



CHARACTERIZATION AND SCARIFICATION OF *NELTUMA* SPP. SEEDS FROM SOIL AND TREES

CARACTERIZACIÓN Y ESCARIFICACIÓN DE SEMILLAS DE *NELTUMA* SPP, PROCEDENTES DEL SUELO Y DE ÁRBOLES

¹S. A. ATARAMA-CASTILLO¹, ¹R. G. CHANDUVÍ-GARCÍA¹,
¹H. MOROCHO-ROMERO¹², ¹R. A. PEÑA-CASTILLO¹, ¹ANA MONTERO SALAZAR¹,
¹MADAI RUESTA-LÓPEZ¹, ¹L. MAZA-CÓRDOVA¹, ¹M. GARCÍA-ZAPATA¹,
¹D. A. MORALES-PIZARRO^{1*}

¹Departamento Académico de Morfofisiología Vegetal, Universidad Nacional de Piura,
Campus Universitario s/n. Urb. Miraflores. Piura, Perú

²Dirección de Supervisión y Monitoreo en las Estaciones Experimentales Agrarias,
Instituto Nacional de Innovación Agraria [INIA]. Lima, Perú

*Email: dmoralesp@unp.edu.pe

The carob tree (*Neltuma/Prosopis* spp.), a native species from Piura region (northeast Peru), is of great importance in the socioeconomic and ecological activity of the area. This tree is an important food source for humans and animals. There is little information about its sexual propagation. Therefore, in this study, the carob fruit and seed are characterized and chemical and biological scarification in the germination of carob collected from the soil and tree are evaluated. The evaluated treatments were: T0 (48 h imbibition), T1 (5 % tinner for 1 h), T2 (15 % tinner for 1 h), T3 (25 % tinner for 1 hour), T4 (35 % tinner for 1 hour), T5 (25 % biol for 20 min), T6 (50 % biol for 20 min), T7 (75 % biol for 20 min) and the germination variables: germination percentage, germination speed and germination index and first day of germination. The characterization of the fruit coincides with that reported in other studies on the identification of *Neltuma piurensis*. In soil-derived seeds, treatments T3 and T7 improved GP (62.5 % and 56.5 %), GS (0.87 and 0.75 germinated seeds per day), and GI (5.36 and 4.79). However, the FDG occurred one day after sowing compared to T0.

Key words: biol, germination indicators, pod and seed biometry, seed scarification, tinner

El algarrobo (*Neltuma/Prosopis* spp.), especie nativa de la región de Piura (noreste de Perú), es de gran importancia en la actividad socioeconómica y ecológica de la zona. Este árbol es una importante fuente de alimento para humanos y animales. Existe poca información sobre su propagación sexual. Por lo tanto, en este estudio se caracteriza el fruto y la semilla de algarrobo, y se evalúa la escarificación química y biológica en la germinación de algarrobo recolectado de suelo y árbol. Se evaluaron los tratamientos: T0 (imbibición a 48 h), T1 (tinner 5 % por 1 h), T2 (tinner 15 % por 1 h), T3 (tinner 25 % por 1 hora), T4 (tinner 35 % por 1 hora), T5 (biol 25 % por 20 min), T6 (biol 50 % por 20 min), T7 (biol 75 % por 20 min) y las variables de germinación: porcentaje de germinación, velocidad de germinación e índice de germinación y primer día de germinación. La caracterización del fruto coincide con lo informado en otros estudios en la identificación de *Neltuma piurensis*. En semillas procedentes del suelo, los tratamientos T3 y T7 mejoraron el PG (62.5 % y 56.5 %), VG (0.87 y 0.75 semillas germinadas por día) e IG (5.36 y 4.79). No obstante, el PDG se dio un día después de la siembra con el T0.

Palabras clave: biol, biometría de vaina y semilla, escarificación de semillas, parámetros de germinación, tinner

Received: September 05, 2024

Accepted: January 30, 2025

Conflict of interest: The authors declare that there is no conflict of interest between them.

CRedit Authorship Contribution Statement: S. A. Atarama-Castillo: **Conceptualization, Methodology.** R. G. Chanduví-García: **Formal analysis, Methodology.** H. Morocho-Romero: **Writing - review & editing.** R. A. Peña-Castillo: **Data curation, Formal analysis.** Ana Montero Salazar: **Writing - review & editing.** Madai Ruesta-López: **Formal análisis.** L. Maza-Córdova: **Formal análisis.** M. García-Zapata: **Conceptualization.** D. A. Morales-Pizarro: **Conceptualization, Methodology, Writing - review & editing.**



This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial (CC BY-NC 4.0). <https://creativecommons.org/licenses/by-nc/4.0/>



