

Germination response and seedling growth performance of *Adansonia digitata* L. tree seeds under innocuous pre-treatment techniques

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Research Article

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Abstract

Adansonia digitata is a multipurpose and highly valued tree species, which produces wild edible fruits. Its seeds are characterized by hard seed coat that impedes water and oxygen penetration into the seed, and thus inhibits seed germination. This investigation was aimed to evaluate the effects of various seed pre-treatment methods on seed germination response and seedling development of the species. The experiment was conducted in greenhouse and used a completely randomized design. Seven treatments (**Trt1**: Scarification, **Trt2**: Soaking in cold water for 24 hours, **Trt3**: Soaking in cold water for 24 hours and scarification, **Trt4**: Soaking in hot water for 1 hour, **Trt5**: Soaking in hot water for 1 hour and soaking in cold water for 24 hours, **Trt6**: scarification and soaking in hot water for 1 hour, **Trt7**: Soaking in cold water, scarification then soaking in hot water) and control (without any pre-treatment). Data on seed germination and seedling growth parameters were recorded. Germination percentage, germination velocity, and mean germination rate of seeds were calculated. The study showed that seed germination and seedling growth parameters significantly varied among the treatments. The highest seed germination (complete germination within a week) and highest seed germination velocity (3 days) were recorded in Trt7 (Soaking in cold water, scarification then soaking in hot water) followed by Trt6 (96.67% germination in three weeks), Trt5 (93.33%), and Trt4 (86.67%). The lowest germination percentage (70% in 11 weeks) and lowest germination value (40 days) were recorded in seeds without any treatment. It was observed that seedlings with rapid seed germination resulted in robust and vigorous seedlings that attained approximately 15 cm in height after 11 weeks. We recommend soaking in cold water, scarification then soaking in hot water to break seed dormancy, promote seed germination, and produce vigorous seedlings of *A. digitata*.

1. Introduction

Adansonia digitata L. (African baobab) is a multipurpose and highly valued tree species in African Savannas (Sidibe and William, 2002; Jitin et al., 2005). It belongs to the Malvaceae family and occurs throughout semi-arid and arid zones of Africa. *A. digitata* is a massive, deciduous tree up to 25 m in height and may live for thousands of years (Sidibe and William, 2002; Baum, 1995). It is native to tropical arid regions of Africa. The ranches are so strange and spectacular, resembling tree roots. The fruit of *A. digitata* is shaped like bread, and the flesh juice is sweet (Sidibe and William, 2002). It is large, ovoid, and covered in a yellow/green velvety indumentum. The pericarp is woody and indehiscent and also seeds are reniform, embedded in a soft dry matrix (Baum, 1995). The seed is considered as the ripened ovule, which comes out due to proper fertilization. A matured seed consists of thick and firm seed coat and embryo, which is the young plant enclosed within the seed coat (Satyanrayana et al., 2011). These seed coat layers develop during maturation and during seed drying (Baskin et al., 2000; Sidibe and Williams, 2002; Kumar et al., 2015). The protective tissues of large seeds are known to increase survival in fire-prone savana and absorb large quantities of CO₂ from the atmosphere (Gashew and Michelsen, 2002) (Assogbadjo et al., 2011). Due to the impermeable hard seed coats, the seeds stay dormant in the soil for long time before germination (Gebauer et al., 2002). In case of these natural factor, regeneration and independent germination of *A. digitata* is poor and facing a high risk of extinction (Baskin et al., 2000; Gebauer et al., 2002). Pre-treatment enhances the accessibility of water and oxygen into the seeds before planting, in order to break dormancy and to obtain optimum germination and improve performance for plantation establishment (Gebauer et al., 2002). Different seed treatments have been tried to enhance the germination of *A. digitata* seeds but germination potential is not satisfactory (Falemara et al., 2014). The aim of this study was to evaluate the effect of different pre-sowing seed treatment techniques to break the physical seed dormancy of the species so as to enhance seed germination and growth performance of *A. digitata*. Seed germination is one of the most important stage in life cycle of plants and it is initiated when the apparent metabolic dormancy of desiccated seeds is disrupted by imbibitions (Agboola, 2003; Ajiboye and Agboola,

2011). The dormancy of *A. digitata* seeds released from ripe fruits imposed by their hard seed coats is well known (Niang et al. 2015) as seeds exhibit water-impermeable seed coats (Razanamherizaka et al.,2006).

