IDENTIFICATION OF SEED SOURCES THROUGH GERMINATION AND SEEDLING VIGOR FOR SOME WOODLAND TREE SPECIES AT ARBA MINCH ZURIA WOREDA, SOUTHERN ETHIOPIA

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ABSTRACT: Ethiopia is one of the most important centers of biodiversity that include high forests, woodlands, bushlands, plantations and trees outside forests. The diversity in these resources is threatened because of mismanagement and environmental degradation which have caused selective and total loss of genetic diversity. Understanding the variation among provenances and progenies during cultivation is essential in tree improvement programmes. Effect of provenance on seed germination and seedling vigor of *Balanites aegyptiaca*, *Ficus sur*, *Terminalia brownii*, *Tamarindus indica* and *Acacia abyssinica* were evaluated at Arba Minch Agricultural Research Center nursery by using Complete Randomized Design. Provenances were considered as treatments for all studied tree species. Data on germination rate, root collar diameter, leaf number, shoot height, fresh biomass and dry biomass weight were collected and analyzed by using ANOVA while Least Significance Difference (LSD) was employed for mean separation. In terms of seedling vigor, significant difference was not observed among provenances for *T. brownii*. Except shoot length, the same holds true for seedling vigor of *F. sur*. For *T. indica* and *A. abyssinica*, all studied parameters, except root collar diameter, showed significant variation among the provenances. Shoot length and leaf number significantly varied among provenance of *B. aegyptiaca* seedlings. Significantly higher *A. abyssinica* and *T. indica* seedling vigor was measured for Gununo and Arba Minch provenances, respectively. The present study concluded that the best seed source for *B. aegyptiaca*, *F. sur* and *T. indica* is Arba Minch area. Similarly, Gununo and Gofa provenances were identified as the best seed sources for *A. abyssinica* and *T. brownii* respectively.

Keywords: Biomass, Provenance, Seed germination, Seedling vigor.

INTRODUCTION

Ethiopia is one of the most important centers of biodiversity, that include high forests, woodlands, bush lands, plantations and trees outside forests (Zegeye et al., 2011). The share of woodland, shrubs and bushland contribute about 45% of the landmass, indicating quite extensive areas and ecosystems (FAO,

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2010). Out of twelve group of vegetation resource of Ethiopia (Friis et al., 2010), seven of these vegetation types are encountered in drier lowland areas of the country and are commonly referred to as dry forests. These forests are the most important forest types both in terms of area coverage and their contribution for livelihoods and economic development (Lemenih and Kass, 2011). Dry forests contain unique native biodiversity (Awas, 2007) and provide divers goods and services such as gum and resins, fodder, fuel, honey, hand crafts and construction materials (Fikir et al., 2016). However, the diversity in these resources is threatened because of mismanagement and environmental degradation that have caused selective and total loss of genetic diversity (PGRC, 1996; Lemenih and Bongers, 2011; Worku et al., 2012).

The cultivation of plantations as a source of forest product and using the protected forests only as seed source could be an appropriate option to reduce the pressure on the natural stand and improving rural livelihood of local communities (Apetorgbor et al., 2004). However, before large-scale plantations, efficient selection of reliable seed sources is required.

Differences among geographic sources in forest tree species are often substantial and economic improvement can be made by an appropriate provenance selection (Falconer and Mackay, 1996; Schmidt, 2000). Information on variation among provenances of indigenous woodland tree species on seed germination and seed vigor is sparse. Seed germination, the emergence of the embryo from the seed, is triggered by a variety of anabolic and catalytic activities (Bewley and Black, 1983). Seed vigor refers to 'the sum total of those properties of the seed that determine the potential level of activity and performance of the seed during germination and seedling emergence' (Perry, 1978). According to ISTA, (2015) seed vigor is not a single measurable character but a concept associated with various aspects of seed performance which include rate and uniformity of seed germination and seedling growth, emergence ability of seeds under unfavorable environmental conditions and performance after storage (ISTA, 2015).

