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Impact of Parkland Trees (*Faidherbia Albida* Delile and *Cordia Africana* Lam) on Sorghum Yield in Fedis District, Eastern Ethiopia

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ABSTRACT

Among several agroforestry practices in Fedis District, East Hararghe zone, Parkland agroforestry practices are common. However, the beneficial effect of tree species on the grain yield and above ground biomass of Sorghum is very scarce to be used for improved agricultural productivity in the study area. The study was conducted with the objectives of investigating the effect of parkland trees on the grain yield and above ground biomass of Sorghum within and outside the trees canopy as influenced by the tree species in Fedis District, Oromia, Ethiopia. Accordingly, six isolated and nearly similar F. albida and C. africana trees of each species growing on similar site conditions were selected and the canopy coverage of each tree was divided into four radial transects. Radial distance-based sorghum yield and biomass (under the canopy, edge to canopy, and far from canopy) was used and composite Sorghum yield and biomass samples from three horizontal distances were collected for analysis. Three plots from the tree trunk were established for assessing the sorghum yields and above ground biomass. The result show that the highest values of sorghum grain yield were 2089.51 and 1789.53 kg ha-1 under F. albida and C. africana respectively at the distance of 2.5 m away from the tree trunks and these values decreased to 1459.40 and 1266.01 kg ha-1 under F. albida and C. africana respectively, at the distance of 25 m away from the tree trunks. The mean biomass recorded at three different distances from the two tree trunks, were not differently significant statistically ($p > 0.05$). In general, the result of analysis indicated that, decreasing pattern of mean sorgum grain yield and biomass as distance from tree trunk increases, for both F. albida and C. africana. The research finding showed that trees have positive relation with grain yield and above ground biomass of sorghum due letter fall. Hence, the growing of Faidherbia albida and Cordia africana trees on small holder farms improve crop productivity for improvement of this agroforestry system.

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KEYWORDS: *Parkland Agroforestry, Transect, Canopy cover, sorghum yield, above ground biomass*

INTRODUCTION

Climate change, soil erosion, unsustainable farming practices, excessive tillage, overgrazing and deforestation including loss of biodiversity, have led to severe land degradation and desertification (Leakey *et*. al. 2005). Poverty levels and population growth rates of Ethiopia (more than 3% per annum) are high, the later exceeding the annual food production growth rates which stand at 2% per annum. The majority of the population (85%) practice subsistence agriculture Hiernaux and Turner (2002) and the dominant land use system and the main provider of food, nutrition, income, and environmental services is the traditional parkland system (integrated crop-tree-livestock systems). Parkland trees on farms are integral parts of smallholder farming systems in Ethiopia. While their contribution to environmental sustainability is well established (Tscharntke et al. 2011), their impact on agricultural productivity is often location specific

(Huth et al. 2010), tree species dependent (Kassa et al. 2010; Siriri et al. 2010) and greatly varies with tree-crop configuration in the fields (Kassa et al. 2010). Although promoting scattered trees for soil conservation, biodiversity maintenance, climate change mitigation and multiple other ecosystem service is a valid goal in itself, there is a tendency for considering them as a solution for every problem that smallholder farmers face. For example, the Ethiopian government has planned to include a 100 million scattered Faidherbia (Faidherbia albida) trees into smallholder farms covering up to 15 million ha of land (Mekonnen et al. 2013). The aim was to make the economy green and climate resilient, improve food security of smallholders, adapt to and mitigate climate change. Although such political will is encouraging, studies that explore natural functionalities by which presence of trees could enhance benefits have usually been less emphasized.

Parkland/Scattered trees within crop fields are an integral part of smallholder agricultural landscapes in Ethiopia and large parts of sub-Saharan Africa (SSA) (Endale et, al.2017). Fast population growth in the region is expected to cause greater demand for food, fuel and timber, intensifying the pressure of agricultural production on the environment (Yu et al., 2012). The centuries-old practice of managing scattered trees on crop fields has been suggested as one of the pathways for sustainable intensification of smallholder agriculture in the region (Pretty et al., 2011). In addition to their direct provision of food, timber and fuel wood (Calvet-Mir et al., 2012), scattered trees on-farm are known to provide multiple ecosystem services (Asaah et al., 2011; Ango et al., 2014). Perennials, either planted fast growing tree species or naturally grown scattered mature trees in crop fields, have been advocated as an affordable and sustainable means to improve and sustain soil fertility for smallholders in SSA (Glover et al., 2012). They can be used to minimize the problem of soil fertility decline (Akinnifesi et al., 2011), which is reported to have an indirect negative impact on household food security in Ethiopia (Haileslassie et al., 2005). Even under situations where short-term negative effects of on-farm trees on crop yield may prevail (Clough et al., 2011), they were reported to have long-term positive effects on the overall system productivity and sustainability (Malézieux, 2012).

