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Evaluation of Selected Woodlot Tree Species in Dry Land of Yabello District, Borana Zone, Ethiopia

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Abstract **Original Research Article**

Woodlot tree species are trees planted or naturally growing in small-scale and or managed forested areas. The study was conducted on four woodlot agroforestry tree species; Grevillea robusta, Cordia africana, Cupressus lusitanica and Casuarina equisetifolia at Yabello Agriculture Research Center to evaluate their adaptability and growth performances. The experiment was laid out in RCBD with three replications. The result of this study revealed that, there was a significant difference among the tree species (P<0.05) in survival rate. All of the tested species; Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia and Cordia africana showed the highest performance in terms of survival rate 99.07%, 76.85%, 69.7% and 67.59% respectively. The mean plant height of Grevillea robusta, Cordia africana, Cupressus lusitanica and Casuarina equisetifolia were 5.92m, 4.46m, 4.03m and 2.75m respectively. The mean diameter at breast height for Grevillea robusta, Cordia africana, Cupressus lusitanica and Casuarina equisetifolia were 6.39cm, 6.63cm, 4.44cm and 2.19cm respectively. The mean canopy diameter of Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia and Cordia africana were 3.2m, 3.02m, 1.36m and 3.91m respectively. Generally, the mortality of some seedlings of all species might be explained as a response to low moisture and soil condition of the study area. Therefore, in the study under Yabello and related agroecology, planting of these better performing tree species and encouraging their promotion were recommended as they are important for timber, fuel wood, construction, soil conservation, shading, forage, and in general as multi-purpose trees in the area.

Keywords: Diameter, height, multipurpose, survival rate.

INTRODUCTION

Trees are essential to our lives and are an integral part of our landscape. They play many roles and confer a multitude of benefits to society such as food, shelter, shade, timber, natural beauty to the countryside, conservation of our soil and water resources and improved air quality. However, Ethiopia's forest resources are rapidly disappearing as a result of the ever-increasing demand both for firewood and unsustainable wood exploitation for lumber crop cultivation and grazing land, stimulated by a rapidly growing population. Agricultural expansion, clearing of land for settlements and commercial farming have contributed to the problem. It is aggravated by the increase in the production of charcoal and timber and management capacity (Million, 2011). Natural woodlands provide majority of rural population with energy source, food, building material and fodder for livestock (Lepetu *et al*., 2015). However, current developments and population growth have exerted enormous pressure on the woodlands and possible extinction of some species. These, the area of natural forest that is currently available for wood production is diminishing (Million, 2011). Human activities, such as deforestation, agriculture actives, and uncontrolled wildfires, have increased environmental degradation around villages. However, the country is becoming dependent upon wood product imports mainly sawn wood, paper and ply wood. To reverse these situation, conservation and sustainable use of forest resources are priorities for the government of Ethiopia (Million, 2011)**.** Despite effort by government to suggest communities to tree planting initiative the uptake is unsatisfactory. Suggestion

Borana zone is one of the areas in which woodlands and shrub lands found in southern parts of the country Jaleta (2010). These woodlands and shrub lands forest resources currently are under problem due to human pressure for construction and fire wood, over grazing and climate change (recurrent drought). Mohammed (2014) estimated the continuous declining of open shrub and tree savanna areas from 45% in the

1976 to 9% in the 2012 (-36%) and forest land declined by 6% from 1976 to 2012 in pastoral rangeland systems of Borana. *Juniperus procera* forests naturally found in the Zone are currently disappearing due to distraction for construction and fire wood and patch of woodland tree species in the area are drying and others are distracting. Hence, introducing different woodlot tree plantations in dry land of Borana will be an important issue to reverse the conditions. Therefore, this study aims to introduce and evaluate both indigenous and exotic woodlot trees plantation in the study area for sustainable conservation and plantation forestry.