In Ethiopia, only few studies look in to the effect of provenance on seed germination (Mebrate and Belachew, 2004; Bahru et al., 2014). These studies reported significant growth differences among provenances. However, only some indigenous species were considered in these studies. Thus, additional studies on variation among provenances of indigenous trees, particularly tree species that are economically and ecologically important are essential for improving quality of plantation, produced to get a higher quality product thereby supporting the conservation by utilization strategy. Therefore, the present study aimed at investigating the effect of provenances on seed germination and seedling performance of some selected woodland tree species namely: *B. aegyptiaca*, *T. brownii*, *T. indica, F. sur* and *A. abyssinica* in Arba Minch Zuria woreda and identifying the best seed source for these species.

MATERIALS AND METHODS

Site description

The study was conducted at Arba Minch Agricultural Research Center which is found in Arba Minch Zuria District of Gamo zone, Ethiopia. Arba Minch Zuria District is geographically located between 37˚26'02"E to 37˚39'49"E and 5˚43'03"N to 6˚08'39"N. The elevation of the district ranges from 1126 to 2100 meters above sea level. Meteorological records reveal that rainfall pattern in Arba Minch Zuria is bimodal with mean annual rainfall ranges from 1100 to 1600 mm, whereas the minimum and maximum temperature varying between 17^{o}C and 35^{o}C. The soil texture of the study site is characterized by clay loam texture and landscape of gentle slope. Seeds were collected from different geographical areas in Arba Minch Zuria woreda (Figure 1).

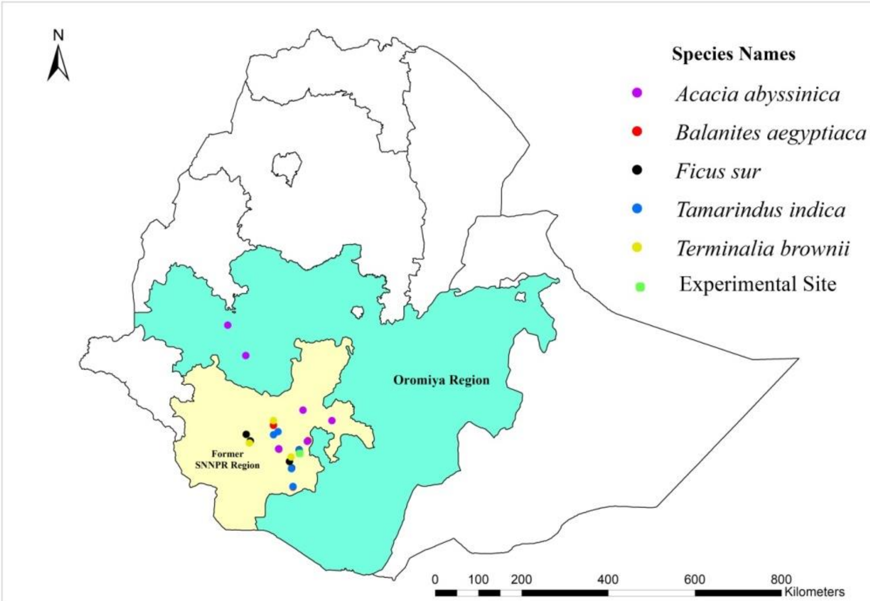

Figure 1. Distribution map of studied tree species.

Research design and management

Seeds of *B. aegyptiaca*, *T. brownii*, *T. indica*, *F. sur* and *A. abyssinica* were collected from different locations. During seed collection, healthy, vigorous and mature trees were selected as source of seed for all the species under the study. Isolated trees of cross-pollinating species or border trees were not selected because of risk of self-pollination (*i.e.* low productivity and viability).