The farmers in the study area active planting, a massive-scale adoption of trees on farmlands can play an important role to enhance tree diversity and cover-at landscape level. Then potentially contribute to enhancing food security of resource poor smallholders through the provision of ecosystem goods and service. Agroforestry is a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits (Leakey, 1996). Increased tree diversity at landscape level potentially contributes to enhancing food security of resource-poor smallholders through the provision of ecosystem goods and service (Zomer et al., 2009). However, the research done on the impact of parkland trees on sorghum gran yield and above ground biomass is limited in the study area. Therefore, the study was initiated the to investigate the effects of *F.albida* and *C.africana* trees on the grain yield and above ground biomass of sorghum under and outside of the canopy with the objective to evaluate the sorghum grain yield and above ground biomass under the canopies of trees species and compared to open field in Fedis district.

Material and Methods

Description of the Study Areas

Location

The study was conducted in Fedis district of East Hararghe Zone, Oromia National Regional State; Ethiopia. It is located in the eastern part of the country at **550** km from Addis Ababa the capital city of Ethiopia and 24 km from Harar town in the southern direction (Figure 1).**The** geographical location of the **district** is **8^0 22' 00" and 9^0 14' 00" N and 42^0 62' 00" and 42^0 19' 00" E**. The altitude of the area ranges from **500-2100** meter above sea level (FWANRDO, 2017/18).