2. Materials and Methods

2.1. Study area

The study was conducted at Bahir Dar Environment and Forest Research Centre, which is located at Bahir Dar city, Amhara regional state in small greenhouse constructed from local plastic. Bahir Dar city is located in North-western part of Ethiopia geographically 11° 38' north 37° 15' east. The average monthly maximum temperature is about 28.0°C and monthly average minimum temperature is about 13.0°C during the study period. May categorized under the warmest month of Bahir Dar city, the mean annual rainfall 1437 mm while 70 mm for average monthly precipitation with 7 rainy days during May of which the study carried out.

2.2. Seed collection and extraction Methods

Mature and healthy fruits of *Adansonia digitata* tree were collected from Quara district in west Gondar zone of Amhara region. The collected *Adansonia digitata* fruits were transported to Bahir Dar and stored in dry and clean store until seeds were extracted.

2.3. Sowing pot preparation and sowing method

Potting mixtures are essential for seed germination as well as seedling growth performance. It's crucial to use the right soil mixture to boost seed germination rates and generate higher-quality seedlings. On the other hand, not much is known about the soil mixtures that are suitable for *Adansonia* seed germination. Based on the nature of the seed we use unusual soil mix with completely randomized design (CRD) with three replications was used to establish the experiment. Seven types of seed pre-treatments and a control were used as treatments. 30 plastic pots with three replication filled with 25% pure sand and the remaining 75% filled with 3:2:1 (forest soil, sand and compost respectively) soil mix was prepared for each treatments.

The eight treatment types were

1. Scarification (Tr1)
2. Soaking in tap water for 24 hour (Tr2)
3. Soaking in tap water for 24 hour + scarification (Tr3)
4. Soaking in hot water for 1 hour (Tr4)
5. Soaking in hot water for 1 hour and soaking in tap water for 24 hour (Tr5)
6. scarification + Soaking in hot water for 1 hour (Tr6)
7. Soak in tap water + Scarification + soak in hot water (Tr7)
8. Control (without any pre-treatment) (Tr8)

2.4. Seed pre-treatment process

In order to facilitate germination of *Adansonia digitata* seeds by breaking their hard seed coat, we employed several cost-effective and environmentally friendly pre-treatment methods that can be easily implemented by farmers, development workers, or anyone interested in cultivating Baobab seedlings. These techniques included mechanical scarification, Tap water immersion, hot water immersion, and various combinations of these approaches one

combined method involved a sequence of steps: first, seeds were submerged in Tap water for a 24-hour period, then subjected to mechanical scarification, and finally placed in hot water for one hour. The impression of seeds in tap water will soften hard seed coat and help to scarified easily while immersion in to hot water assist germination of seeds.

For the treatment combinations, first, hot water was filled in glass bottle and mechanically scarified seeds were immersed for one hour. After one hour immersion, the colour of seeds changed from brown to dark brown and swollen gently.

2.3. Data analysis

Number of germinated seeds was recorded daily and germinated seedlings were marked to avoid double counting. In addition, root collar diameter, shoot height and numbers of leaves of seedlings were recorded weakly from each treatment.

The following parameters were used to evaluate each treatment effect by following the methods of El-bably & Rashed (2018).

