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Provenance Variation in The Nursery Performance of Indigenous Tree Species in Central Ethiopia

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Abstract
Indigenous trees are vital for ecosystem resilience and socioeconomic benefits in Ethiopia. This study aimed to select superior seed sources (provenances) of key species to enhance seedling health and growth. Seeds of economically important indigenous trees were collected from various locations and sown in a nursery.

Results revealed significant differences in growth among provenances for Cordia africana, Acacia abyssinica, Faidherbia albida, and Olea europaea. However, Podocarpus falcatus and Juniperus procera showed no significant difference in seedling biomass across sources. Consequently, specific provenances were recommended as superior seed sources: Wondo Genet for Cordia africana, Arbaminch Zuria for Acacia abyssinica, Durame Zuria for Podocarpus falcatus, and Wolayta for Faidherbia albida and Olea europaea. Selecting seeds from these areas is crucial for producing healthy, vigorous seedlings in central Ethiopia and similar agro-ecologies for afforestation and/or reforestation program. A field trial was not conducted due to resource constraints.

Keywords: Agroecology, Biomass, Forestry, Genetic Variation, Indigenous Trees, Parameters and Provenance

Introduction
Ethiopia is a globally important center of plant diversity and endemism due to its varied climates, altitudes, topography, soil conditions, natural vegetation, and cultures [1]. Indigenous tree species play a key role in ensuring ecosystem resilience under climate change scenarios.

According to a study by Reta Regasa in Hawassa, farmers highly value indigenous tree species such as Cordia africana, Podocarpus falcatus, Prunus africana, Juniperus procera, and Mellitia ferruginea for their timber, fuelwood, medicinal, and construction uses [2].

These trees provide essential services and products for daily human activities, particularly leguminous trees. Leguminous species like Faidherbia albida and Acacia abyssinica as well as Cordia africana, offer significant economic and ecological benefits, including shade soil fertility improvement through organic matter nutrient cycling, and timber production [3-8].

However, significant degradation of diverse forest covers and their biodiversity persists, particularly in the Ethiopian highlands. This is a result of a long history of human settlement, land cultivation, and agricultural intensification, leading to persistent deforestation and overgrazing [9-12].

Forest resources in Ethiopia are declining at an alarming rate of 140,000 hectares per annum eroding biodiversity and other forest-based ecosystem services [1,9,10].

An additional challenge is that many indigenous tree species have seed germination problems, resulting in a shortage of planting materials (seedlings) and pushing some species toward endangerment. Conservation and restoration efforts for natural forests and indigenous trees have had mixed success, particularly when important socio-economic factors in local communities are not adequately incorporated [13].

In this context, intra-specific variability in plant functional traits can be a determinant for improving a species' fitness [14]. This variability, which results from ecological adaptations to different habitats, can manifest in morphological and physiological differences [15]. Provenance studies, which conserve species through utilization, are a promising strategy. These studies acknowledge that provenances may differ in germination and growth, so screening for the best-performing ones is crucial for promoting successful forest plantations [16].

The concept of matching seed sources to planting sites for improved tree production has been recognized since the beginning of the 19th century [17,18]. Noticeable differences among tree provenances in terms of growth and number of trees of saleable quality have a considerable economic impact [6,19]. In Ethiopia, a few studies on indigenous woody species have reported significant differences in growth performance among provenances [17,18,20,21].

However, these previous studies have only included a limited number of indigenous tree species. Therefore, further research on the variation among provenances of economically and ecologically important indigenous trees is essential for improving seedling quality. The present study was designed to evaluate the effect of provenance on the growth performance of seedlings from five indigenous tree species Cordia africana, Faidherbia albida, Acacia abyssinica, Olea africana, and Podocarpus falcatus, at the nursery level.

Materials and Methods

Site Description

The study site, Meskan District is found in Gurage Zone of SNNP Regional State, Ethiopia. It is found 133 km south of Addis Ababa. Butajira is the capital city of meskan werda. The major rainy season of study area is during June to September and the highest temperature is between February and March. According to climatic record near the study area, the mean annual rainfall in the district is 1058 mm and has altitude ranging from 1800-3500 m.a.s.lb [22]. The study area is found in escarpment of Central Rift Valley of Ethiopia. The main parent materials are basalt, ignimbrites, lava, gneiss, volcanic ash, and pumice [23,24]. According to FAO, the dominant soil types of Meskan district includes Eutric Cambisols, Chromic Luvisols, Pellic Vertisols Chromic Vertisols, Eutric Fluvisol sand Leptosols.

Research Design and Management

Certified Seeds of indigenous tree were collected from Ethiopia Environment and Forestry Research Institute (EFERI) Seed technology department and field. For field collection, provenance were identified those had number of tree above 50 and those are naturally found or grown in the area. From 10-12 trees with vigor, healthy and mature those have at least 100m distance spaced were selected from each provenance. Matured 50 seed per a single tree and total of 500-600 seeds were collected from one provenance and mixed together. From the total collected seeds in each provenance only 400 seed were selected and sowed based their purity. 100 Seeds were used for a single experimental unite/ treatment and replicated four times for each provenance. Seed treatment techniques like scarification were applied.

