American Journal of Agriculture and Forestry
2014; 2(6): 278-283
Published online December 02, 2014 (http://www.sciencepublishinggroup.com/j/ajaf)
doi: 10.11648/j.ajaf.20140206.18
ISSN: 2330-8583 (Print); ISSN: 2330-8591 (Online)

Evaluation of propagation methods of *Schefflera abyssinica*

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To cite this article:
Tura Bareke Kifle, Admassu Addi Merti, Kibebew Wakjira Hora. Evaluation of Propagation Methods of *Schefflera abyssinica*. *American Journal of Agriculture and Forestry.* Vol. 2, No. 6, 2014, pp. 278-283. doi: 10.11648/j.ajaf.20140206.18

Abstract: *Schefflera abyssinica* is indigenous bee forage tree species promising for honey production. However due to lack of appropriate propagation methods; *S. abyssinica* is not promoted in wide scale plantation. Therefore, the main objectives of this study were to develop and evaluate appropriate seed pretreatment procedures to improve the germination percentage, and assessing the impacts of seed provenances on the growth performance of this plant. Germination trials were conducted in laboratory, and plastic house at Holeta Bee Research Center and Holeta Agricultural Research Center using mature seed collected from mother trees using treatment of smoke solution and soaking seeds in different chemicals. The result indicated, there was significant improvement in germination capacity and vigor of *S. abyssinica* after pre-treated with aqueous smoke solution ($p<0.05$) particularly at low concentration. Pre-treated seeds of *S. abyssinica* with 1% chlorox, 70% alcohol, imidalm and Ridoml gold chemicals resulted no significant ($P<0.05$) increases, in the final germination percentage as compared to the controls. Seed provenances affect the germination capacity of *S. abyssinica* and their survival rate. *S. abyssinica* can be propagated by seed by producing seedlings and it can grow alone without need of other tree species as an epiphyte.

Keywords: Bee Forage, Smoke-Water, Germination, Survival Rate, Vigor

1. Introduction

Ethiopia has a high land mass endowed with a great diversity of climate, soil and flora. However, currently due to unwise utilization of the available vegetation resources coupled with lack of knowledge and little consideration to the biology of propagation, indigenous trees and shrubs are being depleted at an alarming rate. The sustainable productivity of ecosystems depends to a large extent on the buffering capacity provided by having rich and healthy indigenous forests (Legesse Negash, 1990 and 1995). Hence, it is essential that they are utmost conserved, propagated and developed to the extent possible. In Ethiopia, there is insufficient knowledge about provenance and genetic variability, and propagation of important indigenous tree species in general and *Schefflera abyssinica* in particular.

*Schefflera abyssinica (Hochst. ex A. Rich.) i*s an indigenous tree belonging to the family of Araliaceae, branched, small/medium to 30 m tall trees and is also sometimes growing as an epiphyte. It grows as an epiphyte mainly on *Acacia abyssinica* and *Olea europea* tree species and finally overwhelms it to become an independent tree in highland areas. It produces creamy-yellowish or creamy-white flowers from March to May.

S. abyssinica grows in Afromontana forest, secondary forests and woodlands within the altitudinal range of 1450–2800 m above sea level.; often occurs in association with *Hagenia abyssinica* (Azene *et al*., 1993; Fichtl and Admassu Addi, 1994).It is also usually found left as scattered tree in farmlands.

S. abyssinica is one of the most important honey trees of the country. It has abundant nectar and pollen. Honeybees produce large quantities of a light and pure white honey which has high demand in the market and could generate high income (Fichtl and Admasu, 1994; Tefera Belay, 2005). However, currently the population of this plant species is highly fragmented and becoming scarce because of the continued forest depletion and its nature. In addition, less attention is given to the propagation of this species which put great pressure on honey production. Therefore, the main objective of this study was to develop appropriate seed pretreatment procedures for attaining maximum germination percentage, as well as assessing the impacts of the growth media on nursery performance of *S. abyssinica.*

2. Materials and Methods

2.1. Project Area

The study area was walmera district, Holeta Bee Research Center, located in Special zones of Oromia around Finfinne. The district is geographically located between latitudes 9^0 03` N and longitudes $38^0$ 30` E. The altitude ranges from 2060 - 3380 meter above sea level. The site study is located at an elevation of 2400 meter above sea level. The rainfall pattern is bimodal. The main rainy season is from June to September with a mean annual rainfall of 1150 mm.

