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Adaptation and Growth Performance Evaluation of Agroforestry Tree Species in Babille District, East Hararghe Zone, Oromia, Ethiopia

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Abstract: Study was under taken on five agroforestry tree species: *Moringa oliefera, Gravilea robusta, Azadarichta indica, Leuceana leucocephala and Cordia africana* at Fedis Agricultural Research Center to evaluate their adaptability and growth performance. The experiment was laid out in RCBD with three replications. The growth parameters; diameter, plant height and survival rate were measured and recorded at interval of three months. Results revealed that there were selected agroforestry tree species had no problem on survival and adaptability at study area except some growth variation and the outcome had a significant value at ($p<0.05$) between treatment's parameters. The variations among tree species in height growth, root collar diameter development, diameter at breast height and survival rate were highly significant ($p<0.05$) after four years of age. This could be due to environmental factor and/or genetic potential of the species, which generally govern the growth of a given species. Among the species tasted, *Azadarichta indica* showed the highest performance followed by *Leuceana leucocephala, Moringa oliefera* in terms of height growth, root collar diameter and diameter at breast height. *Moringa oliefera, Azadarichta indica*, and *Leuceana leucocephala* showed the highest survival rate with 84%, 83.67% and 82.33% respectively. On the other hand, *Gravilea robusta* and *Cordia africana* showed lowest performance. Thus, the long dry season, which extended from eight to ten months in the study area, clearly explains the poor survival and growth response in some of the species. Hence it can be inferred that the conditions of Babille matched with the environmental requirement of *Moringa oliefera*, *Azadarichta indica*, and *Leuceana leucocephala*. Therefore, the species offers much promise for future use in agroforestry practices in the area. Generally, the study under Babille conditions and related agro ecology, we advocate these adapted species for further properly allocate species into the site that grow and adapt agro forestry practices, forest plantations and economic and livelihood benefits for different stakeholders.

Keywords: Babille District, Agroforestry, Diameter at Breast Height, Height Growth, Survival Rate

1. Introduction

In the context of climate change, increasing population, deforestation, reduced landholdings and declining soil productivity, Ever Green Agriculture is emerging as an affordable and accessible science-based solution that will help smallholders protect and enrich soils, increase food production, adapt to climate change and reduce greenhouse gas emissions [7]. The challenge of spreading the knowledge and uptake of evergreen agriculture and other "climate smart" agriculture practices is being taken on as a priority by regional governance bodies in Africa [7]. Deforestation causes loss of biodiversity and environmental degradation. Population pressure is the main cause for the depletion of forest resources which in turn poses many social and economic problems in Ethiopia. One way of reducing deforestation problem is through agroforestry the integration of trees with crops on farmlands has a great potential for enhancing land productivity while providing essential services to people and the environment and shielding forests from further deforestation and land degradation problems in the Eastern parts of Ethiopia, particularly East Hararghe high

land. Agroforestry can also provide food, fuelwood and fodder for the farm family on a sustained basis [4]. These agroforestry practices could be intensified by using fast growing multipurpose tree species (MPTS) to satisfy the demands of the growing population. Thus, before introducing any species to a given agro ecology, there is a need for a well conducted field trial for matching of the species/provenance to a particular site [10].

However, trees/shrubs species has its own biotic and abiotic factors in which it performs to its maximum potential. It has specific edaphic and climatic requirements [1]. Some possible research needs on tree species selection and screening including seed tests, establishment, and management. Deciding what species to plant in any agroforestry system to meet the intended objectives require a well- conducted field trial to match a species to a particular site. However information is scarce at Babille district to recommend promising multipurpose tree and shrubs species for use in agroforestry. Therefore this trail was designed to evaluate the adaptation and growth performance of five agro forestry species to Erer conditions and sites of similar agro ecology.