Introduction

The carob tree is a tree species native to the Piura region, initially known as *Prosopis pallida* and renamed as *Neltuma piurensis* (L. Vasquez, Ecurra and Huaman) CE Hughes and GP Lewis (Hughes et al. 2022). Currently, this forest tree belongs to Fabaceae family, subfamily Caesalpinoideae (Hughes et al. 2022). The carob tree's distribution in the Americas extends from arid to tropical zones. In Peru, the carob tree is a representative species of the dry forests of the north, extending from the Tumbes region to the north of La Libertad (Rivera et al. 2020). The carob tree is of great socioeconomic and ecological interest in the Piura region (Caycho et al. 2023). It is used as forage for goats, sheep, and cattle. It is also used as a construction material, in artisanal medicine, and in local cuisine (Depenthal and Meitzner Yoder 2018). The carob fruit is composed of pod (90 %) and seed (10 %) and is used in human and animal feeding (Silva et al. 2000 and Zarzosa et al. 2021). Given its high nutritional value (carbohydrates, fiber, proteins and sugars) (Ludeña Gutiérrez et al. 2021), this fruit has been shown to be a good forage food and to increase the weight of goats (Silva et al. 2000) and rabbits (Macías-Rodríguez and Usca-Méndez 2017), in addition to reducing production costs. Several studies have reported that carob trees improve the physicochemical and biological characteristics of arid and semi-arid soils (Santos-Jallath et al. 2012 and Depenthal and Meitzner Yoder 2018).

In recent decades, this species has been threatened by unsustainable anthropogenic activity such as agricultural expansion, urban sprawl, climate change, and stress from biotic and abiotic factors. Because of this, it has been categorized as a vulnerable species, according to Supreme Decree N°. 043-2006-AG, which categorizes threatened species of wild flora (Organismo de Supervisión de los Recursos Forestales y de Fauna Silvestre 2013). Currently, there is limited research focused on sexual propagation through carob seeds. Therefore, it is necessary to explore scarification strategies that increase seed germination (Asif et al. 2020) and technical information on the propagation of this species.

Seed germination is the initial phase of plantlets development, which begins with water absorption, giving rise to a sequence of metabolic processes until the emergence of the radicle (Huang et al. 2020, Xu et al. 2023 and Ruesta-López et al. 2024). A Good initial seed development favors the adaptability and initial vigor of plantlets and directly influences on crop yield (Vieira et al. 2019 and Morales Pizarro et al. 2023). The main form of propagation of carob tree is through seeds (sexual form), which have a very rigid testa (Ewens et al. 2022), which is why different scarification (stratification) strategies have been used: mechanical, thermal and chemical, which favor seed germination (Bhansali 2010). Based on the above, the objective of this study was to characterize the carob fruit and seed and evaluate chemical

and biological scarification in the germination of carob seeds collected from the soil and the tree

Materials and Methods

The study was carried out in the laboratory of the Academic Department of Plant Morphophysiology, belonging to the National University of Piura, Peru, with coordinates 5°11'40.2" S, 80°37'58.2" W at 30 m o.s.l. (figure 1). The research was conducted from November 2023 to January 2024.

Plant material: In the collection of seeds, healthy, vigorous trees were selected from the Pariñas district, Talara province, Piura Region, located at 4°31'26.6" S, 81°12'26.2" W, at 15 m o.s.l. (figure 1). The fruits were collected based on two criteria: criterion 1 (directly from the tree) and criterion 2 (fallen on the soil).

Characterization of fruits and seeds: Fruit characterization was performed on 50 pods (fruits). The following were evaluated: length (L), width (W), and weight (W). For seed characterization, a total of 100 seeds were selected. Their L, W, W, and shape were determined.

The shape of the seed was determined by the relation between the width (W) and length (L): $W/L > 1$ (flattened or ovoid), $L/W = 1$ (spherical), $W/L < 1$ (elongated or oblong), using the scale proposed by Peña-Castillo et al. (2023).

Products used: It was worked with commercial Thinner products (toluene, methyl acetate, methyl alcohol, 2-butoxyethanol and 4-methylpentan-2-one; Peruvian Chemical Products Corporation S.A. Av. César Vallejo 1851 - El Agustino Lima - Peru) and biol or biofertilizer was provided by the Department of Plant Morphophysiology, prepared using the technique of Chanduvi-García et al. (2023).

Seed scarification treatments: The seeds were disinfected with 70 % alcohol for five seconds. Then, they were subjected to various scarification treatments: soaking in distilled water for 48 h (T0), 5 % thinner for 1 h (T1), 15 % thinner for 1 h (T2), 25 % thinner for 1 h (T3), 35 % thinner for 1 h (T4), 25 % biol for 20 min (T5), 50 % biol for 20 min (T6) and 75 % biol for 20 min (T7). Later, the seeds were sown in Petri dishes containing sterile paper towels moistened with distilled water. Each Petri dish contained 20 carob seeds and formed a repetition. Seed germination was evaluated for 15 d at 25 ± 2 °C using the following variables:

Germination percentage (GP): The GP was determined using the formula proposed by Brown and Mayer (1988), where $GP = (\text{total germinated seeds} / \text{total sown seeds}) * 100$. Seeds were considered germinated when they had 2 mm of radicle length.

