Evaluation of Pre-sowing Seed Treatments on Germination of Selected Indigenous Tree and shrub Species in Borana Zone, Southern Oromia

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Research Article

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Abstract

Background The germination success of indigenous tree and shrub species is crucial for ecosystem restoration and biodiversity conservation. This research focuses on the evaluation of pre-sowing seed treatments to improve germination outcome of selected indigenous tree and shrub species in the lowland of Borana Zone.

Methods Fruits of selected species were collected local areas, and their seeds were extracted manually, air-dried and, diseased and injured seeds eliminate and, stored at room temperature. The seeds were subjected to four pre-sowing treatments; mechanical scarification, chemical scarification, hot water, cold water, and control. The experiment was conducted in a nursery management system, with treated seeds sown in pots in a randomized design with three replications. Seed pots were watered twice daily and weeds were controlled by hand to prevent competition. Data were collected on seed emergence and the number of emerged daily after the day of first germination to the end of germination. The percentage of seeds germination were calculated using equations for each treatment and, analyzed using SAS statistical software a GLM procedures, and significantly different treatments were separated using the LSD test

Results The seed germination rates of Psydrax schimperiana seeds vary significantly among pre-sowing techniques. Cold water and concentrated H_2SO_4 treatments had the highest germination rates, while hot water exposure and 98% sulfuric acid exposure were less effective. The study found that cold water treatment significantly improved germination rates of M. kummel seeds, increasing mean germination rate and germination indexes, and reducing the days until seed emergence, with the lowest rate recorded under control treatments. In the case of Grewia villosa, the highest germination rate (76.67%) was recorded under hot water treatment and mechanical scarification, concentrated H_2SO_4 for 15 minutes had the lowest germination rate. For Terminalia brownie, the maximum germination percentage was recorded under mechanical scarification (50%), and the lowest germination was under the control treatment (19%). The germination percentage of Pappea capensis was greater under soaking seeds in cold water for 36 hours (61%), followed by seeds soaking in cold water for 12 hours (50%). For the B. microphylla, C. myrrha and C. corrugatais species soaking seeds in cold water for 36 or 12 hours more effective technique to get better seeds germination percentage. In the case of Acacia tortilis, the heist germination percentage was observed with the seed soaking in concentrated H_2SO_4 for 15 minutes (81.33±6.41%), followed by the seed soaked in cold water for 36 hours (74.33±6.41%).

Conclusion The research highlights the pre-sowing seed treatments increase the seeds germination and, cold water treatments are being recommended as cheaper and less hazardous pretreatment method.

Background

Indigenous tree and shrub species contribute significantly to biodiversity, ecosystem stability, and various ecological services, particularly in terms of food security and nutrition for local communities [1]. Initiatives on forest and landscape restoration and, agroforestry practices in drylands to promote poverty alleviation and environmental rehabilitation in developing countries seek the integration of indigenous tree species into the system [2]. However, the germination of seeds from these species is often hindered by natural dormancy mechanisms, protective seed coats, or other environmental factors.

Seed dormancy is a state in which viable seeds show no or only little germination within a certain time, although all environmental conditions (moisture, light, and air) are adequate for germination. Regardless of the seed class (recalcitrant, intermediate, or orthodox groups), seed dormancy is an important factor that can affect the germination of each group at any stage [3]. Several reports on the germination behavior of tree seeds indicate that seed dormancy is prevalent among orthodox seeds compared to recalcitrant seeds [3]. Dormancy of seed can be caused by the special quality of the seed coat, such as hard layers of cells, the water impermeability of the coat, or the existence of germination-inhibiting substances in the seed coat, such as oil. Some dormancy is also caused by undeveloped seed [4].

Seed dormancy is classified as primary and secondary seed dormancy. Primary seed dormancy, which is mainly caused by maternal tissues. For example, this could be due to embryo immaturity at harvest, inhibition of water uptake, restriction of embryo expansion, and the absence of leaching of inhibitors [5]. Furthermore, this type of seed dormancy seems to affect many plant species, and it is mainly a function of the prevailing environmental conditions such as temperature, moisture, chemicals, light, and many others. Induced (secondary) seed dormancy occurs after the seeds are harvested and may exist for either recalcitrant, orthodox seeds or sub-classes. Therefore, poor seed handling and storage can bring about secondary seed dormancy [3]. In addition to seed dormancy, the geographic source of seeds significantly affects most germination parameters [6].

To enhance and optimize the germination potential of indigenous tree and shrub species, seed pretreatments have been explored as a valuable tool. Seed pretreatments involve subjecting seeds to specific environmental conditions, mechanical processes, or chemical treatments before planting to break dormancy, soften seed coats, or initiate physiological processes that promote germination. The effectiveness of seed pretreatments can vary among different plant species, making it crucial to assess their impact on the germination of specific indigenous tree and shrub species. Various effective and practical treatments, such as nicking, hot water soaking, physical or acid scarification, cold water treatment, and mechanical scarification have been developed to break dormancy. Appropriate pretreatment depends on the dormancy characteristics of the seed being treated [7, 8, 9].

The most significant and valuable tree species have this dormancy issue in dryland environments. The majority of the trees and shrubs planted in the Borana Zone are foreign species, including those used in watershed management. One of the main issues in the zones is the low survival rate of seedlings that have been planted. High-value indigenous species must be planted instead of introduced ones, and there is a rising need for seedlings of native tree and shrub species. However, germination issues plague the majority of native tree and shrub species. On the evaluation of indigenous trees and shrubs' germination in the zones, no research has been done. Information on germination is crucial for the next agroforestry initiatives. Therefore, this study was undertaken to evaluate and identify appropriate seed pre-treatments for the germination of selected indigenous tree/shrub species in the lowlands of Borana Zones.