MATERIALS AND METHODS

Description of the Study Area and Site Selection

The study was conducted in the Yabello district of Borana range land, southern Oromia (Figure 1). Yabello district is situated in the Borana zone of Oromia National Regional State, 570 km south of Addis Ababa. The study area lies between 4^0 38` 30'' N to 4^0 57' 0'' N and 38^0 2' 0'' E to 38^0 16' 30'' E.

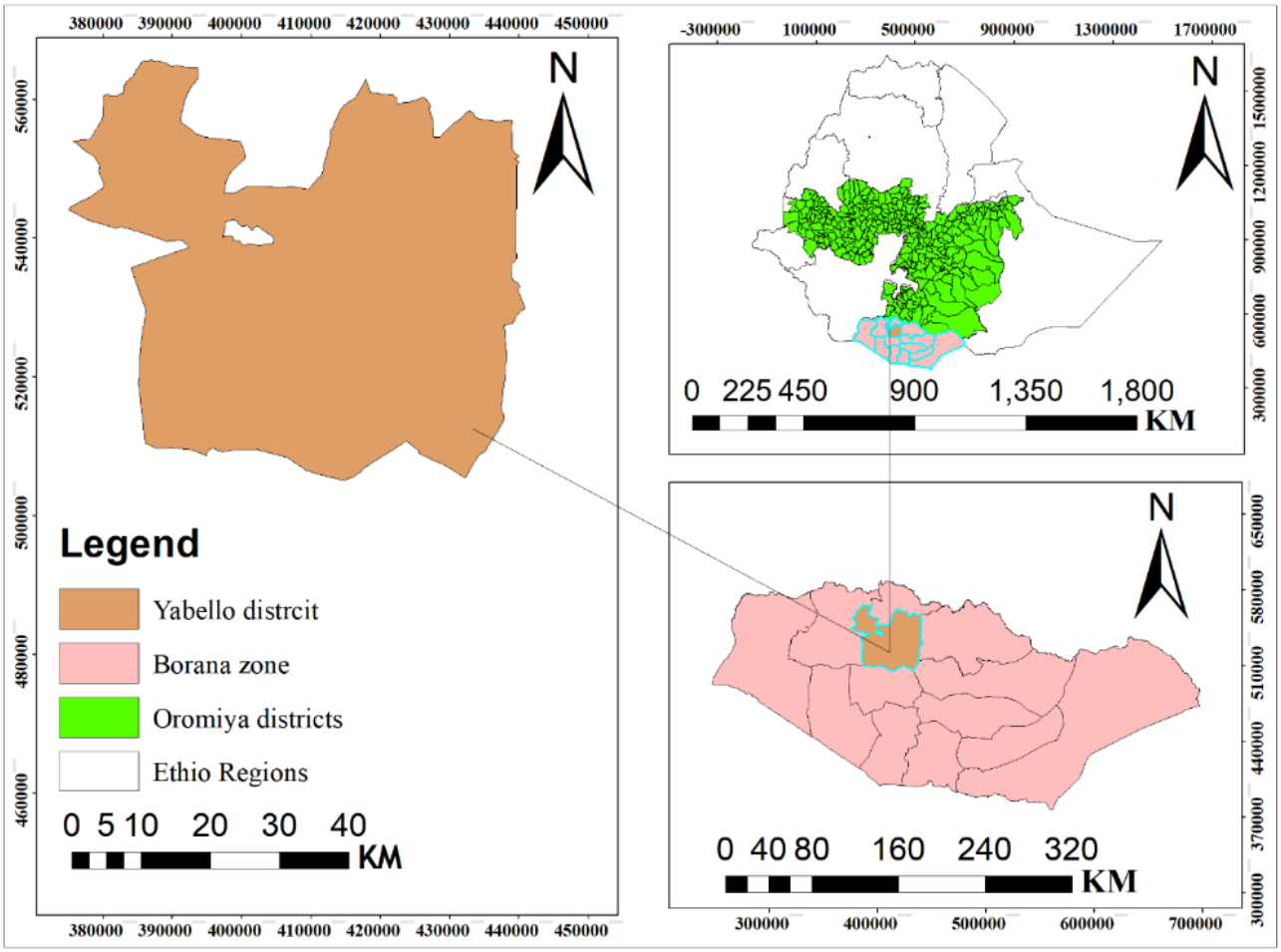

Figure 1: Description of the study area

Yabello district has a bi-modal rainfall pattern, with the main rainy season (Ganna) between March and May and the peak in April (Coppock, 1994). The short rainy season (Hagayya) extends from September to November, with a peak in October. The mean annual rainfall of the area ranges from 352 mm in the southern part to 605 mm in the northern part of the zone. The mean annual rainfall is 587.2 mm. The mean annual temperature varies from 15 to 24˚C and shows little variation across the seasons (Figure 2).