Seeds were pretreated according to the recommendation of Tessema (2007). For *A. abyssinica*, seeds were soaked in hot water for one minute, allowed to cool and soaked for 36-48 hours. Damaged seeds that floated were discarded. For *B. aegyptiaca,* seeds were soaked in cold water for 24 hours, and then the water was changed and soaked for another 24 hours. For *T. indica,* seeds were soaked in cold water for 12 hours. *T. brownii* seeds were pretreated by removing wings and soaking in cold water overnight. No pretreatment was applied for seeds of *F. sur*.

Table 1. Locations and geographic coordinate data of the studied tree species.

Tree Species	Provenance	Altitude (m.a.s.l)	Latitude (N)	Longitude (E)
Balanites aegyptiaca	Arba Minch	1176	6°02'288"	37°34'431"
	Mirab Abaya	1196	6°17!597"	37°45'915"
	Konso	1535	5°20'118"	37°26'255"
	Humbo	1432	6°71'375"	37°85'818"
	Derashe	1325	5°43'579"	37°24'517"
	Gofa	1164	6°37'79"	37°02'69"
Ficus sur	Arba Minch	1185	6°62'040"	37°34'778"
	Basketo	963	6°17'387"	36°33'106"
	Bonke	1519	5°52'729"	37°22'784
	Derashe	1320	5°43'529"	37°24'390"
	Humbo	1434	6°71'208"	37°86'891"
	Melokoza	835	6°25'059"	36°28'074"
Terminalia brownii	Basketo	908	6°15'623"	36°32'915"
	Bonke	1305	5°57'565"	37°24'623"
	Derashe	1319	5°43'219"	37°24'710"
	Gofa	1130	6°43'3"	37°02'71"
	Konso	1384	5°20'542"	37°26'905"
Tamarindus indica	Arba Minch	1190	6°62'101"	37°34'895"
	Derashe	1324	5°43'719"	37°24'413"
	Gofa	1195	6°25'21"	37°02'68"
	Humbo	1384	6°71'545"	37°87'883"
	Konso	1304	5°21'657"	37°26'291"
	MirabAbya	1222	6°29'099"	37°76'835"
Acacia abyssinica	Gununo	1708	6°56'1"	37°39'03"
	Humbo	1597	6°71'375"	37°85'818"
	Loka Abaya	1760	6°43'69"	38°15'825"
	Mirab Abaya	1481	6°17'196"	37°44'19”
	Dabena	1917	8°42'07.91"	36°05'12.48”
	Dembi	1926	8°04'15.22"	36°27'34.27”

Polyethylene pots having 20 cm height and 12 cm diameter were filled with two parts of forest soil one parts of compost and one parts of sand soil to raise seedlings. Twenty polyethylene pots with four replications (5×4) in Complete Randomized Design (CRD) were used for each provenance. Treated seeds were directly sown in the polyethylene pots. The polythene pots were placed in nursery on an open ground and seedlings were maintained in the nursery until they grow. Metrological data of the seed development season compared to the previous year is given in Table 2. Seedlings survival was also monitored until the end of the work. All the necessary nursery operations were done during the entire period of experiment.

Table 2. Monthly maximum (Max) and minimum (Min) mean temperature, rainfall and relative humidity (RH) of Arba Minch area during 2018 and 2019 (trial seasons).

	2018				2019			
Month	Max temp. (°C)	Min temp.(°C)	Rainfall (mm)	RH (%)	Max temp. (°C)	Min temp. (°C)	Rainfall (mm)	RH (%)
January	29.84	15.81	2.46	38.84	28.11	15.62	3.44	36.12
February	30.70	18.85	47.60	39.32	28.64	18.62	38.56	35.75
March	28.66	17.94	35.50	58.77	27.35	17.17	53.94	55.34
April	26.75	17.34	250.70	66.12	26.32	16.59	261.27	64.18
May	26.42	17.86	165.00	64.13	26.01	16.44	189.11	60.26
June	24.78	17.04	89.00	50.56	25.16	16.31	63.41	44.63
July	25.52	18.44	12.80	44.12	26.34	16.64	16.35	44.96
August	26.84	18.26	94.40	63.35	26.11	15.74	101.02	56.89
September	28.68	17.73	159.40	69.11	25.45	15.96	201.11	61.09
October	27.86	17.95	102.60	60.34	26.72	16.17	111.01	60.54
November	28.62	16.75	81.00	57.45	27.58	16.03	76.48	54.75
December	28.94	17.35	17.76	16.34	28.01	17.14	13.16	26.35

Source: National Meteorological Agency, Hawassa Branch (2019).

