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Combining Pre-sowing Treatments in *Faidherbia albida* (Delile) A. Chev. does not Imply Better Germination Success

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Authors' contributions

This work was carried out in collaboration between both authors. Author GBC designed the study, wrote the protocol, guided literature searches, data collection, analysis and manuscript preparation. Author TA managed the literature searches, the experimental process and data analysis. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: Seed dormancy has been an impeding factor in seedling recruitment. In this study we examined the performance of *Faidherbia albida* (Delile) A. Chev. seeds when exposed to the hot water + nicking pre-sowing treatment by evaluating the Cumulative Germination Percentage (CGP), Germination Velocities (GV) and Survival Percentages (SP).
Place and Duration of Study: This study was carried out in the shade house of the Department of Botany and Plant Physiology, Faculty of Science, University of Buea between November 2014 and December 2014.
Methodology: One hundred and eighty viable seeds were exposed to the hot water, nicking, hot water + nicking combination and control treatments, respectively, in germination boxes watered (8 litres) once a week for the duration of the experiment (40 days).
Results: We found significant differences between the type of pre-sowing treatment and resulting Daily Germination Percentages (DGP) (χ^2 = 261.299, *P* <.001). The highest CGP (74.4%), GV (16) and SP (93.3%) were obtained using the nicking treatment with the hot water + nicking combination

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treatment performance as CGP (56.1%), GV (13) and SP (63.4%) and the control, interestingly, produced the second best performance CGP (60.6%). The lowest CGP (51.1%) and GV (6) were obtained with the hot water treatment (51.1%).
Conclusion: Combining the two pre-sowing treatments does not positively influence germination. Nicking is the best pre-sowing treatment method that should be preferred and adopted in the propagation of *F. albida.*

Keywords: Agroforestry; Faidherbia albida; germination; nicking; seed dormancy.

1. INTRODUCTION

Faidherbia albida (Delile) A. Chev. (synonym *Acacia* albida) is a multipurpose agroforestry tree species indigenous to Africa. It belongs to the monotypic genus *Faidherbia* of *Fabaceae* (Leguminosae). It is a natural fertilizer factory supplying the equivalent of 300 kilograms of complete fertilizers and 250 kilograms of lime boosting soil fertility [1] due to its peculiar reverse phenology [2]. It increases productivity in farms where the plant has been adopted by 13% as well as an increase in nutrient content, especially in millet [3], due to leaf fall at the onset of the rainy season. Many farmers in the arid and semi-arid regions have adopted agroforestry practices incorporating the plant because the tree does not compete with plants for light, nutrients and water. Leaves, pods and seeds are a very good source of fodder providing 200, 150 and 260g per kilogram total protein of dry matter, respectively, with total protein digestibility reaching 73% [4]. The tree also serves as a shade or shelter for crops in the farms and livestock during the dry season, as a useful ornamental tree for gardens and avenues, as boundary/barrier/support, and as windbreaks, apiculture, fuel wood and charcoal, as a source of timber, as fibre and source of dye [5]. Extracts from the bark and roots of the tree are used in the treatment of respiratory and digestive disturbances in addition to its use in the treatment of malaria and other fevers.

For plants to efficiently propagate, germination is a requirement. Effective and sustainable germination of seeds is usually affected by seed structures and environmental factors, a condition referred to as seed dormancy [6]. Though seed dormancy is often considered an impeding factor, many plants use it as a survival mechanism which ensures that germination occurs only during favorable conditions. Many forms of seed dormancy have been identified with the degree of dormancy varying depending on the species, genome and type of dormancy [7]. These include physical, chemical, physiological, photo- or thermo-dormancy [8]. Many scholars have proposed pre-sowing treatment methods targeted at breaking seed dormancy in seeds with physical dormancy such as scarification by nicking [9], hot water, concentrated sulphuric acid [10], stratification [11], and many others.

In *F. albida,* seed germination is hampered by the hardness of the seed coats [12] that prevents the entry of water and oxygen necessary for the developing embryo to initiate the germination process. Studies carried out on seed treatments in the plant have proposed and encouraged the adoption of the nicking and hot water treatments independently [4,11-14] with no studies carried out on the potential of using the hot water + nicking combination treatment.

This study was aimed at examining the suitability of the hot water + nicking treatment combination for seeds of *F. albida*. We hope to identify the best, cheap method that can be applied easily by rural farmers who cannot afford large quantities of agrochemicals necessary for increasing food productivity while at the same time conserving biodiversity.

2. MATERIALS AND METHODS

2.1 Study Site and Plant Species

Seeds of *Faidherbia albida* (Delile) A. Chev. used in the study were obtained from the World Agroforestry Centre (ICRAF) headquarters on Gilgil Road, Nairobi, Kenya. The seeds after being checked for viability using the floatation test were subjected to four different pre-sowing treatments.