2.2. Seed Collection and Processing

Seeds were collected from representative provenances depending on accessibility of the species and the natural distribution of the species (table 1).

Table 1. *Provenances and seed zones*

Species	Provenance	Seed zones
Schefflera abyssinica	Bale –Harenna	24.1
	West Showa-Gedo	20.4
	West Arsi-Munessa	21.1
	Jimma zone –Gera	

Provenances were selected following the tree seed zoning system developed by Azene Bekele *et al*., (1993) for the country. .In this study, the term provenance denotes the original geographic area from which seeds were obtained (Hartmann *et al.,* 1997). To ensure maximum genetic variation within the population, the selected trees were kept at least 100 m apart from each other (FAO, 1975). Mature seeds or fruits were collected from 5 to 10 dominant or co-dominant trees with clear bole, well developed crown and with abundant seeds on each site at the end of May in 2012. Immediately after collection, the mixture of fruits and seeds were packed in perforated sacks or plastic bags and transported to the Holeta Bee Research Center for processing and germination tests.

2.3. Germination Experiment

The germination study was conducted at Holeta Bee Research Center and Holeta Agricultural Research Center. Seeds were pre-treated (soaked) for 6 hours in different concentration of various dilution levels of plant-derived aqueous smoke extracts, and pretreated by chemicals (1% chlorox, 70% alcohol, imidalm and Ridoml gold) treatment.

Aqueous smoke extraction was performed by burning 200 gm of small branches and leaves of various plants (among which, *C. macrostachys, J. procera and M. ferrugine*a are some) in a 100 mm diameter and 200 mm depth beekeeper's smoker for 30 minutes. The generated smoke was forced through plastic hose fitted to the mouth of the smoker by applying pressure on bellow into a 250 ml Erlenmeyer flask (E-flask)containing 200 ml of double distilled water. The mouth of the E-flask was plugged with a smoke tight rubber material whose center hollowed to allow the entry of plastic hose to the E-flask. The smoke was forced into the flask for 30 minutes. Then the resulted concentrated smoke water was maintained as a stock solution and used to prepare aqueous smoke extracts of different dilution levels. This method of smoke extraction was based on the method used by Kibebew (2007).

Figure 1. *Extraction of concentrated aqueous smoke solution*

For the studies, seeds obtained from west Arsi (Munessa) were used. Seed pre-treatments were performed employing three dilution levels of aqueous smoke extracts, the concentrations/dilutions levels used were: 1:10, 1:100 and 1:1000 for aqueous smoke extracts.

After soaking seeds in the test solutions for 6 hours, seeds sank to the bottom of each test solution were used for the germination experiments. Also seed pre-treatment were performed for seed collected from Gedo using chemicals for seed were soaked 1 % chlorox and 70% alcohol for 2 minutes washed seeds 3-4 times by water, Imidalm is in powder form and Ridoml gold with water solution for 2 minutes.

A number of pre-treated seeds used for this study was replicated three times, each pre-treated were placed on Whatman`s filter paper in Petri dishes. Then, the Petri dishes were covered with lid and watered as needed based on the moisture conditions of the Petri dishes and this was continued up to the end of the experiment. For the entire experiments, seed germination counts were made every three days after the commencement of seed germination. To facilitate future counts, germinated seeds were removed after recording. The experiments were continued until at least 80% of the replication from each treatment shows no new germination for 2 consecutive counts. A seed is considered germinated at the time when the protrusion of the radicle occurs for the illuminated seeds, and the emergence of the cotyledons for the buried seeds.

