International Journal of Agriculture and Agricultural Sciences (IJAAS) ISSN 1712-3496, Vol. 7(2), pp. 216-224, November, 2022. Available online at www.advancedscholarsjournals.org © Advanced Scholars Journals

Full length Research paper

Effects of *Albizia gummifera* On-farm Tree Species on Selected Soil Properties in Midland Agroecology of Guji Zone, Southern Ethiopia

Aschalew Emire*

Oromia Agricultural Research Institute, Bore Agricultural Research Center, Bore, Ethiopia
Corresponding author email:aschu1511@gmail.com

Accepted 29th October, 2022

The role of on-farm tree based agroforestry practice in reduction of soil erosion, conservation of water and organic matter is significant. Conservation and enrichment of organic matter in the system can increase the activity of microbes in the soil which assists for better nutrient recycling and thus enhancing soil fertility. The objectives of this study was to evaluate the effects of *Albizia gummifera* on-farm tree species on selected soil properties in midland agroecology of Guji Zone, Southern Ethiopia. To achieve these objectives, a total of twenty four composite soil samples were taken from three horizontal distances from surface soil at one depth (0-15cm).Analysis of variance and treatments separation were made by using Tukey's honest significance difference at 5% probability level. Soils under *Albizia gummifera* tree canopies were found to contain significantly higher($p<0.05$) soil organic carbon, total nitrogen, available phosphorus, soil pH, cation exchange capacity and exchangeable potassium than those outside the canopies. However, in terms of soil texture significance differences ($p<0.05$) were not observed between under tree canopies and in open fields. This study also showed that, the recorded soil bulk density in open fields was significantly higher ($p<0.05$) than under tree canopies. The current study also indicated that fertility of the soils gradually decreased with the distance away from the tree trunk. Therefore, *Albizia gummifera* tree species have significant impact on soil physical and chemical properties. Hence, retaining *Albizia gummifera* tree on farm lands of the study area and elsewhere having similar agroecology is paramount importance for soil fertility enhancement so as to improve crop productivity. Moreover, further study on soil microbial population associated with *Albizia gummifera* tree such as mycorrhizal fungal and rhizobial species associations and investigation of its leaves nutrient content is needed.

Key words: Albizia gummifera, On-farm tree, Open fields, Soil properties, Tree canopy

INTRODUCTION

Agroforestry systems as one of the tree-based land-use systems have a potential to store more carbon in their soil system (Nair et al., 2009). Scattered trees grown in farmlands characterize a large part of the Ethiopian agricultural landscape and it is the most dominant agroforestry practice of the country (Kindeya, 2004).Moreover, scattered trees on crop lands are known to bring about changes in micro-climatic, floral, faunal and other components of the eco-system through bio-recycling of mineral elements, environmental modifications and changes in floral and faunal composition (Shukla, 2009; Belay et al., 2014).

A scattered tree on crop land has a positive influence on maintaining soil fertility via addition of nutrient to soil through biological nitrogen fixation and efficient nutrient cycling (Nair, 1993; Jonsson, 1995).Decomposition and nutrient release, addition of litter, pumping of nutrients from deeper soil layers and protecting from nutrient loss are some of the vital processes that have significant contribution for sustainable farm production (Sarvade et al., 2014).

One of the reasons for practicing agroforestry is for domestication of soil improving trees for enhancing soil productivity through a combination of selected trees and food crops on the same farm field (Kassa et al., 2010).Integrating cash crops in an agroforestry system of on farm tree species additionally gives an opportunity for better utilization of land, maintaining the health of tropical soils in terms of biological, chemical and physical property. This could be through root activities, nutrient cycling and numerous additional external factors reducing nutrient losses from erosion and leaching (Rhoades, 1997; Arevalo et al., 2015).

Agroforestry systems provide more benefits than the subsistence agriculture. This could be in terms of generating cash income from selling of multiple products gained from the system (Kalaba et al., 2010). As well, Agroforestry systems provide multiple products for smallholder farmers such as fruit, fuel wood, timber, medicine, fodder, green manure, gum, resins, spices and other diversified products which are believed to improve the livelihoods of small marginal farmers (Raj and Chandrawanshi, 2016).

On-farm tree based agroforestry practice has been considered as an important means to positively influence on soil fertility (Zebene and Agren, 2007). Under different agroforestry systems there is a significant and substantial improvement in soil biological activity in terms of nitrogen, phosphorus, microbial biomass carbon and alkaline phosphatase activity as compared to cropping without incorporating trees and shrubs (Yadav et al., 2011). Earlier study results conducted in different parts of Ethiopia also indicated that under canopies of on farm tree species improvement of soil fertility was showed due to increased organic input and Nitrogen fixation by legume tree species (Tadesse et al., 2000; Jiregna et al., 2005; Zebene Asfaw, 2008).

In Midland Agroecology of Guji Zone, Southern Ethiopia growing on farm tree species such as *Albizia gummifera*, *Cordia africana, Croton macrostachyus, Ficus vasta, Faidheribida albida* and *Millettia ferruginea* are very well practiced by local communities of the study site. However, in the study site information based pragmatic data is lacking on contribution of on farm tree species for soil fertility improvement. Therefore, to fill the research gap a study was conducted to evaluate effects of *Albizia gummifera* on farm tree species on selected soil properties in Midland Agroecology of Guji Zone, Southern Ethiopia.