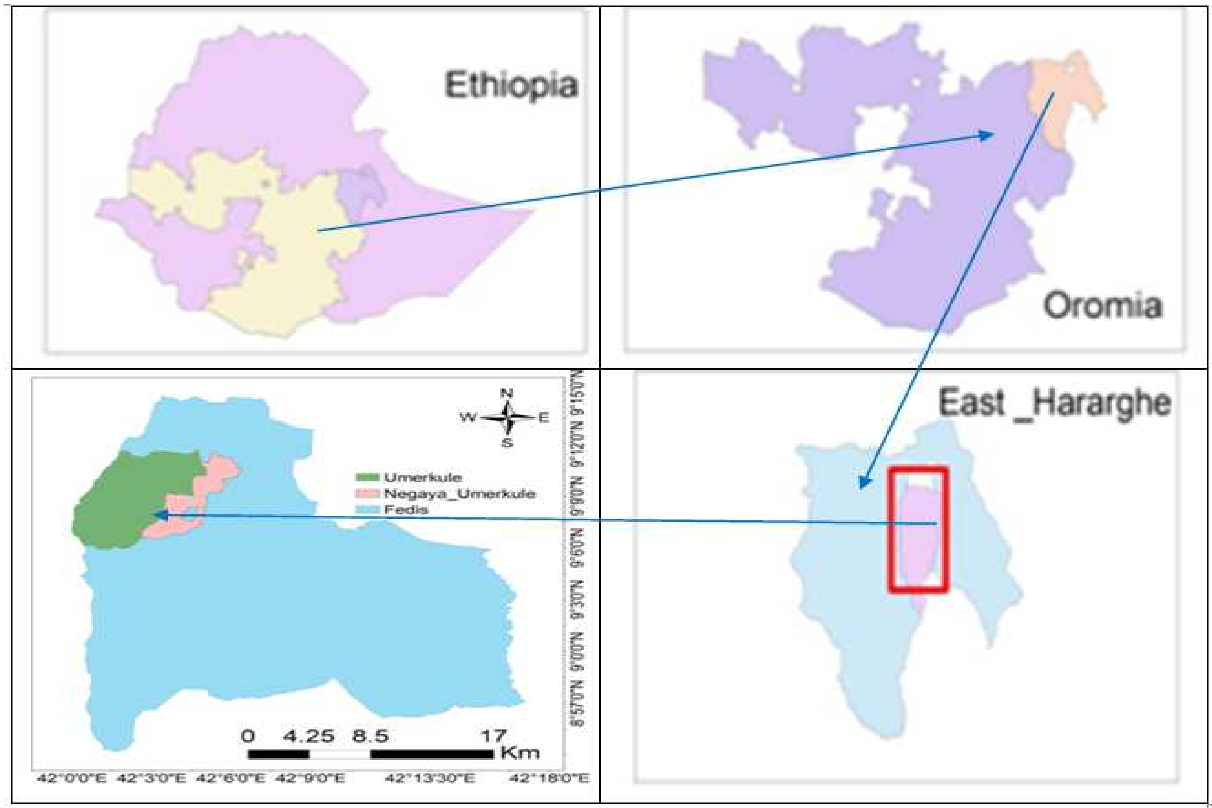

Figure 1: Location map of the study area

Climate and rain fall

According to FWANRDO (2017/18) report, the district has two basic agro-climatic conditions, namely Midland (39%), and lowland (61%). The district experience mean annual maximum and minimum rainfall, mean annual maximum and minimum temperature in the area were 850 to 650 mm, 30.4°C, and 10.0°C, respectively. Accordingly, **the district** has a bimodal rainfall distribution pattern with heavy rains from April to June and long and erratic rains from August to October**.**

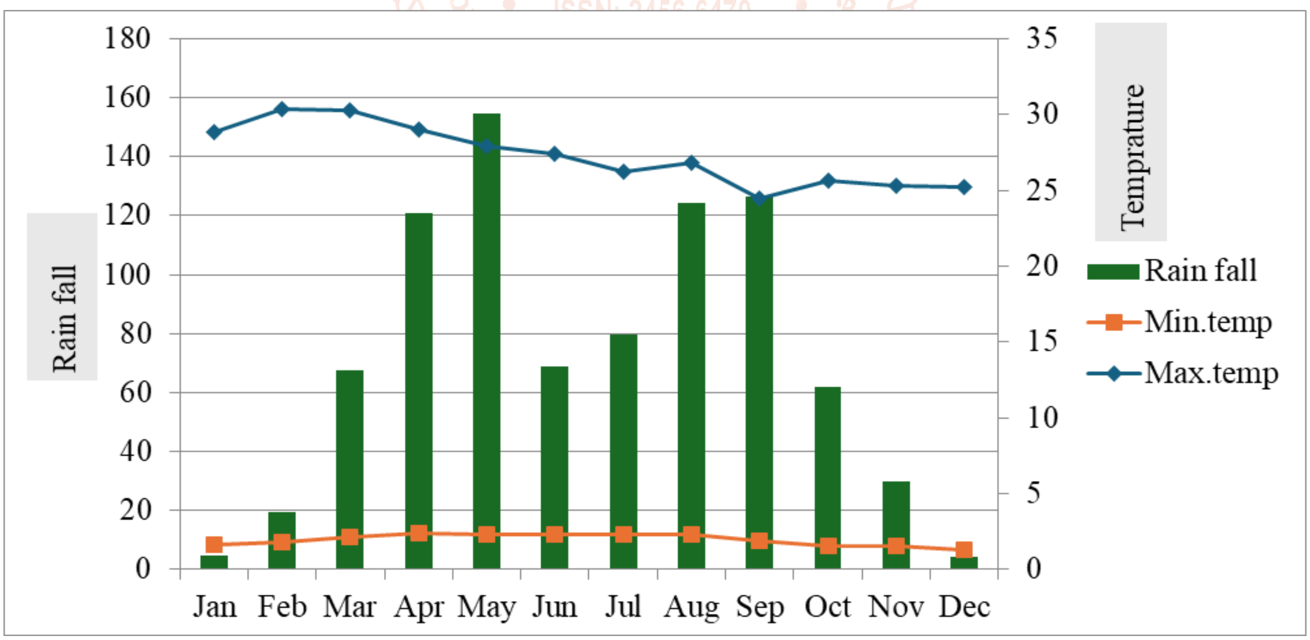

Figure 2: Rain fall and Temperature data of Fedis District, 2020 GC

Topography and land use

Topographic feature of the study area is 70% plain area, 28% plateau and 2% mountain or hill. Cultivable land/cropland (21.02%), pasture (2.80%), forest (11.2%) ,grass land (38.01%) ,communal land (10.5%) and remaining (14.04%) is considered as mountainous, valley and otherwise unusable (FWANRDO,2017/18).