2.4. Provenance Variations and Nursery Establishment

Seed germination provenance variation trials were conducted and seeds were sampled for each seed provenance from the seeds sank to the bottom of the water. For provenances study and nursery establishment experiment, a total of three different soil mixtures were used. These were mixtures of local soil, forest soil, and sand in ratios of 2:1:1 respectively. The control contained sand soil only. The selection of these soil mixtures is based on the recommendation made by Legesse Negash (1995) for nursery

establishment of various indigenous trees of Ethiopia. These treatments were used by 15cm pot sizes of equal length (20cm) and then transplanted to 30 pot sizes. Thus, for each provenance, 10 replications were used for the tests. Pots were arranged on wooden bench in the plastic house at random and the mouth of each of them was covered with dried grass stalk. The pots were watered once a day until the experiment ended. At the onset of seedling emergence the grass cover was removed to facilitate counting and to prevent bending of the seedlings due to the force applied by the grass stalk. For the experiment seed germination counts were examined every three days and seedlings with two expanded leaves were removed after recording observations. The trials were carried out until at least > 80% of the replication from each treatment showed no new germination for 2 consecutive counts. Finally, the germination responses of seeds were then expressed in terms of germination percentage, mean germination time, germination rate and germination vigor.

Growth status of *S. abyssinica* in 15cm pot size before transplanted

Growth status of *S. abyssinica* in 15cm pot size after transplanted

After transplanted to 15 cm pot size *S. abyssinica* highly eaten by aphids

Growth status *after* transplanting to 30 cm pot size and aphids controlled by manual management

Growth status of *S. abyssinica* in field condition

Figure 2. *Growth status of S. abyssinica from different pot sizes to field*

2.5. Early Growth and Survival Rate under Field Conditions

The growth performance and survival rate were evaluated under two different sites (Gedo and Holeta).

3. Statistical Calculations and Analysis

The germination responses of seeds were then be expressed in terms of germination percentage, mean germination time, germination rate and germination vigor.

Germination percentage was calculated according to the following formula:

$$\text{Germination Percentage} = (\frac{n}{N}) \times 100\% ,$$

Where:

n = Total number of germinated seeds;

N = Total number of seeds in the sample.

The mean germination time (MGT), mean germination rate (MGR), and germination vigor was determined according to Labouriau and Agudo (1987) as follow:

$$\text{MGT} = \frac{(\sum n_i t_i)}{n},$$

Where:

n_i = Percentage of seeds germinated between two consecutive counts;

t_i = Time taken since germination experiment started;

n = Total percentage of seeds germinated.

$$\text{MGR} = \frac{1}{\text{MGT}},$$

Where:

MGT = Mean germination time

$$\text{Germination vigor} = \sum(\frac{G_i}{t_i}) / N \times 100\%,$$

Where:

G_i = Number of seeds germinated up to the day under consideration;

t_i = Time taken since the first day of incubation;

N = Total number of seeds

Seedling survival rate (SR) was calculated as follows

$$\text{SR}(\%) = \frac{\text{no. of seedling alive at the end of the test x100}}{\text{Number of seedling transplanted}}$$

3.1. Statistical Analyses were Performed According to the Following Procedures

The effects of smoke solution and distilled water (Control), Chemical treatment and provenance variations on germination of all plants species were analyzed by a one-way ANOVA using SPSS with treatments as factor. Turkey's Honest Significant Difference Test was used for determination of significant differences among mean values for treatments.

4. Result and Discussion

4.1. S. abyssinica Seed Germination Trial Using Aqueous Smoke Solution

The result has indicated that there was significant difference in mean germination percentages and germination vigor among the treatments used ($p<0.05$), whereas, the mean germination time and rate did not differ significantly (table 2). This indicated that the germination capacity of *S. abyssinica* increased as the dilution level of the concentration of aqueous smoke solution decreased. Therefore, use of aqueous smoke solution at 0.001ml dilution level had significant effect on increasing the germination capacity of seeds of *S. abyssinica.* Smoke from a wide variety of biotic sources, including wood, straw, mixtures of dry and fresh plant material and charred wood can result stimulated germination (Brown and Vanstaden, 1997). Drewes et al., (1995) found that high concentrations of smoke-water could be inhibitory to germination but could be leached to promotive levels through irrigation (Delang and Boucher, 1993).Recently, the germination response to smoke is most easily studied using smoke water, the main germination active compound has been identified as the butenolide, 3-methyl-2H-furo [2,3-c]pyran-2-one, from burned plant-derived smoke (Vanstaden et al., 2004) and cellulose (Flematti et al., 2004) that acts at very low concentrations. Smoke-water may be acting on the seed coat in a way similar to scarification, whereby the passage of water and oxygen into the dormant embryo is made easier (Egerton, 1998).