Germination percentage (G %) this parameter will be evaluated by using the following formula

$$G \% = \frac{No. \text{ of germinated seeds}}{Total \text{ seed number}} \times 100 \dots \dots \dots (1)$$

Germination velocity (G.V) this parameter were computed as follows

$$G.V = No. \text{ of days from sowing to emergence of the plumule} \dots \dots \dots (2)$$

Mean germination rate also computed as (M.G.R)

$$M.G.R = Number \text{ of days to attain } 50 \% \text{ of total germination} \dots \dots \dots (3)$$

3. Results and Discussion

3.1. Effects of pre-treatment on seed germination of *A. digitata*

3.1.1. Germination velocity and mean germination rate

According to the study, *Adasonia digitata* seed germination was enhanced by seed pre-treatments. These treatments effectively disrupted the rigid seed coat, thereby reducing dormancy. This process promotes seed germination by facilitating increased absorption of water and oxygen by the seed embryo. The control group, which received no seed treatment, exhibited the lowest seed germination rate. Due to the prolonged breakdown of *Adasonia digitata's* rigid seed coats in untreated seeds, these seeds also required an extended period for germination. The experiment's alternative seed treatments, including mechanical scarification, soaking in tap water, hot water, and their combinations, resulted in increased germination percentages of *Adasonia digitata* seeds. Esenowo, (1991); Sidibe and Williams, (2002); Razanameharizaka et al.,(2006); Niang et al., (2015). Additionally, the importance of seed scarification for breaking the hard seed coat and enhancing seed germination potential was emphasized. Consequently, scarifying seeds prior to sowing is crucial for breaking down the impermeable hard seed coat to enhance the germination potential of the seeds. Furthermore, Falemara et al. (2013) asserted that

seed pre-treatments are essential for breaking seed dormancy and enhancing water absorption and oxygen uptake by seeds, which subsequently facilitates seed germination. Our results also indicated that the germination percentage of *Adasonia digitata* seeds differed significantly among pre-treatments ($P < 0.01$).

The highest seed germination percentage (100%) and most rapid germination (within three weeks) were observed for seeds subjected to a combination of tap water immersion, mechanical scarification, and subsequent hot water immersion treatments. The second most effective pretreatment was scarification followed by tap water immersion, resulting in 96.7% germination of total seeds within three weeks. Seeds treated with scarification followed by hot water immersion, as well as seeds subjected solely to hot water immersion, exhibited 93.3% germination each within five weeks. Scarification alone, tap water immersion, and sequential tap water and hot water immersion resulted in germination rates of 86.7%, 80.0%, and 76.7%, respectively. The control group demonstrated the lowest germination rate of 70.0%, requiring 11 weeks, and produced stunted seedlings compared to other treatment groups (Fig. 2). Kempe et al., (2018) also noted that seeds treated with sulfuric acid achieved approximately 90% germination within six weeks of planting. However, Usman and Asan, (2017) found no significant difference in seed germination between hot water, tap water pre-treatments, and the control group. Additionally, Aziza & Taj, (2015) and Danthu et al., (1995) observed a 20% decrease in germination for untreated seeds compared to treated ones. Similarly, Falemara et al., (2014) reported that *Adasonia digitata* seeds treated with sulphuric acid started to germinate 8 days after sowing. Similar study, Danthu, et al., (1995) indicated that manual scarification always induced the fastest germination of seeds.

3.2. Seedling growth performance under different seed pre-treatments

3.2.1. Leave multiplication

Statistical analysis revealed significant differences in the average leaf count across various pre-treatments ($p = 0.00$). The highest mean leaf number (6) was observed after eleven weeks in seeds subjected to a combination of tap water soaking, mechanical scarification, and hot water soaking (Fig. 8). This result aligns with Usman and Asan's (2017) findings, where six mean leaves were recorded in seeds treated with sulfuric acid. Additionally, Samia et al., 2018 reported an average maximum seedling leaf count of 14.8 for seeds soaked in 98.5% sulfuric acid for 60 minutes over a one-year period.

Three treatments (scarification, hot water soaking, and a combination of hot and tap water soaking) resulted in a mean of five leaves after eleven weeks. Seeds pre-treated with hot water developed five leaves on average starting from the fifth week, while scarification-treated seeds and those treated with both hot and tap water reached this stage by the sixth and ninth weeks, respectively. Tap water-treated seeds produced an average of four leaves by the eleventh week, beginning from the eighth week. Untreated seeds developed four leaves after a three-week delay compared to tap water-treated seeds. These observations suggest that leaf development is influenced by germination timing, with earlier-germinating seeds producing more leaves than those germinating later.