This study was carried out in the shade house (4.15074^{o} N, 9.28354^{o} E, altitude of 585 m above sea level) of the Department of Botany and Plant Physiology of the University of Buea, South West Region, Cameroon. The campus is located at latitude 4.153 N and longitude 9.292 E.

Buea at an altitude of 800 m above sea level has a mountainous terrain with fertile volcanic soils [15]. The climate is humid tropical with an annual rainfall of 2,800 mm mostly received within the months of June to September. The mean annual temperature, relative humidity and annual sunshine for Buea are 28ºC, 85% and 1050 hours, respectively [15].

2.2 Seed Pre-sowing Treatments

One hundred and eighty seeds were exposed to each of the three pre-sowing treatments: Hot water, nicking, hot water + nicking and the control (without any treatment).

In the hot water treatment, after boiling to 100°C, the water was poured onto seeds in a bucket and left to stand for 20 minutes [16]. The seeds were then removed and planted. For nicking, seeds were mechanically nicked on one side away from the micropyle end using nail clippers and planted immediately [17]. The hot water + nicking treatment involved putting seeds in a bucket containing water that had been boiled to 100°C and the setup left to stand for 20 minutes. The seeds were then removed, nicked at the distal end and planted immediately [9]. Seeds in the control treatment were planted without any pre-treatment.

Planting was done in four (4) 1 m × 1 m × 12 cm wooden boxes filled with top soil mixed with coarse sand in the ratio of 60:40. The bottom of each germination box was covered using 3 mm wire mesh. 2 mm mosquito nets were put on the bottom before filling the boxes to stop fine soil particles from falling off. The boxes were placed on a metallic Table 1 m above the ground. Watering was applied once a week (8 litres).

2.3 Data Collection and Analysis

Data was collected on germination. Seeds were considered to have germinated upon observation of a visible protrusion of the embryonic shoot above the surface of the ground. Germinated seeds were counted for 40 days from the day of planting. Germination curves were used to show the trend of germination. Daily Germination Percentages (DGP) and Cumulative Germination Percentages (CGP) were obtained according to the formula of [16].

$$\mathrm{DGP} = \frac{\text{Total daily germination}}{\text{Total seeds planted}} \times 100$$

$$\mathrm{CGP} = \frac{\text{Total Germinated Seedlings}}{\text{Total seeds planted}} \times 100$$

Germination velocity (GV) was computed using the formula [18].

$$\mathrm{GV} = \sum \frac{\text{Number of germinated seeds}}{\text{Day of count}}$$

The survival percentages (SPs) of the seedlings per pre-sowing treatment were also determined using the formula:

$$\mathrm{SP} = \frac{\text{Total Germinated Seedlings} - \text{Dead Seedlings}}{\text{Total Germinated Seedlings}} \times 100$$

Data on total germinated seeds per pre-sowing treatment were subjected to the Chi Squared Test of Association using the Minitab Statistical Software Version 17 (Kivuto Solutions, Inc., USA).

Table 1. Summary of germination characteristics for seeds of *Faidherbia albida* after exposure to different pre-sowing treatments

Treatment	CGP (%)	Germination velocity (GV)	Survival percentage, SP (%)
HW	51.1	6	80.7
HWNI	56.1	13	63.4
NI	74.4	16	93.3
CO	60.6	7	77.1

** HW – Hot water; NI – Nicking; *HWNI - Hot water + nicking; CO – Control*

3. RESULTS

3.1 Germination Percentages

Significant differences in germination rates were observed between the different treatments (χ^2 = 261.299, df = 15, P < .001). Generally, there was a gradual increase in the number of germinated seeds. There existed associations between the type of pre-sowing treatment and the resulting CGPs. Seeds subjected to the different pre-sowing treatments yielded different GP and CGP, respectively. The hot water + nicking combination treatment produced the first seedling emergence four days after planting, nicking on the fifth day, hot water on the sixth and the control (no pre-sowing treatment) on the seventh day.

The highest CGP (74.4%) was obtained with the nicking treatment within a period of eight days from the day of first seedling emergence while the hot water treatment produced the lowest CGP (51.1%) thirty two days from the day of first seedling emergence. A CGP of 56.1% after 19 days from the day of first seedling emergence was obtained with seeds exposed to the hot water + nicking combination treatment while the control produced its highest germination percentage (60.6%) after 39 days. Trend of germination in all treatments is as shown in Fig. 1.

3.2 Germination Velocity (GV)

The GV was highest (16) in seeds treated by nicking and lowest in the hot water (6). The hot water + nicking combination treatment followed with the second highest GV (13) and the control (7) third.