For each provenance, 100 polyethylene pots with the size of 10cmX8 cm was filled with local soil, organic soil and sand soil (2:1:1 ratio) to grow the seedlings. Accordingly, Complete Randomized Design (CRD) with 4 replications having 25 plants plots was designed in the nursery for each species. Seedlings survival was also supervised until the end of the work, which is based on the growth rate of tree species for instant Podocarpus falcatus and Juniporous procera were stay in the nursery site about 10 months and Cordial Africana and acacia species were finalize their field life on 4-5 months; Watering and weeding was done regularly (morning and evening) when it is necessary. Finally, data collection on early survival and mortality rate as well as growth performance of seedlings was carried out on four months after the completion of transplanting in the polyethylene pots. The work is done for two consecutive years.

No.	Provenance	Latitude	Longitude	Altitud(m)
1	**Aleta wondo**	6°36'46"	38°27'49"	2050
2	**Arbaminch zuria**	6°00'55"	37°30'42"	1969
3	**Damot gale**	7°00'06"	37°49'56"	1964
4	**Dembi**	8°31'39"	34°47'21"	1826
5	**Dill zuria**	6°24'25"	38°17'26"	1475
6	**Duguma Fango**	6°56'47"	38°02'17"	1824
7	**Durama zuria**	7°14'00"	37°53'00"	2101

8	**Gurage (meskan)**	8°08'43"	38°20'45"	2135
9	**Halaba**	7°19'05"	38°05'19"	1784
10	**Hawassa zuria(Amora gedel)**	7°02'35"	38°27'32"	1692
11	**Hawassa (tabor)**	7°02'20"	38°27'58"	1810
12	**Shanto**	7°01'35"	37°50'59"	1945
13	**Wondo genet**	7°06'22"	38°37'09"	1790

Table 1: Geographical Location Provenance Where the Seed of Species Were Collected

Data Collection

The shoot length/height of each species seedling was measured using ruler in centimeter (cm), while root-collar diameter (RCD) was measured using caliper among the provenances and species. In addition to this, the number of leaves was counted in each seedling. Seedlings' leaf, stem and root fresh and dry weight estimation was also considered using sensitive balance. To determine the dry weight of each species the shoot and root of sampled seedlings were dried using oven dry at 70oC for 48 hours separately.

Statistical Analysis

In addition, the statistical significance difference was determined by ANOVA and multiple comparison of Least Significance Difference (LSD) to show significance difference among the treatments using R Computer Software Program.

Result and Discussion

Research on patterns of natural variation in commercially and adaptively important traits is essential for developing tree improvement programs and systematic genetic studies of native hardwood species, both globally and in Africa.

Among the studied species, Faidherbia albida, Podocarpus falcatus, and Juniperus procera showed no significant differences in growth characteristics among their provenances. Understanding this variation is critically important for conservation strategies, particularly for over-exploited and highly threatened species such as Prosopis africana and Prunus africana, which face local or even regional extinction [25,26].

Growth Performance of Olea Europaea Subsp. Cuspidate

The table (table 2) compares the first and second-year growth performance of five different provenances (seed sources) of Olea europaea subsp. cuspidata seedlings. The key takeaway is that the Durama_zuria provenance consistently demonstrated superior or among the best performance across almost all measured parameters in both years, particularly in height and initial root collar diameter. The Shanto provenance, which started poorly in the first year, showed a remarkable recovery in the second year, especially in branch number. Shanto have low germination potential from the other in both year recording 37.5% and 77.5% but Durame zuria (87.5% and 90%) have higher germination percent followed by Meska (70% and 85%) in the first and second year respectively.

Provenance	Seedling growth performance							
	Year I				Year II			
	Germ (%)	H (cm)	RCD (cm)	BN	Germ (%)	H (cm)	RCD (cm)	BN
Durama_zuria	87.5	26.8a	0.34a	7.6a	90	29.4a	0.3	8.6
Meskan	70	21.36ab	0.31ab	6.2ab	85	24.6ab	0.25	6.6
Damot gale	53.75	17.54ab	0.25ab	5.6ab	88.75	27ab	0.24	6.6
Shanto	37.5	14.6b	0.23b	5.2ab	77.5	26.8ab	0.26	10.6
Dugumafango	65	12.7b	0.25ab	5b	85	22.6b	0.26	9.2
CV		34.02	20.17	22.66		13.3	24.4	38.15
MSD		11.97	0.103	2.54		6.59	NS	NS

Table 2: Seedling Growth Performance of Different Provenance of Olea Africana in Meskan Wereda, Gurage Zone

Note: Means value with different letters are significantly different (p≤0.05).Whereas; RCD= root collar diameter; Germ=Germination; H=Height; RCD= Root Collar Diamter; BN= Branch number

Biomass of Olea European Subsp. Cuspidata:

This table presents the dry biomass (weight after removing water content) of the shoots (stems) and roots for Olea europaea subsp. Cuspidate seedlings from five different geographic origins (provenances) after their first and second years of growth in Meskan wereda. The key takeaway is that all seedlings showed substantial growth from Year I to Year II. While there are numerical differences in biomass between the provenances in Year II, the statistical analysis indicates that these differences are not statistically significant

	Fresh and dry weight of shoot and root in gm			
	year I		year II	
Provenance	SDW	RDW	SDW	RDW
Durama-zuria	0.38	0.2	1.43	0.87
meskan	0.38	0.2	1.44	0.89
Damot- gale	0.18	0.11	1.6	1.19
Shanto	0.4	0.12	1.29	0.87
Dugum-afango	0.16	0.09	1.48	0.83
CV	59.4	51.97	37.4	30.67
MSD	NS	NS	NS	NS

Table 3: Above and Below Ground Biomass of Different Provenance of Olea Africana Seedling in Meskan Wereda

Means value with different letters are significantly different (p≤0.05).Whereas; SFR= stem fresh weight, RFW= root fresh weight, SDW= stem dry weight, RDW= root dry weight.