Data collection and analysis

There are a number of factors that affect seed viability, longevity, germination and seedling vigor. The parameters selected for this experiment were germination, leaf number, shoots length, root collar diameter, and fresh and dry biomass. Data on growth rates of seedlings were taken regularly at every 15 days interval starting from the first germination. Shoot length of each species was measured using ruler in centimeter (cm), while root-collar diameter (RCD) was measured using caliper. The number of leaves in pairs of each seedling was counted. Fresh and dry biomass weight of a seedling was measured on five randomly selected seedlings (destructive sampling). The measurement of dry weight was done after drying the seedling in an oven for 24 hours at 65^{o}C. The germination percentage data was first arcsine transformed before statistical analysis to fulfill normality (Gomez and Gomez, 1984). Collected data was analyzed and evaluated by using a descriptive statistic. The statistical significance differences among the treatments were determined by using ANOVA and SAS Computer Software Program was used for multiple comparison of Least Significance Difference (LSD).

RESULTS

Acacia abyssinca, Ficus sur, Balanites aegyptiaca, Tamarindus indica and *Terminalia brownii* started germination at 22, 24, 15, 18, 14 days after sowing respectively. Each germinated seedlings produced its first pair of leaves in the first week of germination. Germination and seedling vigor of *B. aegyptiaca, F. sur, T. brownii, T. indica,* and *A. abyssinica* in Arba Minch Zuria woreda are presented in Tables 3 to 7 respectively.

The experimental result for *B. aegyptiaca* showed significant differences among provenances ($p \leq 0.05$) in seed germination, leaf number and shoot length (Table 3).

Table 3. Mean seedling growth performances of *B. aegyptiaca* provenance in Southern Ethiopia.

Provenance	Germination (%)	Leaf number	Shoot length (cm)	RCD	Fresh biomass (gm)	Dry biomass (gm)
Arba Minch	79.47^{a}	35.94^{a}	44.25^{a}	0.18	40.75	15.5
Mirab Abaya	71.62^{b}	31.88a^{b}	37.16^{b}	0.17	41.75	15.3
Konso	69.10^{c}	30.62^{b}	32.94b^{c}	0.26	32	11.82
Humbo	67.65^{d}	29.94^{b}	39.25^{ab}	0.15	34.5	13.45
Derashe	64.32^{e}	29.62^{b}	35.53^{bc}	0.15	34	12.7
Gofa	60.15^{f}	22.38^{c}	29.88^{c}	0.13	32.5	12.43
CV (%)	1.4	9.5	12.4	52.2	20.1	22.7
LSD (5%)	1.44	4.2	6.7	NS	NS	NS

Means value with different superscript letters are significantly different ($P \leq 0.05$).Whereas; RCD= root collar diameter, CV= coefficient of variation, LSD= least significant difference NS= not significant.

The seeding performance of *F. sur* between provenances showed significant difference ($p \leq 0.05$). Germination and shoot length significantly varied but other parameters were not statistically different (Table 4).

Table 4. Mean seedling growth performances of *F. sur* provenance in Southern Ethiopia.