MATERILS AND METHODS

Description of the study site

The study was conducted in Adola Rede District of Guji Zone, in Southern Ethiopia (Figure 1). The district is found at a distance of 475 km from Addis Ababa, capital city of Ethiopia. Geographically, the area lies between 5°44'10″ - 6°12'38″ North latitude and 38°45'10″ - 39°12'37″ East longitude within an altitudinal range of 1500–2000m above sea level.

The study district is characterized by three agro-climatic zones, namely lowland (60%), midland (29%) and highland (11%) (ARANRO, 2020). The mean annual maximum and minimum temperature of the study district is 28 C° and 16 C° respectively. The study site has bimodal rainy seasons and the mean annual rainfall of the study district is 1000mm. The major soil types found in the site are Nitisols and orthcacrosols and it is dominantly brown soil.

Farming system of the study site

The study district is characterized by a crop-livestock mixed farming system anda semi-nomadic economic activity is also practiced as a means of livelihood by some of its residents. The farmers of the study area produce both in autumn and spring seasons. The area is well known for the cultivation of cereal crops such as bread wheat, food barley, teff and maize, pulse crops like haricot bean, and others such as fruits and vegetables. They also engaged in the production of coffee and chat as means of livelihood. Moreover, the study district has a huge potential for livestock production as witnessed by farmer's livestock ownership (ARBoFED, 2017).

Methods of data collection

Tree sampling

From dominant tree species commonly growing on farm lands of the study site, *Albizia gummifera* was selected for this study. The sampled trees of *Albizia gummifera* had similar management practice and grown under similar soil types, climate and landscape. From the study site individual trees of *Albizia gummifera* having almost similar age, tree height (m), diameter at breast height (cm) and crown diameter (m) were marked and selected(Table 1). In this study, eight individual replicate trees of *Albizia gummifera* were randomly selected. Tree height, diameter at breast height and crown diameter of the selected tree species were measured by using hypsometer, caliper and meter tape respectively.

Soil sampling design

Soil samples from *Albizia gummifera* on farm tree species were collected from 8(eight) farmers' fields. For soil sampling the area covered by the tree canopy was divided in to two radial distances. Soil samples were taken in four directions (North, South, East and West) from three horizontal distances; middle of the canopy (2m),edge of the canopy (4m), and outside the tree canopy (15m) from surface soil at one depth (0-15cm). Soil samples from the same radial distances in the four directions were bulked together to form a composite soil sample.

Finally, a total of twenty four composite soil samples (three horizontal distance* one soil depths* eight trees) were collected for soil analysis.

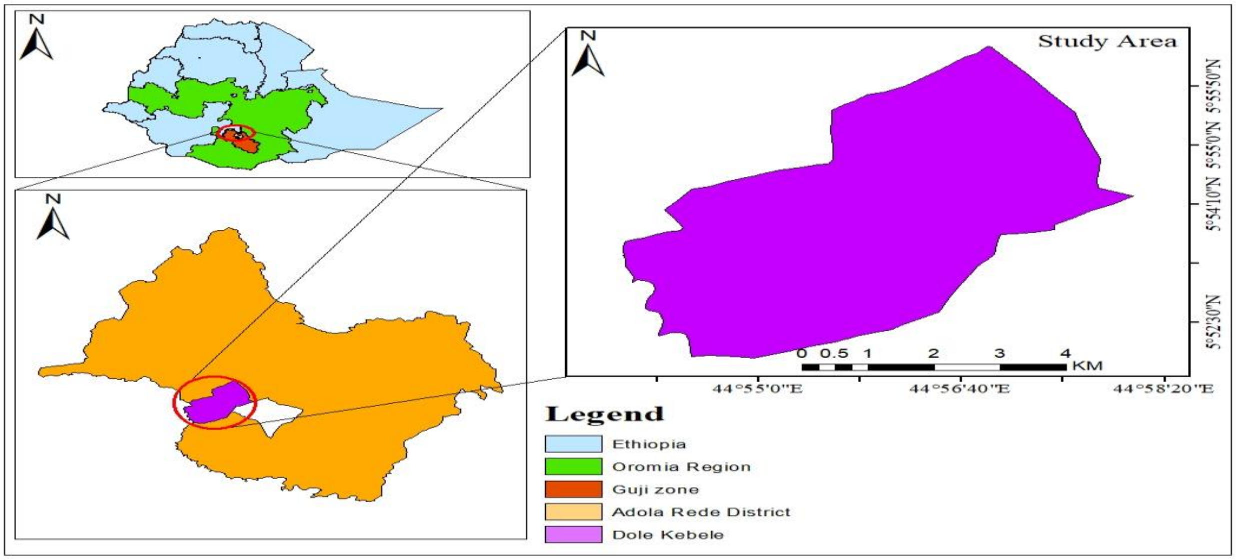

Figure 1. A map showing a study site

Table 1. Age, height, diameter at breast height and crown diameter of sample *Albizia gummifera*tree species in Dole kebele, Adola Rede District, Southern Ethiopia.