2. Materials and Method

2.1. Description of the Study Area

The experiment was conducted at Babille district, Erer research station. Babille district is found in eastern Hararghe zone of Oromia Regional State, Ethiopia. It is located 31km away from the Harar town and about 557 km east from Addis Ababa. The altitude is 1200 - 1300 a. s. l. Rainfall pattern in the area is bi-modal; kiremt rainy season (June, January, August and September) and belg rainy season (February, March, April and May). Average annual rainfall amount is 1145 mm. High amount of rainfall is received in the May (1395mm) and April (l188mm) during the belg rainy season whereas high amount of rainfall is received in the month of July (1180 mm) and August (1462 mm) in the kiremt rainy season. Mean annual temperature is 24°C (Fedis agricultural research center, meteorological station 2015-2018 intervals) Figure 1. Soil of study area is dominantly clay loam in texture. They are generally characterized by low available phosphorous with a pH ranging from 7.94 to 8 in surface soils is in the optimum range for growth (Dawit et al 1987). The vegetation cover of the area is woodland and open wooded grassland types.

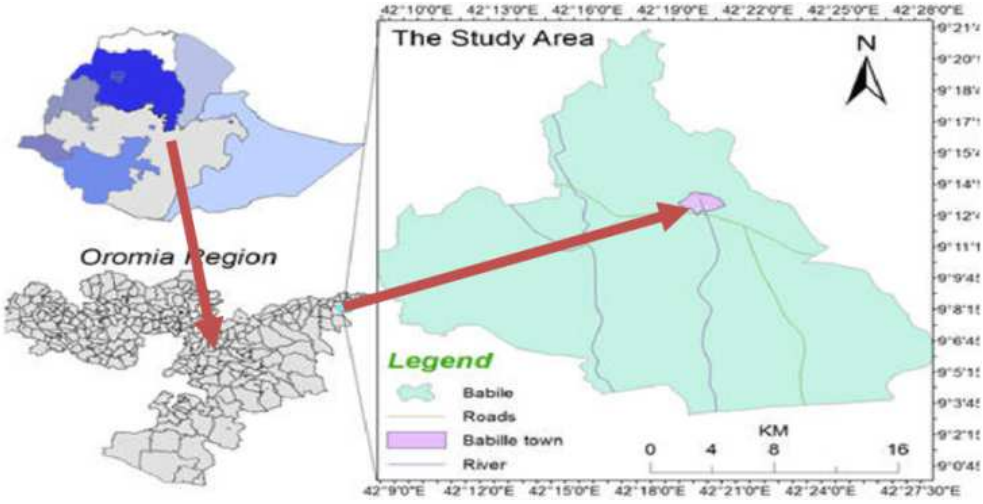

Figure 1. *Map of the study area (Babille district).*

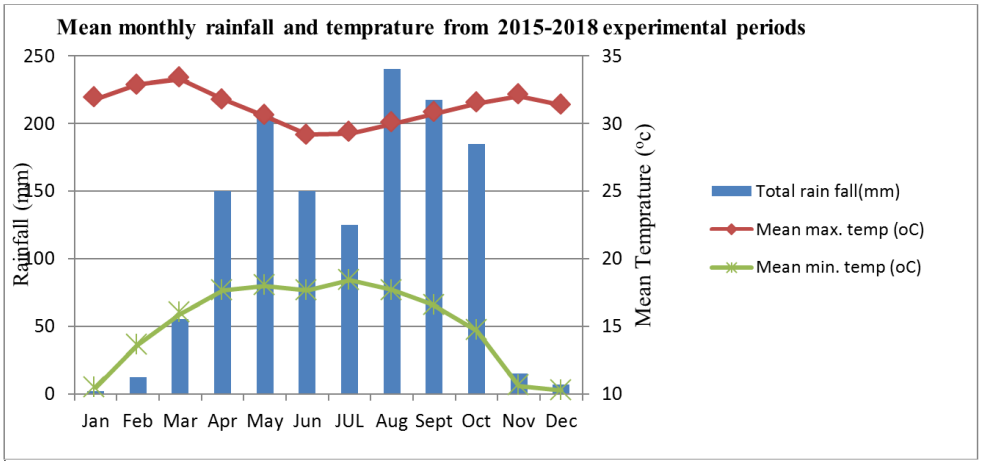

Figure 2. *Mean monthly rainfall and temperature during experimental period of Erer, based on 2015-2018 meteorological data at Fadis Agricultural Research Center.*

