

Seedling performance of different provenances of selected indigenous tree species in Debub Ari District, Southern Ethiopia

Mintesnot Tsegaye, Belayneh Lamage* and Alemayehu Hido

Southern Agricultural Research Institute, Jinka Agricultural Research Center, P.O. Box 96 Jinka, Ethiopia.

*Corresponding author. Email: belaynehlamage@gmail.com

Copyright © 2021 Tsegaye et al. This article remains permanently open access under the terms of the [Creative Commons Attribution License 4.0](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received 7th October, 2020; Accepted 9th March, 2021

ABSTRACT: Better understanding of variations in seed traits and seedling vigor in various populations of a given species is vital for appropriate nursery and tree planting technology. The main objective of this study was to identify better provenance for indigenous trees by testing seed germination and seedling traits. Seeds of six indigenous trees (*Vachellia abyssinica*, *Vachellia seyal*, *Faidherbia albida*, *Balanites aegyptiaca* and *Terminalia laxiflora* Engl.) were collected from different geographic areas. One hundred (100) polyethylene pots (20 cm height and 12 cm diameter) were filled with 2:1:1 ratio of local, forest soil and sand composition for seedlings. A Complete Randomized Design (CRD), 5 x 4 polyethylene pots in four replications of 20 polyethylene pots for each provenance was designed in the nursery and the provenances for selected species. Different early growth performance parameters were measured for each tested provenance. All collected data were analyzed by using ANOVA while the least significance difference was computed for mean separation. The seedling performance of *Vachellia abyssinica* and *Vachellia seyal* were significantly varied among the provenances. *Vachellia abyssinica* from Butajira provenance had the highest mean values across all the studied parameters. Except height, Kako provenance had the highest mean values across all the early performance parameters of *Vachellia seyal*. Seedling performances of *Faidherbia albida* in the nursery was significantly varied among the provenances except for root collar diameter. Provenance from Wondo Genet had the highest mean values of germination percent and comparable leaf numbers with provenance from Hawassa. It can be concluded that the observed patterns of variation will have the implication for genetic resources conservations and tree improvement. Accordingly, Butajira and Kako provenances could be taken as a good source of seed collection for *Vachellia abyssinica* and *Vachellia seyal*, respectively. Wondo Genet and Hawassa provenances could also ensure the provision of planting materials of *Faidherbia albida* for farmers. Further progeny tests in the field should be undertaken for a longer period to obtain definitive recommendations for early selection.

Keywords: Biomass, leaf number, genetic variation, parameters, provenances.

INTRODUCTION

The natural forests of Ethiopia have been declining rapidly due to various reasons. The high rate of deforestation has had severe threats to most of indigenous tree species. Planting and establishment of indigenous trees in the agricultural landscape could be an important step in terms of restoration of floral diversity apart from provision of economically and socially valued products and services (Yirdaw, 2001). To satisfy the growing demand for forest products, countries like Ethiopia should increasingly turn to intensively managed forest plantations. However,

before plantations establishment and cultivating indigenous trees in farmland or other land use, improved understanding of the selection of the most reliable seed sources and quality seedling production is needed. Successful tree growing requires high seedling vigorosity. Nursery practices affect the vigor of seedlings and accordingly on the success of their transplantation in the field. Provenances have been reported as one of the main factors affecting the quality of seedlings (Derero et al., 2017). Differences among geographic sources in forest

tree species are often substantial and economic improvement can be made by an appropriate provenance selection (Schmidt, 2000).

Information on variation among provenances of indigenous tree species is scarce. In Ethiopia, few studies were carried out on the effect of seed traits and seedling vigor for some indigenous woody species (Loha et al., 2006; Mamo et al., 2006; Bahru et al., 2014; Derero et al., 2017). These studies reported significant growth differences among provenances observed. However, only some indigenous species were considered under these few studies. Thus, new studies on variation among provenances of indigenous trees particularly woodland tree species that are economically and ecologically important are essential for improving the quality of plantations produced to get a higher quality product thereby supporting the conservation by utilization strategy. The present study was designed to evaluate the effect of provenances on seedling performance of indigenous tree species (*Vachellia abyssinica*, *Vachellia seyal*, *Faidherbia albida*, *Balanites aegyptiaca* and *Terminalia laxiflora* Engl.) on nursery level.