Selected tree species	Age of the tree	Tree height(m)	Diameter at breast height(cm)	Crown diameter(m)
Albizia gummifera	20.5±3.26	30.6±1.12	28.5±0.54	4.12±2.23

Soil laboratory analysis

The soil samples were air-dried, homogenized and passed through 2 mm sieve for soil analysis. Finally, from each bulked samples, 0.5kg of sub sample was taken for laboratory analysis of selected soil parameters and analyzed at National Soil Laboratory, Addis Ababa. Soil texture was determined by Bouyoucos methods using hydrometer (Bouyoucos, 1962), Soil bulk density was determined by dividing oven dry (105 ^{o}C) mass of soil by the volume of the core (cm3). Soil pH was determined using the potentiometer method (McLean, 1982), Soil organic carbon (SOC) was analyzed using the Walkley-Black oxidation method (Chesworth, 2008), total nitrogen (N) using the Kjeldhal method (Jackson, 1958), available phosphorus (P) using the Olsen method (Olsen & Sommers, 1982) and cation exchange capacity (CEC) was determined using the ammonium acetate method (Houba et al. 1989).

Data analysis

Analysis of variance (ANOVA) was done to determine differences among the means of the treatments (distances from tree trunk) with respect to soil physical and chemical properties by using Genstat 18th Edition. Mean comparison of treatments were performed by Tukey's honest significance difference (HSD) at 5% probability level.

RESULTS AND DISCUSSIONS

Effects of *Albizia gummifera*on soil physical properties

Soil texture

Soil texture is one of the physical soil variables that affect soil sustainability by affecting the absorption of nutrients, microbial activities, tillage and irrigation practices (Gupta, 2004). It is also the measure of the relative percentage of particles such as sand, silt and clay in the soil. Besides, soil texture influences the water holding capacity, aeration, infiltration and porosity of a given soil (Brady and Weil, 2002). In this study, the results of textural analysis indicated that soil particle fractions of sand, silt and clay under canopy of *Albizia gummifera* tree species did not show significant variation ($P < 0.05$) along distance from the tree trunk (Table 2). Therefore, the present study detected that the textural class of the soil in the study area was categorized under sandy clay loam. This may be due to the soil being from similar parent material, vegetation cover and topography.

The finding of this study was consistent with previous study results of Tadesse et al.(2000) and Abebe et al.(2001) which was conducted in southern and Eastern Ethiopia. On their study results reported non

Table 2.Soil textural class and Bulk density (g/cm3) under *Albizia gummifera* within different distance from its trunk in Dole kebele, Adola Rede District, Southern Ethiopia.

Tree species	Sampling distance(m)	Soil Texture			Bulk density(g/cm3)
		Sand (%)	Silt (%)	Clay (%)	
		Mean ± Sd	Mean ± Sd	Mean ± Sd	Mean ± Sd
Albizia gummifera	2 (mid canopy)	30.2a ± 3.1	24.8a ± 2.6	23.8a ± 2.2	0.85a± 0.11
	4 (canopy edge)	29.8a ± 3.6	24.1a±2.3	23.5a ± 2.3	1.1a± 0.12
	15(open fields)	28.6a ± 4.1	23.0a ± 3.4	24.0a±1.8	2.3 b± 0.15

Mean values in the same column with the same superscript are not significantly different at (P < 0.05) level
Mean values in the same column with different superscript are significantly different at (P < 0.05) level

significance difference in soil texture under canopy of *Millettia ferruginea and Cordia africana* tree species and outside the tree canopies. Similarly, Jiregna et al.(2005)and Desalegn and Zebene (2017) reported that in terms of soil texture significance differences were not observed between under canopy of *Cordia africana* and *Croton macrostachyus* trees and adjacent open fields.

However, the finding of this study was contradicted with former study results reported by Kamara and Haque (1992) for *Millettia ferruginea* and *Faidheribida albida* and Amanuel Tilahun(2022) for *Acacia abyssinica* and *Albizia gummifera* who reported significance amount of sand along different radial distances under the tree canopies. Moreover, Pandey et al. (2000) reported a significant influence of *Acacia nilotica* on sand and clay fractions horizontally as a function of distance from tree trunks. On their previous findings, Alemayehu et al. (2017) also reported a significant difference in fraction of silt between under the canopies of *Cordia africana* and *Erythrina abyssinica* tree species and open areas, in Arsi Golelcha District, Ethiopia.

Soil bulk density (g/cm3)

Bulk density is an indicator of soil compaction and soil health. It affects infiltration, rooting depth, available water capacity, soil porosity, plant nutrient availability and soil microorganism activity, which influence key soil processes and productivity. The analysis results of soil bulk density (g/cm3) of this studyshowed that the soil was significantly ($p<0.05$) affected by the distance from the tree trunk (Table 2). However, the analysis result showed that under canopy of *Albizia gummifera* on farm tree species soil bulk density was not significantly vary ($p<0.05$) between the sampling distances (2m and 4m) of the under tree canopies.