The germination vigor of 0.001ml dilution of smoke solution was 16.7% which is higher as compared to the rest. The dilution of smoke treatment increased the germination vigor of *S. abyssinica* at 0.001ml. This result was similar with (Paasonen et al., 2003) that smoke water dilutions improve germination and seedling vigority. As the result indicated that the mean germination time and germination rate of all treatment was not significantly different among the treatments used, therefore aqueous smoke solution has no effect on the germination rate and time required to germinate.

Table 2. *Mean + SE of mean germination percentage (MGP), mean germination time (MGT), mean germination rate (MGR) and germination vigor (GV) of S. abyssinica seed germination trial using aqueous smoke solution*

Treatment	MGP	MGT	MGR	GV
	Mean + SE	Mean + SE	Mean + SE	Mean + SE
0.1ml	63.3 ± 0.19^{d}	7.7 ± 0.4^{a}	0.13 ± 0.02^{a}	12.8 ± 0.45^{d}
0.01ml	66.67 ± 0.38^{c}	8.1 ± 0.02^{a}	0.12 ± 0.01^{a}	13.3 ± 0.2^{cd}
0.001ml	83.3 ± 0.4^{a}	9.3 ± 0.2^{a}	0.11 ± 0.00^{a}	16.7 ± 0.4^{a}
control	73.33 ± 0.19^{b}	9 ± 0.5^{a}	0.11 ± 0.00^{a}	14.6 ± 0.07^{b}

4.2. S. abyssinica Laboratory Seed Germination Trial Using Different Chemicals

Pre-treated seeds with all the used chemicals resulted in non-significant ($P<0.05$) increases in the final germination percentage as compared to the controls (table 3). Accordingly, the mean germination percentage of control was better than seeds treated with chemicals. From this it is evident that seeds of *S. abyssinica* do not require any of the above mentioned chemicals treatments because the mean germination percentage of control was higher than chemical treatment.

Mean Germination Time (MGT) for seed pre-treatments employing all the chemicals was non- significantly ($P<0.05$) different from control. Mean Germination Time (MGT) of the seed pre-treated with Imidalm and control was 13.2 days, which was the lowest, while for 1% chlorox up to 16.2 days it was the highest and the rest treatment were between those treatments (table 3). Germination vigor and germination rate were non-significantly different ($P<0.05$) for seed pre-treatments employing all chemicals compared to the controls. Thus, the chemicals used did not show any significant stimulatory effect on final germination percentage, MGT, germination rate and germination vigor (%) of *S. abyssinica* seeds compared to the control, hence, these treatments did not offer any advantage in increasing the germination capacity, germination rate and vigority of seeds of *S.*

abyssinica.

Table 3. *Mean + SE of mean germination percentage (MGP), mean germination time (MGT), mean germination rate (MGR) and average germination vigor (GV) of S. abyssinica laboratory seed germination trial using different chemicals*

Treatment	MGP	MGT	MGR	A GV
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
1% Chlorox	24±5.16[a]	16.2±1.78[a]	0.04±0.00[a]	1.2±0.25[a]
70% alcohol	19±1.00[a]	14.6±1.06[a]	0.04±0.00[a]	0.95±0.05[a]
Imidalm	25±3.00[a]	13.2±0.21[a]	0.04±0.00[a]	1.25±0.15[a]
Ridoml gold	18±2.58[a]	15.3±0.63[a]	0.04±0.00[a]	0.9±0.12[a]
control	33±4.12[a]	13.2±0.23[a]	0.04±0.00[a]	1.65±0.20[a]