Material and Methods

Description of the study area

The study was conducted in the Borana Zone of southern Oromia which is situated in Oromia National Regional State at 570 km south of Addis Ababa. The zone lies between 4̊ 3′ N to 5̊ N and 37̊ 4′ E to 38̊ 2′ E with a total area of approximately 95,000 km². The elevation of the zone ranges from 1000 to 1600 m a.s.l. [10]. Borana is a zone known for its diverse ecosystems, ranging from arid to semi-arid landscapes, and, has a bi-modal rainfall pattern with the main rainy season (Ganna) between March and May with the peak in April [10]. The short rainy season (Hagayya) extends from September to November with a peak in October. Historically, the mean annual rainfall of the zone ranges from 352 mm in the southern part to 605 mm with mean annual rainfall is 587.2 mm and, the mean annual temperature varies from 15–24˚C [10]. The vegetation in Borana often includes a mix of grasslands, shrublands, and scattered trees. Acacia species are commonly found in the area and are adapted to arid conditions.

The seeds of tree species selected for this study were collected from the Yaballo, Dhas, Elwoya and Gomole districts of the Borana zone. The seed germination experiments were conducted on a station at the tree nursery of Yaballo Pastoral and Dryland Agriculture Research Center.

Methods

Species selection

Before starting the experiment, important tree species in the context of agrosilvopastoral production systems were identified through key informants and local elders’ interviews across districts of the Borana Zone. Moreover, the phonologies (flowering time, seed production seasons, and seed collection time) of those important tree species were identified. Then, the fruits of the selected tree species were collected from where they were most commonly found.

Table 1
Importance of tree species selected for this study in the Borana agrosilvopastoral production system

No	Tree species	Importance	Seed collection time
1	*Acacia tortilis*	Known fodder (pods) tree species during dry seasons. It also used as shade and ritual values	February to Murch
2	*Boswellia microphylla*	Source of Gum and incense, used as hygienic and perfuming for local communities and, its leave use as fodder.	February to Murch
3	*Commiphora corrugata*is	Source of Gum and incense and, used as hygienic and perfuming for local communities leave to use as fodder,	February to Murch
4	*Commiphora myrrh*	Source of Gum and incense used as a medicinal plant for local communities.	February to Murch
5	*Grewia villosa*	Fruits have food and ethnomedical value and are sold by pastoralists in the market in Arero district. Its leaves used as fodder	February to Murch
6	*Mimusops kummel*	Fruits have food and ethnomedical value and are sold by pastoralists in the market in Arero district. Used as Firewood, charcoal, local utensils, and local construction.	February to Murch
7	*Pappea capensis*	Use as fodder, wild edible, medicinal, and firewood for local communities	January to February
8	*Psydrax schimperiana*	Use as wild edible, medicinal pant, construction, and firewood for local communities	January to Murch
9	*Terminalia brownie*	Use as fodder, hygienic and perfuming, construction and firewood for local communities	January to Murch

Seed collection and preparation

Fruits of selected indigenous tree species were collected from lowland agroecology Borana Zones. *Terminalia brownie, Pappea capensis, Commiphora myrrha (Qumbii), Boswellia microphylla (Ilkabuqis), Psydrax schimperiana (*Gaallee), *Acacia tortilis*, *Commiphora corrugatais*, *Grewia villosa* and *Mimusops kummel* were among the tree species selected for this experiment. From these tree species, the mature fruits were collected from promising mother trees, and their seeds were extracted manually. The extracted seeds were air-dried and sorted at room temperature (24 to 26°C) to keep the seeds viable for the germination experiments. Before experimenting, the collected seeds were initially sorted to eliminate diseased and injured seeds.

Experimental designs

Pre-sowing seed treatments were applied following the method used and recommended by other studies [7, 8, 11, 9, 6].

Seeds of each species were subjected to four pre-sowing methods, for a total of eight (8) treatments. (1) Mechanical scarification: seeds were sacrificed manually by cutting/rubbing the seed coat at the opposite side of the hilum; (2) Chemical scarification: seeds were soaked in concentrated sulphuric acid (98%) for 5 and 15 minutes and after treatments, seeds were thoroughly rinsed in tap water and finally air-dried; (3) Hot water: seeds were soaked in boiling distilled water at 100°C and left for 5 and 15 minutes; (4) cold water: seeds were soaked in cold tap water for 12 and 36 hours. (5) Control: no seed pre-sowing treatment was applied. The pre-sowing treatments were:

T1: Mechanical scarification (De-coating)

T2: Soaking in concentrated H_2SO_4 for 5 minutes.

T3: Soaking in concentrated H_2SO_4 for 15 minutes.

T4: Soaking in boiled water for 5 minutes

T5: Soaking in boiled water for 15 minutes

T6: Soaking in cold water for 12 hours

T7: Soaking in cold water for 36 hours

T8: Control

The experiment was conducted in a nursery management facility (in a polythene tube). The treated seeds were sown in the recommended soil mixing ratio in pots (2:1:1, forest, agriculture soils, and animal manure respectively). The pots were arranged in a nursery bed in a completely randomized design (CRD) with three replications. Each replication has 30 pots, which were used as a plot, which means 8 treatments multiplied by 3 replications, for a total of 24 plots. Seed pots were watered twice daily as usual by nursery management. Weeds were controlled by hand to prevent competition.

The soils used in the nursery as growing media were collected from the nearby *Juniper's procera* natural forest, agriculture land, and farmyard manure. To determine their nutrient contents, samples were taken from collected soils, air dried, crushed in a mortar, sieved through a 2 mm sieve, and analyzed for their nutrient contents. The laboratory result is summarized in the following table.

Table 2
Mean ± Std of soil physicochemical values for forest and agricultural soil collected from the upper surface (0–30 cm).