Conversely, there was significant difference ($p<0.05$) in soil bulk density between the distance of under tree canopy and open fields. As a result, the highest mean value of soil bulk density was observed in open fields than under tree canopy (Table 2). The highest soil bulk density in open fields might be due to the soils outside the canopy of the tree being exposed to direct solar radiation that dries out more and this leads quick organic matter decomposition thus making the soil more compact(Aweto & Dikinya,2003). However, the decline in soil bulk density under tree canopy might be due to high accumulation of organic matter than in open fields. On their study findings, Brady and Weil (2002) also showed that incorporation of organic matter under tree canopy through litter fall addition and root turnover improves physical and biological properties of soils. Moreover, organic matter increases the porosity of the soil which is very vital to facilitate the availability and movement of air or water within the soil environment resulting in lower bulk density for soils under the tree canopy.

The finding of present study was in agreement with the findings of Abebe (2006) who reported non significance difference in soil bulk densities under canopies of *Croton macrostachyus, Cordia africana* and *Faidheribida albida* tree species in highlands of Harargie, Ethiopia. Similar to the current study, Belay et al. (2014) also reported lower bulk densities under scattered *Faidherbia albida* and *Croton macrostachyus* tree species in the Umbulo Wacho watershed, southern Ethiopia. Likewise, Tadesse et al. (2001), Abebe et al. (2001) and Hailie et al. (2019) were reported that soil bulk density under the canopies of *Millettia ferruginea*, *Cordia africana* and *Ziziphus Spina-Christi* tree species was lower than open areas. However, in contrast with this study finding, Enideg Diress(2008) was reported non-significance difference in soil bulk density under the tree canopy of *Ficus thonningii* as compared to open fields in Gondar Zuria, Northern Ethiopia.

Effects of *Albizia gummifera*on soil chemical properties

Soil pH

Soil pH is a key characteristic that can be used to make informative analysis both qualitative and quantitatively regarding soil characteristics. Soil pH also describes the degree of acidity or alkalinity of a soil and influences plant growth through its effect on nutrient solubility and availability (Brady &Weil, 2002). The finding of this study showed that, higher value of soil pH was recorded

Table 3. Soil pH, Total nitrogen (%) and SOC (%) under *Albizia gummifera* within different distance from its trunk in Dole kebele, Adola Rede District, Southern Ethiopia

Tree species	Sampling distance(m)	pH	TN (%)	SOC (%)
		Mean ± Sd	Mean ± Sd	Mean ± Sd
Albizia gummifera	2(mid canopy)	6.9a ±0.3	0.65a ±0.12	5.6a ± 0.7
	4(canopy edge)	6.8a ±0.2	0.61a ± 0.11	5.2a ±0.6
	15(open fields)	6.1b ±0.1	0.05b ±0.02	2.4b ± 0.3

Mean values in the same column with the same superscript are not significantly different at (P < 0.05) level
Mean values in the same column with different superscript are significantly different at (P < 0.05) level

under *Albizia gummifera* tree canopy than in open fields. Thus, the soil pH values ranging 6.9 under tree canopy and 6.1 in open fields. However, between the sampling distances of the soils under tree canopies significance difference (p<0.05) in soil pH was not observed. The higher pH value recorded under tree canopy might be due to its canopy cover, which may lead to increasing volumes of leaf litter and other organic material available to the soil than relative to open fields.

Similar to this study finding, Alemayehu et al. (2017) for *Cordia africana* and *Erythrina abyssinica,* in Arsi Golelcha district, Ethiopia and Souza et al. (2012) for soil properties in coffee agroforestry systems, in the Atlantic rainforest indicated that the soil pH value was higher under tree canopies than in an open area. In addition, Zebene Asfaw (2016) reported that the soil pH under the crown of *Ficus vasta* was significantly higher than soils from open field, in central rift valley of Ethiopia.

However, in contrary to this finding, Hailemariam et al. (2010) and Belay et al. (2014) reported that soil pH undercanopies of *Balanites aegyptiaca, Faidherbiaalbida* and *Croton macrostachyus* tree species were lower than in open area. Moreover, Jiregna et al (2005) reported that there was no significant difference in soil pH under canopies of *Cordia africana* and *Croton macrostachyus* tree species compared to the outside the tree canopy.On their former findings, Kahi et al. (2009) also reported a significant difference in soil pH between the soils within and outside the canopies of *Acacia tortilis* and *Prosopis juliflora* with a higher pH in the open cultivated land than under the canopy areas.

Soil organic carbon (SOC)

Organic matter has an important influence on soil physical and chemical characteristics, soil fertility status, plant nutrition and biological activity in the soil and soil organic carbon is very essential to determine the amount of organic matter in the soil (Brady and Weil, 2002).

In this study, soil organic carbon was significantly (P<0.05) affected by distance from the tree canopy (Table 3). The recorded 5.4% mean soil organic carbon value under the canopy of *Albizia gummifera* tree was reduced to 2.4% in open fields and it was significantly higher under canopy of the tree.

This variation in soil organic carbon with distance away from the tree canopy was quite logical as the higher contents of organic carbon under the tree canopies were due to the leaf litter fall and decomposition of dead roots from the tree. Young (1998) also reported that, leaf, fine roots, and twigs are the major source of organic matter for soil under the crown of trees. Moreover, the roots of trees absorb nitrate from the inner soil horizon and subsequently recycle to the top soil which is vital to increase soil organic carbon under canopy of the tree. Similar to this study finding, Tadesse et al. (2000) and Abebe et al. (2001) on their study results were reported an increase in soil organic carbon under *Millettia ferruginea and Cordia africana* tree canopies than outside the canopy coverage. Furthermore, the finding of this study was consistent with previous study results of Alemayehu et al. (2017) and Desalegn and Zebene (2017). On their study results reported that soil organic carbon under canopies of *Cordia africana, Erythrina abyssinica and Croton macrostachyus* tree species were significantly higher than outside the canopies.

