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Assessment of the Germination Potential of *Moringa oleifera* Seeds under Different Treatment Conditions

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ABSTRACT

Seed dormancy is the major concern that prevents or slowed down germination resulting in poor inhibitions and germination potential. In order to improve and promote *Moringa oleifera* cultivation strategies in Algeria, a country known for its extreme climatic conditions, the objective of this study was to evaluate the effectiveness of different pretreatment approaches to increase the seed germination percentage in a reduced time. a plant recognized for its nutritional and therapeutic benefits. Treatments included soaking in cold water for three different durations: 24, 48 and 72 hours, as well as scarification. Germinated seeds, identified by the appearance of their stems above the soil, were counted daily for 15 days at intervals of 5, 8, 10, 12, and 15 days. The result is expressed in terms of the seeds' germination rate (G%) and the speed at which the germination process is completed (time of germination).
Results showed that the germination rate of *M. oleifera* seeds was 96.66% after 15 DAS (days after sowing), demonstrating that scarification is a successful treatment for maximizing germination potential. Seeds soaked for 72 hours showed a germination rate comparable to that of scarified seeds, reaching 83.33% by 15 days after sowing. This soaking time proved to be almost as effective as scarification. Shorter soaking times of 48 and 24 hours resulted in lower rates of 70% and 63.3%, respectively, indicating that while brief immersion in cold water stimulates germination, it remains less effective than longer soaking times. Control seeds, which received no pre-treatment, exhibited the lowest germination rate throughout the study period, culminating in a rate of 53.33% by the fifteenth DAS. These findings highlight the crucial role of pre-treatments in overcoming seed dormancy and promoting timely germination.

Keywords: germination rate, germination seeds, germination time, *Moringa oleifera,* pre-treatments.

INTRODUCTION

As the ecological crisis deepens, it becomes more conflictual. Hardly any area of society is untouched by climate change or the consequences of ecological degradation. Environmental concerns are moving to the forefront, leading to new tensions, new conflicts, and new actors entering environmental discourses (Eskjær et al., 2023). The combination of population growth and agricultural practices has led to the depletion of forest cover, resulting in significant losses of traditionally important food sources and medicinal plants, threatening food security. Food insecurity and malnutrition are major challenges across the African continent (FAO, 2023). Mustafa et al. (2021) emphasize the need to integrate food strategies to eradicate poverty, address malnutrition and combat non-communicable diseases, while ensuring environmental protection. Consequently, there is a need to develop emerging crops such as Moringa. *M. oleifera* is one of the world's most useful and nutritious plants for humans and animals (Anwar et al., 2007; Mubvuma et al., 2013; Yerima et al., 2016). It is reported that various parts *Moringa oleifera* plant, including leaves, roots, seeds, bark, and fruit, are reported to have numerous beneficial properties such as antitumor, anti-inflammatory, antibacterial, and antifungal activities, and are utilized in traditional medicine for treating a range of ailments (Gopalakrishnan et al., 2016). The leaves of *Moringa oleifera* are particularly nutritious, providing a rich source of vitamins A, B, and C, as well as essential minerals such as calcium, iron, and potassium, and are also high in protein content (Leone et al., 2015). Mature seeds and young pods of *Moringa oleifera* are sources of ben oil, an edible oil known for its high content of behenic acid (Anwar and Rashid, 2007). Moringa seeds include dimeric cationic proteins that absorb water impurities and colloidal particles, which are then removed as sludge by settling or filtration (Ghebremichaelet al., 2005).

Germination of *M. oleifera* occurs within 5–30 days, depending on the age of the seed, soil or media type, and pre-treatment method used, which might include: cracking the shells, soaking seeds with shells, dehulling seeds, and soaking seeds (Quintin, 2009). Understanding the effects of these treatments is vital for optimizing the germination rate and overall success of *M. oleifera* cultivation (Gomaa et al., 2011). Algeria's climate varies significantly across its regions; the northern part of the conutry enjoys a Mediterranean climate with warm, dry summers and mild, rainy winters (Kendouci et al., 2023). In contrast, the geographic conditions, characterized by arid and semi-arid zones, resulting to significant water scarcity and temperature fluctuations that limit agricultural productivity (Touitou and Quasem, 2018). These factors can worsen germination conditions, reduce seed viability and lead to a shortage of seedlings. in fact, the germination of *M. oleifera* is reported to be low due to unfavorable environmental conditions, such as changes in soil chemistry and drought stress (Ali et al., 2012). This underlines the importance of adopting strategies to promote successful Moringa cultivation in these two different regions. The objective of this study was to evaluate the germination ability of *Moringa oleifera* seeds aiming to improve and promote its cultivation strategies.