Soil properties		Forest Soil			Agricultural Soil		
	N	Min	Max.	Mean ± Std	Min.	Max.	Mean ± Std
% Carbon	5	0.70	2.73	1.67 ± 0.91	1.40	1.79	1.51 ± 0.16
% Total Nitrogen	5	0.04	0.19	0.90 ± 0.06	0.06	0.17	0.101 ± 0.04
PH	5	6.02	7.00	6.47 ± 0.4	6.94	7.03	6.98 ± 0.04
EC (mmhos/cm at 25^0c)	5	0.02	0.07	0.04 ± 0.02	0.08	0.14	0.10 ± 0.02
Av.K (ppm)	5	296.00	397.50	329.3 ± 42.46	14.50	139.50	67.50 ± 56.92
Av. P(ppm)	5	1.84	15.46	7.31 ± 7.39	1.24	11.12	5.30 ± 4.24
Ca (meq/100m soil)	5	15.00	20.00	18.30 ± 2.07	14.25	19.25	16.50 ± 2.15
Mg (meq/100m soil)	5	5.75	12.00	9.35 ± 2.35	6.00	12.00	9.30 ± 2.47
Exch. Na (ppm)	5	0.07	0.13	0.11 ± 0.03	0.02	0.11	0.05 ± 0.03
exch. K (ppm)	5	0.08	0.32	0.19 ± 0.11	1.01	1.16	1.06 ± 0.06
%sand	5	51.00	57.00	53.80 ± 2.28	63.00	69.00	65.80 ± 2.68
%silt	5	24.00	30.00	27.60 ± 2.61	8.00	20.00	13.20 ± 4.38
%clay	5	17.00	21.00	18.60 ± 1.67	11.00	25.00	21.00 ± 6.16
Textural classes				Sandy loam			Sandy clay loam

Data Collection

Data was collected on seed emergence and the number of emerged seedlings daily after the day of first germination to the end of germination.

Data Management and Statistical Analysis

Percentage seed Germination (GP) and Germination Rate (GR) were estimated with the following equations

(1) Number of days to start Germination: was determined by counting the number of days after sowing to the first day germination observed.

(2) Seeds Germination Percentage (GP); the number of germinated seeds as a percentage of the total number of tested seeds is given as;

$GP = (\text{germinated seeds}/\text{total tested seeds}) \times 100\%$

(3) Germination meantime: was taken according to [12] as;

$GMT = \sum T_i N_i / S$

Where Ti is the number of days from the beginning of the experiment, Ni is the number of seeds germinated per day, and S is the total number of seeds germinated.

(4) Germination index (GRI): was calculated for each treatment using the following equation:

$GRI = (G1/1) + (G2/2) + \ldots + (Gx/x)$,

Where G is the germination day 1, 2, and x represents the corresponding day of germination [13].

The data was subjected to analysis of variance following a GLM using SAS statistical software. The treatment means that significantly different at a 5% level of significance was separated using the LSD test.

Results and Discussions

Effect of pre-sowing seed treatments on germination of Psydrax schimperiana (Gaallee)

The percentage of seed germination of *Psydrax schimperiana* differed substantially among pre-sowing treatment techniques ($P < 0.05$), with soaking in cold water for 12 hours and soaking in concentrated (98%) H_2SO_4 for 5 minutes treatments recording the highest mean percentage germination of 76.33% each and the lowest percentage germination (37.67%) being produced under control treatment. Seeds soaked in cold water for 12 and 36 hours both recorded the highest percentage of germination compared to other treatments except seeds immersed in 98% sulphuric acid concentration for 5 minutes, which had a similar germination percentage with cold water treatments (Table 3). This is consistent with [14] finding that cold water treatment contributes to the high mean germination of tree seeds. The germination indexes (GI) were similarly significantly different among the pre-treatments, and seeds were treated with cold water and seeds immersed in 98% sulphuric acid concentration for 5 minutes recording the highest germination indexes compared to other treatments (Table 3). The capacity of cold water to improve seed coat permeability may be the reason why the Cold-water treatment recorded the greatest percentage and quickest time to first seed emergence. This made it possible for the embryo to be transformed into a seedling via enzymatic hydrolysis and gaseous exchange without adversely compromising the seed's functioning organs [15]. This concurs with the findings of [16] who determined that water is needed for seed germination.

Pre-treatments with socking in 98% concentrated sulphuric acid for 15 minutes and hot water treatments recorded a low germination rate compared to coldwater pre-treatment (Table 3). A lower percentage of seeds germinated after hot water pre-treatment than after cold water pre-treatment, most likely because of the high temperature to which the seeds were exposed. The study by [17] found that using hot water as a pre-treatment may likely be harmful to enzymatic activity at higher temperatures. The comparatively low proportion of seeds that germinated after being immersed in 98% sulfuric acid for 15 minutes seems to indicate that *Psydrax schimperiana* seeds are sensitive to greater concentrations of this chemical. This is consistent with [18] finding that sulphuric acid harms seed embryos.

In comparison to most pretreatments (Coldwater, 98% sulphuric acid, and hot water), the control treatment and mechanical scarification (nicking) often reported low percentage germination, an indication of some level of dormancy in *Psydrax schimperiana* seeds. This implies that pretreatments have an advantageous effect on *Psydrax schimperiana* seed germination, which may be advantageous to nursery managers and foresters for the domestication of the species.

Table 3
Effect of different pretreatments on percentage germination, first seed emergence, and germination rate of *Psydrax schimperiana* (Gaallee)