Germination speed (GS): It was calculated using the formula proposed by Maguire (1962), where $GS = \text{number of germinated seeds} / \text{germination time}$.

Germination index (GI): It was calculated with the formula proposed by Scott et al. (1984), where:

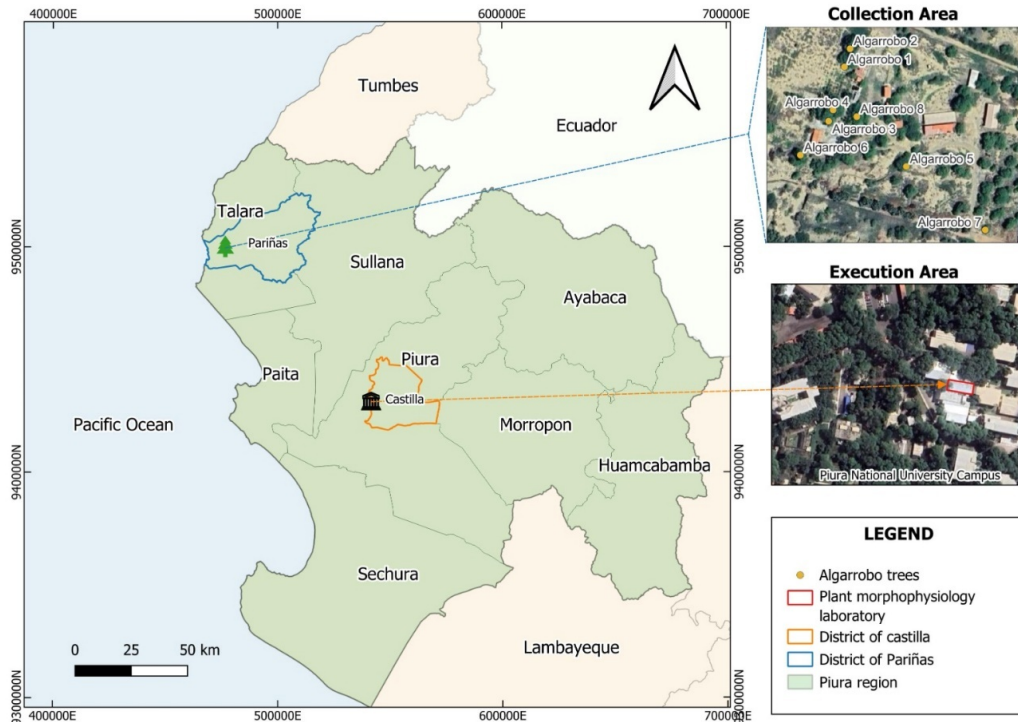


Figure 1. Carob harvesting and processing area.

$GI = \sum (\text{the number of germinated seeds on the } n\text{th day} * \text{number of days after sowing}) / \text{total number of seeds sown}.$

First day of germination: The germination start time was evaluated using the method proposed by [Gutiérrez-Gutiérrez et al. \(2022\)](#).

Statistical analysis: For the characterization of fruits and seeds, the arithmetic mean (mean), standard deviation (SD) and coefficient of variation (CV) were used. The study was carried out in a completely random design (CRD) with eleven treatments and five repetitions per treatment. The obtained values were analyzed using ANOVA (analysis of variance) and Tukey's multiple comparison of means test ($P \leq 0.05$).

Results

Characterization of fruit and seed: The carob fruit (pod) had a length of 19.12 cm, a width of 12.10 mm, and a fruit

weight of 7.58 g. The seed showed a length of 6.62 mm, width of 2.39 mm, weight of 0.05 g and the L/W ratio was 0.36 ([table 1](#)).

Germination variables: In the GP (tree), T4 with 32.5 % was significantly higher than the other treatments, followed by T3 with 23.75 % ([table 2](#)). In the GP (soil), T3 exceeded T0 by 20 %, being significantly higher than the other treatments ([table 2](#)). The highest GP was from seeds, whose fruits were collected from the soil compared to those harvested directly from the tree.

In the GS (tree), T4 with 0.43 germinated seeds per day significantly exceeded the other treatments ([table 2](#)), and in the GS (soil), the treatments did not have significant differences, with values between 0.5 to 0.87 germinated seeds per day ([table 2](#)). The highest GS values were obtained from fruits collected from the soil.

Table 1. Biometric description of fruits and seeds of carob tree *Neltuma piurensis* (L. Vasquez, Escurra & Huaman) CE Hughes & GP Lewis.

