International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 9 Issue 2, Mar-Apr 2025 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Adaptation and Growth Performance of Selected Agroforestry Tree Species Under Fedis and Metta District Condition, East Hararghe Zone, Oromia, Ethiopia

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ABSTRACT

A study was conducted to evaluate the adaptation and growth performance of four agroforestry tree species at Fedis and Meta districts, East Hararghe Zone, oromia for four years (June 2018 - June 2022). Four multipurpose tree species (Moringa stenophatala, Acacia albida, Acacia saligna and Casuirina equistifolia) were tested in RCBD design with three replications. Data on growth parameters, plant height, survival rate and diameter were measured and recorded at interval of three months .Results revealed that there were highly significant ($p<0.05$) variations among tree species in survival rate.. Among the species tasted, A. saligna, M. stenophatala, and A. albida, showed the highest performance followed by C. equistifolia in terms survival rate at Fedis condition. While M. stenophatala showed poor survival rate at the Meta condition. Poor survival rate might be attributed to the climate, soil type and agro ecology of the study area. Concerning of plant height, root collar diameter and DBH, A. saligna and C. equistifolia were showed good performance followed by M. stenophatala but A. albida were shoed poor performance at Fedis area. A. saligna and C. equistifolia were showed good performance in height growth, followed by A. albida and M. stenophatala at Meta site. A. saligna, A.albida, and C.equistifolia howed the highest mean survival rate at the study area. Hence it can be inferred that the conditions of Fedis and Meta matched with the environmental requirement of those tree species. On the other hand, species of M. stenophatala showed lowest performance at the Meta area. Accordingly, those tree species which had better performance were recommended for further demonstration in the study area and similar agro ecologies. Therefore; planting of these better performing tree species and promotion as agroforestry practices were recommended for soil conservation, shading, and fuel wood and in general multifunction purposes in the area.

How to cite this paper: Bira Cheneke | Musa Abdella | Robe Elema "Adaptation and Growth Performance of Selected Agroforestry Tree Species Under Fedis and Metta District Condition, East Hararghe Zone, Oromia, Ethiopia" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-9 | Issue-2, April 2025, pp.28-34, URL: www.ijtsrd.com/papers/ijtsrd75126.pdf

IJTSRD75126

KEYWORDS: *Survival rate, Agroforestry, Multipurpose trees, Climate change, Growth*

INTRODUCTION

Eastern Ethiopian high land is well known by vegetation cover and most of the surrounding area is covered by forests comprised of a rich mixture of woody species (Abebaw, 2006). In spite of the importance of forest ecosystem to the livelihoods of the people in the area, the forest is dwindling from time to time due to high exploitation of woody and non-woody products. Rapid deforestation caused by an escalating demand for fuel wood expansion for agriculture has brought an ever-increasing pressure on native woodland species (Mihretu *et al.,* 2004). If no remedial action is taken, this will cause severe impact on agricultural productivity leading to energy poverty and environmental degradation.

Frequent and severe droughts often present a serious threat for millions of lives (Brocker, 2008), which have occurred once in a decade in the 1970s and 1980s. Shortages of animal feed and biomass energy are also such an unsustainable use of natural resources. Currently, biomass energy constitutes 88.7% of all energy consumed in Ethiopia which is mainly derived from the woody biomass resources (forests, woodlands, shrub lands, planted trees, agro

forests). Agro forestry system has much potential for supplying fodder, poles, farm equipment, fuel wood and agricultural improvements (Yadessa et *al.,* 2000). Multipurpose tree and shrubs species (MPTS) play a considerable role in addressing such multifaceted demands in the mixed crop-livestock production system (Alemu *et al*., 2000). They have the ability to fit into the farming system to be used as a source of manure, mulch, soil conservation, forage, fuel wood, farm implements and other like shade and shelter (Berhe *et al*., 2001).

In East Hararghe farmers practice on farm and Homegarden for economic, social and environmental benefits (Yakob *et al.,* 2014). These traditional 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 always a need for a well conducted field trial for matching of the species/provenance to a particular site (Mihretu *et al.,* 2004). The species screening trial that will test the survival and early growth of the species in one to three years. 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. Many species screening experiments have been conducted in different parts of country (Alemu *et al.,* 2000). However information is scarce at Fedis and metta districts, to recommend promising multipurpose tree and shrubs species for use in agroforestry practices (Musa A, and Bira Che., 2020). Hence, there is a need to investigate adaptable and promising selected tree and shrubs species in the area. Therefore, this study was designed to evaluate the adaptation and growth performance of four multipurpose tree species and to identify early best performing exotic and indigenous trees species to Fedis and metta conditions and sites of similar agro ecologies.