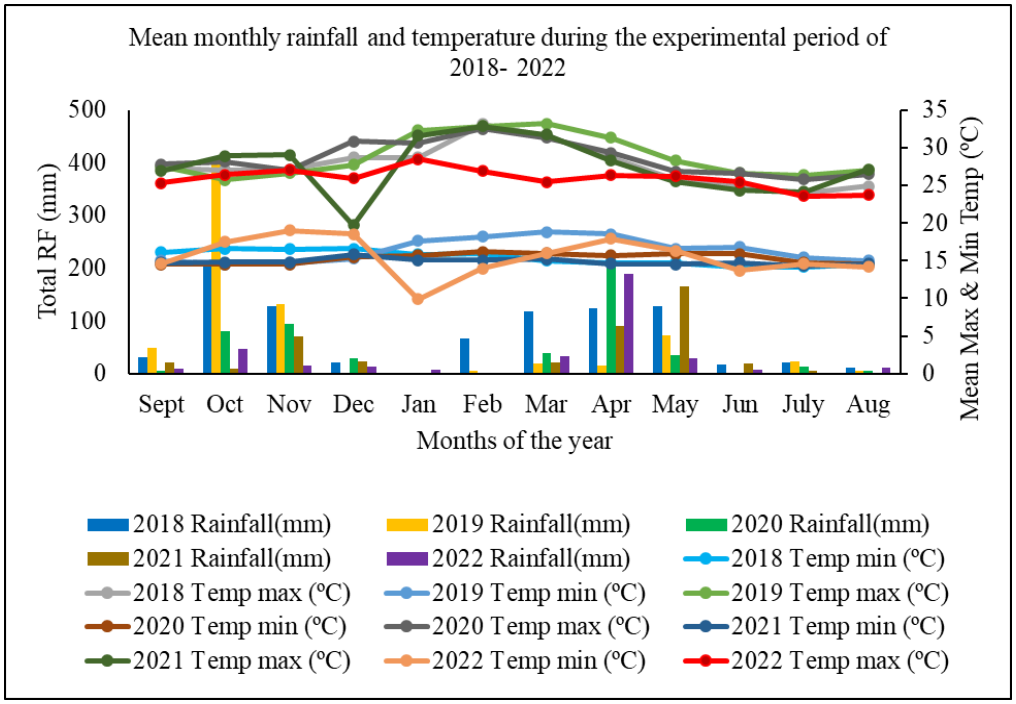

Figure 2: Mean monthly rainfall and temperature during the experimental period of 2018- 2022

Methods

Study sites selection

The study was conducted in Yabello districts of the Borana zone. The sites have been selected purposively, and the experiment was conducted at the Yabello on-station site.

Multipurpose trees and shrubs species selection

Tree species selected for the study were *Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia and Cordia africana.* The species selection was these tree species that are compatible and have the potential to grow well in the study area, which is adapt in degraded and moisture-stressed area, and used for timber, construction and fuel wood. Seeds of the selected species were obtained from Dima Tree Seed Processing and Storage Center (Sebata).