Description	Variable	Sample	Mean	SD	CV, %
Fruit	Pod length, cm	50	19.12	4.22	22.07
	Pod width, mm	50	12.10	1.43	11.81
	Pod weight, g	50	7.58	1.73	22.79
Seed	Seed length, mm	100	6.62	0.50	7.56
	Seed width, mm	100	2.39	0.22	9.29
	Seed weight, g	100	0.05	0.01	22.29
	Width/ length	100	0.36	0.03	9.30

Table 2. Analysis of germination variables of carob seeds *Neltuma* spp.

Treat*.	GP		GS		GI		FGD	
	Tree	Soil	Tree	Soil	Tree	Soil	Tree	Soil
T0	12.5±2.89 ^{cd}	52.5±6.45 ^{ab}	0.23 ^{ab}	0.74 ^a	0.75 ^{cd}	4.17 ^a	1.5 ^a	1.0 ^a
T1	15±4.08 ^{bc}	43.75±2.5 ^{ab}	0.21 ^{ab}	0.61 ^a	1.28 ^{bcd}	4.0 ^a	3.0 ^{ab}	3.75 ^{ab}
T2	15±7.07 ^{bc}	41.25±8.54 ^{ab}	0.23 ^{ab}	0.64 ^a	1.49 ^{bc}	3.34 ^a	7.75 ^c	6.25 ^b
T3	23.75±6.29 ^{ab}	62.5± 9.57 ^a	0.32 ^{ab}	0.87 ^a	2.33 ^{ab}	5.36 ^a	3.75 ^{ab}	3.25 ^{ab}
T4	32.5±5 ^a	36.25±11.09 ^b	0.43 ^a	0.5 ^a	3.41 ^a	3.36 ^a	3.5 ^{ab}	4.5 ^b
T5	2.5±2.89 ^d	41.25±16.0 ^{ab}	0.17 ^b	0.55 ^a	0.19 ^d	3.48 ^a	1.5 ^a	4.25 ^{ab}
T6	15.0±4.08 ^{bc}	50.0±7.07 ^{ab}	0.25 ^{ab}	0.69 ^a	0.98 ^{cd}	4.86 ^a	3.5 ^{ab}	3.75 ^{ab}
T7	15.0±4.08 ^{bc}	56.25±12.5 ^{ab}	0.22 ^{ab}	0.75 ^a	1.29 ^{bcd}	4.79 ^a	4.5 ^b	3.00 ^{ab}
<i>P</i> Value	0.0351	0.0000	0.0228	0.0928	0.0000	0.0547	0.0000	0.0049

In the GI (tree), T4 with 3.41 obtained the highest GI, being superior to the other treatments. The GI (soil) treatments did not have significant differences with values between 3.34 to 5.36 (table 2), which showed that the highest GI is obtained from the samples extracted from the soil.

In the FGD (tree), the T0 and T5 treatments germinated in a shorter time by 1.5 days (table 2). However, the FGD (soil), T0 germinated in 1 day, being its germination significantly faster, showing that the FGD was in seeds from the soil zone.

Discussion

In the characterization of fruits and seeds, we agree with the research carried out by Prokopiuk *et al.* (2000) in the identification of *Prosopis pallida*, currently renamed *Neltuma piurensis* (L. Vasquez, Ecurra & Huaman) CE Hughes & GP Lewis (Hughes *et al.* 2022). However, the seed width was smaller at 2.39 mm (table 1), showing that the environment influences on the carob genotype. The seed's L/W ratio indicates an oblong shape (Peña-Castillo *et al.* 2023).

Germination variation is influenced by the collection area, as well as the fruit (pod) maturity, sugar content, and storage time (Ludeña Gutiérrez *et al.* 2021). Likewise, Henciya *et al.* (2017) mention the presence of phytochemicals: alkaloids, flavonoids, terpenes, tannins, phenolic compounds (quinones) in fruits and seeds of *Neltuma/Prosopis* spp., which are in higher concentrations in freshly harvested fresh fruits, which influences on seed germination. However, dried pods used in animal feeding should not exceed 40 % of phytochemicals substances of those freshly harvested (Ruiz-Nieto *et al.* 2020). De Sousa Leite *et al.* (2018) show that the physiological maturity of the seed directly influences on the germination and vigor of the seed.

Regarding the results of this research, seeds from the soil showed the highest GP with chemical scarification with Thinner at 25 % (T3) and biological with Biol at 75 % (T7). These results are consistent with Abdala *et al.* (2020)

in that chemical scarification based on sulfuric acid for three minutes had the highest GP compared to physical and thermal scarification. The effect of chemicals alters, degrades and softens the seed coat composed of hydrophobic and lignified substances (macrosclereids) present in the seeds of *Neltuma/Prosopis* genus. This lignified layer is responsible for preserving, protecting and preventing the imbibition of the seed. In addition, De Sousa Leite *et al.* (2018) increased the GP of *Bromelia laciniosa* seeds to 83 % with acetone for 90 min in mature seeds and to 60 % in immature seeds compared to the control with 40 % and 35 %, respectively. Similarly, these authors reduced the germination days to 15 (mature seed) and 25 (immature seed), days after sowing (DAS), compared to a control that began germination at 45 and 55 DAS, respectively. Rivera Curi *et al.* (2020) obtained the highest GP with 33.3 % in *P. pallida* seeds, treated with 100 % acetone for 10 min, being higher than the control with a GP of 30 %.