Materials and Methods

Description of the Study Area

The experiment has been conducted at Fedis and Metta Districts, East Hararghe zone, oromia. **Fedis district is one of the twenty districts in East Hararghe zone, which is located at 550 km east of Addis Ababa and about** 24 km from Harar town in the southern direction. **The** geographical location of the **district** is **9^0 14' 0" N and 42^0 19' 62" E**.

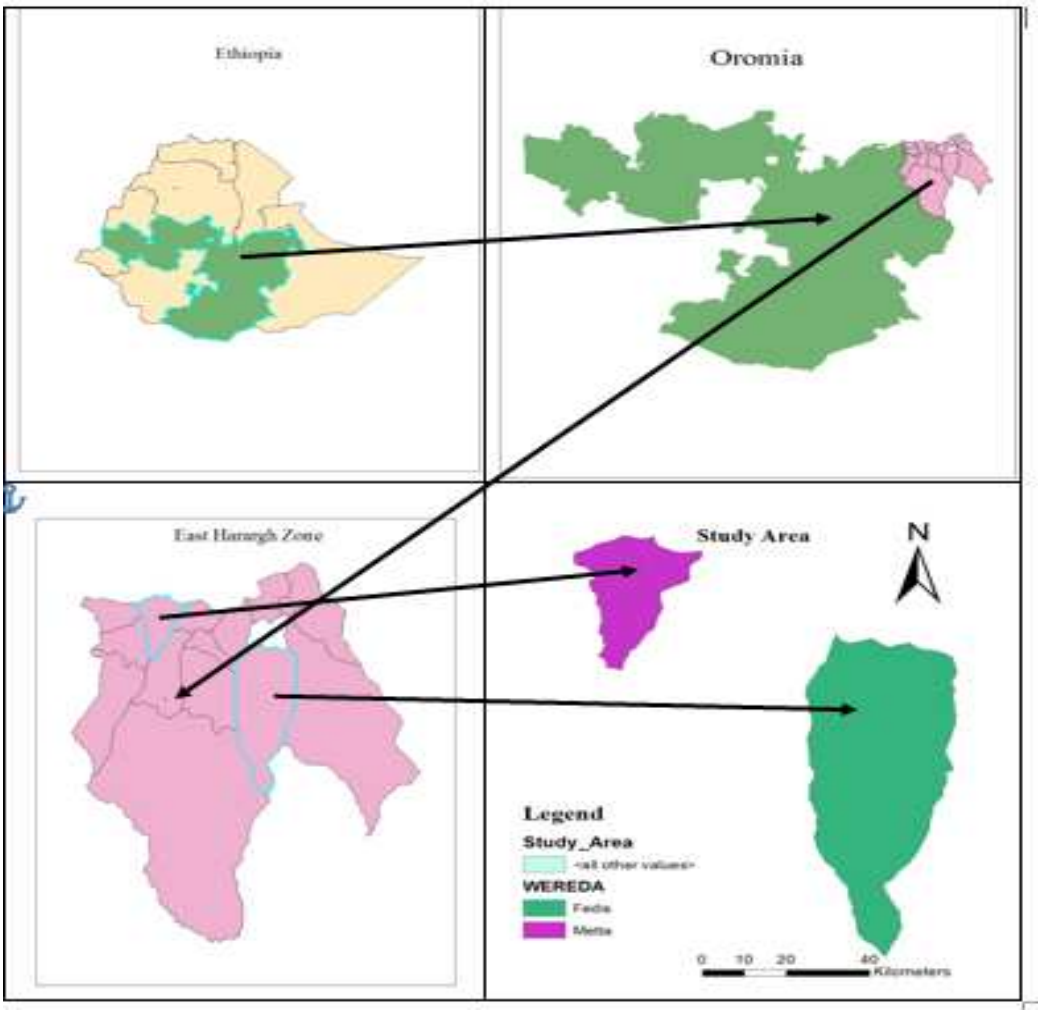

Figure 1: Map of study areas

The altitude of the area ranges between **1200 to 2100** m.a.s.l. The district has mean annual rainfall of 650 to 850mm and the average temperature is 25 ^{0}C to 30 ^{0}C**.** According to DOA 2017/18 report, the district has two basic agro-climatic conditions, namely midland (39%), and lowland (61%). The district consists of 19 rural PAs and two rural towns and has total human population is **149,664 of which 76,182**(50.9%) **are males and 73,482**(49.09%) **are females (CSA, 2007). The average family size is estimated to be 6 and 4 per household in rural and urban areas respectively.** The average landholding per farm family is 0.73 hectare and has a total area of 110502 hectare **(**DOA 2017/18**).** Agriculture in the district is characterized by small-scale subsistence mixed farming-system with livestock production as an integral part.