Podocarpus Falcatus: The early growth performance of Podocarpus falcatus (Yellow wood) seedlings were evaluated from four different provenances over two years (table 4). It measures four key metrics: germination success (%), seedling height (H), root collar diameter (RCD - a measure of stem thickness and sturdiness), and branch number (BN). The key takeaway is that while all provenances germinated well initially, they suffered a very high rate of seedling mortality between the first and second year. Furthermore, the only statistically significant difference detected among the provenances after two years was in the Root Collar Diameter (RCD). There is a catastrophic drop in germination percentages. The values now represent the survival rate of the original seedlings. The rates have plummeted to between 11.25% and 21.25%. This indicates extreme environmental stress (e.g., drought, soil conditions, pests) or poor seedling establishment after germination. Damot gale has the lowest survival rate (11.25%), making it the poorest performer in this regard.

	Seedling growth performance							
	year I				year II			
Provenances	Germ (%)	H (cm)	RCD (cm)	BN	Germ (%)	H (cm)	RCD (cm)	BN
Shanto	80	11.2	0.27	6.6	21.25	20.6	.25ab	4
Duguma Fango	72.5	10.9	0.28	5.6	21.25	16.6	.198b	5.2
Dill zuria	80	9.7	0.28	5.6	20	16.6	0.29a	4.2
Damot gale	83.75	9.5	0.27	5.6	11.25	16.9	.21b	4.2
CV		14.38	18.6	10.7		13.62	14.6	29.19
MSD		NS	NS	NS		NS	0.06	NS

Table 4: Seedling Growth Performance of Different Provenance of Podocarpus Falcatus in Meskan Wereda

Means value with different letters are significantly different (p≤0.05). Note: Germ=Germination; H=Height; RCD= Root Collar Diamter; BN= Branch number

	Fresh and dry weight of shoot and root in gm			
	year I		year II	
Provenances	SDW	RDW	SDW	RDW
Shanto	0.46	0.16	2.32	2.23
Duguma-Fango	0.4	0.2	1.79	2.57
Dill zuria	0.46	0.24	1.91	2.77
Damot gale	0.46	0.2	1.63	1.58
CV	27.29	47.43	30.11	34.3
MSD	NS	NS	NS	NS

Table 5: Above and Below Ground Biomass of Different Provenance of Podocarpus Falcatus Seedlings in Meskan Wereda, Gurage Zone

Means value with different letters are significantly different (p≤0.05).Whereas; SDW= stem dry weight, RDW= root dry weigh, NS=non significance's; MSD=minimum significance differencet

Juniperus procera Hochst. Ex endl. The overarching conclusion from this data is that there are no statistically significant differences in the morphological growth and biomass production among the five provenances of Juniperus procera seedlings at the nursery stage. Although the raw mean values (e.g., Damote Gale has the highest height and leaf number, Halaba has the highest fresh and dry root weight) show numerical variations, the statistical analysis confirms that these differences are likely due to random chance or natural variation within each group rather than a true effect of the seed provenance.

Seedling height ranges from 15.79 cm (Durame zuria) to 17.23 cm (Damote gale). This is a relatively narrow range, suggesting similar growth rates across provenances in the nursery. RCD values are very consistent, ranging from 0.18 cm (Meskan) to 0.24 cm (Halaba). A thicker RCD is often associated with better sturdiness and field survival. The number of leaves varies more noticeably, from 12.3 (Durame zuria) to 18.2 (Damote gale).

	Morphological growth(cm)			Biomass of seedling(gm)			
Provenance	Height	Root collar diameter	Leaf number	Root fresh weight	Shoot fresh weight	Root dry weight	Shoot dry weight
Debrebihan	16.1	0.22	15.7	2.14	1.51	0.499	0.53
Durame zuria	15.79	0.22	12.3	1.96	1.55	0.488	0.54
Halaba	17.01	0.24	14.6	2.42	1.9	0.618	0.62
Meskan	16.58	0.18	13.1	1.69	1.29	0.408	0.47
Damote gale	17.23	0.23	18.2	2.59	1.68	0.581	0.54
CV	31.5	28.6	31.65	94.9	46.79	84.76	45.3
MSD	NS	NS	NS	NS	NS	NS	NS

Table 6: Means of Combined Analysis of Morphological Growth and Biomass of Different Provenance of Juniperus Procera Hochst. Ex endl. Seedling at nursery level

Means value with different letters are significantly different (p≤0.05).Whereas; NS=non significance's; MSD=minimum significance difference t.

Biomass measurements show greater numerical variation than morphological measurements, especially in root systems. Damote gale has the highest root fresh weight (2.59g), while Halaba has the highest shoot fresh weight (1.9g). Meskan has the lowest values for both. Dry weight eliminates water content, showing the actual mass of plant tissue. Halaba has the highest root (0.618g) and shoot (0.62g) dry weight. Meskan consistently shows the lowest values.

Juniperus procera faces significant threats across its range, including poor regeneration. Provenance trials are a critical tool for selecting appropriate genetic material for conservation and restoration programs. Research on J. procera in Ethiopia has highlighted its ecological importance and threatened status. Studies have called for "conservation strategies that include establishing provenance trials to identify suitable seed sources" for assisted regeneration [27].