3.2.2. Root collar diameter

The mean root collar diameters of seedlings subjected to different pre-treatments were analyzed (Table 3). Significant differences in mean root collar diameter increment between treatments were observed at the 0.05 level ($P = 0.019$). The highest mean root collar diameter increment was observed in seedlings treated with scarification and hot water pre-treatment. The second-highest mean root collar diameter was recorded in seedlings subjected to

scarification with tap water pre-treatment. The remaining pre-treatments yielded the following results: scarification, tap water with hot water and scarification, tap water with hot water, and hot water (Table 1).

3.2.3. Height of seedlings

ANOVA results indicate that the height increments of *A. digitata* seedlings among different pre-treatments were not significantly different. The highest height increment of seedlings was observed in tap water with scarification pre-treatment, followed by tap and hot water with scarification, hot water with scarification, hot water, scarification, and tap water with hot water over eleven weeks (Table 1). A previous study by Chia et al. (2008) confirmed that the average maximum seedling height was 13.7 cm in two months. Furthermore, Usman and Asan (2017) reported that the greatest plant height recorded was 6.51 cm in eight weeks. Additionally, Samia et al. (2018) demonstrated that the average maximum seedling height was 27.25 cm when soaked in 98.5% sulfuric acid for 60 minutes over a one-year period. Tap water and control treatment seedlings did not exhibit measurable height increments during the data recording period. These findings suggest that seedling height increments are dependent on germination time.

3.2.4. Root length of seedlings

Roots of *A. digitata* seedlings have two parts namely tuber parts and taper root (main long root) parts. The first part (tuber part) is very thick and the next part is taper root part. The ANOVA results indicated that the root lengths of seedlings subjected to different pre-treatments were not significantly different. The greatest mean root length of seedlings was observed in seedlings treated with hot water and scarification pre-treatment. The second greatest root length of seedlings was observed in seedlings treated with a combination of tap water and hot water with scarification pre-treatment. The least root length was observed in seedlings treated with hot water and tap water, which was comparatively lower than other pre-treatments. Similarly, Lennart et al. (2020) confirmed that *Adasonia digitata* has two parts and an average root length reaching 24.2 cm. The vigor of the root system plays an important role in survival in harsh environments.

Table 1
Mean growth performance of African baobab seedlings along pre-treatment seedlings

Treatments	Root collar diameter (cm)	Shoot height (cm)	Root length (cm)
Tr1	26.9 (0.297) ^a	24.6 (0.64) ^b	17.41(0.58) ^b
Tr2	-	-	-
Tr3	28.51(0.48) ^b	24.3 (1.1) ^b	16.66 (1.44) ^b
Tr4	25.2 (0.63) ^b	22.36 (0.85) ^b	15.97 (0.50) ^b
Tr5	26.5 (0.85) ^b	22.38 (1.1) ^b	16.70 (0.89) ^b
Tr6	26.98 (1.57) ^b	20.76 (1.67) ^b	14.62 (0.31) ^b
Tr7	32.47 (0.81) ^b	25.47 (1.85) ^b	16.44 (0.31) ^b
Tr8	-	-	-

Means within a row designated by similar letters are not significantly different at $p \leq 0.05$.

Tr₁ Scarification, **Tr₂** Soaking in cold water, **Tr₃** Soaking in cold water + scarification, **Tr₄** Soaking in hot water, **Tr₅** Soaking in cold water + hot water, **Tr₆** Scarification + soaking in hot water, **Tr₇** Soaking in cold water + scarification + soaking in hot water, and **Tr₈** Control.