Meta **district is one of the twenty districts in East Hararghe zone, which is located at 532 km east of Addis Ababa and about** 84 km from Harar town in the Northern direction. **The** geographical location of the **district** is **9^0 14' 60" N and 41^0 24' 59" E**. The altitude of the area ranges between **1400 to 2850** m.a.s.l. The district has mean annual rainfall of 350 to 900mm and the average temperature is 17 ^{0}C to 27 ^{0}C**.** The district has three basic agro-climatic conditions, namely highland (28%), midland (44%), and lowland (28%). The district consists of 22 rural PAs and The Meta total population is 252,185 (127, 3 11 male persons and 124,874 female persons **(CSA, 2007). The average family size is estimated to be 7 and 3 per household in rural and urban areas respectively.** The average landholding per farm family is 0.74 hectare**.** Agriculture in the district is characterized by small-scale subsistence mixed farming-system with livestock production as an integral part.

Treatments and Experimental Design

The activity were conducted at Fedis and Metta Districts, Boko research station and Metta TVET College. Seeds of the species (*Casuarina equisetifolia, Moringa istinipetala, Acacia albida* and *Albizia gummifera)* that were used for the experiment purchased from Central Ethiopian Environment and Forestry Research Center (EEFRC) and Ethiopian Biodiversity Institute (EBI). Seedlings were raised directly in to polythene tubes at Fadis on nursery site, which close to the study area with the recommendation nursery activities. Seedlings of tree species were planted in the field in June, 2019 at experimental sites using a randomized complete block design (RBCD) with three replications. Each replication had four experimental plots, representing four tree species of nine seedlings each. The spacing between blocks and plots were 2m and 2m; respectively and the space between trees in a plot was 2m

Method of Data Collection

In order to fit the objectives data were collected on the following parameters: on growth and adaptation parameters such as survival rate, Plant height, root collar diameter, and diameter at breast height for the four years at interval of three months. Trees height and survival rate were collected up to the end of the period of the activity by the interval of three months and root collar diameters were collected only up to the trees reaches 1.3meter in height, and diameter at breast height were collected after tree reaches 1.3m whereas plant height . Height growth was determined by using measuring tape and root collar diameter and diameter at breast height by digital caliper.

Method of Data Analysis

Analysis of variance was computed using SAS software 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

Results and Discussion

Survival rate at Fedis and Metta Districts across a years

The analysis of variance revealed that highly significant variations among tree species in survival rate (P<0.05) was recorded. *A. albida, A. saligna C. equistifolia* and *M. stenophatala, show* good performance among tested trees species at Bokko station. The survival that recorded in this experiment for *A. albida, A. saligna,* and *C. equistifolia* were relatively show better survival rate than *M. stenophatala,* at Metta site. Generally four tree species performed well at Fedis condition, survival about 84.01%, 88.33%,80.33% and 86.8%, recorded for *A. albida, A. saligna, C. equistifolia and M. stenophatala,* respectively show good performance. At Metta condition, survival about 83.35%, 92.09%, and 84.01% recorded for *A. albida, A. saligna,* and *C. equistifolia* respectively showed good performance than *M. stenophatala* (35.93%) showed least performance. Therefore, planting of these better performing tree species and increase their promotion to in the study area. Hence, it can be show that the condition of Fedis and Metta matched well with the environment requirement of these species adapted. Yitebitu Moges (2004) also reported that Moringa olifera, *A. saligna* and *A. albida,* species are quite drought resistant species which is similar to the observation of the present study. *M. stenophatala* showed least

performance *35.93%* due environmental factors of metta not suitable for moringa stenopetala. The survival trend for all tree species showed declining trend their survival rate for all the assessment period.