2.2. Seeds Source

Seeds of five multipurpose tree species were obtained from Central Ethiopian Environment and forestry research Center

Table 1. *Details of tree species used in the adaptation trial.*

Tree species	Family name	Seeds source
Cordia africana	Boraginaceae	CEFRC
Leuceana leucocephala	Leguminosae	CEFRC
Moringa oliefera	Moringaceae	CEFRC
Azadarichta indica	Meliaceae	CEFRC
Gravilea robusta	Proteaceae	CEFRC

CEEFRC: Central Ethiopian Environment and Forestry Research Center.

2.3. Treatments and Experimental Design

Seeds of the tree species (*Cordia africana, Gravillea robusta, Azadarichta indica, Leuceana leucocephala and Moringa oliefera*) that used for the experiment. Seedlings were raised directly into polythene tubes at kurfa kasa nursery site, Babille district with the recommendation of nursery activities. Seedlings with the same age of these species were planted in the field in June 2015 G. C using a randomized complete block design with three blocks. Each block had five experimental plots, representing five species of sixteen seedlings each. The spacing between blocks and plots was 2.5m, plot size was 6m x 6m, and the space between trees in a plot was 2m. In each plot, 16 trees were planted, and the four inner seedlings were taken as a sample for data collection. After planting, the site was protected from grazing and human interferences for the duration of the study. Plantation plots were neither irrigated nor fertilized. Survival, height (from ground level to the tip of the plant), diameter at breast height (DBH) and root collar diameter (RCD) were recorded every three months from June 2015 up to June 2018 G. C.

2.4. Data Collection

In order to fit the given objectives, data were collected on four growth and adaptation parameters such as Plant height, root collar diameter, diameter at breast height and survival rate for the three years at interval of three months. Root collar diameter were collected only up to the tree reaches 1.3 m in height whereas plant height and survival rate were up to the end of the period of the activity by interval of three months survival count was made for the whole trees in a plot (sixteen trees per plot), while the trees in the middle (four trees per plot) were taken as sample for height, root collar diameter and diameter at breast height measurement so as to minimize the border effect. Height growth was determined by using measuring tape and root collar diameter and diameter at breast height by digital caliper.

2.5. Data Analysis

Analysis of variance was computed using Genstat software package to test the significant difference among tree species. Least significant different (LSD) test was employed to separate statistically different means using the software package at 0.05 level of probability.

3. Resuts and Discussion

3.1. Survival Rate

Among tree species, differences were highly significant ($p<0.05$) for survival as well (Table 3). After three years of establishment, three species: *Moringa oliefera, Azadarichta indica and Leuceana leucocephala* demonstrated the highest survival rate with values of 84%, 83.67% and 82.33% respectively. Hence, it can be inferred that the condition of Babille matched well with the environment requirement of these species. Yitebitu Moges (2004) also reported that *Moringa species* are quite drought resistant species which is similar to the observation of the present study. [14]This can be attributed to the moisture stress experienced, which as Kozlowski et al. (1991) [9] also stated can affect the growth, survival and distribution of forest trees. *Gravilea robusta* (35.33%) and *Cordia africana* (23%) on the other hand, showed lowest survival rate. The long dry season, which extended from seven to nine months in the study area, clearly explains the low survival of the *Gravilea robusta and Cordia africana* seedlings during this season. On the other hand, *Azadarichta indica, Moringa oliefera*, and *Leuceana leucocephala* were found to be highly resistance to moister stress in the study area. In the present study, the mortality was subjectively attributable to abiotic factors such as drought and moisture stress during the initial growth from October to June, although biotic problems like termites were also experienced during the assessment period.. Thus, the environmental condition of Erer may not suitable for *Gravillea robusta* and *Cordia africana*. Soil and below ground competition are also other factors that influence the growth and survival rate [6]. highly significant variations was among species in survival rate ($p<0.05$) was recorded at all three years of age after transplanting. The survival trend for all tree species (*Moringa oliefera*, *Azadarichta indica*, *Leuceana leucocephala*, *Cordia africana*, *Gravillea*) showed declining trend their survival rate for all the assessment period (Table 2).