Experimental Design and Field Planting

Seedling raising and caring

Seeds of the selected species were obtained from the Dima Tree Seed Processing and Storage Center. After acquiring the seeds, necessary seed dormancy breaking techniques (mechanical, chemical, and heat scarification) were used before sowing the seeds according to the species. Based on this, seeds were raised in polythene tubes of size 10 cm and 12cm diameter and 15cm length at Yabello nursery site. The maximum possible cares were taken and seedlings in the nursery were watered every day, early in the morning and evening.

Field planting and managements

Before field establishment and planting, necessary land preparation, the construction of soil and water conservation, and planting hole/pit were done. Following this, the selected tree species were planted on the field plots in a randomized complete block design. The experimental field was blocked along the slope to reduce soil variation per site and replicated three times. The selected woodlot tree species were randomly allocated to the plots in each block to reduce the error of planting the same species on the same line with different slopes within different blocks. To control the edge effects, other trees and shrubs naturally found in and around the experimental field were removed. Plantation plots were neither irrigated nor fertilized; however, they were planted in recommended soil and water conservation structures (soil micro basins). A plot size of 10m x 6m was used, and the spacing between blocks and plots was 3m and 2m, respectively. The spacing between plants was 2.5m x 2.5m, consisting of 12 plants over a single plot. In each plot, 12 trees were planted, and the six inner seedlings were taken as a sample for data collection. To reduce the error of initial size variation in seedlings, seedlings with the same sizes (height and RCD) of these species were planted. After planting, the site was protected from grazing and human interference for the duration of the study. The experimental plots were kept free of weeds.

Data collection

Trees and shrubs data collection

After field planting, survival and growth parameters were taken after the main rainy seasons. Survival rate of each tree species was taken in the first year of the experimental period while, height (from ground level to the tip of the plant), diameter at breast height (DBH), and root collar diameter (RCD) were taken every year. Data of canopy diameter and

aboveground biomass of the species were taken at 4th year (final) year of plantation. Diameter at breast height (DBH) was collected only after the tree reached 1.3m in height. Height growth was determined by measuring pole and, root collar diameter and diameter at breast height with a digital caliper. The trees aboveground biomass was taken by destructive methods. Three representative trees samples were selected for each plot and felled at the ground level. A total nine individual trees were felled from each species. The felled trees species were separated into stem, branches and leaves and the fresh weight of each part of the felled tree was measured separately in the field and recorded. Aboveground tree/shrub biomass was calculated for each tree species as:

Aboveground dry biomass = Aboveground fresh weight of a tree x 0.5 ----------eq 1

Soil sample collection and analysis

From selected plantation site, soil sample were collected to identify the soil characteristics of the study area. Thus, soil physical properties (bulk density and soil texture) and soil chemical properties (Ph, Tot N, Av P, OC and OM) were analyzed. Bulk density was analyzed using Gravimetric (oven dry) method and soil texture was analyzed using Hydrometry method. pH was analyzed using 1:2.5 water suspension (pH meter). Total Nitrogen was analyzed using Kjeldhal method. Available phosphorus was analyzed using Olsen method (Olsen, 1954). Organic carbon and matter were also analyzed using Walkley and Blank method (1934).

Data Analysis

The analysis of variance was computed using the SAS statistical software package to test the significant difference among tree species. The least significant difference (LSD) test was employed to separate statistically different means using the software package at the 0.05 level of probability.

RESULTS AND DISCUSSIONS

Survival Rate of Tree Species

The survival rate of the tree species selected for this study revealed that there was significant difference observed ($P<0.05$) for survival rate among the tree species (Table 1). After a year of establishment, *Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia* and *Cordia africana* attain the highest mean values of survival percentages 99.07%, 76.85%, 69.7% and 67.59% respectively. This suggests that the condition of the study area matches well with the environmental requirements of these species. This also implies that; all of the tree species were found to be highly resistant to the moisture stress of the study area. The finding was in line with the study in Haro sebu district, which reported that the average survival rate *for Grevalia robusta* was 81.81% (Kitaba *et al*., 2017). However, the observed mean survival rate value *for Grevalia robusta* was higher than the result reported by Mamo *et al*., (2016) which stated that, the mean survival rate value *for Grevalia robusta* was 55.9% *in similar agroecology of* Hawi Gudina District, West Hararghe Zone.

