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Evaluation of Soil Physicochemical Properties under the Canopy of Coffee Shade Trees Effect (Cordia africana and Erythrina abyssinica) in Arsi Golelcha District, Ethiopia

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Abstract
Agroforestry from which soils are derived effectively sets the upper limit of nutrient supply. Contrasting this vegetation component of the ecosystem acts as a means by which mineral nutrients are sequestered, and carbon and/or nitrogen is fixed, and subsequently added to the soil through litter fall by decomposers of organic matter. Coffee shade trees is important to improve over all soil and coffee health, sustain and restore agroecology,biodiversity, and diversified nature based agroforestry practices. The study was conducted on farmers' fields in Golelcha District of East Arsi Zone, Ethiopia. The study was intended to evaluate the influence of coffee shade trees on selected soil physicochemical properties under the canopy of (Cordia africana and Erythrina abyssinica) trees and to get appropriate distance of coffee seedling plantation area in which away from shade tree trunks. Randomized complete block design on three farmers' fields as a replication in each PAs were used for data collection. A total of 48 circular samples were taken for both treatments' parameters, under both coffee shade tree species at the distance of 1m, 3m, 6 m and 25m away from shade tree trunk including unshaded zone. The two widely grown indigenous coffee shade tree species in the area were Cordia africana and Erythrina abyssinica. Even though farmers' preference focused on Cordia africana tree based on its utility, the best results were recorded under Erythrina abyssinica tree. The outcome had a significant value at ($p<0.05$) and highly significance value at ($p<0.01$) between and within the treatments. Integration of shade in coffee farming system created creditable promising in producing organic coffee as a result of organic soil improvement. Shade utility was also adopted as ecologically sustainable, economically viable and socially acceptable practice. The second distance layer (3m) away from shade tree trunks illustrated the highest mean value across PAs in most parameters. Almost all the given soil parameters' value increased significantly under the tree canopy than in the open area in both PAs showing decreasing trend with increasing distance from the tree trunks except phosphorus. Average result of both PAs' soil; the greater value of pH 44%, and 54%, OC; 60.5% and 92%, TN; 40% and 50.5%, CEC; 68.75% and 87%, ex. K; 13.5% and 14%, silt; 22.65% and 27.5% than open area were detected under the canopies of Cordia africana and Erythrina abyssinica, respectively. The best shade tree was Erythrina abyssinica and the recommended distance of coffee seedling plantation area away from shade tree trunk was 3m. Generally, the imperative indicator of the treatment's means difference were indicated between s' d and unshaded rather than within shaded means variation at most treatments' parameters.
Keywords: Coffee-based agroforestry system, Coffee shade value, Soil fertility ascription and Coffee quality attributions.

1. INTRODUCTION

1.1. Background and Justification

Agroforestry systems, as well as many natural tree based ecosystems, are perceived to improve or maintain soil fertility and productivity, to promote soil conservation, reduce soil degradation and achieve sustainable production.In many parts of the world, small scale coffee growers use multi-purpose trees for shade, shelterbelt, soil nuitreint and windbreaks to prevent coffee plants from excessive sun and high temperatures (journal of Travis and Idol, 2010). Coffee (Coffea arabica L.) is the most important agricultural shade lover goods and half of world's people take it in daily life process that more than 400 billion cups of coffee are consumed each year (Illy E, 2002). In African continent; among 25 coffee producers country, Ethiopia is the first largest producer and the fifth of the world after Brazil, Vetinam, Indonesia and Colombia based on agroforestry system (AfDB, 2010).

Organic farming system meinly focused on avaliablity of soil nuitreints which is mainly geined from agroforestry practice and also from parent materials. Agroforestry practice is a worldwide issue given attention to sustain and restore soil natures progresively. Coffee production with shade is one of the best instances of agroforestry practices of organic farming system in Ethiopia.Organic agriculture promotes acceptability of production and sustainability of natural resource utilization so that ecological and economical contribution of shade tree in coffee production based on agroforestry practice to be taken as the best example of organic coffee production as a result of organic soil nuitrient (Mark, 2005). This organic agriculture could be gained by application of nature with nature for nature rooted in nutreint of the soil and it has been reflecting carbon sequestration which can be'sold'to developed nations to pay compensation for developing countries as a shade advantage through soil nuitrient improvements (Mejia, 2007). Soil organic matter is a fundamental component in the plant-soil nutrientcycleofecosystems. Its maintenance or increase, in some cases, is a prerequisite in the long-termimprovement and sustainability of these ecosystems. In recent years, soil organic matter has received additional attention because of its potential to sequester carbon emanating from atmospheric CO2 (Rasmussen & Collins, 1992)

The Shade tree improve soil nutrient, genetic resource of Coffea arabica, biodiversity and ecological management approachs. Additionally, it has potential to conserve water, prevent soil degradation, restore soil microorganism, diversify income opportunity and sustain ecosystem service (Gole et al., 2002). Arabica Coffea is self-pollinator and a heavy flower initiator plant species. So as to develop such heavy flower to fruit rapidly, it needs high carbohydrate, shelter and other essential soil nutrients unless and other-wise roots damage leaves abscise and branch dies back (Yunianto, 1986). Shade trees also play great role in taking up the leached nutrient in which outside the reach of coffee plants' root and recycling nutrient on top soil through litter fall (Tan,lam, 2003).