MATERIELS AND METHODS

Plant material

The mature seeds of *M. oleifera* obtained from southern Algeria (Ghardaia nursery) were de-shelled and dried at ambient temperatures (25 °C) for 5 days.

Preparation of seeds for germination tests

All seeds were sterilised for 3 mins with 1% (w/v) sodium hypochlorite (NaClO), then washed twice with distilled water. The seed was placed on filter paper, kept constantly moist without being waterlogged.

Germination test

Germination is a natural physiological plant process that starts with water uptake and concludes with the appearance of the radicle (Nonogaki et al., 2010). This stage is vital for plant propagation, significantly impacting agricultural productivity. Moringa seeds were subjected to various pre-treatments to assess their effects on germination. Treatments included soaking in cold water for three different durations: 24, 48 and 72 hours, as well as scarification, which involves physically damaging the seed coat to reduce its hardness while preserving seed viability (Finch-Savage et al., 2006). Control seeds, which received no pre-treatment, were sown directly into sand for comparison. The seeds were sown in a mixture of sand and organic manure compost (1:2) at a maximum depth of 2 cm, then placed in a growth chamber under a photoperiod of 16 hours and at a temperature of 25 ± 1 °C.

Measurements

The germination parameters calculated are:

- Germination rate (%) – germination percentage (*G %*) was expressed as follows:

$$G\% = (NSG \,/\, TNSS) \times 100 \tag{1}$$

where: *NSG* is the number of seeds germinated *TNSS* is the total number of seeds sown. The variables measured were the time of germination and the number of sprouted grains.

- Time of gemination (days) – germinated seeds, identified by the appearance of their stems above the soil, were counted daily for 15 days at intervals of 5, 8, 10, 12, and 15 days, with each treatment replicated three times with batches of 60 seeds each.

The calculated parameters were measured across five groups: control seeds, scarified seeds, and pre-treated seeds soaked for 24, 48, and 72 hours.

Statistical analysis

The data were analyzed using MINITAB 18 software. The analysis was carried out using analysis of variance (ANOVA). For each parameter three experimental replicates were performed, followed by a Fisher comparison of means test at 5% levels. The homogeneous groups were separated using the Newman-Keuls test at 5% levels.

RESULTS AND DISCUSSION

The results, as presented in Table 1, indicate highly significant differences in germination rates among the various pre-treatments ($p < 0.001$) at the 5% significance level.

Scarified seeds were the first to germinate, starting from the 5th day after sowing (DAS), with a germination rate of 36.6%. By the 8th DAS, seeds that were pre-soaked for 72 hours and 48 hours showed germination rates of 26.66% and 6.66%, respectively.

At this stage, no germination was observed for the seeds pre-soaked for 24 hours or the control seeds. However, by the 10th DAS, the seeds pre-soaked for 24 hours exhibited a germination rate of 6.66%, and the control seeds showed a rate of 3.33%. By the 12th DAS, the scarified seeds had a germination rate of 83.33%, followed by seeds pre-soaked for 72 hours at 73.33%. Seeds pre-soaked for 48 hours and 24 hours had identical germination rates of 43.33%, while the control seeds had a rate of 16.66%.

By the 15th day DAS, scarified seeds had the highest germination rate at 96.66%, followed by seeds pre-soaked for 72 hours at 80%. Seeds pre-soaked for 48 hours and 24 hours had germination rates of 70% and 63.33%, respectively, while the control seeds had a rate of 53.33%. By the 20th day, all seeds germinated (Fig. 1).