The present study focused to identify better provenances for indigenous trees by testing seed germination and evaluating the early growth performance of seedling in the nursery. The targeted indigenous tree species were studied to evaluate their performance in reference to different provenances where they are collected from in different locations. These species are not studied in depth to promote its importance and increase its use value, the current research was conducted to identify the better performing provenances of indigenous tree species in main station of Jinka Agricultural Research Center Nursery Site.

MATERIAL AND METHOD

Site description

The study was conducted at the nursery of Jinka Agricultural Research Centre located in Debub Ari District of South Omo zone, with an altitude of 1,383 meter above sea level (m.a.s.l.). The soil type is characterized as Cambisols with fine to very fine particles, pH ranges of 4.87 to 6.18 and strongly acidic to slightly acidic (Kebede et al., 2017) which is the preferable range for most crops with some management. The study site has a bi-modal rainfall pattern with a shorter rainy season from March to May and the longest rainy season from August to November. The total annual rainfall is $1,272.4 \pm 250.7$ mm. The annual mean minimum and maximum temperatures are 16.3 ± 0.9 and $27.7 \pm 1.4^\circ\text{C}$.

Research design and management

Seeds of indigenous trees were collected from different

geographic areas. During seed collection, the points considered were healthy and vigorous trees selected as a source of seed. Isolated trees of cross-pollinating species or border trees were not considered during selection because of the risk of self-pollination (low productivity and viability). Seeds were treated according to the recommendations of Bekele and Tengnäs (2007). Following the seed collection and treatment, 100 polyethylene pots having 20 cm height and 12 cm diameter were filled with 2:1:1 ratio of local, forest soil and sand composition for seedlings. Using a Complete Randomized Design (CRD), 5 x 4 polyethylene pots in four replications of 20 polyethylene pots for each provenance was designed in the nursery and the provenances for selected species. Seedling survival was monitored until the end of the experiment. Weeding activities and watering were done regularly (morning and evening) whenever it was necessary. Finally, data on early survival and mortality rate as well as growth performance of seedlings were carried out four months after the completion of transplanting in the polyethylene pots.

Data collection

The shoot length/height of each species seedling was measured using a ruler in centimeter (cm), while root-collar diameter (RCD) was measured using caliper among the provenances and species. In line with this, the number of leaves in pairs of each seedling was counted. Seedlings' leaf, stem and root fresh, and dry weight estimation were considered.

Statistical analysis

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 percentages. In addition, the statistical significance difference was determined by analysis of variance (ANOVA) and multiple comparisons of Least Significance Difference (LSD) to show significance difference among the treatments using Statistical Analysis System (SAS) Software Programme.

RESULT

The growth performance parameters were evaluated for each provenance of all studied indigenous tree species. The seedling performances of *Vachellia abyssinica* was significantly ($p \leq 0.05$) varied among the provenances. Butajira provenance had the highest performance across all the studied growth performance parameters while the leaf number was comparable with Dembi, Humbo and Kembata provenances. Humbo provenance recorded the least germination percent while Shaba provenance had

Table 1. Means of early growth performance of *Vachellia abyssinica* in South Omo zone, Debud Ari District (Means±Std).

Provenances	Mean ± Std				
	Germination After 50 days	%	Height (cm)	BNO	RCD (cm)
Butajira	95.0		36.38±15.24 ^a	26.8±9.04 ^a	0.23±0.08 ^a
Dembi	83.3		25.66±5.91 ^c	24.8±10.52 ^a	0.14±0.06 ^c
Humbo	80.0		26.59±5.88 ^{bc}	25.59±10.21 ^a	0.16±0.06 ^{bc}
Kembata	91.7		29.69±7.55 ^b	26.05±8.92 ^a	0.17±0.07 ^{bc}
Luka	81.7		25.96±5.55 ^c	20.51±9.04 ^b	0.14±0.06 ^c
Shaba	91.7		20.93±8.04 ^d	13.82±4.80 ^c	0.18±0.07 ^{bc}

Means value ± Std with different letters are significantly different ($p \leq 0.05$). Whereas; GA=germination rate (%), RCD= root collar diameter, DBH= diameter at Brest height, BNO= branch number, STD= standard deviation.