Pre-sowing treatments	**Germination (%)**	**Days to emergence (No.)**	**MGT**	**Mean Germination rate (seedlings/day)**	**Germination indexes (GI)**
Mechanical scarification (nicking)	42.33 ± 5.69^{bc}	46.33 ± 1.12^{a}	4.80 ± 0.28^{ab}	0.209 ± 0.01^{ab}	3.09 ± 0.62^{c}
Soaking in concentrated $H_2SO_4$for 5 min.	76.33 ± 5.69^{a}	37 ± 1.12^{b}	5.35 ± 0.28^{a}	0.24 ± 0.01^{a}	5.86 ± 0.62^{b}
Soaking in concentrated H_2SO_4for15 min.	56.67 ± 5.69^{b}	44 ± 1.12^{a}	4.80 ± 0.28^{ab}	0.21 ± 0.01^{ab}	5.34 ± 0.62^{b}
Soaking in boiled water for 5 minutes	41.00 ± 5.69^{bc}	45 ± 1.12^{a}	4.55 ± 0.28^{ab}	0.22 ± 0.01^{ab}	4.19 ± 0.62^{bc}
Soaking in boiled water for 15 minutes	55.67 ± 5.69^{b}	43.33 ± 1.12^{a}	4.76 ± 0.28^{ab}	0.21 ± 0.01^{ab}	5.03 ± 0.62^{b}
Soaking in cold water for 12 HRs	76.33 ± 5.69^{a}	37.33 ± 1.12^{b}	4.47 ± 0.28^{b}	0.22 ± 0.01^{ab}	7.76 ± 0.62^{a}
Soaking in cold water for 36 HRs	69.00 ± 5.69^{ab}	39 ± 1.12^{b}	4.04 ± 0.28^{b}	0.25 ± 0.01^{a}	7.86 ± 0.62^{a}
Control	37.67 ± 5.69^{c}	46 ± 1.12^{a}	4.35 ± 0.28^{b}	0.187 ± 0.01^{b}	3.05 ± 0.62^{c}
LSD	17.05	3.35	0.84	0.04	1.87
CV%	17.35	4.58	10.45	11.59	20.44
R^2	0.0004	< .0001	0.1364	0.043	0.0002

NB: Means within a column that shares a superscript letter do not differ substantially at a significance level of 0.05.

Effect of pre-sowing seeds treatments on germination of Mimusops kummel (Qolaatii)

The germination rate showed a significant difference among various seed treatments ($P < 0.0001$). A higher percentage of seeds germinating of *M. kummel* seeds was recorded after soaking seeds in cold water for 36 hours (79%), followed by soaking seeds in cold water for 12 hours (57.67%), and the lowest germination rate was recorded under control treatments (21.33%) (Table 3). Cold water treatment not only improves the germination rate but also significantly increases the mean germination rate and germination indexes; moreover, it reduces significantly the days until the emergence of seeds (Table 4). A similar result was reported a higher germination percentage of *M. kummel* seeds treated with cold water [19]. A study by [14] also found that cold water treatment contributed to the high mean germination rate of tree seeds. The low germination rate under controlled treatment which improved after seed treatments indicated that the seed dormancy of *M. kummel* belongs to morphological dormancy. A study by [19] indicated that *M. kummel* seed exhibits non-physiological dormancy, which makes it simple to germinate in a controlled setting.

Table 4
Effect of different pre-sowing treatments on percentage germination, first seed emergence and germination rate of *Mimusops kummel*

Pre-sowing treatments	**Germination (%)**	**Days to emergence (No.)**	**MGT**	**Mean Germination rate (seedlings/day)**	**Germination indexes (GI)**
Mechanical scarification (nicking)	36.67 ± 3.21^{c}	75 ± 4.98^{ab}	4.39 ± 0.30^{ab}	0.23 ± 0.02^{ab}	2.91 ± 0.48^{c}
Soaking in concentrated $H_2SO_4$for 5 min.	31.00 ± 3.21^{cd}	87 ± 4.98^{a}	3.98 ± 0.30^{ab}	0.26 ± 0.02^{ab}	2.61 ± 0.48^{c}
Soaking in concentrated H_2SO_4for15 min.	25.33 ± 3.21^{de}	81.67 ± 4.98^{a}	3.74 ± 0.30^{b}	0.28 ± 0.02^{a}	2.64 ± 0.48^{c}
Soaking in boiled water for 5 minutes	27.67 ± 3.21^{cde}	87.67 ± 4.98^{a}	4.87 ± 0.30^{a}	0.21 ± 0.02^{b}	1.84 ± 0.48^{c}
Soaking in boiled water for 15 minutes	24.33 ± 3.21^{de}	80.67 ± 4.98^{a}	3.64 ± 0.30^{b}	0.28 ± 0.02^{a}	2.28 ± 0.48^{c}
Soaking in cold water for 12 HRs	57.67 ± 3.21^{b}	65 ± 4.98^{b}	3.59 ± 0.30^{b}	0.28 ± 0.02^{a}	6.01 ± 0.48^{b}
Soaking in cold water for 36 HRs	79.00 ± 3.21^{a}	65 ± 4.98^{b}	3.69 ± 0.30^{b}	0.27 ± 0.02^{a}	8.62 ± 0.48^{a}
Control	21.33 ± 3.21^{e}	88 ± 4.98^{a}	4.01 ± 0.30^{ab}	0.25 ± 0.02^{ab}	1.77 ± 0.48^{c}
LSD	9.61	14.93	0.8944	0.0566	1.4268
CV%	14.67	10.95	12.95	12.76	22.98
P-values	< 0.0001	0.0142	0.0923	0.1168	< 0.0001

NB: Means within a column that share a superscript letter do not differ substantially at a significance level of 0.05.

Effect of pre-sowing seeds treatments on germination of Grewia villosa (Ogomdii)

The effects of various pretreatments on seed germination of *Grewia villosa* are significantly different ($p < 0.0001$), as presented in Table 5. The seeds treated with hot water germinated more than with other treatments. The maximum germination rate is recorded for seeds soaked in boiled water for 5 minutes (76.67%), followed by the seeds soaked in boiled water for 15 minutes (61.33%). Moreover, the hot water treatments significantly improved the days to start emergence and germination indexes for *Grewia villosa* seeds. The lowest germination rate was recorded under seeds soaked in concentrated H_2SO_4 for 15 minutes. No significant variation was observed among mechanical scarification, soaking in concentrated H_2SO_4 for 5 min, cold water treatments, and control (Table 5). The current finding contrasts with studies by [20], who indicated mechanical scarification pretreatment for breaking seed dormancy in *Grewia villosa* seeds, and [21], who identified cold water as a suitable seed treatment method for *Grewia villosa* seeds.