Table 2. *Mean survival rate (%) of agroforestry tree species planted in Erer research station, Babille district over three years.*

Tree species	Stages age of seedling after transplanting		
	Year I	Year II	Year III
Gravilea robusta	42.67^{c}	39^{b}	35.33^{b}
Azadarichta indica	89^{ab}	85.33^{a}	83.67^{a}
Leuceana leucocephala	89.67^{a}	83.67^{a}	82.33^{a}
Moringa oliefera	86.33^{b}	84.67^{a}	84^{a}
Cordia africana	44.67^{c}	26.67^{c}	23^{c}
LSD (0.05)	3.046	3.866	4.009
CV (%)	2.3	3.2	3.5
Mean	70.47	63.87	61.67
P value	<.001	<.001	<.001

NB: Means in columns with the same letters are not significantly difference using LSD.

3.2. Height Growth

Analysis of variance revealed that variations in height among species were highly significant ($p<0.05$) after three years of age. Height growth trend (Table 3) shows that *Azadarichta indica* (3.317m) and *Leuceana leucocephala* (3.3m) were the tallest tree, followed by *Moringa oliefera* (2.917m) but *Cordia africana* show the shortest tree (1.8m). Result on growth performance also showed that *Azadarichta indica*, *Leuceana leucocephala* and *Moringa oliefera* were higher than the other species. Similarly, Raebild et al. (2003) [11] also stated that apart from indicating productivity, height may also be seen as a measure of the adaptability of trees to the environment as tall trees usually being better adapted to the site than short trees [11]. Moringa species could also play a great importance in the rehabilitation process especially during periods of drought or in areas where nutrient resources are no available. Several similar studies also showed that fast growth of seedling is an important indicator in terms of determining the situation of growth response especially in the first growing period and it is commonly assumed that the early fast growth rates of tropical trees reflect productivity status of the [2].

3.3. Diameter Growth

As depicted in Table 3, there is significant variation among tree species in root collar diameter growth. The highest root collar diameter was recorded for *Azadarichta indica* (4.197cm) followed by *Moringa oliefera* (4.00cm) and *Leuceana leucocephala* (3.85cm) but the lowest root collar diameter was recorded for *Cordia africana* (1.833cm). Growth in diameter at breast height also highly significant ($p<0.05$) for the five tree species. The difference in growth of diameter at breast height (1.3m) above the ground of tree species *Azadarichta indica* (3.2cm), *Moringa oliefera* (2.85cm), *Leuceana leucocephala* (2.6cm) showed highest diameter at breast height within four years data records. On other hand *Gravillea robusta* (1.49cm) and *Cordia Africana* (1.46cm) showed lowest diameter at breast height growth.

Table 3. *The mean of Plant height, survival rate, diameter at breast height and root collar diameter of agroforestry tree species for three years (June 2015 to June 2018).*

Tree species	Survival rate (%)	Plant height (m)	Root collar diameter (cm)	Diameter at breast height (cm)
Gravillea robusta	35.33^{b}	2.55^{c}	2.713^{d}	1.497^{d}
Azadarichta indica	83.67^{a}	3.317^{a}	4.197^{a}	3.2^{a}
Leuceana leucocephala	82.33^{a}	3.3^{a}	3.85^{c}	2.6^{c}
Moringa oliefera	84^{a}	2.917^{b}	4^{b}	2.85^{b}
Cordia Africana	23^{c}	1.8^{d}	1.833^{e}	1.467^{d}
LSD (0.05)	4.009	0.107	0.109	0.108
CV (%)	3.5	2.1	1.7	2.5
Mean	61.67	2.777	3.319	2.323
P value	<.001	<.001	<.001	<.001

CV=Coefficient of Variation LSD= Least Significant Difference.
NB: Means with the same letters are not significantly different using LSD.