4. Conclusion and Recommendations

First soaking in tap water then manually scarifying finally soaking in hot water pretreatment technique was effective and efficient method of Baobab seed pretreatment. This technique is affordable and environmentally safe because it is free from using any hazardous chemicals. These methods are also effective as they germinate all seeds sown while it is efficient as it takes only one week to germinate all seeds. Soaking in tap water helps soften the seed's hard coat, which makes the scarification process easy and safe while soaking in hot water promotes and initiates germination early. Important lesson learned from this study is that mechanical scarification should be an integral part of *Adansonia digitata* seed pre-treatment. Growth performance of *Adansonia digitata* seedlings could emerge six highest average leaves in eleven weeks. Different seed pretreatments also show significant differences in terms of root collar diameter, and number of leaves produced. Besides taking a long time to germinate the emerged seedlings are very stunted and easily attacked by defoliators for untreated seeds thus further study needed to be conducted on the health and survival of seedlings with different treatments. Finally, this study is limited to specific site conditions and confined to Bahir Dar, Amhara region, Ethiopia.

Declarations

Author Contribution Statement

Mitku Alemu: Contributed on implementation of the experiment, monitored the experiment, data collection, analyzed and interpreted the data and prepared the manuscript. Melkamu Abere: Conceived and designed the experiment, revised the manuscript. Dereje Gasheye: Contributed on implementation of the experiment and revised the manuscript. Moyibon Jifar: contributed on implementation of the experiment and data collection. Demelash Alem: Data analysis, writeup and reviewing the manuscript. All authors read and approved the final manuscript.

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Data Available Statement

Please contact the author for data requests.

Declaration of Interest Statement

The authors declare no conflicts of interest.

Additional Information

No additional information is available for this paper.