The present work directly answers this call by providing the essential first step: identifying multiple provenances that can be effectively grown in a nursery for future field testing. Furthermore, molecular studies have confirmed moderate genetic differentiation among Ethiopian populations which makes the lack of phenotypic differences in this study even more interesting, suggesting the nursery environment is not selective for these genetic differences [28].

Generally, the high Coefficient of Variation (CV) and non-significant (NS) MSD for Olea Africana, Podocarpus falcatus and Juniperus procera indicate no statistically superior provenance at the nursery stage. Discussion with Literature: This is a common outcome in early-stage provenance trials. The uniform and optimal conditions of a nursery (e.g., ample water, nutrients, weeding) often mask genetic differences between populations by allowing the full expression of phenotypic plasticity within each population. This results in high within-group variation that overshadows between-group differences. A study on Pinus patula in Ethiopia found that, provenance differences were not pronounced at the nursery stage due to the uniform nursery environment minimizing selective pressures Similarly, a review of tropical trees suggests that nursery growth is often a poor predictor of field performance because it does not test traits critical for survival, like drought tolerance [29,30].

Despite the lack of statistical significance, numerical trends exist (e.g., Halaba and Damote Gale showing higher mean biomass). These trends are ecologically interesting and may hint at underlying genetic adaptation. Provenances from more favorable environments (e.g., higher rainfall, deeper soils) might be genetically predisposed to allocate more resources to growth, a pattern that can be visible even in a benign nursery. The concept of local adaptation is a cornerstone of forest genetics, which means provenances often perform best in environments similar to their origin.

For example, a provenance trial of Acacia Senegal in Sudan found that certain populations were inherently faster growing; a trait visible across sites [31].

Numerical trends of this work suggest similar inherent potentials that warrant further investigation under field conditions.

Cordia Africana The dry biomass of shoots (SDW) and roots (RDW) for seedlings of Cordia Africana from five different provenances measured over two consecutive years in Meskan wereda.

Shoot Dry Weight (SDW):

In first year there were clear, significant differences. Wondo Genet had the highest shoot biomass (19.65g), significantly outperforming Halaba, Gurage (Meskan), and Arbaminch Zuria. Hawassa Zuria (13.05g) was statistically similar to Wondo Genet but also similar to the lower-performing groups. Halaba, Gurage, and Arbaminch Zuria formed the lowest-performing group, with no significant difference between them.

Similarly in second year Wondo Genet again had the highest biomass (37.16g) and was statistically superior to all other provenances. Hawassa Zuria (24.24g) was in a distinct second place. Halaba, Gurage, and Arbaminch Zuria formed the lowest group, with Halaba, showing the poorest growth (0.38g).

Root Dry Weight (RDW):

In first year Hawassa Zuria had the highest root biomass (5.9g), which was significantly greater than Halaba and Arbaminch Zuria. The other provenances (Wondo Genet, Gurage) were in an intermediate group, not statistically different from the highest or lowest.

While, in the second year Gurage (Meskan) and Wondo Genet had the highest root biomass, though they were only significantly different from Hawassa Zuria and Arbaminch Zuria. Halaba was in an intermediate statistical group.

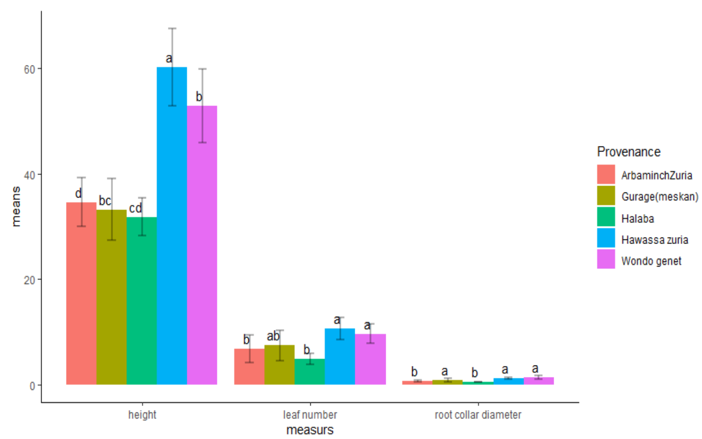

Figure 4: Growth performance of Cordia Africana Seedlings at Nursery

Superior Performance of a Non-Local Provenance

The Wondo Genet provenance produced the highest shoot dry weight (SDW) in both Year I (19.65g) and Year II (37.16g), significantly outperforming the local Meskan provenance and others. This finding challenges the simple "local is best" paradigm and is consistent with a growing body of evidence that certain non-local provenances can outperform local ones, especially in degraded or specific environments. This phenomenon is often attributed to genetic gain from selecting pre-adapted genotypes. A similar result was found in a provenance/progeny test of Cordia africana in Ethiopia, where the Wondo Genet source again showed promising growth, indicating its genetic potential for wider planting This suggests that the favorable traits of the Wondo Genet population are reproducible across sites [6]. Studies on other species support this. For example, research on Faidherbia albida in Nigeria found that provenances from certain zones consistently performed better across different test sites, leading to recommendations for assisted migration [32]. The superior growth of Wondo Genet in this study suggests it may possess alleles better suited to the conditions in Meskan than the local population itself.