4.3. S. abyssinica Seed Provenance Germination Trial

The results indicated that there was significant difference in mean germination percentage, mean germination rate and mean germination vigority among seed provenances at ($p<0.05$), while the mean germination time was non-significant ($p<0.05$) (table 4). The mean germination percentage was highest for seed collected from Munessa. This indicated that seed provenance has great impact on seed germination capacity of *S. abyssinica*. The germination vigor was also highest for Munessa. This indicated that seed source is great factor that should be considered in germination vigor of *S. abyssinica*. This difference is mainly due to environmental variation. This idea was also supported by Lange (1961) as the variation within plant species was highly affected by environmental factors. Factors such as climatic conditions, abundance and coordinated maturation of pollen grains and thoroughness of pollination can produce variation in seed provenances (Bell *et al.*, 1995; Legesse Negash, 2003). The mean germination rate was highest for Munessa and Gedo whereas low for Harenna and Gera. This showed that seed collected from Munessa and Gedo was highly significant as compared to Harenna and Gera. Therefore, seed source has impact on germination rate. There is no significance difference among seed provenances in terms of mean germination time (MGT). However, MGT was needed short time for seeds collected from Munessa and somewhat long time for Harenna. Therefore seed provenance has non-significant effect on seed germination time of *S. abyssinica*.

Table 4. *Mean + SE of mean germination percentage (MGP), mean germination time (MGT), mean germination rate (MGR) and average germination vigor (GV) of S. abyssinica seed provenances germination trial in green house.*

Treatment	MGP	MGT	MGR	AGV
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
Gedo	45.57 ± 2.73[b]	18.47±1.39[a]	0.03 ± 0.00[a]	3.04±0.18[b]
Gera	24.57 ± 2.43[c]	21.64±0.74[a]	0.02 ± 0.00[ab]	1.38±0.16[c]
Munessa	66.72 ± 4.48[a]	18 ± 0.42[a]	0.03 ± 0.00[a]	4.45±0.30[a]
Harenna	5 ± 0.68[d]	23.12±5.81[a]	0.02 ± 0.00[b]	0.2 ± 0.04[d]

4.4. S. abyssinica Seedling Provenances Survival Rate after Transplanting

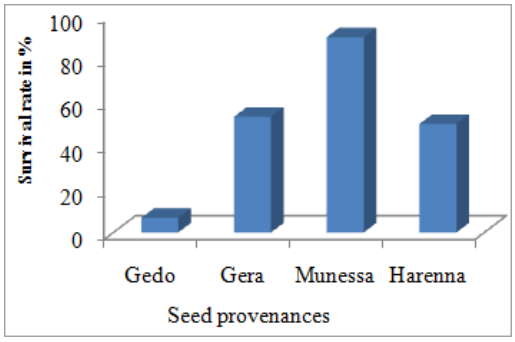

Figure 3. *S. abyssinica seedling provenances survival rate after transplanting*

The survival rate of seedlings of *S. abyssinica* after transplanting was highest for Munessa, whereas, seedlings of Gedo have poor survival rate after germination and transplanting. Seedlings of *S. abyssinica* collected from all provenances were affected by aphids. Particularly seedlings of seed collected from Gedo, Harenna and Gera were highly affected by aphids, whereas, seedlings of Munessa were less affected when compared with other provenances. To control aphids we used manual management only.

5. Conclusion and Recommendation

In conclusion the study revealed that *S. abyssinica* produces large number of seeds and it`s expansion, therefore, could be achieved by means of seed propagation. So far it was considered as an epiphyte which grows on another tree species and finally overwhelms it and becomes an independent tree in highland areas. However, the present study clearly indicates that aqueous smoke solution showed potent germination activity of *S. abyssinica* at low concentrations.

Accordingly, there was significant improvement in germination capacity of its seeds after pre-treatment with aqueous smoke solution, especially the low concentration aqueous smoke solution (0.001ml). Seed provenance also has great impact on germination capacity and vigor of *S. abyssinica* and seed collected from Munessa showed good germination capacity, whereas, seed collected from Harenna showed very low. Thus, there is evidence that seed provenances affect the germination capacity of *S. abyssinica* and their survival rate. *S. abyssinica* can be propagated by seed by producing seedlings and it can grow alone without the need of other tree species as an epiphyte. Use of smoke solution is recommended to multiply *S. abyssinica* seeds through seedling

Acknowledgements

The authors are thankful to Holeta Bee Research Center and Oromia Agricultural Research Institute for providing required facilities and logistics. Our sincere thanks are also

extended to Holeta Agricultural Research center for allowing their laboratory, Zewdu Ararso, Gemechis Legesse and Dejene Takele for their help on how to control aphids, and Konjit Asfaw and Tesfaye Abera, for their inspiration and support in the implementation and follow-up of the research.

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