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Figures

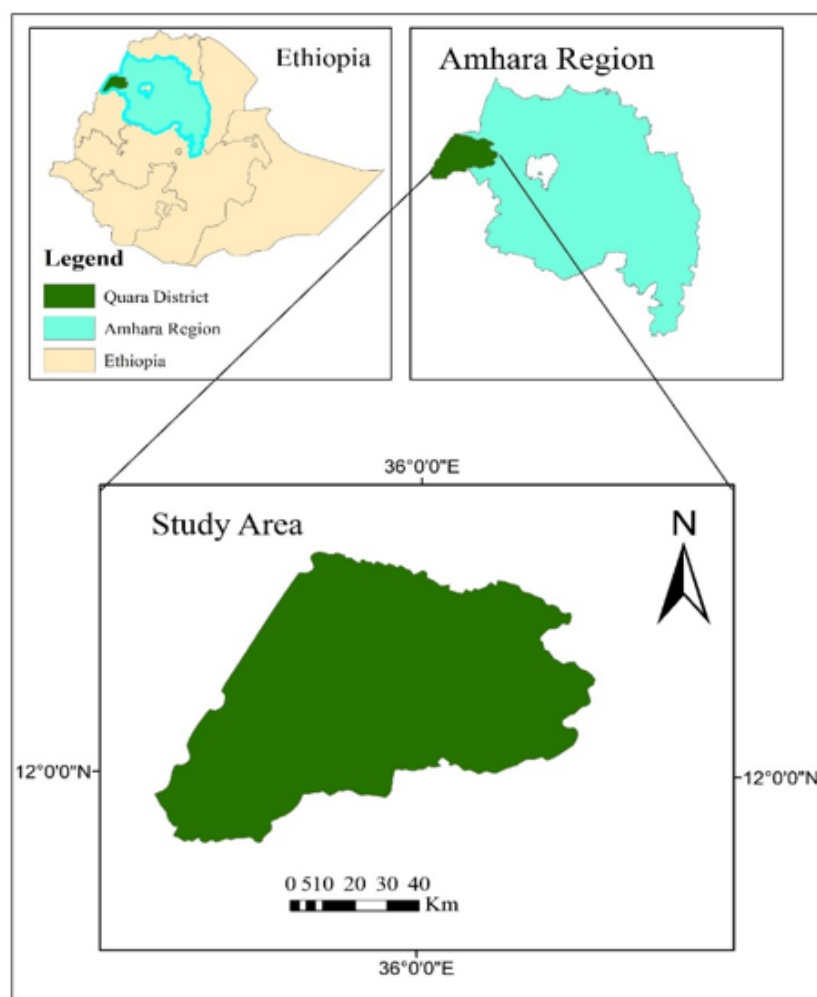


Figure 1

Map of the seed collection site

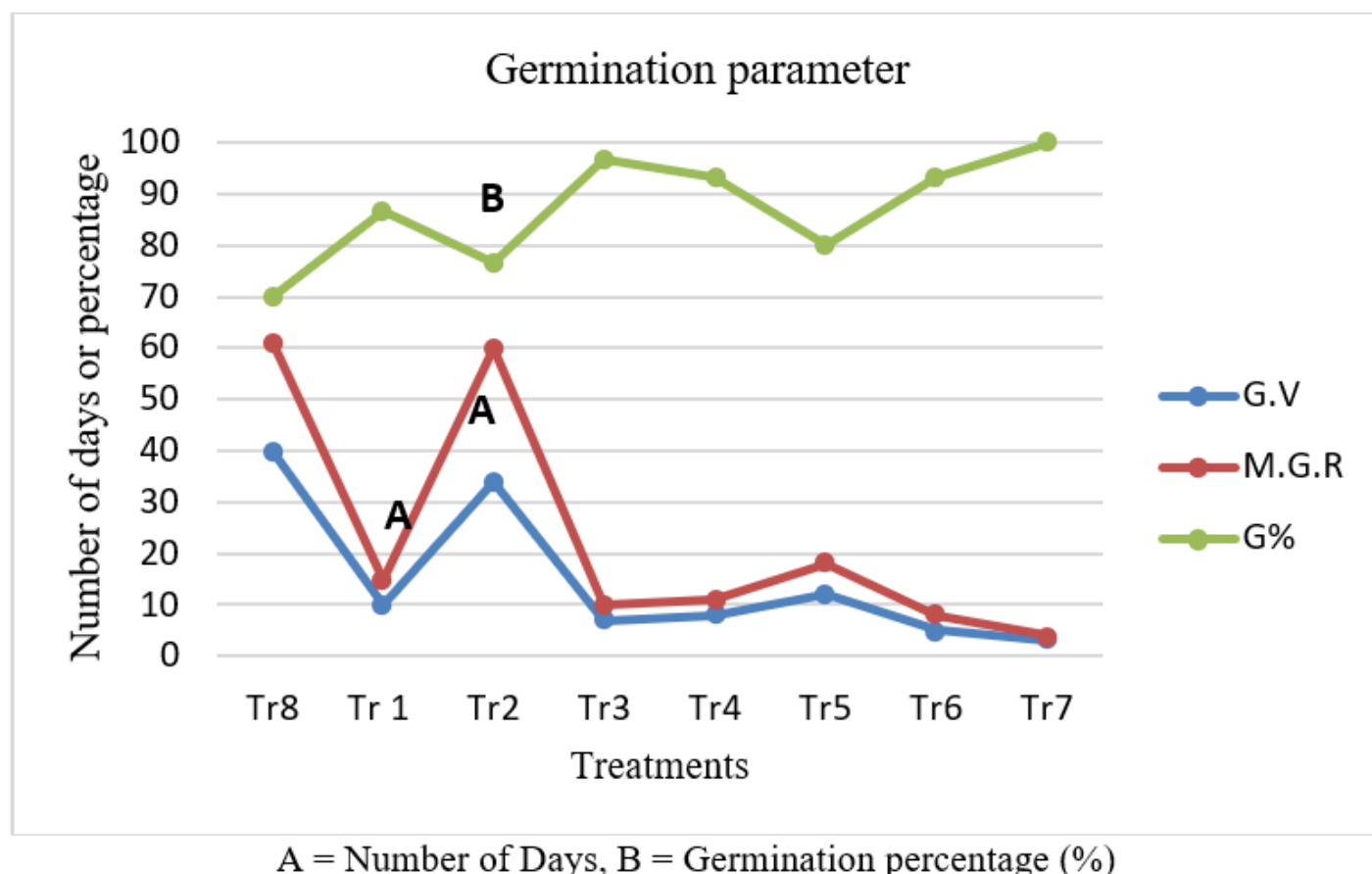


Figure 2

The effect of seed pretreatments on germination of *Adansonia digitata* seeds

Where:- G.V = germination velocity, M.G.R. = Mean Germination Rate, G(%) = Germination percentage, Tr1. Scarification