Change in Performance and Variability Between Years

The Coefficient of Variation (CV) was extremely high in Year I (over 116%) but dropped to moderate levels in Year II (around 35%). The statistical separation between provenances became much sharper in the second year. This pattern is classic in forestry trials. High initial CV often reflects seedling establishment stress (e.g., drought, herbivory, planting shock), which affects individuals randomly and masks genetic differences. As seedlings stabilize, their inherent genetic growth potential is more fully expressed. This aligns with the principle that long-term assessments are crucial for valid provenance selection. A review of tropical tree trials emphasized that "rankings of provenances based on early results are often unstable," and reliable conclusions require data from beyond the establishment phase Your study's Year II data is therefore far more reliable for making recommendations than Year I data [30].

Implications For Biomass Production and Carbon Sequestration

Provenance selection is increasingly recognized as a tool for enhancing carbon sequestration in afforestation projects. The significant difference in dry biomass (both shoot and root) directly translates to varying carbon storage capacities among provenances. Using Wondo Genet could sequester substantially more carbon per tree because using genetically superior material accelerates biomass accumulation. Research on Acacia senegal showed that provenances with higher growth rates directly correlated with higher biomass and gum yields, highlighting the link between genetics, productivity, and ecosystem services (E. A. Y. Raddad & Luukkanen, 2006) [33]. Similarly, a study on Pinus patula found that the best-performing provenances fixed significantly more carbon than poorer-performing ones [29]. Your results confirm that selecting the right provenance of Cordia africana is a direct strategy for maximizing carbon sequestration in landscape restoration.

Poor Performance of the Local Provenance

The local Gurage (Meskan) provenance was one of the poorest performers in terms of shoot growth, despite being planted in its home environment. Thise low performance many be as result of small population size: The local provenance might be derived from a small, fragmented population suffering from inbreeding depression, reducing its fitness and growth vigor; site degradation: The planting site's conditions (e.g., soil quality, water availability) may be more degraded than the original habitat of the local provenance, giving an advantage to provenances from harsher environments; genetic drift: In small, isolated populations, genetic drift can cause the loss of advantageous alleles, leading to reduced performance compared to larger, more genetically diverse populations like Wondo Genet. Studies on Prunus africana have shown that fragmented populations often exhibit reduced genetic diversity and lower seedling viability This underscores that "local" seed sources are not always genetically robust, especially for threatened species [34].

	dry biomass of shoot and root (gm)			
	year I		year II	
Provenance	SDW	RDW	SDW	RDW
Wondo genet	19.65a	3.9ab	37.16a	0.72ab
Hawassa zuria (amora gedel)	13.05ab	5.9a	24.24b	0.25c
Halaba	2.61b	0.8b	0.38c	0.49abc
Gurage(meskan)	5.59b	2.1ab	9.89c	0.74a
Arbaminch Zuria	5.35b	1.2b	8.06c	0.38bc
CV	116.3	121.6	34	36.4
MSD	13.68	4.28	10.6	0.35

Table 7: Above and Below Ground Dry Biomass of Different Provenance of Cordia Africana Seedling in Meskan Wereda, Gurage Zone

Means value with different letters are significantly different ($p \leq 0.05$).Whereas; SDW= stem dry weight, RDW= root dry weight, NS=non significance's; MSD=minimum significance difference.

The biomass of Cordia Africana shows significant difference among the provenance in both years ($p>0.05$). According to table 7 Wondo genet (19.65gm) provenance had show significantly higher than Halaba, Meskan and Arbaminch provenances shoot dry weight (SDW) and Hawassa provenance (5.9gm) show significantly higher on root dry weight (RDW) than Halaba and Arbaminch (0.8gm & 1.16gm) respectively in first year. In second year shoot dry weight (SDW) wondo genet (37.16gm) have significant difference from Halaba, Meskan and Arbaminch zuria and in root dry weight (RDW) Maskan (0.74gm) are significantly higher than Hawassa zuria and Arbaminch.

Accacia Abysinica

Except root collar diameter, other measured growth parameters of Accacia abysinica showed significant difference among provenance in the first year and only height in the second year. The biomasses of seedling have a significant difference in first year and no significance difference in the second year. Arbaminch-zuria provenance was significantly higher by height and branch number in first year and by height in second year. According to biomass, similar provenance has also highly significant over others. Meskan provenance has no significant difference with Arbaminch and Aleta Wondo by height in both years. In most parameter Aleta wondo has significantly lower from others. The seed collected from Hawassa (Tabore) significantly lower by height in both years (Table 7).

	Seedling growth performance							
	year I				year II			
Provenance	Germination (%)	Height (cm)	RCD (cm)	Branch number	Germination (%)	Height (cm)	RCD (cm)	Branch number
Arbaminch zuria Meskan	75 100	48.6a 42.8ab	0.396 0.38	9a 8.4ab	75 70	42a 38a	0.29 0.27	12 11
Wondo genet	60	32.8abc	0.35	7.8ab	74	33ab	0.26	9.6
Dembi	93.75	29abc	0.31	7.4ab	72	30.4ab	0.256	12
Hawassa (Tabore)	15	20.2bc	0.25	6.4ab	71	22.8b	0.198	9.1
Aleta wondo	25	15.6c	0.24	6.2b	69	21.9b	0.197	8.6
CV		42.35	31.9	19		33.37	45.8	30.66
MSD		26.09	NS	2.78		13.82	NS	NS

Table 8: Seedling Growth Performance of Different Provenance of Acacia Abyssinica in Meskan Wereda