Table 2. Early growth performance of different provenance of *Vachellia seyal* in Debub Omo zone, Debub Ari District (Means ±Std).

Provenances	Mean ± Std			
	Germination %After 50 days	RCD (cm)	Height (cm)	BNO
Alduba	28.3	0.12±0.04 ^b	15.71±9.8 ^c	8.18±5.87 ^{bc}
Halaba	45.0	0.13±0.05 ^b	17.30±10.63 ^c	12.44±7.03 ^b
Hawassa (loke Abaya)	65.0	0.14±0.05 ^b	11.36±6.71 ^d	8.08±7.09 ^c
Shaba	48.3	0.13±0.05 ^b	21.97±8.58 ^{ab}	10.24±5.32 ^{bc}
Kako	93.3	0.19±0.08 ^a	27.43±6.36 ^a	19.34±4.45 ^a

Means value ± Std with different letters are significantly different ($p \leq 0.05$). Whereas; RCD= root collar diameter, DBH= diameter at Brest height, BNO= branch number, STD= standard deviation.

the least mean values of height and branch numbers. Luka and Dembi provenances have the least and comparable mean values of root collar diameter with the remaining provenances except for Butajira (Table 1).

The early growth performances of *Vachellia seyal* was significantly ($p \leq 0.05$) varied among the provenances. Kako provenance had the highest mean values across all the early performance parameters except the height was comparable with Shaba provenance. Alduba provenance had the least germination percentage while it was comparable in root collar diameter with all the provenances except for Kako. Hawassa (Loke abaya) provenance had the least mean values of height and branch numbers while the root collar diameter was comparable with the remaining provenances except for Kako (Table 2).

Early seedling performance of *Faidherbia albida* in the nursery was significantly ($p \leq 0.05$) varied among the provenances except root collar diameter in early growth performances. Wondo Genet provenance had the highest mean values of germination percent and comparable branch numbers with Hawassa provenance. Shaba provenance had the least across all the early growth

performance parameters followed by Meskan provenance (Table 3).

Considerable variation in seed germination of *Balanites aegyptica* existed among the studied provenances ranging from 10 to 75% with the highest value observed in Key-Afer provenance. The early seedling growth performances of *Balanites aegyptiaca* was significantly ($p \leq 0.05$) varied among the provenances except for root collar diameter. Key-Afer provenance had the highest germination percent and comparable number of branches with the remaining provenances except for Humbo provenance, while Konso (midland) provenance had the highest mean values of height. Humbo recorded the least germination percent and least comparable height with the remaining provenances except for Konso (Table 4).

The seedling performances of *Terminalia laxiflora* Engl. was significantly ($p \leq 0.05$) varied among the provenances except for root collar diameter, in early growth evaluation. Kure provenance had the highest mean values across all the early performance evaluation parameters. Baytseml provenance had the least germination percentage, while the height and branch number were comparable with Kako provenance (Table 5).

Table 3. Early growth performance of *Faidherbia albida* in different provenance in Debub Omo zone, Debub Ari District (Means± Std).

Provenances	Mean ± Std			
	Germination % After 50 days	Height (cm)	RCD (cm)	BNO
Hawassa	76.7	18.89±7.48 ^a	0.16±0.06	15.57±7.70 ^a
Kako	58.3	18.49±5.00 ^a	0.16±0.07	14.29±7.36 ^{bc}
Luka	16.7	13.40±5.38 ^b	0.17±0.05	10.30±2.75 ^b
Meskan	16.7	6.9±3.48 ^c	0.15±0.05	4.7±4.0 ^c
Shaba	11.7	4.29±1.80 ^c	0.16±0.05	3.29±1.70 ^c
Wondo Genet	90.0	17.74±6.00 ^{bc}	0.17±0.06	15.34±5.96 ^a

Means value ± Std with different letters are significantly different ($p \leq 0.05$). Whereas; RCD= root collar diameter, DBH= diameter at Brest height, BNO= branch number, STD= standard deviation.