3.3 Survival Percentage (SP)

The highest SP (93.3%) was achieved with seeds exposed to the nicking pre-sowing treatment followed by those treated with hot water (80.7%), control (77.1%) and the hot water + nicking combination treatment produced the lowest SP (63.4%) as summarized.

The highest number (134) of germinated seeds and the lowest number of dead seedlings (9) were recorded using the nicking treatment. The lowest germination (92) was obtained with the hot water treatment while the hot water + nicking combination treatment produced the highest number of dead seedlings (37) and the lowest number of surviving seedlings (64). The control treatment had the second highest total number of seedlings (109) and surviving seedlings (84).

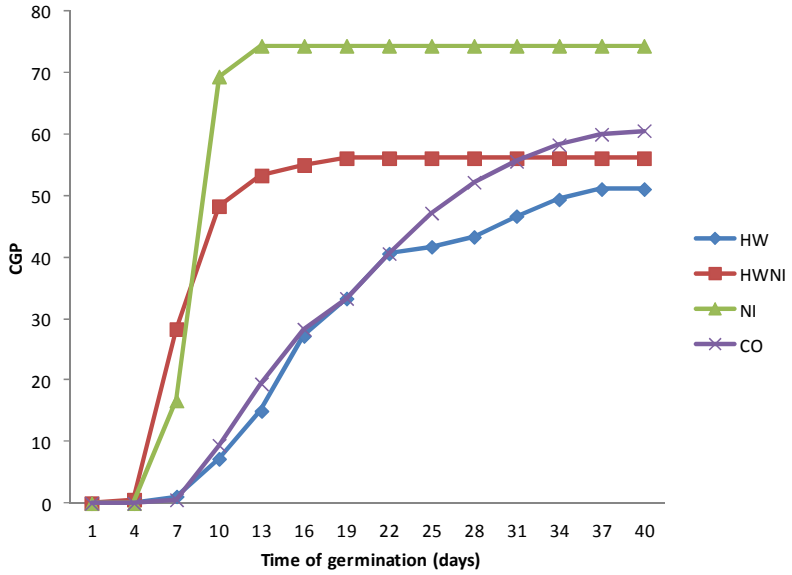

Fig. 1. Trends in the germination of seeds of *Faidherbia albida* after exposure to different pre-sowing treatments

HW – Hot water; HWNI – Hot water + Nicking; NI – Nicking; CO – Control

4. DISCUSSION

Effective and sustainable germination of seeds that must occur to ensure plant propagation is usually affected by seed morphology and anatomy and environmental factors [5]. The current study found that seeds subjected to the nicking pre-sowing treatment had the highest CGP when compared to all the other seed treatments with the MGT second to the shortest MGT duration in the hot water + nicking combination treatment in agreement with similar studies conducted by Mwase and Mvula [9] on the effect of seed size and pre-treatment methods of *Bauhinia thonningii* Schum. on germination and seedling growth. This could be due to the fact during nicking, a portion of the seed coat is a cut that allows for the unrestricted entry of water and oxygen to solubilise stored food reserves and promote respiration, respectively.

The treatment of seeds with hot water yielded the lowest CGP of 51.1% which is not in agreement with the works of Mwase and Mvula [9], Pahla et al. [16] and Sinhababu and Banarjee [12]. This could be due to the small time of exposure of the seeds to hot water which was not sufficient to cause a high degree of softening of the coats. It may also have been due to either the inactivation and/or destruction of the enzymes necessary to initiate germination due to high temperature of the water. It has already been proven that at high temperatures, the oxygen content of water is reduced [19] which can interfere with normal respiration in the embryo. The control treatment resulted in the second highest CGP differing from the findings of Mwase and Mvula [9] and Pahla et al. [16]. Seeds exposed to the hot water + nicking combination treatment did not produce the highest germination percentage as initially hypothesized. Since the treatment of the seeds with hot water could have denatured and/or destroyed some enzymes, the additional nicking treatment therefore could not produce any appreciable effect.

Higher SPs are evidence that the embryo was fully mature and that the pre-sowing treatments did not in any way negatively affect the seeds. Nicking resulted in the highest GRI (10), GV (16) and SP (93.3%) probably because the procedure simply creates an opening to allow entry of water and air for the developing embryo without affecting the original physiological state of the seed. Therefore, in considering seed pre-treatment options to break dormancy, the physiology of the species needs to be clearly understood, to better guide treatment options. Metabolic barriers have been reported as limiting germination potentials and have been checked through the use of hormones and nitrogenous substances [12].

5. CONCLUSION

Exposing seeds to combination treatments does not improve on the CGP and SP which are vital indicators of potential future establishment success. We propose and encourage the adoption of nicking as the best pre-sowing treatment method when *Faidherbia albida* is set to be introduced and incorporated into farming systems in Africa and the rest of the world suffering from excessive use of herbicides and poverty in the rural areas.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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