Carob seeds treated with biol significantly improved GP. These results are consistent with those described by Ruesta-López *et al.* (2024) in passion fruit (*Passiflora edulis* S.) seeds treated with 5 % biol, increasing GP to 80 % during 12 h of imbibition. However, at 24 h the GP was lower with 8.33 %. According to Chanduvi-García *et al.* (2023), Galecio-Julca *et al.* (2023) and Morocho-Romero *et al.* (2024), the biol has carboxylic acids, humic acids and microorganisms, which weaken the seed coat and increase the GP. Utello *et al.* (2023) show that heat treatments reduce the growth of embryonic roots compared to chemical or mechanical treatments performed on seeds.

The highest germination speed is in seeds extracted from the soil with treatments based on Thinner at 25 % (T3) and Biol at 75 % (T7). These products weaken the seed layer of carob seed, which facilitates seed imbibition or hydration; activating various metabolic processes that initiate seed germination and gas exchange (Batista Sánchez *et al.* 2017 and Utello *et al.* 2023). Ruesta-López *et al.* (2024) mention that passion fruit seeds exposed to 5 % biol for 12 h,

increase the GS to 1.5 germinated seeds per day, surpassing the control. The positive effect of the biostimulant (biol) significantly influences on cell multiplication, promoting the development and emergence of the radicle (Mendivil-Lugo *et al.* 2019). The highest GI was obtained with seeds collected from the soil with chemical treatments T3 (tinner 25 %) and organic treatments T6 (biol 50 %) and T7 (biol 75 %). These results coincide with those reported by Abdala *et al.* (2020), indicating that chemical scarification (sulfuric acid) improves the germination speed index (GSI). On the other hand, Utello *et al.* (2023) report that mechanical scarification (sanding) was superior to chemical (sulfuric acid) and thermal scarification, improving the uniformity and spontaneity of the germination process, being a key factor in the propagation stage in the nursery. Coa *et al.* (2014) mention that the combined effect of mechanical scarification and imbibition at 12 and 24 h of the seeds, improved the GI compared to chemical treatments (sulfuric acid and muriatic acid) and without scarification with imbibition. On the other hand, Ruesta-López *et al.* (2024) improved the GI in passion fruit seeds treated with 5 % biol.

The FDG was lower at T0 (48 h imbibition) in seeds from the soil (1 d) and from the tree (1.5 d). The results of the study differ from those obtained by Abdala *et al.* (2020), who show that chemical scarification (sulfuric acid) accelerates the beginning of germination. Morales Pizarro *et al.* (2023) show that the imbibition time and the concentration of stimulants influences on the FDG. Similarly, Ruesta-López *et al.* (2024) accelerated the FDG by imbibition of seeds for 12 h and 24 h. However, when passion fruit seeds were treated with higher concentrations of biol, the FDG was delayed.

Conclusions

The morphometric characteristics of the fruit and seeds coincide with those from *Neltuma piurensis* genus. However, the seed width shows to be larger than those described for this species. Seed maturity is a key factor in seed germination of *Neltuma* spp. genus. The chemical pre-germination treatment with Tinner (T3), followed by the organic treatment with biol (T7), improved the germination variables GP (62.5 % and 56.25 %), GS (0.87 and 0.75 germinated seeds per day) and GI (5.36 and 4.79) and the FDG was given a DAS with T0, the best values were showed by seeds from the soil.

Acknowledgments

Thanks to the technical staff of the Department of Plant Morphophysiology, belonging to the Faculty of Agronomy of the National University of Piura, Peru, for their support to this research.

References

Abdala, N.R., Bravo, S. & Acosta, M. 2020. Germinación y efectos del almacenamiento de

frutos de *Prosopis ruscifolia* (Fabaceae). *Bosque (Valdivia)*, 41(2): 103-111, ISSN: 0717-9200. <https://doi.org/10.4067/S0717-92002020000200103>.

Asif, M.J., Ali, A., Mazhar, M.Z., Tanvir, A., Zia, B., Anmbreen, I., Anjum, M.Z. & Mahr, M.S. 2020. Effect of different pre-treatments on seed germination of *Prosopis juliflora* and *Dalbergia sissoo*: A step towards mutation breeding. *Journal of Forest Science*, 66(2): 80-87, ISSN: 1805-935X. <https://doi.org/10.17221/64/2019-JFS>.