Table 4. Early growth performance of *Balanites aegyptica* with difference provenance in Debub Omo zone, Debud Ari District (Mean ± Std).

Provenances	Mean ± Std			
	Germination %After 50 days	RCD (cm)	Height (cm)	BNO
Alduba	71.7	0.17±0.08	13.95±4.73 ^b	13.74±4.85 ^{ab}
Humbo	10.0	0.15±0.05	11.65±4.41 ^b	8.83±4.12 ^b
Key Afer	75.0	0.15±0.05	14.24±5.1 ^b	14.49±5.38 ^a
Konso(midland)	41.7	0.16±0.08	20.6±8.01 ^a	17.00±6.65 ^a

Means value ± Std with different letters are significantly different ($p \leq 0.05$). Whereas; RCD= root collar diameter, DBH= diameter at Brest height, BNO= branch number, STD= standard deviation.

Table 5. Early growth performance of different provenance of *Terminalia laxiflora* in Debub Omo zone Debub Ari District (Mean ± Std).

Provenances	Mean ± Std			
	Germination% After 50 days	RCD (cm)	Height (cm)	BNO
Baytsemal	85.0	0.20±0.07	5.73±3.12 ^b	4.67±2.10 ^b
Kure	91.7	0.18±0.08	8.47±5.49 ^a	6.85±2.82 ^a
Kako	91.7	0.19±0.07	5.73±2.92 ^b	4.73±2.06 ^b

Means value ± Std with different letters are significantly different ($p \leq 0.05$). Whereas; RCD= root collar diameter, DBH= diameter at Brest height, BNO= branch number, STD= standard deviation.

DISCUSSION

Research on patterns of natural variation in commercially and adaptively important traits is essential in order to develop tree improvement and conservation strategies for native hardwood species in Africa. There has been little systematic research on genetic variation in the growth and survival of native hardwood species in the world and Africa. According to Derero et al. (2017), a study done on 12 provenances of cordial in Ethiopia, Addis Abeba shows the germination percentage of those provenances ranges from 16% for Guraferda and Sekoru to 69% for Hirna. Similarly, the research done in Holeta Research Center indicates that there was a significant difference in mean germination percentage, mean germination rate and mean

germination vigourosity among seed provenances at ($p < 0.05$) (Kifle et al., 2014). The work done on Mediterranean maritime Pines (*Pinus pinaster aiton*) shows there is very low germination percent in the different provenance of the species (Vizcaino-Palomar et al., 2014).

In contrast, there are relatively few published reports of genetic variation in growth, survival and other commercially or adaptively important traits of native African hardwoods. For instance, *Acacia nilotica* (Diallo et al., 2000; Wolde-Mieskel and Sinclair, 2000); *Acacia Senegal* (Diallo et al., 2000; El Amin and Luukkanen, 2006; Raddad, 2007); *Cordia africana Lam.* (Loha et al., 2006); *Faidherbia albida* (Dangasuk et al., 1997; Rounsard et al., 1998).

Higher shoot length (seedling height) and RCD values

are important for better survival rate and higher growth performance with better adaptation capacity of the seedlings at field conditions. In turn, a large number of seedlings' leaves might contribute to a higher rate of photosynthesis, which in turn resulted in a higher growth rate as also reported by Tadesse et al. (2010). A similar result was obtained from Kenya on *Faidherbia albida* (Fredrick et al., 2015). Another study under taken in Burkina Faso sought that the growth rate and germination speed of four native for the country were affected by provenance difference. Another study in Ethiopia done on *Cordia africana* from the total of 12 provenances in 290 days shows 19.3 cm and 5.7 mm for mean height and mean root collar diameters, respectively, and individually seedlings have a measure of 3.5 to 49.5 cm for height and 1 to 12 mm for collar diameter (Derero et al., 2017). The research conducted in Great Britain on two pinus species, *Pinus tecunumanii* and *P. patula*, shows that provenance affects the height growth of these two species and also develops model that used to indicate climate dissimilarity of the site (Leibing et al., 2013). FAO was initiated and the Danida forest seed center analyzed several trials to identify some superior provenances from Africa and other continents for reforestation in arid and semi-arid zones in Africa (Raebild et al., 2003; Weber et al., 2008).