These results align with those of Fuglie and Sreeja (2001), who suggested that germination should occur between 5 and 12 days. The increased germination rates can be attributed to the pre-treatment of the seeds, which allowed them to absorb water before sowing, thus enhancing their germination. Additionally, our results are consistent with the findings of Njehoya et al. (2013), who reported that the rapid germination of scarified seeds, compared to other treatments, can be attributed to the direct exposure of the seeds to temperature. This exposure increases water absorption through the seed's teguments, making them more permeable. Yerima et al. (2016) reported that the germination percentage can be influenced by factors such as

Table 1. Delay and germination rate of *Moringa oleifera* seeds under different pre-treatments

Germination time (days)	Control	Scarified seeds	Pre-soaked seeds (72h)	Pre-soaked seeds (48h)	Pre-soaked seeds (24h)
5	0.0 ± 0.0b	36.6 ± 2.8a	0.0 ± 0.0b	0.0 ± 0.0b	0.0 ± 0.0b
8	0.0 ± 0.0c	46.6 ± 2.8a	26.6 ± 2.8ab	6.6 ± 0.57bc	0.0 ± 0.0c
10	3.3 ± 0.57d	70 ± 1.0a	40.0 ± 1.0b	20.0 ± 1.0c	6.6 ± 0.57cd
12	16.6 ± 0.57c	83.3 ± 0.57a	73.3 ± 0.57a	43.3 ± 1.5b	43.3 ± 2.8b
15	53.3 ± 0.57d	96.6 ± 0.57a	83.3 ± 0.57b	70.0 ± 1.0c	63.3 ± 0.57cd

Note: Means followed by the same letter are not statistically different according to the Fisher test ($p < 0.05$).

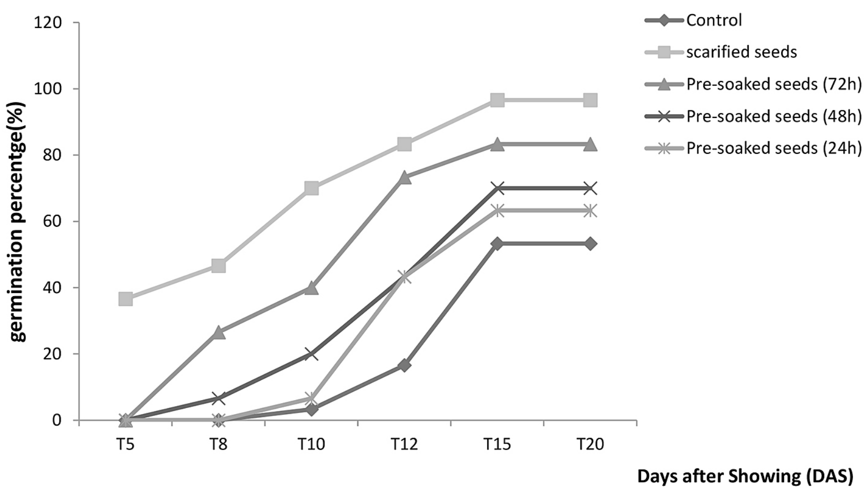

Figure 1. Germination kinetics following various treatments of *Moringa oleifera* seeds

seed pre-treatment, the composition of the substrate, and environmental conditions. Other research by Ubaidillah et al. (2020) has also shown that partial two-sided scarification can enhance the number of petioles, increase height, and improve the density of seedlings.

The analysis of growth kinetics offers a clearer understanding of the behavior of Moringa seeds under various pre-treatments over time (Fig. 1). Significant variability is observed in the response of Moringa seeds to different treatments ($p < 0.001$). The germination process can be divided into three phases: an initial rapid phase, followed by a plateau where the germination rate stabilizes, and finally, a decline as maximum germination capacity is reached (Bewley et al., 2013).

The kinetics show that untreated seeds germinate last and have the lowest germination rates. Seeds soaked in cold water for 72 hours had high germination rates (83.33% on day 15). This soaking time proved to be almost as effective as scarification. Germination rates increased progressively with time, while shorter soaking times of 48 and 24 hours resulted in lower rates of 70% and 63.3%, respectively, indicating that while brief immersion in cold water stimulates germination, it remains less effective than longer soaking times.

Scarified seeds consistently showed the highest germination rates, highlighting the important role of scarification in improving and optimizing *M. oleifera* seed germination.

CONCLUSIONS

The study demonstrated that effective seed treatment is crucial for breaking dormancy and optimize *Moringa oleifera* cultivation strategies, thus responding to the need to improve agricultural practices. The study found that seed scarification resulted in an exceptionally high germination rate on day 15 after sowing, which is remarkable compared to the existing literature. Furthermore, this research stands out from earlier studies by is the detailed analysis of the influence of soaking time on germination rates, showing that longer soaking times significantly improved germination, while shorter periods were less effective.

The information gained from the study can inform and encourage broader agricultural practices aimed at improving food security and resilience to environmental challenges, particularly in regions with extreme climates.

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