Batista, D., Murillo, B., Nieto, A., Alcaráz, L., Troyo, E., Hernández, L.G. & Ojeda Silvera, C.M. 2017. Mitigación de NaCl por efecto de un bioestimulante en la germinación de *Ocimum basilicum* L. *Terra Latinoamericana*, 35(4): 309-320, ISSN: 2395-8030. <https://doi.org/10.28940/terra.v35i4.317>.

Bhansali, R.R. 2010. Biology and Multiplication of *Prosopis* species Grown in the Thar Desert. In K. G. Ramawat (Ed.), *Desert Plants* (pp. 371-406). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-02550-1_18.

Bonner, F.T. & Karrfalt, R.P. 2008. The Woody Plant Seed Manual. Agric. Handbook No. 727. Washington, DC. U.S. Department of Agriculture, Forest Service. 1223 p. <https://research.fs.usda.gov/treesearch/32626>.

Brown, R.F. & Mayer, D.G. 1988. Representing Cumulative Germination. 1. A Critical Analysis of Single-value Germination Indices. *Annals of Botany*, 61(2): 117-125, ISSN: 1095-8290. <https://doi.org/10.1093/oxfordjournals.aob.a087534>.

Caycho, E., La Torre, R. & Orjeda, G. 2023. Assembly, annotation and analysis of the chloroplast genome of the Algarrobo tree *Neltuma pallida* (subfamily: Caesalpinoideae). *BMC Plant Biology*, 23(1): 570, ISSN: 1471-2229. <https://doi.org/10.1186/s12870-023-04581-5>.

Chanduví-García, R., Sandoval-Panta, M.A., Peña-Castillo, R., Javier-Alva, J., Álvarez, L.Á., Quiroz-Calderón, M.V., Granda-Wong, C., Aguilar-Ancota, R., Galecio-Julca, M. & Morales-Pizarro, A. 2023. Biofertilizante y su Correlación entre Parámetros Productivos y de Calidad en Limón Sutil (*Citrus aurantifolia* Swingle). *Terra Latinoamericana*, 41: e1685, ISSN: 2395-8030. <https://doi.org/10.28940/terra.v41i0.1685>.

Coa, M., Méndez, J.R., Silva, R. & Mundarain, S. 2014. Evaluación de métodos químicos y mecánicos para promover la germinación de semillas y producción de fosforitos en café (*Coffea arabica*) var. Catuai Rojo. *Idesia (Arica)*, 32(1): 43-53, ISSN: 0718-3429. <https://dx.doi.org/10.4067/S0718-34292014000100006>.

De Sousa, M., Freitas, L.A., De Queiroz, F., De Sousa, T. & Barros Torres, S. 2018. Germination of spineless *Bromelia laciniosa* Mart. Ex Schult (Bromeliaceae) seeds subjected to chemical scarification. *Idesia*, 36(4): 135-137, ISSN: 0718-3429. <https://dx.doi.org/10.4067/S0718-34292018005002102>.