However, the mortality of some seedlings of all species might be explained as a response to the specific site condition of the study area. Soil and below ground competition are also other factors that influence the growth and survival rate (Casper and Jackson, 1997). Thus, the result of laboratory analysis for organic matter and carbon of the study area was low and this might be limited the growth of tree species on the field and indicated that the growth of planted tree species might be affected due to the soil conditions of the study rea (Table, 7).

Moreover, the long dry season, which extended for the last four seasons in the study area, clearly explains the low survival rate of the seedlings. Thus, during the assessment period, the mortality of the seedlings was subjectively attributable to abiotic factors such as drought and moisture stress. Generally, the trend of survival rate for all tree species (*Grevalia robusta*, *Cordia africana*, *Cupressus lusitanica* and *Casuarina equisetifolia*) showed a declining trend throughout the study period.

Table 1: Survival rate of tree species

Tree species	Mean survival rate across (%)
Grevalia robusta	99.07[a]
Cupressus lusitanica	76.85[ab]
Casuarina equisetifolia	69.7[b]
Cordia africana	67.59[b]
Mean	78.3
CV (%)	15.19
LSD (0.05)	23.76

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

Plant Height

The result revealed that the mean height of each species over the years of the study period was shown significant variation (Table 2). Hence, the plant heights of *Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia and Cordia africana* at four-year ages were 5.92m, 4.03m, 2.75m and 4.46m respectively. Thus, results on the growth performance also showed that the higher height of *Grevillea robusta, Cupressus lusitanica and Cordia africana* showed that increase their importance for soil conservation in the area, since trees with fast growth habit can shorten the establishment period and protect the soil from excessive soil erosion. Similarly, it 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 are usually better adapted to the site than short trees (Raebild *et al*., 2003). Several similar studies also showed that the fast growth of seedlings 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 the productivity status of the species (Ozel and Ertekin, 2011). This might be attributed to the environmental requirements of the species and/or their genetic superiority.

Table 2: Tree height of tree species within different year intervals

Tree species	Mean plant height across the year (m)			
	Year I	Year II	Year III	Year IV
Grevalia robusta	1.26	2.05	4.34	5.92
Cupressus lusitanica	0.61	1.11	3.76	4.03
Casuarina equisetifolia	0.66	0.72	2.38	2.75
Cordia africana	0.70	1.36	3.60	4.46

Root Collar Diameter (RCD) and Diameter at Breast Height (DBH)

The root collar diameter for this study was recorded until the height reaches height of 1.3m. Accordingly, the root collar diameter of the species was recorded for the first and second year of the study area. Hence, the root collar diameter of *Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia* and, *Cordia africana* tree species in the second experimental period were 4.21cm, 1.58cm, 1.01cm and 3.14cm respectively (Table 3). All the planted seedlings did not reach 1.3m in height during the first two years of the study, and the diameter at breast height was recorded for the third and fourth years of the experiment. Following this, the diameter at breast height of *Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia* and, *Cordia africana* in the final year of the study period were 6.39cm, 4.44cm, 2.19cm and 6.63cm respectively (Table 3).

Table 3: Root collar diameter and diameter at breast height (cm) of tree species within different year intervals

Tree species	Mean root collar diameter across the year (cm)		Mean diameter at breast height across the year (cm)	
	Year I	Year II	Year III	Year IV
Grevalia robusta	1.81	4.21	4.12	6.39
Cupressus lusitanica	0.61	1.58	2.68	4.44
Casuarina equisetifolia	0.63	1.01	1.67	2.19
Cordia africana	1.62	3.14	4.71	6.63

Canopy diameter

The result revealed that the mean canopy diameter of each species of the study period was shown comparatively (Table 4). Hence, the mean canopy diameter of *Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia and Cordia africana at four-year age* were 3.2m, 3.02m, 1.36m and 3.91m respectively.