Conclusion and recommendation

In general, raising high quality and a large number of seedlings in the nursery plays a significant role in better survival, growth performance, and adaptation of seedlings at field conditions. The present study indicates that the performance of seedling in nursery site is highly affected by the source of seed. In order to get high, rapid, and uniform early performance of seedling, selection of appropriate seed source is important.

Different provenance of five indigenous trees were tested and observed inter-population difference for all species. According to the result of this study, it can be concluded that Butajira (Meskan) provenance is the best provenance for the study area to grow *Vachellia abyssinica* compared to others; Kako provenance is for *Vachellia seyal* species. Wondo-genet provenance is selected for growing of *Accacia albida* in the study area, Key-Afer is preferred provenance for *Balanites aegyptiaca* and Kure provenance for *Terminalia laxiflora*.

Meskan (Butajira), Kako, Wondo genet, Key-Afer, and Kure provenances were recommended for *Vachellia abyssinica*, *Vachellia seyal*, *Faidherbia albida*, *Balanites aegyptiaca* and *Terminalia laxiflora* respectively. Therefore, these provenances can be used as a seed source for the study area. Since the period of this study was short, at the nursery level, further progeny tests in the field should be undertaken for a longer period to obtain definitive recommendations for early selection. Finally, selecting and analyzing additional provenances in future

studies could be considered in order to get a more suitable provenance.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this article.

ACKNOWLEDGEMENTS

The authors acknowledge Southern Agricultural Research Institute for financial support to conduct this experimentation and Jinka Agricultural Research Center for its strong administrative facilitation by providing important inputs to handle the research accordingly. The collaboration of researchers in the Natural Resource Research Directorate is highly appreciated. In addition, the intimate communications of field assistants, expert participation in seed collection and handling were strongly acknowledged.

REFERENCE

- Bahru, T., Eshete, A., Mulatu, Y., Kebede, Y., Tadesse, W., Mohammed, O., & Dejene, T. (2014). Effect of provenances on seed germination, early survival and growth performance of *Tamarindus indica* L. in Ethiopia: a key multipurpose species. *Advances in Materials Science and Engineering: An International Journal (MSEJ)*, 1(1), 1-8.
- Bekele-Tesemma, A., & Tengnäs, B. (2007). *Useful trees and shrubs of Ethiopia: identification, propagation, and management for 17 agroclimatic zones* (p. 552). Nairobi, Kenya: RELMA in ICRAF Project, World Agroforestry Centre, Eastern Africa Region.
- Dangasuk, O. G., Seurei, P., & Gudu, S. (1997). Genetic variation in seed and seedling traits in 12 African provenances of *Faidherbia albida* (Del.) A. Chev. at Lodwar, Kenya. *Agroforestry Systems*, 37(2), 133-141.
- Derero, A., Tesfaye, G., & Woldemariam, Z. (2017). Variation in seed traits and seedling vigor of *Cordia africana* Lam. provenances in Ethiopia. *Journal of Forestry Research*, 28(5), 925-933.
- Diallo, B. O., Sanou, J., Some Dao, M., Cao, T. V., & Asimi, S. (2000). *Rapport d'activité final. Projet FAC N894*. CD/78/BKA Volet 1: Amélioration génétique des ligneux soudano-sahéliens. Centre National de la Recherche Scientifique et Technologique (CNRST).
- El Amin, Y. R., & Luukkanen, O. (2006). Adaptive genetic variation in water-use efficiency and gum yield in *Acacia senegal* provenances grown on clay soil in the Blue Nile region, Sudan. *Forest ecology and management*, 226(1-3), 219-229.
- Fredrick, C., Muthuri, C., Ngamau, K., & Sinclair, F. (2015). Provenance variation in seed morphological characteristics, germination and early seedling growth of *Faidherbia albida*. *Journal of Horticulture and Forestry*, 7(5), 127-140.
- Gomez, K. A., and Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John Wiley & Sons.
- Kebede, M., Shimbir, T., Kasa, G., Abera, D., & Girma, T. (2017).