- Depenthal, J. & Meitzner Yoder, L.S. 2018. Community Use and Knowledge of Algarrobo (*Prosopis pallida*) and Implications for Peruvian Dry Forest Conservation. *Revista de Ciencias Ambientales*, 52(1): 49-70, ISSN: 2215-3896. <https://doi.org/10.15359/rca.52-1.3>.
- Ewens, M., Felker, P. & Paterson, A. 2022. Genetic improvement in *Prosopis*. En *Prosopis* as a Heat Tolerant Nitrogen Fixing Desert Food Legume (pp. 139-156). Elsevier. <https://doi.org/10.1016/B978-0-12-823320-7.00015-8>.
- Galecio-Julca, M., Neira-Ojeda, M., Chanduví-García, R., Peña-Castillo, R., Álvarez-Bernaola, L.A., Granda-Wong, C., Lindo-Seminario, D., Saavedra-Alberca, E., Javier-Alva, J. & Morales-Pizarro, A. 2023. Efecto de la eficacia de los microorganismos nativos y la composta en tres pisos altitudinales en el cultivo de quinua (*Chenopodium quinoa*) variedad INIA 415-Pasankalla. *Terra Latinoamericana*, 41: e1622, ISSN: 2395-8030. <https://doi.org/10.28940/terra.v41i0.1622>.
- Ludeña Gutiérrez, A.L., Colomer Winter, A., Castillo Chung, L.B., Peña Castillo, R. & Timana Rojas, S. 2021. Cuantificación de hidroximetilfurfuralen la algarrobina por concentración a vacío. *Revista Universidad y Sociedad*, 13(6): 250-257, ISSN: 2218-3620. http://scielo.sld.cu/scielo.php?script=sci_art-text&pid=S2218-36202021000600250.
- Gutiérrez-Gutiérrez, O.G., Rivero-Hernández, O., Vega-Mares, J.H. & Melgoza-Castillo, A. 2022. Patrones de germinación en gramíneas presentes en el Desierto Chihuahuense. *Botanical Sciences*, 100(4): 989-999, ISSN: 2007-4476. <https://doi.org/10.17129/botsci.3007>.
- Henciya, S., Seturaman, P., James, A.R., Tsai, Y.H., Nikam, R., Wu, Y.C., Dahms, H.U. & Chang, F.R. 2017. Biopharmaceutical potentials of *Prosopis* spp. (Mimosaceae, Leguminosae). *Journal of Food and Drug Analysis*, 25(1): 187-196, ISSN: 2224-6614. <https://doi.org/10.1016/j.jfda.2016.11.001>.
- Huang, H., Ran, J., Li, X., Wang, Z., Chen, R., Wu, F., Ye, M., Jia, F., Niklas, K. J. & Deng, J. 2020. A General Model for Seed and Seedling Respiratory Metabolism. *The American Naturalist*, 195(3): 534-546, ISSN: 1537-5323. <https://doi.org/10.1086/707072>.
- Hughes, C.E., Ringelberg, J.J., Lewis, G.P. & Catalano, S.A. 2022. Disintegration of the genus *Prosopis* L. (Leguminosae, Caesalpinioideae, mimosoid clade). *PhytoKeys*, 205: 147-189, ISSN: 1314-2003. <https://doi.org/10.3897/phytokeys.205.75379>.
- Macías-Rodríguez, E. & Usca-Méndez, J. 2017. Utilización de la harina de algarrobo (*Prosopis pallida*) en la alimentación de conejos en crecimiento, engorde. *Revista Ciencia UNEMI*, 10(22): 105-110, ISSN: 2528-7737. <https://www.redalyc.org/journal/5826/582661263011/html>.
- Maguire, J.D. 1962. Speed of Germination-Aid In Selection And Evaluation for Seedling Emergence And Vigor. *Crop Science*, 2(2): 176-177, ISSN: 1435-0653. <https://doi.org/10.2135/cropsci1962.0011183X000200020033x>.
- Mendivil-Lugo, C., Nava-Pérez, E., Armenta-Bojórquez, A.D., Ruelas-Ayala, R.D. & Félix-Herrán, J.A. 2019. Elaboración de un abono orgánico tipo bocashi y su evaluación en la germinación y crecimiento del rábano. *Biotechnia*, 22(1): 17-23, ISSN: 1665-1456. <https://doi.org/10.18633/biotechnia.v22i1.1120>.
- Morales Pizarro, A., Rivas Chero, A. A., Zapata Córdova, A. C., García Guevara, E., Ruesta López, M. & Peña-Castillo, R. 2023. Efecto de diferentes dosis de ácido giberélico en la germinación de papaya (*Carica papaya* L.) variedad criolla. *Chilean Journal of Agricultural & Animal Sciences*, 39(3): 392-400, ISSN: 0719-3890. <https://doi.org/10.29393/CHJAA39-35EDAM60035>.
- Morocho-Romero, H., Peña-Castillo, R., Chanduví-García, R., Vilchez-Navarro, S., Quiroz-Calderón, M., Calero-Merino, M., Galecio-Julca, M., Javier-Alva, J., Cruz-Grimaldo, C. & Morales-Pizarro, D.A. 2024. Influence of Organic Fertilization on the Fruit Morphology and Production of Mango (*Mangifera Indica* L.) Var. Kent. *Tropical and Subtropical Agroecosystems*, 27(3): 137, ISSN: 1870-0462. <https://doi.org/10.56369/tsaes.5606>.
- Organismo de Supervisión de los Recursos Forestales y de Fauna Silvestre. 2013. Decreto Supremo N.º 043-2006-AG - Aprueban Categorización de Especies Amenazadas de Flora Silvestre. <https://www.gob.pe/institucion/osinfor/normas-legales/792195-043-2006-ag-aprueban-categorizacion-de-especies-amenazadas-de-flora-silvestre>.
- Peña-Castillo, R., Murillo, M., Galecio-Julca, M., Calero Merino, M., Chanduví-García, R., Javier-Alva, J., Álvarez, L., Quiroz-Calderón, M.V., Granda-Wong, C. & Morales-Pizarro, A. 2023. Efecto de aplicaciones foliares de magnesio y hierro sobre la productividad de lima ácida (*Citrus aurantifolia* Swingle). *Idesia (Arica)*, 41(3): 105-113, ISSN: 2218-3620. <https://doi.org/10.4067/S0718-34292023000300105>.
- Prokopiuk, D., Cruz, G., Grados, N., Garro, O. & Chiralt, A. 2000. Estudio comparativo entre frutos de *Prosopis alba* y *Prosopis pallida*. *Multequina*, 9(1): 35-45, ISSN: 1852-7329.
- Rivera, J.C., Cabrera, R.M. & Bulnes, C.F. 2020. Micropropagación de *Prosopis pallida* (Humb y Bonpl. Ex Willd.) Kunth a partir de yemas apicales. *Revista Colombiana de Biotecnología*, 22(1): 18-26, ISSN: 1909-8758. <https://doi.org/10.15446/rev.colomb.biote.v22n1.70949>.
- Ruesta-López, M., Zurita-Chinguel, L., Lizano-Pintado, M., Delgado-Vite, M., Zapata-Durand, D., Jiménez-Castillo, J., Peña-Castillo, R., Galecio-Julca, M., Chanduví-García,