Table 5
Effect of different pre-sowing treatments on percentage germination, first seed emergence, and germination rate of *Grewia villosa* (Ogomdii)

Pre-sowing treatments	**Germination (%)**	**Days to emergence (No.)**	**MGT**	**Mean Germination rate (seedlings/day)**	**Germination indexes (GI)**
Mechanical scarification (nicking)	52 ± 4.2^{cd}	31.67 ± 1.91^{a}	4.36 ± 0.31^{a}	0.23 ± 0.03^{b}	3.91 ± 0.66^{bc}
Soaking in concentrated $H_2SO_4$for 5 min.	46.67 ± 4.2^{cd}	23 ± 1.91^{b}	3.45 ± 0.31^{ab}	0.29 ± 0.03^{ab}	5.06 ± 0.66^{b}
Soaking in concentrated H_2SO_4for15 min.	27.67 ± 4.2^{e}	27 ± 1.91^{ab}	3.07 ± 0.31^{b}	0.33 ± 0.03^{a}	2.98 ± 0.66^{c}
Soaking in boiled water for 5 minutes	76.67 ± 4.2^{a}	23 ± 1.91^{b}	3.49 ± 0.31^{ab}	0.29 ± 0.03^{ab}	8.51 ± 0.66^{a}
Soaking in boiled water for 15 minutes	61.33 ± 4.2^{b}	23 ± 1.91^{b}	3.23 ± 0.31^{b}	0.32 ± 0.03^{a}	7.63 ± 0.66^{a}
Soaking in cold water for 12 HRs	35.33 ± 4.2^{de}	26.33 ± 1.91^{ab}	3.41 ± 0.31^{b}	0.3 ± 0.03^{ab}	3.76 ± 0.66^{bc}
Soaking in cold water for 36 HRs	43.33 ± 4.2^{cd}	25 ± 1.91^{b}	3.48 ± 0.31^{ab}	0.29 ± 0.03^{ab}	4.17 ± 0.66^{bc}
Control	47.67 ± 4.2^{cd}	28.33 ± 1.91^{ab}	3.38 ± 0.31^{b}	0.3 ± 0.03^{ab}	4.63 ± 0.66^{bc}
LSD	12.60	5.74	0.92	0.08	1.98
CV%	14.91	12.80	15.23	15.80	22.59
P-values	< 0.0001	0.0541	0.2240	0.3882	0.0002

NB: Means within a column that shares a superscript letter do not differ substantially at a significance level of 0.05.

Effect of pre-sowing seed treatments on germination of Terminalia brownie, Pappea capensis and Acacia tortilis

Pre-sowing treatments have a significant effect on the germination percentage of *T. brownie* seeds *(p* < 0.0001), and the number of days to seedling emergence is significantly different ($P = 0.0018$). The maximum germination rate was recorded under the seed treatment of mechanical scarification (50%), and the lowest germination rate was recorded under the control treatment (19%). Moreover, mechanical scarification significantly reduced the number of days to seedling emergence compared to other treatments. In addition to mechanical scarification, cold water treatment significantly increased the germination rate of T. brownie seeds when compared to the control treatment; the *T. brownie* seeds soaked in cold water for 36 hours germinated at 45.67%, and those treated by soaking in cold water for 12 hours germinated at 42% (Table 6). The result is in line with the finding of [22], which indicated the average germination performance of *T. brownie* was 50%. A study on *Terminalia chebula* by [23] reported that the highest germination percentage (70.6%) was observed in the mechanical breaking of the seed coat. Achieving the maximum germination rate of *T. brownie* seeds is still challenging. [21], also indicated that *T. brownie* seeds have low germination rate behavior and remove wings as recommendable seed pretreatment. The various sources of seed germination failure could be the seed's exogenous or endogenous factors. A study found that *Penicillium* seed-borne fungi affected the seed germination of *T. browni* [24].

Pappea capensis is an important tree species that receives development attention as a forage resource in Borana rangeland. The species propagate by seed and, an efficient and effective seed germination method is necessary for producing planting materials. Different pre-sowing seed treatments were applied to collected seeds. There was a significant difference between treatments in the number of days it took for seedlings to emerge ($p = 0.0005$) and the percentage of seeds that germinated ($p < 0.0001$). Compared to the other treatments and the control, seeds treated by soaking in cold water for 36 hours emerged sooner and had a greater germination percentage (61%), followed by seeds Soaking in cold water for 12 hours (50%) (Table 6). The lowest germination rate was observed for seeds treated with hot water and concentrated H_2SO_4.

The other important dryland tree species naturally found in the Borana zone, which currently during across Borana rangeland is *Acacia tortilis* (Fork). To conserve such important tree species, an effective and efficient seed-germination method is necessary for producing planting materials. There were significant variations (p = 0.0005) in the proportion of seeds that germinated among other treatments. The highest germination percentage was observed with the seed soaking in concentrated H_2SO_4 for 15 minutes (81.33 ± 6.41%), followed by the seed soaked in cold water for 36 hours (74.33 ± 6.41%) and the seed soaked in concentrated H_2SO_4 for 5 minutes (73.33 ± 6.41%). The lowest seed germination was recorded under control treatment (25.67%) (Table 6). The study by [25] found that acid treatments are the most effective method in improving seed germination of *F. albida* species. The findings of this study are comparable with the previous study which recommended soaking the seed in water until root protrusion as a pre-sowing seed treatment for *A. tortilis* [26]. Both study of [25] and [26] indicated, mechanical scarification as another option for acacia species seeds pretreatment, which is different from our finding. This may be attributed to differences in the way mechanical scarification was performed.