Total nitrogen (TN)

Based on the findings of this study, the total nitrogen also showed a significant difference (p<0.05) between radial distances and total nitrogen significantly decreased with increasing distance from tree trunk base (Table 3). The recorded total nitrogen under canopy of *Albizia gummifera* tree species at radial distances of 2 and 4 meters were 0.65% and 0.61% respectively. However, the total nitrogen value recorded at 15m distance in open area was only 0.05%. The observed higher total nitrogen under canopy of *Albizia gummifera* tree species as compared to open area might be due to leaf litter fall and decomposition of dead roots from the tree and nutrient cycling and nitrogen fixation behavior of the tree.

Azene Bekele et al. (1993) and Zebene and Agren (2007) also indicated that the mechanisms by which

Table 4. Effect of *Albizia gummifera* tree speciesand distance from its trunks on CEC, AP and EK in Dole kebele, Adola Rede District, Southern Ethiopia.

Tree species	Sampling distance(m)	CEC	AP	EK
		Mean ± Sd	Mean ± Sd	Mean ± Sd
Albizia gummifera	2(mid canopy)	45.4a ±0.7	9.8a±0.41	2.65a±0.94
	4(canopy edge)	43.3a ± 0.6	9.4a±0.39	2.41a±0.72
	15(open fields)	37.5b ± 0.4	5.2b±0.51	1.32b±0.32

Mean values in the same column with the same superscript are not significantly different at (P < 0.05) level
Mean values in the same column with different superscript are significantly different at (P < 0.05) level

Albizia gummifera trees increased total N under their canopy is attributable to addition of nitrogen input into the system through biological nitrogen fixation as it is Nitrogen fixing tree species.

In line with present study findings, Tadesse et al. (2000) for *Millettia ferruginea,* Jirenga et al. (2005) for Cordia *africana* and *Croton macrostacyus*, Zebene Asafw (2008) for *Millettia ferruginea,* Kahi et al. (2009) for *Acacia tortilis*, Desalegn and Zebene (2017) for *Croton macrostacyus* and Aschalew and Zebene (2018) for *Cordia africana* and *Ficus sur* found higher total soil nitrogen under tree canopies than in open fields. However, in contrary with present study results Fentahun Mengistu (2008) reported that significance difference in total nitrogen was not observed between under canopy of *Ziziphus spina-christi* tree species and away from the tree canopy area in western Amhara region, Ethiopia.

Available phosphorus (AP)

The mean concentration of available phosphorus (AP) recorded under the canopy of *Albizia gummifera* tree species was significantly (P<0.05) higher than open fields (Table 4). The soil analysis result revealed that the recorded mean value of available phosphorus under tree canopy and open fields were 9.6ppm and 5.2ppm respectively.The higher concentration of soil phosphorus under the canopy of *Albizia gummifera* tree species might be attributed to the higher accumulation of organic matter through litter fall and decomposition of dead roots from the tree. Brady and Weil (2002) also on their study findings indicated that, the horizontal variation could be attributed to high organic matter accumulation under the tree canopy than in open fields. Decomposition of organic matter results in release of phosphorus containing materials, which increase the availability of phosphorus.

Moreover, Rhoades (1997) reported that the soil near the tree trunk is richer in nutrients because of the leaching of dust from the leaf surface, scraps of dead insects, and nutrients from the tree trunk carried by flowing water or rainfall which concentrates at the tree trunk base. The findings of present study is in agreement with several reports on different tree species which was conducted in different areas by Pandey et al. (2000) for *Acacia nilotica* trees in a traditional agroforestry system in central India; Tadesseet al.(2000) for *Millettia ferruginea* in southern Ethiopia ; Jiregna et al.(2005) for *Cordia africana* and *Croton macrostacyus* in Badessa, Eastern Ethiopia and Aschalew and Zebene(2018) for *Cordia africana* and *Ficus sur* in Adola Rede District, Southern Ethiopia were reported higher value of available phosphorus under canopies of the trees than in open fields. However, in contrary to current study, Yeshanew et al. (1998) reported lower available phosphorus under canopy of *Croton macrostachyus* tree species than in open fields in northern western Ethiopia.

Cation Exchange Capacity (CEC)

Cation exchange capacity (CEC) is a measure of the soils ability to hold positively charged ions. It is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants (Hazleton and Murphy, 2007). Based on the findings of this study, under *Albizia gummifera* tree canopies cation exchange capacity was significantly higher (P<0.05) than outside the tree canopies(Table 4). The average cation exchange capacity values of soils for *Albizia gummifera* tree species at mid canopy, edge of canopy and outside the canopy coverage were 45.4, 43.3 and 37.5 meq/100g respectively. Therefore, the values of soil cation exchange capacity decreased with increasing distance from tree base.