- R. & Morales-Pizarro, D.A. 2024. Bioestimulante y tiempos de imbibición sobre la germinación de semillas de maracuyá (*Passiflora edulis* S., passifloraceae). *Tropical and Subtropical Agroecosystems*, 27(2):076 ISSN: 1870-0462. <https://doi.org/10.56369/tsaes.5199>.
- Ruiz-Nieto, J.E., Hernández-Ruiz, J., Hernández-Marín, J., Mendoza-Carrillo, J., Abraham-Juárez, M., Isiordia-Lachica, P.M. & Mireles-Arriaga, A.I. 2020. Mesquite (*Prosopis* spp.) tree as a feed resource for animal growth. *Agroforestry Systems*, 94(4): 1139-1149, ISSN: 1572-9680. <https://doi.org/10.1007/s10457-020-00481-x>.
- Salazar Zarzosa, P.C., Mendieta-Leiva, G., Navarro-Cerrillo, R.M., Cruz, G., Grados, N. & Villar, R. 2021. An ecological overview of *Prosopis pallida*, one of the most adapted dryland species to extreme climate events. *Journal of Arid Environments*, 193(1): 104576, ISSN: 1095-922X. <https://doi.org/10.1016/j.jaridenv.2021.104576>.
- Santos-Jallath, J., Castro-Rodríguez, A., Huezo-Casillas, J. & Torres-Bustillos, L. 2012. Arsenic and heavy metals in native plants at tailings impoundments in Queretaro, Mexico. *Physics and Chemistry of the Earth, Parts A/B/C*, 37-39: 10-17, ISSN: 1464-1895. <https://doi.org/10.1016/j.pce.2011.12.002>.
- Scott, S.J., Jones, R.A. & Williams, W.A. 1984. Review of Data Analysis Methods for Seed Germination. *Crop Science*, 24(6): 1192-1199, ISSN: 1435-0653. <https://doi.org/10.2135/cropsci1984.0011183X002400060043x>.
- Silva, M. P., Martínez, M. J., Coirini, R., Brunetti, M. A., Balzarini, M. & Karlin, U. 2000. Valoración nutritiva del fruto del algarrobo blanco (*Prosopis chilensis*) bajo distintos tipos de almacenamiento. *Multequina*, 9(1): 65-74, ISSN: 1852-7329. https://www.scielo.org.ar/scielo.php?pid=S1852-73292000000100008&script=sci_art-text.
- Utello, M.J., Tarico, J.C., Demaestri, M.A. & Plevich, J.O. 2023. Evaluación de tratamientos pregerminativos en semillas de *Prosopis caldenia*. *Bosque (Valdivia)*, 44(1): 37-45, ISSN: 0717-9200. <https://doi.org/10.4067/s0717-92002023000100037>.
- Vieira, H., Martins, J.V.D.S., Barreto, G.G., Gomes, R.D.S.S., Silva, E.C. & Nascimento, L.C. 2019. Sanitary and physiological quality of ‘purple’ corn (*Zea mays* L.) seeds submitted to thermotherapy. *Arquivos do Instituto Biológico*, 86: e1222018, ISSN: 1808-1657. <https://doi.org/10.1590/1808-1657001222018>.
- Xu, N., Lu, B., Wang, Y., Yu, X., Yao, N., Lin, Q., Xu, X. & Lu, B. 2023. Effects of salt stress on seed germination and respiratory metabolism in different *Flueggea suffruticosa* genotypes. *PeerJ*, 11: e15668, ISSN: 2167-8359. <https://doi.org/10.7717/peerj.15668>.



Available in:

<https://www.redalyc.org/articulo.oa?id=653781853004>

How to cite

Complete issue

More information about this article

Journal's webpage in redalyc.org

Scientific Information System Redalyc
Diamond Open Access scientific journal network
Non-commercial open infrastructure owned by academia

S. A. Atarama-Castillo, R. G. Chanduví-García,
H. Morocho-Romero, R. A. Peña-Castillo,
Ana Montero Salazar, Madai Ruesta-López, L. Maza-Córdova,
M. García-Zapata, D. A. Morales-Pizarro

**Characterization and scarification of Neltuma spp. Seeds
from soil and trees**

**Caracterización y escarificación de semillas de Neltuma
spp, procedentes del suelo y de árboles**

Cuban Journal of Agricultural Science

vol. 59, e05, 2025

Ediciones ICA,

ISSN: 0864-0408

ISSN-E: 2079-3480