- Description, characterization and classification of the major soils in Jinka Agricultural Research Center, South Western Ethiopia. *Journal of Soil Science and Environmental Management*, 8(3), 61-69.
- Kifle, T. B., Merti, A. A., & Hora, K. W. (2014). Evaluation of propagation methods of *Schefflera abyssinica*. *American Journal of Agriculture and Forestry*, 2(6), 278-283.
- Leibing, C., Signer, J., Van Zonneveld, M., Jarvis, A., & Dvorak, W. (2013). Selection of provenances to adapt tropical pine forestry to climate change on the basis of climate analogs. *Forests*, 4(1), 155-178.
- Loha, A., Tigabu, M., Teketay, D., Lundkvist, K., & Fries, A. (2006). Provenance variation in seed morphometric traits, germination, and seedling growth of *Cordia africana* Lam. *New forests*, 32(1), 71-86.
- Mamo, N., Mihretu, M., Fekadu, M., Tigabu, M., and Teketay, D. (2006). Variation in seed and germination characteristics among *Juniperus procera* populations in Ethiopia. *Forest ecology and management*, 225(1-3), 320-327.
- Raddad, E. A. Y. (2007). Ecophysiological and genetic variation in seedling traits and in first-year field performance of eight *Acacia senegal* provenances in the Blue Nile, Sudan. *New Forests*, 34, 207-222.
- Raebild, A., Diallo, B. O., Graudal, L., Dao, M., & Sanou, J. (2003). *Evaluation of a provenance trial of Acacia nilotica and A. tortilis at Gonsé, Burkina Faso*. Danida Forest Seed Centre.
- Roupsard, O., Joly, H. I., & Dreyer, E. (1998). Variability of initial growth, water-use efficiency and carbon isotope discrimination in seedlings of *Faidherbia albida* (Del.) A. Chev., a multipurpose tree of semi-arid Africa. Provenance and drought effects. In *Annales des sciences forestieres* (Vol. 55, No. 3, pp. 329-348). EDP Sciences.
- Schmidt, L. (2000). *Guide to handling of tropical and subtropical forest seed* (p. 511). Humlebaek: Danida Forest Seed Centre.
- Tadesse, W., Alem, S., Guzmán, P., López, R., Yohannes, Y., & Gil, L. (2010). Rehabilitation of degraded lands through participatory tree planting in Wayu and Anget Mewgia Kebele, North Shewa, Ethiopia. *Eucalyptus Species Management, History, Status, and Trends in Ethiopia*, 15, 114.
- Vizcaino-Palomar, N., Revuelta-Eugercios, B., Zavala, M. A., Alía, R., & González-Martínez, S. C. (2014). The role of population origin and microenvironment in seedling emergence and early survival in Mediterranean maritime pine (*Pinus pinaster* Aiton). *PloS one*, 9(10), e109132.
- Weber, J. C., & Montes, C. S. (2008). Geographic variation in tree growth and wood density of *Guazuma crinita* Mart. in the Peruvian Amazon. *New Forests*, 36, Article number 29.
- Wolde-Mieskel, E., & Sinclair, F. L. (2000). Growth variability in a Senegalese provenance of *Acacia nilotica* ssp. *tomentosa*. *Agroforestry Systems*, 48(2), 207-213.
- Yirdaw, E. (2001). Diversity of naturally regenerated native woody species in forest plantations in the Ethiopian highlands. *New Forests*, 22(3), 159-177.