Note: Means value with different letters are significantly different (p≤0.05).Whereas; Germ=Germination; H=Height; RCD= Root Collar Diamter; BN= Branch number

Regarding growth and survival, there are relatively few published reports on genetic variation in native African hardwoods. Examples include studies on Acacia nilotica Acacia Senegal Cordia africana Lam [33,35,36]. Faidherbia albida [29,37,38]. Higher seedling height and RCD are important indicators of better potential survival rates, growth performance, and adaptation capacity in field conditions. A plant with a larger number of leaves may have a higher photosynthetic rate, leading to increased growth, a result corroborated by a study on Faidherbia albida in Kenya [39].A study in Burkina Faso found that the growth rate and germination speed of four native species were affected by provenance differences. Another study in Ethiopia on Cordia africana reported that at 290 days, the mean height and RCD across 12 provenances were 19.3 cm and 5.7 mm, respectively, with individual seedling height ranging from 3.5 to 49.5 cm and RCD from 1 to 12 mm [6]. Research in Great Britain on Pinus tecunumanii and Pinus patula demonstrated that provenance affects height growth, leading to models that account for climatic dissimilarity [40]. Furthermore, FAO and the Danida Forest Seed Centre have analyzed numerous trials to identify superior provenances from Africa and other continents for reforestation in arid and semi-arid zones [41,42]. The RCD of Acacia abyssinica and Acacia seyal in the present study was significantly affected by provenance. This agrees with research in Noiweite, which found a high provenance effect on RCD, ranging from 0.79 cm to 1.3 cm [39]. Similarly, the RCD of Faidherbia albida was affected by provenance, with the wet-provenance Geres showing a higher RCD than the dry provenances Pesqueira and Aljezur [43].

	Dry weight of shoot and root in gm			
	year I		year II	
provenances	SDW	RDW	SDW	RDW
Arbaminch zuria	3.79a	2.09a	1.739	1.348
Gurage	2.89ab	1.68ab	1.44	1.236
Wondo genet	2.35ab	1.35ab	1.43	1.18
Dembi	0.71c	1.5ab	0.78	1.193
Hawassa (Tabore)	1.23bc	0.74b	1.12	0.928
Aleta wondo	2.45ab	0.67b	1.42	1.03
CV	35.4	41.2	79.4	87.9
MSD	1.55	1.03	NS	NS

Table 9: Above and Below Ground Biomass of Different Provenance of Acacia Abyssinica Seedling in Meskan Wereda

Means value with different letters are significantly different (p≤0.05).Whereas; SFR= stem fresh weight, RFW= root fresh weight, SDW= stem dry weight, RDW= root dry weight.

Above and below ground dry biomass of Acacia abyssinica seedlings measured and analyzed for two consecutive years. Based on the data both shoot and root dry mass of seedlings were shows significant difference in the first year. Arbaminch zuria provenance detect significantly higher than Dembi and Hawassa in shoot dry biomass and Hawassa in root dry weight (RDW) ($p<0.05$). On the other hand there were no any significant difference on root and shoot dry biomass of Acacia abyssinica in second year. However, arbaminch zuria have mean advantage of shoot and root dry biomass over other provenance.

Faidherbia Albida

Germination percent of the seedlings show that there was high germination percent having 95%-100% in the first year and lower germination in the second year 69% to 75%. In the first year all growth parameter and in the second only root collar diameter did not showed significances among the provenances. Height and branch number of Faidherbia albida have shows significance difference among the provenance in the second year ($p<0.05$). Dembi provenance significantly higher than Meskan by seedling height and all other by branch numbers.

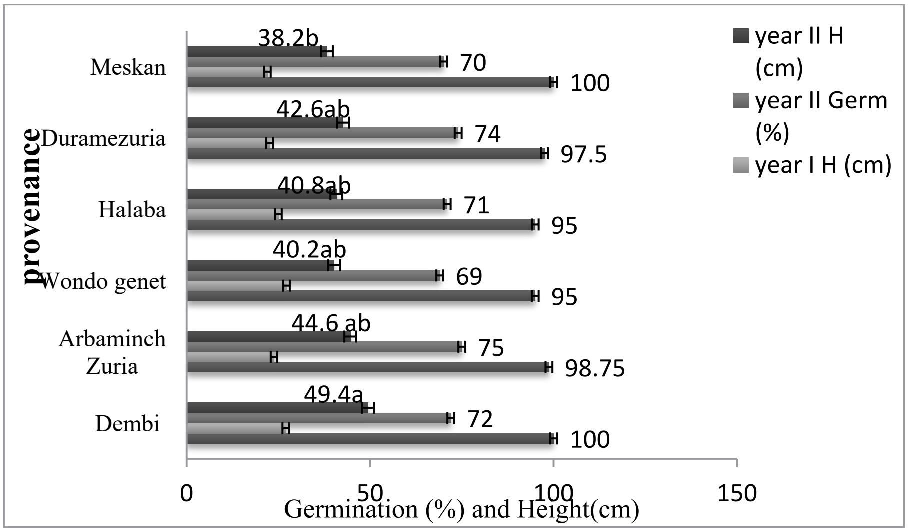

Figure 3: Germination and Height of Different Provenance of Faidherbia Albida Seedling in Meskan Wereda, Gurage Zone; Note: H=Height, Germ= Germination