Table 1. The mean of survival rate (%) of the species over the years/months of study period

Tree species	Year I(12 month)		Year II(24 month)		Year III(36 month)		Year IV(48 month)		Average mean	
	Fadis	Meta	Fadis	Meta	Fadis	Meta	Fadis	Meta	Fadis	Meta
A. albida	89.30^{b}	89.50^{b}	83.55^{b}	83.30^{b}	82.53^{b}	82.54^{b}	80.67^{b}	78.07^{b}	84.01^{b}	83.35^{b}
A. saligna	94.38^{a}	100.0^{a}	89.33^{b}	90.16^{a}	85.60^{b}	89.60^{b}	84.00^{b}	88.60^{b}	88.33^{a}	92.09^{a}
C. equistifolia	85.51^{b}	86.13^{b}	81.07^{b}	85.87^{b}	80.37^{b}	84.32^{b}	78.37^{b}	80.12^{b}	80.33^{b}	84.11^{b}
M.stenophatala	92.38^{a}	42.33^{c}	85.99^{b}	38.33^{c}	85.60^{b}	34.33^{c}	83.33^{b}	27.77^{c}	86.83^{a}	35.93^{c}
CV (%)	1.20	2.30	1.70	3.00	2.40	2.40	8.18	15.90	7.16	9.18
LSD(0.05)	2.11	3.54	2.80	4.40	3.75	3.40	20.93	11.20	19.73	22.73

N/B: Means in columns with the same letters are not significantly different, LSD= Least significant difference

Results obtained from the study show that, except the site significant difference ($p<0.05$) were observed for the survival rate of the species of *M. stenophatala* (table 1). During the years of study period, *A. albida, A. saligna, and C. equistifolia* attain the highest mean values ranging from 80.33% to 92.01%. This indicted the condition of the study area matched well with the environmental requirement of these species. Against to this *M. stenophatala* had the lowest survival rates over the entire experimental period at Metta condition.

Tree Height, Root Collar Diameter, and Diameter at Brest height at Fedis and metta districts

Others growth parameters like tree height, root collar diameter, and diameter at brest height were measured during adaptation and growth performance of the same (provenance) tree species. But this precept study were the growth performance depends only survival rate (%) to evaluated variations among tree species in the study area. The height, root collar diameter, and diameter at breast height of tree species were measured independently in both locations.

Accordingly, Height growth of F. albida (1.42m), A. saligna (3.24m), C. equistifolia (3.22m) and M. stenophatala (2.69m) were measured, root collar diameter growth of A. albida (2.78cm), A. saligna (4.01), C. equistifolia (3.89cm) and M. stenophatala (3.65cm) were measured and diameter at brest height growth of F. albida (1.21cm), A. saligna (3.22cm), C. equistifolia (3.42cm) and M. stenophatala (2.22cm) were respectively measured at Fedis district. Height growth of A. albida (1.11), A. saligna (3.76m). C. equistifolia (3.26m) and M. stenophatala (1.01m) were measured, root collar diameter growth of F. albida (2.53cm), A. saligna (4.10cm), C. equistifolia (4.05cm) and M. stenophatala (1.66cm) were measured and diameter at brest height growth of A. albida (1.12cm), A. saligna (3.31cm), C. equistifolia (3.07cm) and M. stenophatala (0.32cm) respectively were measured at Metta district.

Raebild *et al.* (2003) stated that the growth and productivity of trees, 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 (Table 2). Accordingly, *A. albida (*1.42m) the shortest trees at Fedis district. The tree species having greatest root collar diameter were those, which grew tallest. Similarly, species with lower height growth had lower root collar diameter growth (Raebild *et. al.*2003).

Table 2. Average mean growth performance of tree species in plant height (m), root collar diameter (cm) and diameter at breast height (cm) across experimental period

Types of Trees	Others growth parameters					
	Fedis district			Meta district		
	Height(m)	RCD(cm)	DBH(cm)	Height(m)	RCD(cm)	DBH(cm)
A. albida	1.42^{c}	2.78^{c}	1.21^{c}	1.12^{b}	2.53^{b}	1.11^{b}
A .saligna	3.24^{a}	4.01^{a}	3.22^{a}	3.76^{a}	4.10^{a}	3.31^{a}
C. equistifolia	3.22^{a}	3.89^{b}	3.42^{a}	3.26^{a}	4.05^{a}	3.07^{a}
M. stenophatala	2.69^{b}	3.65^{b}	2.22^{b}	1.01^{b}	1.66^{c}	0.32^{c}
CV (%)	5.53	8.42	24.35	6.37	7.37	22.40
LSD(0.05)	2.40	2.83	3.75	1.36	4.40	3.40