Soil and vegetation

The soil of the study area was dominantly sand clay loam soils (moderately fine texture). The area of the district covered by forest, bushes and shrubs is **42,954 ha** (FWANRDO, 2011). Fedis district has few patches of natural vegetation cover and some of the area is occupied by plantation forests and farmers incorporating trees on farmlands, boundary plantings, trees in croplands and woodlots agroforestry etc. The most dominant tree species found in the area include; **acacia species,** *Croton macrostachyus***,** *Cordia africana, Fedhrbia albida, Eucalyptus camaldulences,* **and many others** (FWANRDO, 2011).

Agricultural activities

Agriculture in the district is characterized by small-scale subsistence mixed farming-system with livestock production as an integral part. The livelihood of the Fedis district is highly associated with agricultural activities for the fulfillment of household needs. Farmers are growing trees and /or shrubs in the agricultural landscape and also crop production is a leading economic activity of the area. Crop production is mainly rain-fed, practically all annual crops produced by this way for household consumption. Cereal crops including maize (Z*ea mays* L.), sorghum (S*orghum bicolor*), and haricot beans (*Phaseolus vulgaris*) are grown on the study area. Haricot bean (*Phaseolus vulgaris*) is growing as an intercrop with maize and sorghum crops in the study area. A cash crop such as *Chat* (*Catha edulis*) is also grown predominantly in the study area. In addition to these different fruits, vegetables, cereal crops, and tuber crops are the most common agricultural products of the study area (FWANRDO, 2017/18).

Tree management practices

There are certain management techniques which are applied to trees in park land agroforestry systems in the study area by some farmers. According to their respond there are two types of pruning i.e. Removal of branches from the lower part of the tree crown which is known as side pruning and pruning of a tree branches near the stem. Side pruning is specially used for young trees, in order to improve their growth. As they said, at least two or three layers of the green branches of young trees should remain uncut. For mature trees they cut the branches near the steam for the reduction of shade for crops near the tree. Sometimes Farmer of the study area uses pollarding for fodder that is out of the reach of livestock. There are also some farmers who remove trees from their farm land completely in order to insure suitable for machine harvesting technique. In general their objectives of pruning are to reduce shading effect of the tree and early harvest of branch for fencing or fuel wood. They also said good time for pruning is towards the start of rain season for fencing their farm land when the work will not interfere with growing crops and when the workload in other agriculture tasks is not so heavy

Research Design and Methods of Data Collection

Tree sample selection

The study was carried out on farmers' field in Fedis District, **East Hararghe Zone of Oromia Regional State** to compare the sorghum yield performance under traditionally retained parkland *F. albida and C.africana* trees against the open field outside the canopy cover. *F. albida and C. africana trees being the most abundant scattered tree species on crop fields were selected for this study. The selected farm fields with this tree species are characterized by a gentle slope where sorghum and maize* are staple food crops of the area. Relatively homogenous site conditions in terms of aspect and topography and growth of the trees were also considered in the selection of the trees of each species. Farmers of the study area rarely apply inorganic fertilizers to their farmlands. *The farmers used manual land preparation methods like hand hoeing and oxen to cultivate the sampled farm fields. The sampled trees had also more or less similar management history.*

On the selected field, individual trees of *F.albida and C. africana* having approximately similar height, diameter at breast height (DBH), crown diameter and from uniform site condition were marked to make other soil forming factors nearly constant. Of all the marked trees, six individuals of *F.albida and C. africana* trees were systematically selected for this study, their DBH, height and crown diameter was measured by using caliper, hypsometer and meter tape, respectively. Each tree species was replicated six times. The dimension of each replication was almost uniform with the average DBH, height, and crown radius of 27.5 cm, 10.67 m and 4.65 m for *F. albida*, respectively. Similarly, for *C. africana* the average DBH, height and crown radius were 31.83 cm, 12 m and5.49 m respectively.