Table 6
Effect of different pre-sowing seed treatments on germination of some selected tree species (*T. brownie, P. capensis and A. tortilis*)

Pre-sowing treatments	*Terminalia brownie*		*Pappea capensis*		*Acacia tortilis*	
	Germination (%)	**Days to emergence (No.)**	**Germination (%)**	**Days to emergence (No.)**	**Germination (%)**	**Days to emergence (No.)**
Mechanical scarification	50 ± 1.94^{a}	23 ± 1.83^{c}	39 ± 0.2^{c}	38.66 ± 2.62^{cb}	62 ± 6.41^{bc}	11 ± 1.28^{bc}
Soaking in conc. $H_2SO_4$for 5 min.	32.33 ± 1.94^{cd}	31 ± 1.83^{ab}	32 ± 0.2^{cde}	40 ± 2.62^{b}	73.33 ± 6.41^{ab}	9 ± 1.28^{c}
Soaking in conc. H_2SO_4for15 min.	34.67 ± 1.94^{c}	31 ± 1.83^{ab}	24.33 ± 0.2^{e}	40 ± 2.62^{b}	81.33 ± 6.41^{a}	9 ± 1.28^{c}
Soaking in boiled water for 5 min.	27.67 ± 1.94^{de}	32.33 ± 1.83^{a}	27.67 ± 0.2^{de}	40 ± 2.62^{b}	52.33 ± 6.41^{c}	12 ± 1.28^{bc}
Soaking in boiled water for 15 min.	23.33 ± 1.94^{ef}	32.33 ± 1.83^{a}	26.67 ± 0.2^{de}	39.33 ± 2.62^{b}	60 ± 6.41^{bc}	13 ± 1.28^{b}
Soaking in cold water for 12 HRs	42 ± 1.94^{b}	23 ± 1.83^{c}	50 ± 0.2^{b}	38 ± 2.62^{c}	65.33 ± 6.41^{abc}	12 ± 1.28^{bc}
Soaking in cold water for 36 HRs	45.67 ± 1.94^{ab}	23 ± 1.83^{c}	61 ± 0.2^{a}	38 ± 2.62^{c}	74.33 ± 6.41^{ab}	12 ± 1.28^{bc}
Control	19 ± 1.94^{f}	25.67 ± 1.83^{bc}	33.33 ± 0.2^{c}	42 ± 2.62^{a}	25.67 ± 6.41^{d}	21.67 ± 1.28^{a}
LSD	5.83	5.47	7.84	1.45	19.21	3.84
CV%	9.805	11.429	12.33	2.13	17.96	17.80
P-values	< 0.0001	0.0018	< 0.0001	0.0005	0.0005	< 0.0001

NB

Means within a column that share a superscript letter do not differ substantially at a significance level of 0.05.

Effect of pre-sowing seed treatments on germination of B. microphylla, C. myrrha and C. corrugatais tree species

Boswellia microphylla, Commiphora myrrha and *Commiphora corrugata*is are among the resin-bearing tree species naturally found in Borana rangeland. The seeds of these species have a problem of low germination rate for producing planting materials under nursery management [27]. This experiment of pre-sowing treatments was conducted to improve their germination rate.

Significant differences in germination rate and days to start germination were observed among treatments (Table 7). The highest germination rates recorded under seeds treated with cold water were seeds soaking in cold water for 36 hours, which had the highest germination rate (61%), followed by seeds soaking in cold water for 12 hours (58.67%). Next to cold water, mechanical scarification improved the germination rate of *B. microphylla* seeds (41%). The lowest germination rate was observed under seed soaking in concentrated H_2SO_4 for 15 minutes and seeds soaking in boiled water for 15 minutes at 27.67% and 28.67%, respectively. Moreover, cold water treatments significantly reduced the days to start germination of *B. microphylla* seeds compared to other treatments. The findings of this study are similar to those studies on other *Boswellia* species, which indicated that the seeds of *Boswellia sacra* soaked in cold water had the highest germination rate and germinated quickly [28, 29].

In the case of *C. myrrha*, even though the germination percentage of the species was not satisfactory to promote the seed pre-treatments, a significant difference was observed among the pre-sowing treatments ($p = 0.0008$) (Table 7). It was found that seeds soaked in cold water for 12 and 36 hours germinated more than other treatments (55.67% and 53.33%, respectively), and the lowest germination rate was recorded for the untreated seeds (30%). All other pre-treatments did not substantially differ from one another or resulted in a considerably lower germination rate. The low germination rate may be due to soil or water salinity problems. A study discovered that the increase in salinity level significantly reduced seed germination percentage and seedling growth of *Commiphora boranensis*, *Commiphora habessinica*, and *Commiphora corrugate* species [30].

Table 7
Effect of different pre-sowing seed treatments on germination and days to emergence of *B. microphylla, C. myrrha* and *C. corrugatais*

Pre-sowing treatments	***Boswellia microphylla***		***Commiphora myrrha***		***Commiphora corrugata*is**	
	Germination (%)	**Days to emergence (No.)**	**Germination (%)**	**Days to emergence (No.)**	**Germination (%)**	**Days to emergence (No.)**
Mechanical scarification	41 ± 2.88^{b}	12 ± 0.41^{bc}	47.67 ± 3.41^{ab}	16 ± 0.41^{ab}	61 ± 3.97^{c}	10.67 ± 0.53^{a}
Soaking in conc. $H_2SO_4$for 5 min.	34.67 ± 2.88^{bc}	12 ± 0.41^{bc}	$40 \pm 3.41b^{cd}$	16 ± 0.41^{ab}	73.33 ± 3.97^{ab}	10 ± 0.53a
Soaking in conc. H_2SO_4for15 min.	27.67 ± 2.88^{c}	11.33 ± 0.41^{cd}	41 ± 3.41^{bc}	15.33 ± 0.41^{bc}	65.67 ± 3.97^{abc}	10.67 ± 0.53^{a}
Soaking in boiled water for 5 min.	34.67 ± 2.88^{bc}	12 ± 0.41^{bc}	35.67 ± 3.41^{cd}	16 ± 0.41^{ab}	72.33 ± 3.97^{abc}	11.33 ± 0.53^{a}
Soaking in boiled water for 15 min.	28.67 ± 2.88^{c}	12.67 ± 0.41^{b}	37.67 ± 3.41^{bcd}	16.67 ± 0.41^{a}	63.33 ± 3.97^{bc}	10.67 ± 0.53^{a}
Soaking in cold water for 12 HRs	58.67 ± 2.88^{a}	10.67 ± 0.41^{de}	55.67 ± 3.41^{a}	14.67 ± 0.41^{cd}	74.33 ± 3.97^{ab}	10 ± 0.53^{a}
Soaking in cold water for 36 HRs	61 ± 2.88^{a}	10 ± 0.41^{e}	53.33 ± 3.41^{a}	14 ± 0.41^{d}	75.33 ± 3.97^{a}	10 ± 0.53^{a}
Control	39 ± 2.88^{b}	14 ± 0.41^{a}	30 ± 3.41^{d}	16 ± 0.41^{ab}	41.33 ± 3.97^{d}	11.33 ± 0.53^{a}
LSD	8.62	1.22	10.22	1.22	11.88	1.58
CV%	12.25	5.98	13.84	4.53	10.43	8.62
P-values	< 0.0001	0.0002	0.0008	0.0059	0.0003	0.4010