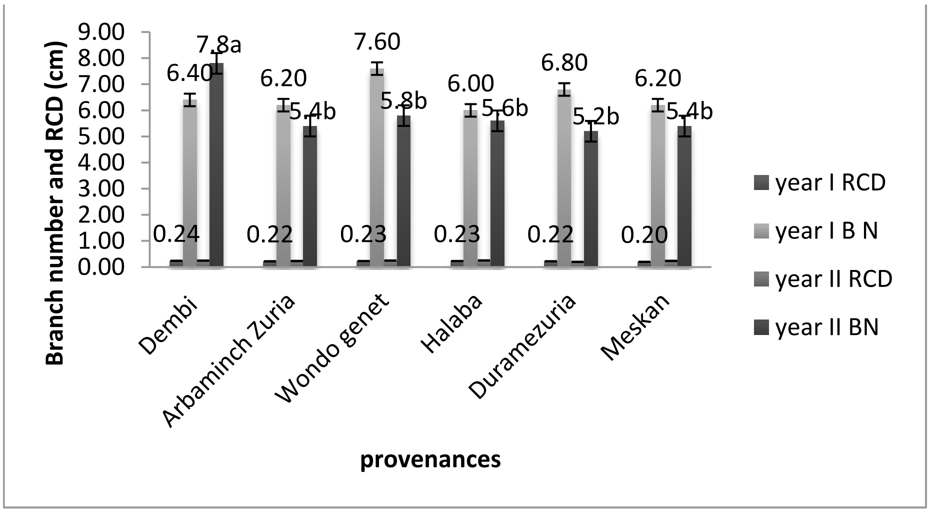

Figure 4: Branch Number and Root Collar Diameter of Faidherbia Albida Seedling Under Different Provenance at Nursery Level; Note: RCD= Root Collar Diameter, BN=Branch Number.

The biomass of seedlings were showed significant difference among provenance in both years ($p<0.05$). Halaba provenance in first year significantly higher in the biomass of seedling having 3.43 gm and 2.33gm than Durame zuria (0.75gm & 0.45gm) and Meskan (0.36gm &0.29gm) by SDW and RDW respectively. In Second year Duramea Zuria (2.66gm) and Arbaminch zuria (1.86gm) records significantly higher over Halaba (1.28gm and 0.87gm) on SDW and RDW respectively.

Generally in second year most of provenance have no significant difference among them. That means sinficant difference is declar only between Durame-zuria and halaba for Shoot dry weight and b/n Arbaminch zuria and Halaba in root dry weight.

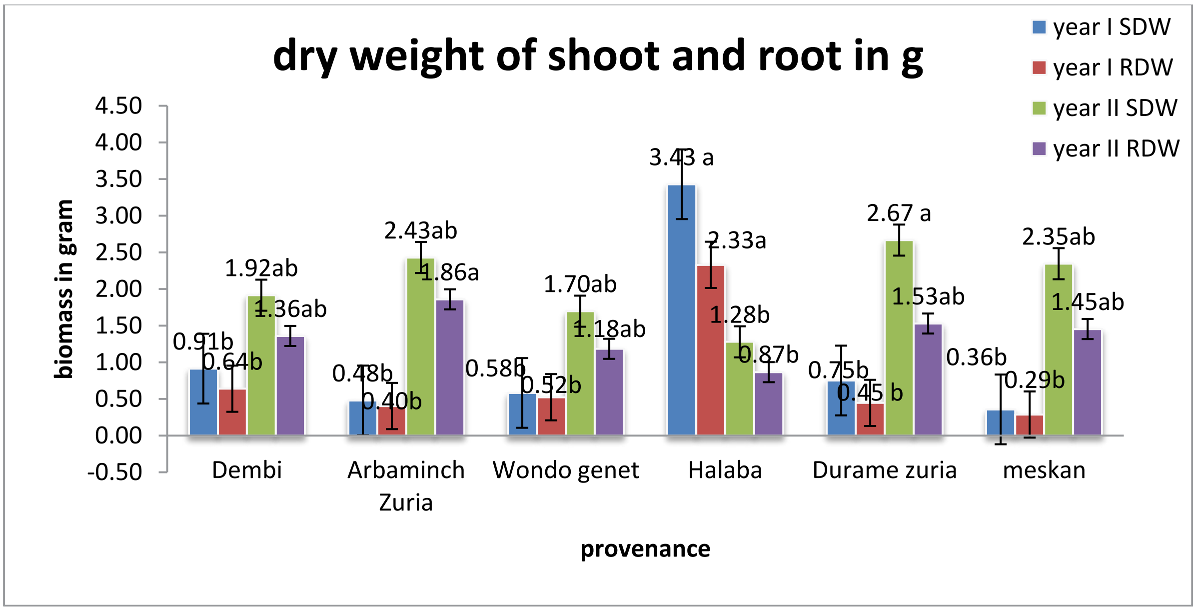

Figure 5: Effect of Provenance Above and Below Ground Dry Biomass of Faidherbia Albida Note: SDW=Shoot Dry Weight; RDW=Root Dry Weight

Growth Performance

Research on patterns of natural variation in commercially and adaptively important traits is essential for developing tree improvement programs and systematic genetic studies of native hardwood species, both globally and in Africa. Faidherbia albida showed no significant differences in growth characteristics among their provenances. Understanding this variation is critically important for conservation strategies, particularly for over-exploited and highly threatened species such as Prosopis africana and Prunus africana, which face local or even regional extinction [25,26].

