their implications on invasiveness of the ornamental Canary Islands date palm (Phoenix canariensis). European Journal of Ecology [en línea], vol. 6, no. 2, [consulta: 5 septiembre 2025]. ISSN 1339-8474. DOI 10.17161/eurojecol.v6i2.13474. Disponible en: https://journals.ku.edu/EuroJEcol/article/view/13474.

UTELLO, M.J., TARICO, J.C., DEMAESTRI, M.A. y PLEVICH, J.O., 2023. Evaluation of pre-germination treatments in Prosopis caldenia seeds. Bosque (Valdivia) [en línea], vol. 44, no. 1, pp. 37-45. [consulta: 5 septiembre 2025]. ISSN 0717-9200. DOI 10.4067/s0717-92002023000100037. Disponible en: http://www.scielo.cl/scielo.php?script=sci_abstract&pid=S0717-92002023000100037&lng=en&nrm=iso&tlng=en.

VIVEROS VIVEROS, H., HERNÁNDEZ PALMEROS, J.D., VELASCO GARCÍA, M.V., ROBLES SILVA, R., RUIZ MONTIEL, C., APARICIO RENTERÍA, A., MARTÍNEZ HERNÁNDEZ, M. de J., HERNÁNDEZ VILLA, J. y HERNÁNDEZ HERNÁNDEZ, M.L., 2015. Análisis de semilla, tratamientos pregerminativos de Enterolobium cyclocarpum (Jacq.) Griseb. y su crecimiento inicial. Revista Mexicana de Ciencias Forestales [en línea], vol. 6, no. 30, pp. 52-65. Disponible en: https://www.scielo.org.mx/pdf/remcf/v6n30/v6n30a5.pdf.

ZAPATA, R.M., AZAGRA MALO, C. y KARLIN, M.S., 2017. Tratamientos pregerminativos para la ruptura de la dormición en semillas de tres poblaciones de Ramorinoa girolae, leñosa endémica de zonas áridas en Argentina. Bosque (Valdivia) [en línea], vol. 38, no. 2, pp. 237-245. [consulta: 5 septiembre 2025]. ISSN 0717-9200. DOI 10.4067/S0717-92002017000200002. Disponible en: http://www.scielo.cl/scielo.php?script=sci_abstract&pid=S0717-92002017000200002&lng=es&nrm=iso&tlng=es.

ZEBERIO, J.M. y PÉREZ, C.A., 2020. Tratamientos pregerminativos en especies leñosas del monte patagónico para su uso en restauración ecológica. Foresta Veracruzana [en línea], vol. 22, no. 1, pp. 11-16. [consulta: 5 septiembre 2025]. Disponible en: https://www.redalyc.org/journal/497/49765033005/html/

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