Treatments and experimental design

There were two factors involved in this study: distance from the tree trunk and tree species were involved. The distance factor had three different treatment levels; at half of the canopy radius under the tree, canopy edge (radius of the canopy) and at three times canopy radius away from the trunk outside the canopy as control following the procedure by Jiregna *et al*., (2005). The tree species factors involved two tree species; *F.albida and C. africana* trees that are traditionally grown commonly on croplands were selected independently in the study area. The design employed had 3*2 factorial arrangements of treatments in randomized complete block design (RCBD) replicated six times, totaling 3*2*6 =36 *total* sample units or sample size for sorghum yield were *used in this study*.

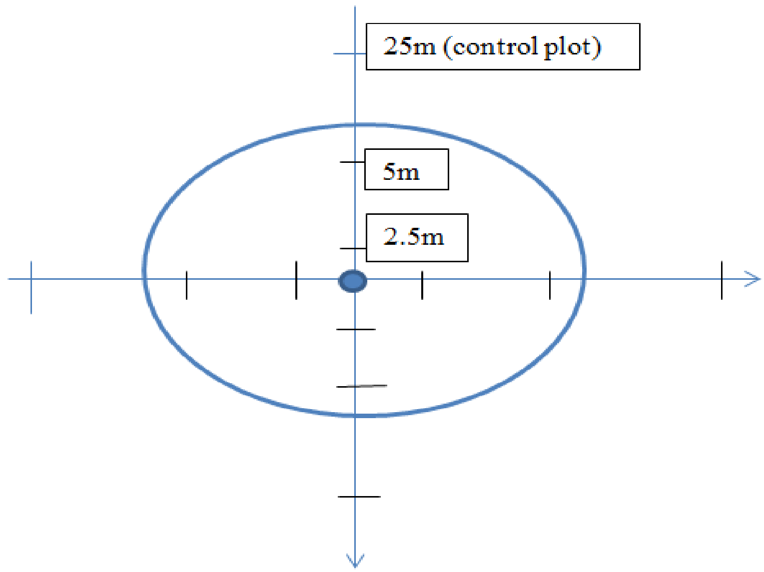

Figure 3: Experimental design of the sampling in the field work.

Grain yield data collection

Three plots of 1 m*1 m was laid at mid canopy radius, at edge canopy radius and open field in four compass directions (North, South, East and West) under selected trees on the existing sorghum farm field for assessing the sorghum yield on the farmer managed farm field. Sorghum was harvested from each plot. The harvested sorghum from the same radial distance was composited for each replication. The grain yield of sorghum was harvested and weighed after drying. Grain yield of sorghum were measured in each plots. Threshing of sorghum were done manually, cleaned and weighed and the grain yield obtained was reported as kg ha^{-1}.

Statistical Analysis

Randomized complete block design (RCBD) with two ways (ANOVA) were carried out to statistically compare the difference among treatments using SAS computer soft ware SAS Institute (1996). Statistical differences were tested using the least significant difference (at 0.05%).

Results and Discussion

Grain yield and biomass

The analysis of variance of the study showed that the grain yields of sorghum and biomass were significantly different ($P<0.05$) due to the effects of tree species and distance from the tree trunk. The grain yield of sorghum was decreased significantly and gradually as the distance from the trees trunk increased. The Highest values of sorghum grain yield were 2089.51 and 1789.53 kg ha^{-1} under *F.albida and C. africana* trees respectively at the distance of 2.50 m away from the tree trunks and these values decreased to 1459.40 and 1266.01 kg ha^{-1} under *F.albida and C. africana* respectively, at the distance of 25.00 m away from the tree trunks. The biomass also under both trees species were decreased as distance from the tree trunk increases (Table 1). The increase in grain yield under the trees could be due to improvement of soil properties under the tree canopies than the open fields. Soils under tree canopies were better than the outside due to higher accumulation of soil organic matter, nutrient cycling and nitrogen fixation by tree species, especially *F.albida and C. africana*. Abebe (2006) reported increased grain yield of sorghum and haricot bean under the canopy of *F.albida, C. africana* and C. macrostachyus trees as compared to the open cultivated land on Harergie high land.