NB

Means within a column that share a superscript letter do not differ substantially at a significance level of 0.05.

Similar to *C. myrrha*, the seed germination percentage of *Commiphora corrugata*is among the treatments showed significant ($p = 0.0003$) differences (Table 7). Seeds soaked in cold water for 36 hours had the highest germination percentage (75.33 ± 3.97%), followed by seeds that were soaked in cold water for 12 hours (74.33 ± 3.97%), which were not statistically different from seeds soaked in concentrated H_2SO_4 for 5 minutes and seeds soaked in boiled water for 5 minutes, whereas the control, which represented no pretreatment applied, had the least (41.33 ± 3.97%). Pre-sowing treatment has no significant effect (p = 0.4010) on days to emergence after sowing of *C. corrugata*is. The finding of this study is comparable to previous findings on other *Boswellia* and *Commiphora* species, which indicated that the seeds soaked in cold water had the highest germination percentage compared to control [28, 29, 31].

Conclusion and Recommendation

Seedling multiplication is the process of growing seedlings of a certain species in nurseries to achieve the highest quality seedlings at the lowest feasible cost, time, and labor. Regardless of the seed class (recalcitrant, intermediate, or orthodox groups), seed dormancy is an important factor that can affect the germination of each group at any stage. Pre-sowing treatment is required to either break dormancy or the hard seed coat to boost the germination percentage of some species with poor germination rates. The findings in this study showed that the ability of a particular pre-treatment to break seed dormancy was significantly varied with the tree species. For *Psydrax schimperiana, M. kummel, Pappea capensis, Boswellia microphylla, Commiphora myrrha*, and *Commiphora corrugata*is, soaking seeds in cold water for 36 or 12 hours is a more effective technique to get a better seed germination percentage. The most efficient strategy for promoting germination in *Grewia villosa* seeds is soaking in boiled water for 5 minutes, followed by the seeds for 15 minutes. Acid treatments are the most effective methods followed by cold water treatment in improving seed germination of *A. tortilis*, increasing germination percentage, and reducing dormancy period (mean germination time), but soaking in cold water for 36 h or 12 h is being recommended as a cheaper and less hazardous pretreatment method since sulphuric acid is expensive and requires proper handling techniques. Mechanical scarification increased the germination percentage of *T. brownie* seeds and, reduced the number of days to seedling emergence compared to other treatments. In comparison to most pretreatments, the control treatment often reported a low percentage of germination, which is an indication of some level of seed dormancy in these tree species. The improvement of germination with the application of pretreatments implies that pretreatments have an advantageous effect on seed germination, which may be advantageous to nursery managers and foresters for the domestication of these tree species in the study area.

Declarations

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Authors’ contributions

Siraj Kelil Gobelle: Conceptualization and design of the study, Data collection and investigation, Data analysis and interpretation, writing original draft preparation.

Sisay Taye: Design of the study, Data collection and investigation, review and editing the manuscript

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The authors declare no competing interest