Note: RCD- Root Collar Diameter, DBH- Diameter at Brest height

Description of the Selected Tree Species

Faidherbia albida

Faidherbia albida is family Fabaceae which one of the largest thorn trees, reaching 30 m in height, with spreading branches and a rounded crown. The basal thickening is a characteristic distinguishing this species from the acacias with long thorns. Agroecological zone of *Faidherbia albida is* dry and moist kolla and dry weyna dega *Faidherbia albida* grows at an altitude of 270-2700 m, mean annual temperature of 18-30^{0}C, mean annual rainfall of 250-1200 mm and soil type of Coarse-textured well-drained alluvial soils. It tolerates seasonal waterlogging and salinity but cannot withstand heavy clayey soils. *Faidherbia albida*, during the dry season, people eat the seeds. Products of *Faidherbia albida* is firewood, timber, farm tools, household tools, medicine, fodder and ich of the species are scattered on crop land, in homestead, boundary/live fence, Soil conservation. Ecological Services from tree species are dead fence, shade, erosion control, soil fertility improvement through nitrogen-fixing, and wind break. The origin of *Faidherbia albida* is native (Baris H, Ertenki M., 2010).

Acacia saligna

Acacia saligna is family Fabaceae which is a dense and multi stemmed, thorn less, spreading shrub or a single-stemmed, small tree up to 9 m in height, bark is smooth and grey to red-brown on branch lets becoming dark grey and fissured with age. Agroecological zone of *Acacia saligna is* dry and moist kolla and dry weyna dega. *Acacia saligna* grows at an altitude of 0-500 m, mean annual temperature of 23-36^{0}C, mean annual rainfall of 250-600 mm and soil type of grows light-to-medium loams and well-drained soils. Income, firewood, timber for construction, fodder, and gums/resins are products from *Acacia saligna.* Nich of *Acacia saligna* in scattered on crop land, in homestead, boundary/live fence, Woodlot, Soil conservation, riparian areas. Ecological Services; live fence, shade, erosion control, soil fertility improvement through nitrogen-fixing, wind break. The origin of *Acacia saligna* is exotic species. The trees are susceptible to white-scale insects, which attack the leaves and stems (Baris H, Ertenki M., 2010).

Casuarina equisetifolia

Casuarina equisetifolia is Casuarinaceae family an evergreen, dioecious or monoecious tree 6- 35 (60) m tall, with a finely branched crown. Crown shape initially conical but tends to flatten with age. Trunk straight, cylindrical, usually branchless for up to 10 m, up to 100 cm in diameter. The climate in its natural range is semi-arid to sub humid (dry, moist, and wet kolla and wenya dega). Altitude: 0-1400m, mean annual temperature 10-35^{0}C, mean annual rainfall 200-3 500 mm, soils are invariably well-drained and rather coarse textured, principally sands and sand loams. C. equisetifolia wood is hard to very hard and strong use for timer. Since it is salt tolerant and grows in sand, C. equisetifolia is used to control erosion along coastlines, estuaries, riverbanks and waterways. Its general tolerance to strong winds has encouraged its use in protective planting. C. equisetifolia to fix atmospheric nitrogen. With high productivity and properties that enhance soil fertility, C. equisetifolia shows promise as an agroforestry species for arid and semi-arid areas. The origin of *Acacia saligna* is exotic species. C. equisetifolia is only rarely attacked by diseases and pests, unless if grown under unfavorable conditions (Baris H, Ertenki M., 2010).

Moringa stenopetala

Moringa stenopetala is moringaceae family is a tree 6-12 m tall having a diameter of 60cm (DBH) and a smooth bark. Ecologically, *moringa stenopetala* grows naturally is *arid, semi-arid and semi-humid areas* and often found in well-drained soils at altitudes of 400-2100 m, mean annual temperature 24-30^{0}C. The species is quite drought resistant. it has been found in areas of an annual rainfall ranging from 500-1400mm. Cold temperatures are limiting factor for the cultivation of the species, in Ethiopia because it does not tolerate frost. The species does not have any specific soil requirements, except it does not grow on waterlogged or swampy soils. The soil PH ranges from acidic to alkaline but mostly exhibit neutral reaction. The leaves and fruits are eaten as vegetables (food) and are rich in proteins, calcium, and iron, phosphorous as well as vitamins A and C. Products; fruits, Other foods, firewood, timber for construction, medicine. The use of leaves and pods for animal fodder is currently of minor importance compared to their use for human consumption. Yet, due to their high protein content this is a promising potential use. Growing rapidly, these trees have softwood that is not particularly suitable for fuel. The species is grown in mixed multi-storey stands with food crops. *Moringa stenopetala* is more resistant to insect pests than other species of its family. Most farmers in its natural range report that they never saw diseases or pests on this tree (Baris H, Ertenki M., 2010).