Table 1: Effect of tree species and distance from trees on grain yield and biomass of sorghum at Fedis District

Distance from tree trunk (m)	*Faidherbia albida*		*Cordial aficana*	
	Grain yield kg/ha	Biomass kg/ha	Grain yield kg/ha	Biomass kg/ha
2.5	2089.51[a]	2860.00	1789.53[b]	2360.00 [a]
5.0	1805.02[b]	2831.50	1559.22[c]	2245 .30[a]
25	1459.40[c]	2808.61	1266.01[d]	1837.20[b]
CV	9.56	14.10	9.56	14.10
LSD (0.05)	109.31	NS	109.31	322.19

* Means with the same letter are not significantly different at (P< 0.05)

The combined analysis of variance of the study showed that grain yield of sorghum were significantly different (p <0.05) due to distance from the tree trunk and tree species. Similarly there were a significant difference of overall means between the two tree species (p<0.05). The Highest values of sorghum grain yield were 2022.17 kg/ha under *F. albida* and *C. africana* at distance of 2.50 m away from the tree trunks and these values decreased to 1354.40 kg/ha under *F. albida* and *C. africana* at the distance of 25.00 m away from the tree trunks. The finding indicated that, crop grown under the canopy of *F. albida* and *C. africana* obtained more advantage compared to the open field i.e. at distance 25.00 m from tree trunk. The mean variation at three distances might be come from modification of microclimate and soil physical and chemical properties by the trees species (Table 1). Trees influence microclimate and soil property through organic matter accumulation and canopy produced shade which reduced evaporation from the soil surface and modifies air temperature extreme. Kho et al. (1996) reported the same result and colleagues reported a 36% increase in dry matter production of pearl millet (Pennisetum glaucum) under tree canopies compared to open crop-only plots. This result suggested that the effect of *F. albida* on crop production is more pronounced in conditions of low soil fertility Sileshi (2016) as nutrients are less limiting to crops at greater fertility levels. These yield increases under *F. albida* (often referred to as the 'albida effect') are attributed to the combined effects of improved soil fertility, soil water and microclimate. Trees can improve water holding capacity of soil, organic matter through addition of litter fall and root decay, reduce evaporation from the soil surface under the canopy, nutrient cycling and nitrogen fixation Buresh and Tian, (1998). These factors could boost grain yield and biomass production of sorghum under the canopy of the two species, since they advance contents of the indicated factors in the soil. Because of the fertility and moisture content under the canopies of both trees were better than that of out of canopy, the mean grain yield under the canopies were greater than the open cultivated land. Victor sh (2012) done research on yields of maize from plots under canopies of *F. albida* trees were significantly (p < 0.05) higher than those from plots outside the canopies.

Table 2: Effect of *F.albida* and *C. africana trees* on grain yield and biomass of sorghum

Effects		Grain yield and Biomass	
Distance from trunk(m)		Grain yield kg/ha	Biomass kg/ha
2.5		2022.17[a]	3818.21
5.0		1659.59[b]	3530.20
25		1354.40[c]	3281.03
CV		10.39	8.93
LSD (0.05)		103.9	NS
Tree species			
F.albida		1803.33[a]	3125.72[a]
C. africana		1555.14[b]	2679.19[b]
LSD (0.05)		8.48	6.70
Distance x Tree species			
2.5 m	*F.albida*	2055.02	3928.20
	C. africana	1889.12	3618.12
5.0 m	*F.albida*	1810.40	3408.02
	C. africana	1508.22	3418.33
25 m	*F.albida*	1443.14	3328.67
	C. africana	1266.23	3218.44
LSD (0.05)		NS	NS

* Means with the same letter are not significantly different at (P< 0.05)