The reason for higher cation exchange capacity under canopy of *Albizia gummifera* tree species might be due to higher organic matter accumulation under the base of the tree more cations would be released to the soil through mineralization as a result CEC could be higher under canopy of the tree trunk than outside the canopy coverage. Similarly, Brady and Weil(2002) also indicated that CEC of a soil is a measure of soils negative charge and thus of the soils capacity to retain and release cations for uptake by plant roots and the CEC of a soil is strongly related with the organic matter content of a soil.

The findings of this studywas in agreement with the study results of Abebe et al. (2001) for *Cordia africana* in croplands of western Oromia, Tadese et al. (2000) for *Millettia ferruginea* in southern Ethiopia, Abebe (2006) for *Croton macrostachyus, Cordia Africana* and

Faidheribia albida tree species in highlands of Harargie, Ethiopia, Ameha (2006) for *Prosopis juliflora* in the middle Awash, rift valley, Ethiopia, Belay et al. (2014) for *Faidherbiaalbida* and *Croton macrostachyus* tree speciesat umbulo Wacho watershed, southern Ethiopia were reported increments of CEC under the canopy of the trees than in open fields. However, the present study contradicted with the findings of Jiregna et al. (2005) for *Cordia africana* and *Croton macrostacyus* in Badessa, Eastern Ethiopia and Zebene and Agren (2007) for *Milletia ferrugenia* tree in parkland Agroforestry in central rift valley of Ethiopia described higher CEC outside the canopy area than under canopy of the tree.

Exchangeable Potassium (EK)

The analysis results showed that, under canopy of *Albizia gummifera* tree species the recorded value of exchangeable potassium at 2m(mid canopy), 4m(canopy edge) and 15m(open fields) distances were 2.65, 2.41 and 1.32 cmol (+)/kg respectively. Therefore, this result indicated that the value of exchangeable potassium showed a decreasing trend with increasing distance from tree trunk.

This may be due to more organic matter deposition under canopy of the trees and increased biological activities that enhance organic matter decomposition and subsequent mineralization. On their former study findings, Kindu et al. (1999) and Berger et al. (2006) also indicated that enrichment of the nutrients under tree canopies could be associated to the rooting system and efficient nutrient cycling power of the trees. Deep-rooted trees and shrubs often act as 'nutrient pumps', taking nutrients from deep subsoil horizons into their root systems, translocating it to their leaves, and recycling it back to the surface of the soil via leaf fall and leaching.

Similar to current study findings, Abebe (2006) was reported significantly higher concentration of exchangeable potassium under canopies of *Croton macrostachyus, Cordia africana* and *Faidherbia albida* tree species than outside the canopy coverage. Former study results conducted by Zebene Asfaw (2016) also showed that, concentration of exchangeable potassium under canopies of *Ficus vasta* and *Albizia gummifera* tree species were significantly higher than outside the tree canopies.

CONCLUSION AND RECOMMENDATION

On farm tree species improve soil fertility through biological nitrogen fixation and efficient nutrient cycling and they can be integrated into crop production and soil restoration. The result of this study showed that, concentration of soil fertility status under canopy of *Albizia gummeifera* tree species was significantly higher than outside the canopy coverage. This is expressed in terms of increased concentrations of soil organic carbon, total nitrogen, soil pH, available phosphorus, cation exchange capacity and exchangeable potassium under canopy of the tree as compared to the open fields.

The overall differences in assessed soil variables between the open fields and under tree canopies can be due to cumulative effects of nutrient recycling by leaf litter fall and decomposition of dead roots from the trees.

However, significance difference was not observed in terms of soil texture between under canopy of *Albizia gummifera* on farm tree species and in open fields. This could be due to the soil being from similar parent material, vegetation cover and topography. Moreover, concentration of soil bulk density in open fields was significantly higher than under tree canopies. This might be due to the soil dries out more, being exposed to direct sun light and making the soil more compact.
Based on the findings of this study, fertility of the soils gradually decreased with the distance away from the tree trunk due to the inputs from *Albizia gummifera* tree species and the nutrients are more concentrated near the tree trunk.

Therefore, a recommendation for soil fertility management and soil restoration is to sensitize farmers to maintain more on farm tree species in their fields and to cultivate more crops near the tree trunks. Moreover, improvement of soil physical and chemical properties under the canopy of *Albizia gummifera* tree species was primarily due to increments of soil organic matter as compared to open fields. Thus, the tree species which are retained on farmers' lands are contributed positively to the increment of soil nutrients, which play a role in sustaining the crop production system of the study area.

Hence, retaining *Albizia gummifera* tree species on farm lands of the study area and elsewhere having similar biophysical profile is of paramount importance for soil fertility enhancement so as to improve crop productivity of small holder farming households. Moreover, further study on soil microbial population associated with *Albizia gummifera* tree species such as mycorrhizal fungal and rhizobial species associations and investigation of its leaves nutrient content is needed.

Conflict of interests

The author declare that there is no any conflict of interest

ACKNOWLEDGEMENT

The author acknowledges Oromia AgriculturalResearch Institute for the financial support and Bore Agricultural Research Center for provision of the necessary facilities for research work. Moreover, the
author likes to thanks farmers of Adola Rede District for

making their fields available for soil sampling.