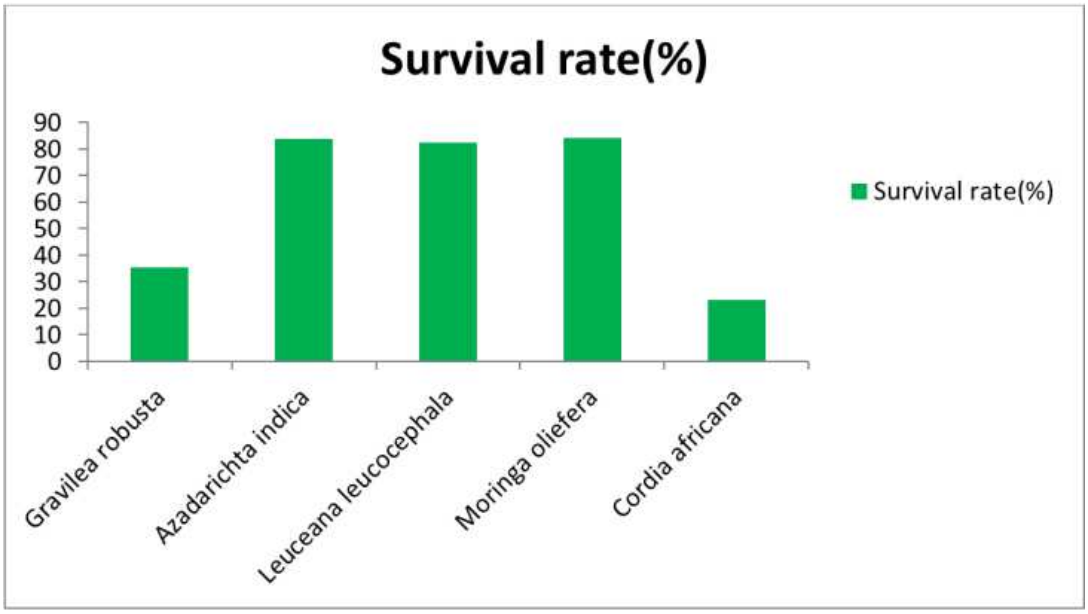

Figure 3. *Means of survival rate (%) of Gravillea robusta, Azadarichta indica, Leuceana leucocephala, Moringa oliefera and Cordia africana through sequential periods from June 2015 to June 2018.*

Figure 4. *Performance of agroforestry tree species at Erer research station, Babille district.*

4. Conclusion and Recommendation

The experiment was conducted for three consecutive years to evaluate adaptation and growth performance of five agro forestry tree species at Fadis Agricultural Research Center, Erer on- station, for three years (2015-2018 G. C). The results indicated that there were significant effect among treatments for plant height, survival rate, root collar diameter and diameter at breast. The result revealed that the survival rate of *Moringa oliefera* was the highest followed by *Azadarichita indica* and *Leuceana leucocepha*la. While *Gravilea robusta* and *Cordia africana* showed poor survival rate. Poor survival rate and growth performance might be explained as response to site the condition and termite problems of the study area. *Azadarichta indica*, *Leuceana leucocephala* and *Moringa oliefera* were the species attained the highest mean heights, while *Gravilea robusta* and *Cordia africana* species had the lowest values. The comparisons between the height and diameter at breast height average of the species showed that Azadarichta indica had the highest mean height followed by *Moringa oliefera* and *Leuceana leucocephala.*

Generally, results on growth performance showed that *Azadarichta indica, Leuceana leucocephala* and *Moringa oliefera* had better performance than *Gravillea robusta* and *Cordia africana*. Therefore planting of these better performing tree species and increase their promotion as agro forestry practices were recommended as importance for soil conservation, shading, forage, fuel wood and in general multifunction purposes in the area. For *Leuceana leucocephala* and *Moringa oliefera*, on farm evaluation of their contribution to soil improvement and crop yield either in inter- cropping or biomass transfer has to be further investigated to make use of their potential in agro forestry practices.

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