The mean under the two species was significant from each other; the mean under *F.albida* was greater than that of grown under *C. africana*, which could be as result of phonological characteristics of the tree species. *F.albida* shades its leaves during crop growing season, which allows more lights for photosynthesis reaction. Therefore, crops grown under *F.albida* gets more advantages compared to those crops grown under *C. africana*. The mean biomass recorded at three different distances from the two tree trunk, was not differently significant statistically (p >0.05) (table 2). In general, the result of analysis indicated that, decreasing pattern of mean biomass as distance from tree trunk increases, for both *F. albida* and *C. africana*. The mean values of biomass under canopy was 3818.21 kg/ha and decreased to 3281.03 kg/ha in open field. There were significant variation of biomass between tree species (p<0.05). The mean biomass obtained under *F. albida* was greater than that of mean biomass obtained under *C. africana* (3125.72 kg/ha and 2679.19 kg/ha respectively), which could be due to deference in the level of light incidence under the two trees and variation in soil fertility emanating from organic litter decomposition and subsequent nutrient release under the canopies of the species. The case of variation among distance from tree trunk was alike to that of the grain yield stated above i.e. fertility gradient cause for biomass difference was created by the role played by *F. albida* and *C. africana* on the soil under its canopy. Trees affect soil properties through several pathways Buresh and Tian (1998); Silashi, (2016). Thus, higher biomass obtained under the canopy of *F. albida* and *C. africana* as compared to on field one.

Conclusions and Recommendations

The study has been done on the effect of *F. albida* and *C. africana* on yield and biomass of sorghum grown under canopies of both trees in Fedis District, **East Hararghe, Oromia**. As a result of significant difference in nutrient available between under canopy and open plot grain yield was greater under the canopy. According to combined analysis both trees showed significant effect on grain yield and biomass of sorghum grown under canopies compared to that grown out of canopies of both trees. The higher mean of grain yield and biomass were observed under canopies than that grown on open field, which could be as result of additional nutrients, through litter fall, root turnover and exudates, and n-fixation. Parkland agroforestry system is very important in soil fertility management especially for poor farmers in order to boost their productivity. Retaining these tree species and in particularly *F. albida* on farms in the study area is of paramount importance for soil fertility enhancement so as to improve food security of small farming households. **Based on the findings the following recommendations are forwarded.** (1). Further research should be required on **F. albida and C. africana** trees on appropriate component management practices and the number of trees retaining per hectare associated crop productivity. (2) .In addition to their role in maintaining soil fertility, these two species provides various products and services to the farmers. Thus, the continued use of these species in the agricultural setting of Fedis district and other areas in the eastern Hararghe area to maintaining soil fertility and provide services to the farmers.(3) .The result of grain yield and biomass of sorghum reported in this study was from under farmer's management practice. So, further study is needed under controlled experiment in association with these trees.

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References

[1] Abebe Nigusie 2006. Status of soil fertility under indigenous tree canopies on farm lands in Highlands of Hararghe, Ethiopia. MSc. Thesis, Haramaya University, Ethiopia.

[2] Buresh, RJ. and Tian, G. 1998. Soil Improvement by Trees in Sub-Saharan Africa. Agroforestry Systems 38: 51–76.

[3] Hiernaux, P. and Turner M. D. 2002. The influence of farmer and pastoralist management practices on desertification process in the Sahel. In: Global Desertification: Do Humans Cause Deserts?, edited by J. F. Reynolds and D. M. Stafford Smith, 2002, p. 135-148. Dahlem University Press, Berlin/Germany.

[4] Leakey, R. (1996). Definition of agroforestry revisited. Agroforestry Today 8 (1): 5-7.

[5] Leakey, R. R. B., Tchoundjeu, Z, Schreckenberg, K., Schackleton, S., Schackleton, C. M. 2005. Agroforestry tree products (AFTPs): targeting poverty reduction and enhanced livelihoods. International Journal of Agricultural Sustainability 3 (1):1-23.

[6] Sileshi GW (2016). The magnitude and spatial extent of influence of Faidherbia albida trees on soil properties and primary productivity in drylands. J Arid Environ 132: 1-14.

[7] Victor SH, 2012. Analyses of crop trials under faidherbia albida, Department of soil science.

[8] Zomer, R. J., A. Trabucco, R. Coe. And Place, F. 2009. Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry ICRAF Working Paper no. 69. World Agroforestry Centre, Nairobi, Kenya.

[9] Zomer, Trabucco., Coe, and Place. 2009. Trees on Farm: Analysis of Global Extent and Geographical Patterns of Agroforestry. ICRAF Working Paperno. 89. Nairobi, Kenya: World Agroforestry Centre.

[10] Jiregna *et al*., (2005).