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Figures

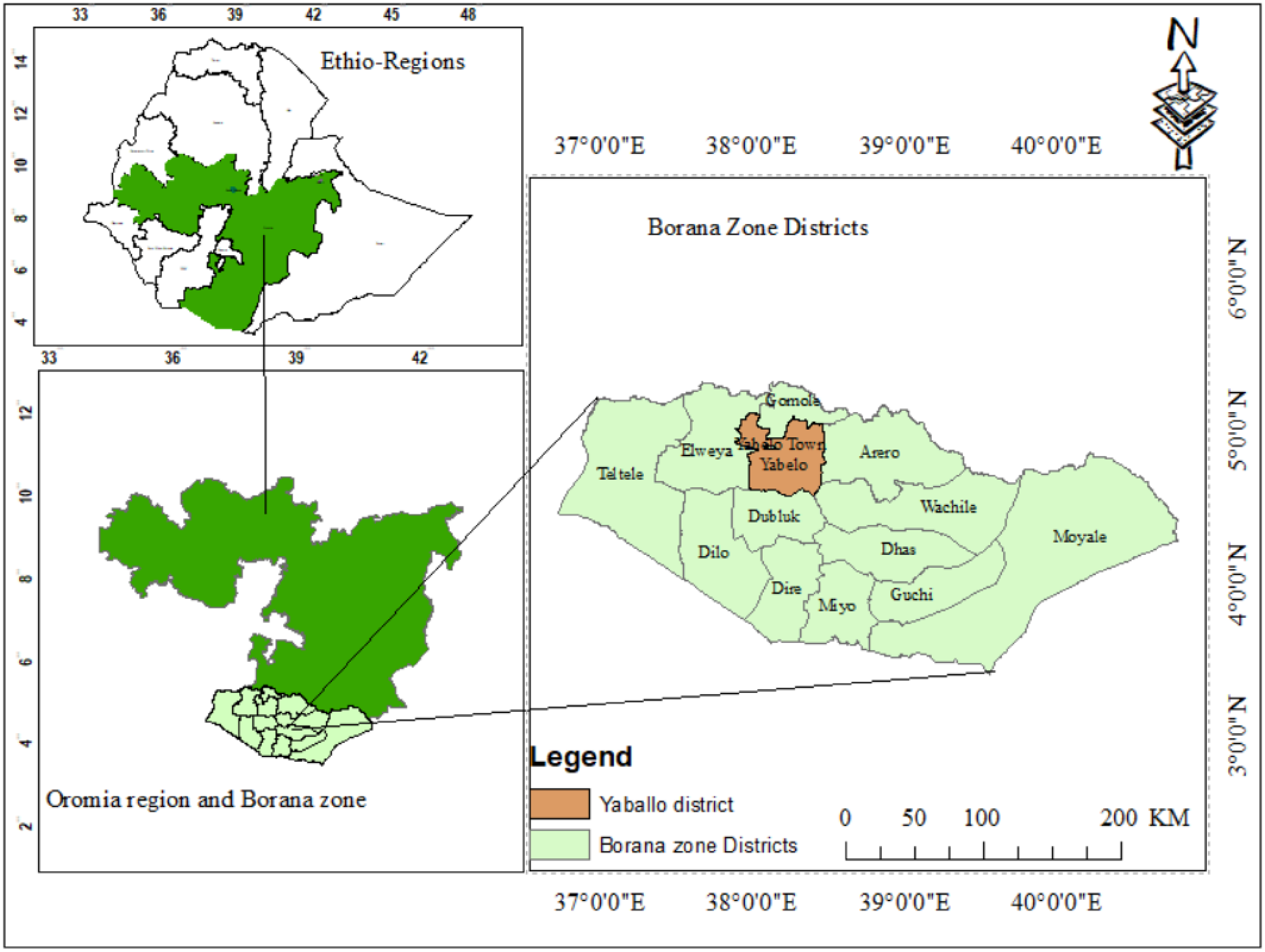

Figure 1

Location of the study area

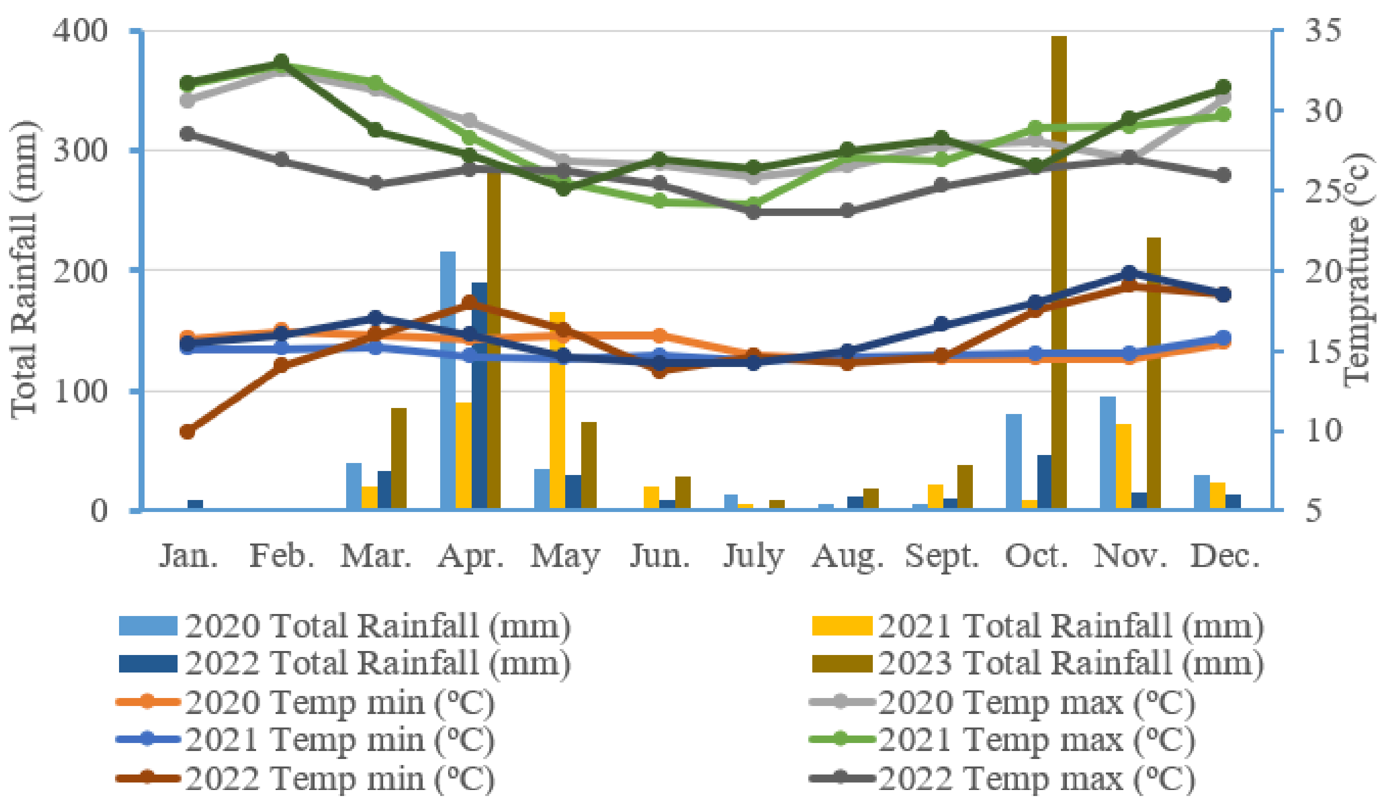

Figure 2

Total monthly rainfall and mean monthly temperature during the experimental period (Data source Hawassa Meteorological Agency)