Table 3. Characteristics of selected tree species in the study areas.

Description	Tree Species			
	Acacia albida	Acacia saligna	C. equisetifolia	Moringa steopetala
Family	Fabaceae	Fabaceae	Casuarinaceae	Moringaceae
Agroecological Zone	Dry and Moist Kolla and Dry Weyna Dega	Dry and Moist Kolla and Dry Weyna Dega	Dry, moist, and wet Kolla and Wenya Dega	*Arid, semi-arid and semi-humid areas*
Rainfall	250-1200 mm	250-600 mm	200-3 500 mm	500-1400mm
Temperature	18-30^{0}C	23-36^{0}C	10-35^{0}C	24-30^{0}C
Altitude	270-2700 m	0-500 m	0-1400 m	400-2100m
Height	30 m in height	up to 9 m in height	6- 35 (60) m tall	6-12 m tall
Products	Firewood, Timber, Farm tools, Medicine, Fodder	Income, Firewood, Timber for construction, Fodder, Gums/Resins	Fodder	Fruits, Other Foods, Firewood, Timber for construction, Medicine
Niche	Scattered on crop land, in homestead, boundary/live fence, Soil conservation	Scattered on crop land, in homestead, boundary/live fence, Woodlot, Soil conservation	Scattered in homestead	Scattered in homestead, Contours/Soil conservation
Ecological Services	Dead fence, Shade, Erosion control, Soil fertility improvement through Nitrogen-fixing, Wind break	live fence, Shade, Erosion control, Soil fertility improvement through Nitrogen-fixing, Wind break	Live fence, Shade, its use in protective planting	Ornamental, Shade. It is a valued ornamental in its natural range.
Growth rate	Fast growing	Fast growing	Fast growing	Fast growing
Soil	Coarse-textured well-drained alluvial soils	light-to-medium loams and well-drained soils	sands and sand loams soils	The species does not have any specific soil requirements, except it does not grow on waterlogged soils.
Origin	Native	Exotic	Exotic	Native

Sources: Azene Bekele. 2007

Conclusion and Recommendations

The results indicated that there were significant different among tree species for survival rate. The survival rate of *A. saligna*, *M. stenophatala*, *A. albida*, and *C. equistifolia* were showed good performance at Fedis condition. The survival rate of *A. saligna*, *C. equistifolia* and *A. albida* were good performance than *M. stenophatala* at Meta condition. While *M. stenophatala* showed poor survival rate at the Meta condition. Poor survival rate and growth performance of *M. stenophatala* might be attributed to the condition environmental factors like climatic condition and soil types of the study area. Concerning of plant height, root collar diameter and diameter at breast height of individual trees of A. *saligna* and *C. equistifolia* were the tallest heights tree, followed by *M. stenophatala* but *A. albida* were measured the shortest tree heights at Fedis site. *A. saligna* and *C. equistifolia* were showed the tallest tree height, followed by *A. albida* and *M. stenophatala* were show the shortest tree height at Meta site. The maximum diameter were measured for A. *saligna* followed by *C. equistifolia* than *M. stenophatala* and *A. albida* at Fedis site and for A. *saligna* and *C. equistifolia* followed by *A. albida* then and *M. stenophatala,* at Meta site entire experimental period were measured. Generally, based on these results, we further recommend those four tree species A. *saligna, A.albida,C.equistifolia and M. stenophatala* had better performance and high mean value of survival rate in the study area of Fedis and those three tree species A. *saligna, A.albida, and C.equistifolia* showed better performance and higher mean value of survival rate. However, *M. stenophatala* performed least and failed to adapt at Meta district. Therefore; planting of these better performing tree species and increase their promotion as agroforestry practices for soil conservation, shading, forage, fuel wood and in general multifunction purposes in the area. It is also better to use for plantation purpose on degraded area rehabilitation.

Acknowledgements

The authors express their gratitude to the staff of Agroforestry Research Team of Fedis Agricultural Research Center for their follow-up and data collection and Oromia Agricultural Research Institution for its financial support.

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