The present study aligns with research conducted in Nairobi, Kenya, which found no significant difference in height, root collar diameter (RCD), and leaf number per plant between two Ethiopian provenances (Lake Hawassa and Lake Koka). However, these Ethiopian provenances did differ significantly from provenances from other African countries [39].

For instance, a study on 12 provenances of Cordia africana in Addis Ababa, Ethiopia, reported germination percentages ranging from 16% for the Guraferda and Sekoru provenances to 69% for the Hirna provenance [6]. Similarly, research at the Holeta Research Center found significant differences in mean germination percentage, germination rate, and germination vigor among seed provenances at $p<0.05$ [44]. Correspondingly, Charity Fredrick identified a significant provenance effect on germination percentage, with an overall mean of 70.2% varying from 32.7% (Taveta) to 93.3% (Hawassa) [39]. Studies on Mediterranean maritime pines (Pinus pinaster Aiton) also indicate low and variable germination percentages among provenances. In contrast, a study in Addis Ababa on Tamarindus indica L. found germination was unaffected by agro-ecology, with rates from 97% to 100% and no significant differences among provenances.

Regarding growth and survival, there are relatively few published reports on genetic variation in native African hardwoods. Examples include studies on Acacia nilotica Acacia Senegal Cordia africana Lam. Faidherbia albida [29,33,35-38]. Higher seedling height and RCD are important indicators of better potential survival rates, growth performance, and adaptation capacity in field conditions. A plant with a larger number of leaves may have a higher photosynthetic rate, leading to increased growth a result corroborated by a study on Faidherbia albida in Kenya [39]. A study in Burkina Faso found that the growth rate and germination speed of four native species were affected by provenance differences. Another study in Ethiopia on Cordia africana reported that at 290 days, the mean height and RCD across 12 provenances were 19.3 cm and 5.7 mm, respectively, with individual seedling height ranging from 3.5 to 49.5 cm and RCD from 1 to 12 mm [6]. Research in Great Britain on Pinus tecunumanii and Pinus patula demonstrated that provenance affects height growth, leading to models that account for climatic dissimilarity [40]. Furthermore, FAO and the Danida Forest Seed Centre have analyzed numerous trials to identify superior provenances from Africa and other continents for reforestation in arid and semi-arid zones [41,42]. The RCD of Acacia abyssinica and Acacia seyal in the present study was significantly affected by provenance. This agrees with research in Noiweite, which found a high provenance effect on RCD, ranging from 0.79 cm to 1.3 cm [39]. Similarly, the RCD of Faidherbia albida was affected by provenance, with the wet-provenance Geres showing a higher RCD than the dry provenances Pesqueira and Aljezur [43].

Biomass of Seedlings
In the present study, the fresh and dry weights of shoot and root biomass for the selected indigenous trees were highly affected by provenance, except for Faidherbia albida, Podocarpus falcatus, and Juniperus procera, which showed no significant differences among their provenances for any parameters. This aligns with research in Kenya involving sixteen provenances from different African countries, which found significant variation in early growth among countries but no significant differences within the provenances from Ethiopia and South Africa in terms of biomass [45]. A similar result was reported in a study on Khaya senegalensis A. Juss in Burkina Faso using four provenances, which found differences in leaf, stem (e.g., Bopiel=0.27g, Koyenga=0.26g), and total biomass (Koyenga=12.1g) [46]. Research on Tamarindus indica also found that shoot and root fresh and dry weights were highly affected by provenance [20]. Conversely, as noted, Faidherbia albida, Podocarpus falcatus, and Juniperus procera showed no significant provenance differences. A study on Moringa stenopetala by Medjella reported that above-ground and below-ground biomass were highly affected by provenance [47]. Similar work in Tanzania shows that there were significance difference b/n provenances by their biomass of Moringa oliefera [48]. Moreover, research in Sierra Leone revealed significant differences ($p < 0.05$) in the biomass of Gmelina arborea Roxb. For example, at two months after planting, seeds from the East (4g) and South (3.87g) had significantly higher shoot dry weight than those from the West (2.37g). This pattern persisted at three months, with seeds from the East having the highest dry weight (7.8g). Root dry weight also differed significantly, with seeds from the South (2.40g) and East (2.33g) outperforming those from the West (1.4g) [49]. Additionally, a study in the Aride Chaco of Argentina on two cultivars of Moringa oleifera (the Indian cultivar PKM-1 and an African accession from Tanzania) found significant differences in production metrics. The PKM-1 cultivar generally had higher yields for oil, pods, and seeds per tree. One PKM-1 individual (E4-9) had significantly ($P < 0.05$) higher production than all others, extrapolating to an oil yield of approximately 580 kg ha^{-1}. Seed weight was also significantly greater in 2003 than in 2004 [50].

Conclusion And Recommendation
Conclusion
From the present study, higher inter-population variability was observed in most species in the study area and some species have no any significance difference. Generally, based on this we concluded that the performance of seedling in nursery site highly affected by the source of seed except Podocarpus falcatus and Junipores procera. In spite of this Wondo genet, Arbaminch Zuria and Halaba, Duramezuria, and Wolayta are seed source for Cordia africana Lam., Acacia abyssinica, Podocarpus falcatus, Faidherbia albida and Olea europaea respectively.

Recommendation
Based on their better performance Guragae and Duramea-zuria, Guragae and Dembi and Guragae and Hawassa were recommended for Olia African, Acaccia abyssinica and Cordia Africana respectively. This work is equally important for other area with similar and different tree species by considering outfield planting in addition to nursery level.

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