REFERENCES

Abebe N (2006).Status of soil fertility under indigenous tree canopies on farm lands in highlands of Harargie, Ethiopia. Msc.Thesis, Haramaya University, Ethiopia

Abebe Y., Itanna. F., Olso, M. (2001). Contribution of indigenous trees to soil properties: the case of scattered trees of *Cordia africana* Lam. in croplands of western Oromia. *Ethiopian. J Nat. Resource 3(2):245–270*

Alemayehu, D.R.,Muktar, M., Lisanework, N. (2017). Evaluation of soil physic-chemical properties under a canopy of coffee shade trees effect (*Cordia africana* and *Erythrina abyssinica*) in Arsi Golelcha district Ethiopia. *Journal of Resources Development and Management. 32, 2017*

Amanuel T(2022). Effect of dominant shade tree species on selected soil physicochemical properties and coffee production in Sayyo district, western Ethiopia. *Trees, Forests and People 8(2022)100245*

Ameha T(2006). Impact of *Prosopis Juliflora*: Invasion of plant biodiversity and soil properties in the middle Awash, rift valley,Ethiopia. M.Sc.Thesis, Hawasa Unversity,Ethiopia.

ARANRO(Adola Rede Agricultural and Natural Resources Office)(2020). Agricultural statistical abstract.

Arévalo-gardini, E. Canto, M., Alegre, J., Loli, O., Julca, A. and Baligar, V (2015). 'Changes in Soil Physical and Chemical Properties in Long Term Improved Natural and Traditional Agroforestry Management Systems of Cacao Genotypes in Peruvian Amazon', PLOS ONE, 10(7), pp. 1–29. doi: 10.1371/journal.pone.0132147

Aschalew E, Zebene A(2018). Status of Soil Properties Under Canopy of Farmers Preferred Coffee Shade Tree Species, in Adola Rede District, Guji Zone, Southern Ethiopia. *American Journal of Agriculture and Forestry.Vol.6, No.5, 2018, pp148-155*

Aweto, A.O., Dikinya, O (2003). The Beneficial Effects of two Tree Species on Soil properties in a Semi-arid Savanna rangeland in Botswana. *Journal of Land Contamination and Reclamation, 11, 334-339.*

Azene B, A. Birnie, and B. Tengäs (1993). Useful trees and shrubs of Ethiopia: identification, propagation and management for agriculture and pastoral communities. SIDA's Regional Soil Conservation Unit, Technical Handbook No 5.

Belay M, Tesfaye A , Abdu A(2014).Effects of scattered *F. albida* (Del) and *C. macrostachyus* (Lam) tree species on key soil physicochemical properties and grain yield of Maize (Zea Mays): a case study at umbulo Wacho watershed, southern Ethiopia.*Wudpecker Journal of Agricultural Research, ISSN 2315-7259 Vol. 3(3), pp. 063 – 073*

Berger, T. W., Swoboda, S., Prohaska, T. and Glatzel, G (2006). The role of calcium uptake from deep soils forspruce (Picea abies) and beech (Fagus sylvatica). *Forest Ecology and Management 229: 234-246.*

Brady N. C. and Weil, R. R (2002). The nature and properties of soils, 13th Ed. New Jersey, USA.

Chesworth W (2008). Encyclopedia of soil science, 1st edn. Netherland, Springer

Desalegn M, Zebene A(2017). Status of Selected Soil Properties under *Croton macrostachyus* Tree at Gemechis District, West Hararghe Zone, Oromia, Ethiopia. *Journal of Resources Development and Management, Vol.31, 2017*

Enideg D (2008). Importance of *Ficus thonningii Blume* in soil fertility improvement and animal nutrition in Gondar Zuria, Ethiopia. MSc. Thesis, University of Natural Resources and Applied Life Science, Vienna, Austria

Fentahun M(2008). Fruit tree species in the wild and in home garden agroforestry: species composition, diversity and utilization in western Amhara region, Ethiopia. PhD Dissertation University of Natural Resources and Applied Life Sciences Vienna, Austria

Gupta, P.K (2004). 'Soil, plant, water and fertilizer analysis', Shyam Printing Press, Agrobios, India, 38p.

Hailemariam K, Kindeya G, Charles Y (2010). *Balanites aegyptica*, a potential tree for parkland agroforestry systems with Sorghum in Northern Ethiopia. *J. Soil Sci. Environ. Manage.1(6):107-114*

Hailie Sh, Bekele L, Tefera M(2019).Effects of *Ziziphus Spina-Christi* (L.) on Selected Soil Properties and Sorghum Yield in Habru District, North Wollo, Ethiopia.*Malays. j. med. biol. res.Volume 6, No 2/2019*

Hazelton PA, Murphy BW (2007). Interpreting soil test results. What do all the numbers mean? CSIRO Publishing:Melbourne.