Provenance	Germination (%)	Leaf number	Shoot length (cm)	RCD	Fresh biomass (gm)	Dry biomass (gm)
Arba Minch	89.1[a]	12.81	24.75[a]	0.46	176	36.98
Basketo	76.45[c]	10.81	17.25[b]	0.35	131	32.05
Bonke	77.38b[c]	10.19	13.62[b]	0.36	113.8	24.55
Derashe	78.62[b]	11.25	16.38[b]	0.31	153.2	30.95
Humbo	79.00[b]	10.5	13.34[b]	0.32	105.5	26.25
Melokoza	74.30[c]	10.06	12b	0.28	70.5	18.25
CV (%)	3.3	15.3	26.1	30.8	39.3	39.7
LSD (5%)	3.96	NS	6.3	NS	NS	NS

Means value with different superscript letters are significantly different ($P \leq 0.05$).Whereas; RCD= root collar diameter, CV= coefficient of variation, LSD= least significant difference NS= not significant.

The experimental result of *T. brownii* showed significant difference among the different provenances ($p \leq 0.05$) with regards to seed germination. However, the other parameters did not show significant difference among the provenances. Even though no significant variation was observed in early growth parameters, the provenances of Gofa and Derashe performed well compared to the others (Table 5).

Table 5. Mean seedling growth performances of *T. brownii* provenance in Southern Ethiopia.

Provenance	Germination (%)	Leaf number	Shoot length (cm)	RCD	Fresh biomass (gm)	Dry biomass (gm)
Basketo	71.95[c]	14.81	18.85	0.22	54.25	18.48
Bonke	68.6[d]	14.69	17.75	0.23	51.75	17
Derashe	80.8[b]	15.38	21.44	0.21	63.5	18.93
Gofa	85.9[a]	14.25	21.98	0.38	60	19.65
Konso	71.35[c]	14.75	19.8	0.21	56.25	17.10
CV (%)	1.4	6.5	13.8	40.8	27.7	25.9
LSD (5%)	1.63	NS	NS	NS	NS	NS

Means value with different superscript letters are significantly different ($P \leq 0.05$).Whereas; RCD= root collar diameter, CV= coefficient of variation, LSD= least significant difference NS= not significant.

For *T. indica*, significant ($p<0.05$) differences were detected in most of the parameters except root collar diameter. Arba Minch provenance recorded the highest mean value of fresh biomass weight and dry biomass weight than the other provenances. Konso and Mirab Abaya provenances recorded the least mean value of shoot length (Table 6).

Table 6. Mean seedling growth performances of *T. indica* provenance in Southern Ethiopia.

Provenance	Germination (%)	Leaf number	Shoot length (cm)	RCD	Fresh biomass (gm)	Dry biomass (gm)
Arba Minch	87.9^{a}	15.19^{a}	20.91^{ab}	0.16	24.00^{a}	8.47^{a}
Derashe	72.3^{c}	13.75^{ab}	21.25^{ab}	0.15	17.25^{b}	5.82^{bc}
Gofa	76^{c}	12.56^{b}	20.75^{ab}	0.29	16.5^{b}	6.2^{b}
Humbo	81.1^{b}	14.81^{a}	22.19^{a}	0.11	17.25^{b}	6.15^{b}
Konso	82.1^{b}	13.13^{b}	18.44^{c}	0.22	15.00^{b}	4.85^{c}
Mirab Abaya	71.2^{c}	14.00^{ab}	19.69b^{c}	0.27	16.5^{b}	5.42b^{c}
CV (%)	4.2	7.1	6.9	15.7	14.3	14
LSD (5%)	4.92	1.5	2.1	NS	3.76	1.28

Means value with different superscript letters are significantly different ($P \leq 0.05$). Whereas; RCD= root collar diameter, CV= coefficient of variation, LSD= least significant difference NS= not significant.

The statistical test of *A. abyssinica* indicated that there was significant difference ($p \leq 0.05$) among provenances in most studied parameters. Generally, Gununo provenance recorded highest seed germination percentage and fresh biomass than the rest five provenances and the same provenance showed significantly higher mean value of shoot length than Debena, Denbi, Humbo and Loka Abaya provenances (Table 7).

Table 7. Mean seedling growth performances of *A. abyssinica* provenance in Southern Ethiopia.