Table 4: Canopy diameter (m) of tree species within different year intervals

Tree species	Mean canopy diameter across the year (m)
Grevalia robusta	3.20
Cupressus lusitanica	3.02
Casuarina equisetifolia	1.36
Cordia africana	3.91

Aboveground biomass of the species

The result revealed that the mean aboveground biomass of each species of the study period was shown variation (Table 5). Hence, the mean above biomass of *Cordia africana, Grevalia robusta, Cupressus lusitanica and Casuarina equisetifolia and* were 99.03Kg, 35.9Kg, 14.97Kg and 3.39Kg respectively.

Table 5: Above biomass (Kg) of tree species within the last year of the study

Tree species	Mean above biomass of the species (Kg)		
	Branch and leaf biomass	Trunk (stem log) biomass	Total
Cordia africana	57.3	41.73	99.03
Grevalia robusta	16.30	19.60	35.90
Cupressus lusitanica	8.70	6.27	14.97
Casuarina equisetifolia	1.03	2.36	3.39

Soil physical and chemical properties of the study area

Soil physical properties of the study area

The result of laboratory analysis revealed that, the soil type of the study area was sandy loam and bulk density of the study area was moderate (Table 6).

Table 6: Soil physical properties of the study area

Soil depths	BD (g/cm3)	% Sand	% Clay	% Silt	Textural classes
Depth 1	1.21	61.12	10.32	28.56	Sandy loam
Depth 2	1.42	59.12	12.32b	28.56	Sandy loam

Soil chemical properties of the study area

The laboratory analysis result for soil chemical properties also revealed that, the soil pH of the study area was slightly acidic according to the rating classification (Tadesse *et al*., 1991). Likewise, organic matter and carbon of the study area was low (Table 7). This might be limited the growth of tree species on the field and indicated that the growth of planted tree species might be affected due to the soil conditions of the study area.

Table 7: Soil chemical properties of the study area

Soil depths	pH	% TN	AV. P (mg/kg)	% OC	% OM
Depth 1	6.48	0.09	5.27	1.09	1.88
Depth 2	6.77	0.06	4.56	0.7	1.21

CONCLUSION

The experiment was conducted to evaluate adaptation and growth performance of four woodlot tree species. The results indicated that there was significant difference among tree species for survival rate. The result revealed that, the survival rate of all tested species*; Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia* and *Cordia africana* showed the highest performance in terms of survival rate 99.07%, 76.85%, 69.7% and 67.59% respectively. However, the mortality of some seedlings of all species might be explained as a response to low moisture condition and soil condition of the study area. The mean plant height of *Grevillea robusta, Cordia africana, Cupressus lusitanica and Casuarina equisetifolia* were 5.92m, 4.46m, 4.03m and 2.75m respectively. The mean diameter at breast height for *Grevillea robusta, Cordia africana, Cupressus lusitanica and Casuarina equisetifolia* were 6.39cm, 6.63cm, 4.44cm and 2.19cm respectively. The mean canopy diameter of *Grevalia robusta, Cupressus lusitanica, Casuarina equisetifolia and Cordia africana* were 3.2m, 3.02m, 1.36m and 3.91m respectively. Generally, the poor moisture and soil conditions in the research area may be the cause of mortality for some seedlings.

Recommendations

Generally, the results on growth performance showed that, all tested species had better performance. Therefore, in the study under Yabello conditions and related agroecology, planting of these better performing tree species and encouraging their promotion as woodlot tree species plantation were recommended for Yabello and similar agroecologies as these tree species are important for timber, fuel wood, construction, soil conservation, shading, forage, and in general as multi-purpose trees in the area. Training was also need to be given to the wider community regarding woodlot tree plantations, management and its importance.

Conflict of Interests

The authors have not declared any conflict of interests.

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