Houba V, Vander L, Novazamsky I, Walinga I (1989). Plant and soil analysis procedures. Department of Soil Science and Plant Nutrition Agric. Univ, Wageningen

Jackson M (1958). Soil chemical analysis, 6th edn. Prentice; Halls, Inc., Englewood Cliffs, New Jersey, p 498

Jiregna G, Rozanov, A. and Legesse N(2005). Trees on farms and their contribution to soil fertility parameters in Badessa, Eastern Ethiopia. *Biology and Fertility Soils, 42 (1), 66–71.*

Jonsson K(1995). Agroforestry in Dry Savanna Areas in Africa: Interactions between Trees

Kahi, C.H., Ngugi, R.K., Mureith, S.M., Ng'ethe, J.C., 2009. The canopy effects of *Prosopis juliflora* (dc.) and *Acacia tortilis* (Hayne) trees on herbaceous plants species and soil physicochemical properties in njemps flats, Kenya. Trop. Subtrop. *Agroecosyst. 10, 441–449.*

Kalaba, K. F., Chirwa, P., Syampungani, S. and Ajayi, C. O (2010). 'Contribution of agroforestry to biodiversity and livelihoods improvement in rural communities of Southern African regions', *Environmental Science and Engineering, pp. 461–476. doi: 10.1007/978-3-642-00493-3*

Kamara, C.S., Haque, I. (1992). *Faidheribida albida* and its effect on Ethiopian highland vertosols. The Netherlands. *J. Agrofor. Syst. 18, 17–29.*

Kindeya G(2004). Dryland agroforestry strategy for Ethiopia. Mekelle University paper presented at the drylands agroforestry workshop 1st-3rd. ICRAF Headquarters, Nairobi,Kenya pp26.

Kindu, M., Buresh, R. J., Richard, C. and Kipleting, K. M (1999). Root length and nitrate under *Sesbania*: Vertical and horizontal distribution and variability. *Agroforestry Systems 42: 265-282.*

Liang, J., Reynolds, T., Wassie, A., Collins, C. and Wubalem, A (2016). Effects of exotic *Eucalyptus spp*. plantations on soil properties in and around sacred natural sites in the northern Ethiopian Highlands. *AIMS Agric. Food. 1(2): 175-193.*

McLean EO (1982). Soil pH and lime requirement. In: Page AL, Miller LH, Keeney DR (Eds.), Methods of soil analysis. Part 2. Chemical and microbiological properties, Agronomy Monograph 2nd ed., vol. 9, American Society of Agronomy, Madison, 199-224

Nair P. K. R., (1993). An Introduction to Agroforestry, Kluwer Academic Publisher, Dordrecht, Nether land. Pp 272

Nair, P.K, Kumar, B.M. and Nair, V. D. (2009) 'Agroforestry as a strategy for carbon sequestration', Journal of Plant Nutrition and Soil Science, 172(1), pp. 10-23. doi: 10.1002/jpln.200800030

Olsen SR, Sommers LE (1982). Phosphorus. In: Page AL, Miller LH, Keeney DR (Eds.), Methods of soil analysis. Part 2. Chemical and microbiological properties, Agronomy Monograph 2nd ed., vol. 9, American Society of Agronomy, Madison, 403-430

Pandey, C. B., Singh, A. K., Sharma. D. K. (2000). Soil properties under *Acacia nilotica* trees in a traditional agroforestry system in central India. *Agroforestry Systems 49 (1), 53-61*

Raj, A. and Chandrawanshi, S (2016) 'Role of agroforestry in poverty alleviation and livelihood support in Chhattisgarh', *South Indian Journal of Biological Sciences, 2(3), pp.326-330.*

Rhodas C (1997). Single tree influences on soil properties in Agroforestry. *Journal of Agroforestry system, 35-94*

Sarvade, S., Singh, R., Prasad, H. and Prasad, D (2014). 'Agroforestry practices for improving soil nutrient status', Popular Kheti, 2(1), pp.60-64.

Shukla PK (2009). Nutrient dynamics of teak plantations and their impact on soil productivity-A case study from India. Proceedings of the 8thWorld Forestry Congress, Oct. 18-23, Buenos Aires, Argentina, p. 1-11.

Souza, N.H., Goedea, G.M, Brussaard, L., Cardoso, M.I., Duarteb, M., Gomes, C., Pulleman, M (2012). Protective shade, tree diversity, and soil properties in coffee agroforestry systems in the Atlantic rainforest biome. *Agric. Ecosyst. Environ. 146, 179–196.*

Tadesse H, Legesse N, L. Olsson, M (2000). *Millettia ferruginea* from southern Ethiopia: impacts on soil fertility and growth of maize. *Eth. J.Agroforestry Systems 46: 9-15*

Yadav, R. S., Yadav, B. L., Chhipa, B. R., Dhyani, S. K. and Ram, M (2010). 'Soil biological properties under different tree based traditional agroforestry systems in a semi-arid region of Rajasthan, India', *Agroforestry Systems, 81(3), pp. 195-202. doi: 10.1007/s10457-010-9277z*

Yeshanew, A., Mats,O. and Tekalign, M (1998). Contribution of *Croton macrostachyus* to soil fertility in maize-based subsistence agriculture of Bure area, North western Ethiopia.Proc.6th ESA maize conference. Pp232-234

Zebene A , Agren I.G (2007). Farmers, local knowledge and topsoil properties of agroforestry practices in Sidama, southern Ethiopia. *Agroforest Syst 71:35-48*

Zebene A(2016). Woody species composition and soil properties under some selected trees in parkland Agroforestry in central rift valley of Ethiopia. *International Journal of Development Research, 06 (11): 10150-10156*

Zebene A. (2008). Growth of *Millettia ferruginea* and its impact on soil properties of three coffee plantations of southern Ethiopia. *Ethiopian Journal of Natural resources. 10(2):147-160*