only, Tr2 soaking in tap water, Tr3. soaking in tap water then scarification, Tr4 Soaking in hot water, Tr5. Soaking in tap water, then in hot water, Tr6. Scarification, then soaking in hot water, Tr7. Soaking in tap water, scarification, then soaking in hot water. Tr8. Control.

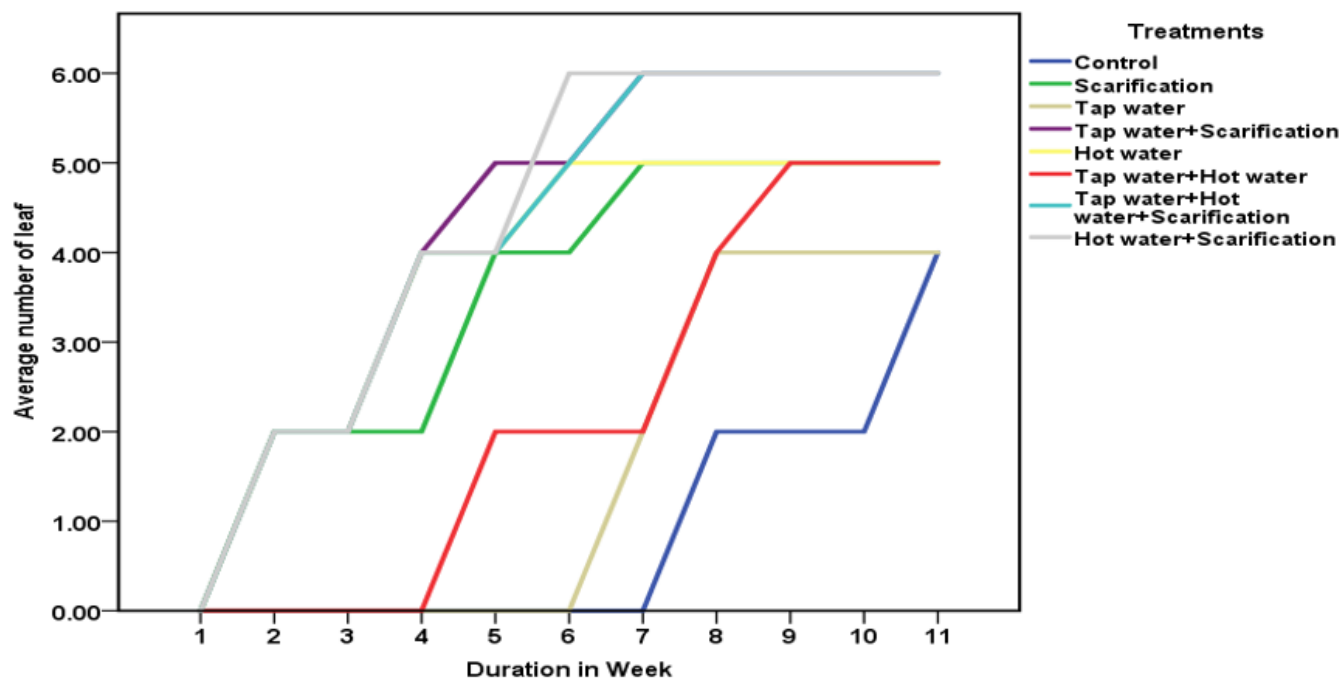


Figure 3

Seedling performance in terms of leaf emergence