Provenance	Germination (%)	Leaf number	Shoot length (cm)	RCD	Fresh biomass (gm)	Dry biomass (gm)
Dabena	70.73^{b}	18.79^{ab}	22.22^{b}	0.17	37.5^{bc}	9.9^{bc}
Denbi	65.25^{d}	17.12^{b}	20.88^{b}	0.16	17.75^{c}	5.12^{c}
Gununo	79.35^{a}	24.12^{a}	34.19^{a}	0.22	128.75^{a}	38.8^{a}
Humbo	67.98^{c}	15.06^{b}	22.88^{b}	0.14	51b^{c}	15.62^{bc}
Lokaabaya	64.25^{d}	14.81^{b}	22.25^{b}	0.11	45.5^{bc}	15.28^{bc}
Mirab	63.33^{d}	17.79^{b}	26.35^{ab}	0.19	66^{b}	20.88^{b}
CV (%)	2.4	19.1	21.8	32.3	46.9	47.7
LSD (5%)	2.47	5.075	8.04	NS	40.22	12.7

Means value with different superscript letters are significantly different ($P \leq 0.05$). Whereas; RCD= root collar diameter, CV= coefficient of variation, LSD= least significant difference NS= not significant.

DISCUSSION

In most plant species, seeds vary in their degree of germination between and/or within provenance individuals (Mkonda et al., 2003; Loha et al., 2006). In the present study, variations between provenances were observed. Generally causes of such variability might be attributed to either genetic characters of source population/plant (Shu et al., 2012), or impact of mother plant's environment (Singh et al., 2010). Gutterman (2000) stated that germination of seeds can be influenced by maternal factors, such as position of the seed in the fruit/tree, the age of the mother plant during seed maturation, as well as environmental factors such as day length, temperature, light quality, water availability and altitude. The differences in germination patterns and seedling growth rates may be also related to climatic and geographic influences or to genetic differences (Moles and Westoby, 2004; Raddad, 2007). In the present study, age of mother plant during seed collection and environmental factors such as light quality, water availability and altitude might be the cause for the observed variation in seed germination and seedling vigor. Low germination percent observed in the current study could also be related to seed handling or mixing of ripened and unripen fruit during collection.

Variation among provenances in seedling height has been reported for most tree species. Most variation in seedling height of different species in common-garden studies has been attributed to provenance effect (Shu et al., 2012). Loha et al. (2006) also reported that diameter of *Cordia africana* at the early stage of growth (4 months) had a significant correlation with seed length and weight and stated that these correlations are expected since the emerging seedling depends on the seed reserve for its initial growth until it becomes autotrophic. This implies that seed traits could affect seedling growth at an early stage. In present study, variation was observed in seedling height between provenances, which agrees with the finding of Shu et al. (2012). However no relationship between seedling height and weight was observed in the current study as reported by Loha et al. (2006). Fandohan et al. (2010) noted that larger seeds also showed higher growth speed than smaller ones and that seed traits can be determinants for seedling growth and survival during early life stages of plants. The same pattern was also observed in seedling growth performance of other tree species growing in arid or semiarid areas, such as *Moringa peregrine* (Gomaa et al., 2011), *Acacia senegal* (L.) Willd. in Sudan (Raddad, 2007), *Acacia tortilis* (Forrsk.) Hayne and *Faidherbia albida* (Del.) A. Chev.; in Kenya (Stave et al., 2005). In the present study, large sized seeds showed higher growth speed compared to the smaller ones which might be the result of an adaptation of these provenances to their environments (Ghosh and Singh, 2011).

CONCLUSION AND RECOMMENDATION

Evidence from this study indicated that provenances have an effect on seed germination and seedling performance and best seed sources were identified for selected indigenous tree species. The best seed source for *B. aegyptiaca*, *F. sur* and *T. indica* is Arba Minch area. Similarly, Gununo and Gofa provenances are identified as the best seed source for *A. abyssinica* and *T. brownii* respectively. Since the period of this study was short and at nursery level, progeny tests in the field should be undertaken for a longer period. Further study covering wider geographical range and higher number of provenances is also recommended.

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