Coffee shade has a great advantage on coffee value for price determine and quality analysis as a result of shade trees therefore, worldwide influence in coffee price directly coincide with its quality attributer rather than genetic and geographical location such as post harvesting, pre-harvesting, processing and soil nuitreints condition are also an influential factors (Mohammedsani, 2014). Internal pressure of coffee shade utility value for coffee producer countries to stabilize environmental impact through soil nuitreint improvements and diversify the system from insecure mono-cropping to secure poly-cropping economy, and change the high input for 'green revolution' in national production system (Promecafe, 1995). Shade trees enable coffee plants to develop periscarp and perisperm tissue which is serve as higher peak of action in developing endosperm based on organic soil factors for mature coffee beans which is being improve organoleptic coffee quality (Steiman,2003; Geromele et al., 2008). Shade tree improves soil nutreints thereby advances coffee production moderately for a long period of time. Shade tree reduces evapotranspiration because of organic soil aspects in order to favor the condition of microorganism activation as well as to endure drought without adverse effects of micro climate adoption to the nearby crops (Kim et al., 2004) as compared to fully sun grown coffee plants.

In golelch District, the farmers adopted with intensive utility of coffee production by means of shade tree request on specific farm land. The intensive utilities of shade trees are reflected as if natural forest at coffee farm land only. In the contrary, mountainous area of the district which were out of coffee plantation, along the border of "Arbagugu Terara" (Laftorifenso, Tulluqararo, Bibirsa qunne, culul ciriqisa etc. PAs) have been continuing deforestation and land degradetion problem due to the people shift to hilly side for their livelihood dependency.

The district was selected for this study based on the fact that, it is one of the major organic coffee producer based on the shade trees effect thereby soil nutreint improvement.

Therefore; the study was carried out in order to evaluate the effect of shade tree on physicochemical property of the soil under selected shade tree species in the district based on agroforestry practice. In doing so, importance of the study was indicated the following points: (a) to fill the gap of local practice with scientific implication and encourage indigenous knowledge concerning to coffee shade tree utilization and species selection (b) to be a base-line study for further scientific research extension to promote coffee shade trees' advantage on soil nutreint improvements and advanced ecosystem service utility for other coffee growers area, specially Western and Eastern Hararghe Districts which are coffee producers without shade trees.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

2.1.1. Location

According to Oromia livelihood profile (2006), Golelcha (figure 1) is one of the Districts found in Arsi Zone, Oromia Regional state of Ethiopia. It is located 307 km south east of Addis Ababa Ethiopia's capital city. The geographical coordinate of the area is between 08°00'0" and 08°37'00" N and 40°00'00" and 40°29'00" E.

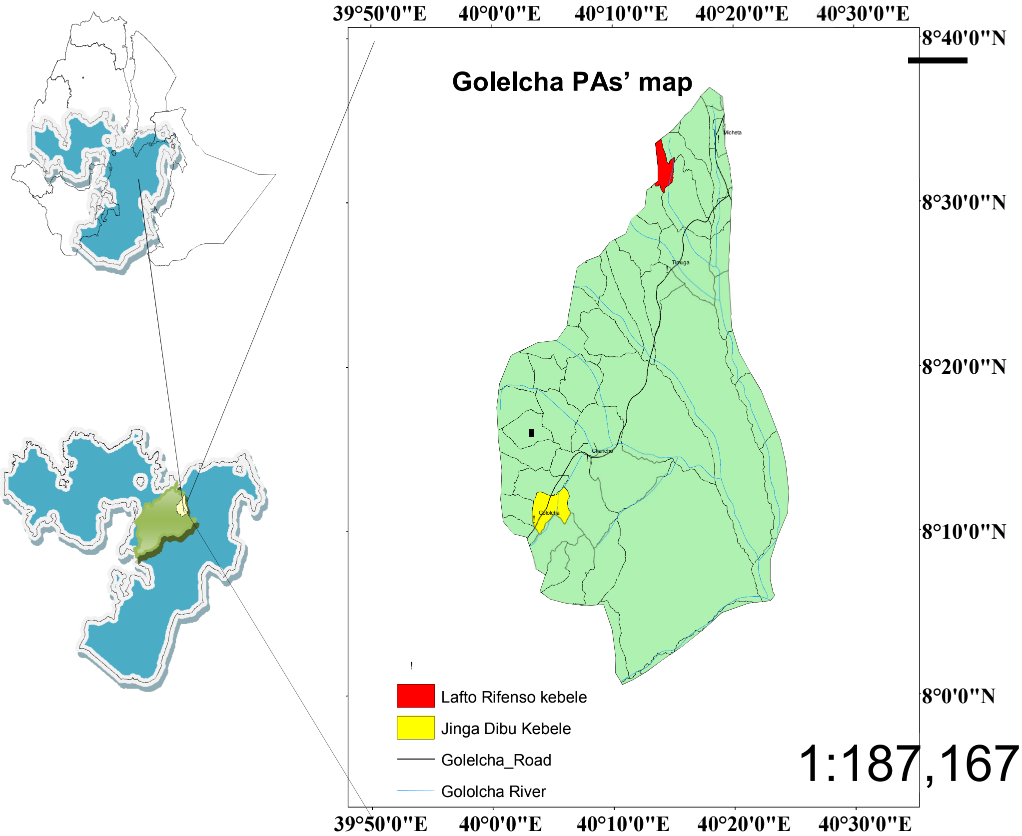

Figure 1 Study area map of Arsi Golelcha district (Source: Ethio-GIS lab in Haramaya University)

2.1.2. Climate and Rain fall

The study district experiences mean annual and monthly minimum and maximum temperature of 15 and 27°C, respectively and receives mean annual and monthly rainfall (figure 2) is 550 mm in the year of 2015 crop season. The seven years data of mean annual and monthly rainfall (figure 3) in the district are 703 mm minimum in the year of 2012 and 1486 mm maximum in the year of 2013 respectively which characterize the area having bimodal rainfall type.

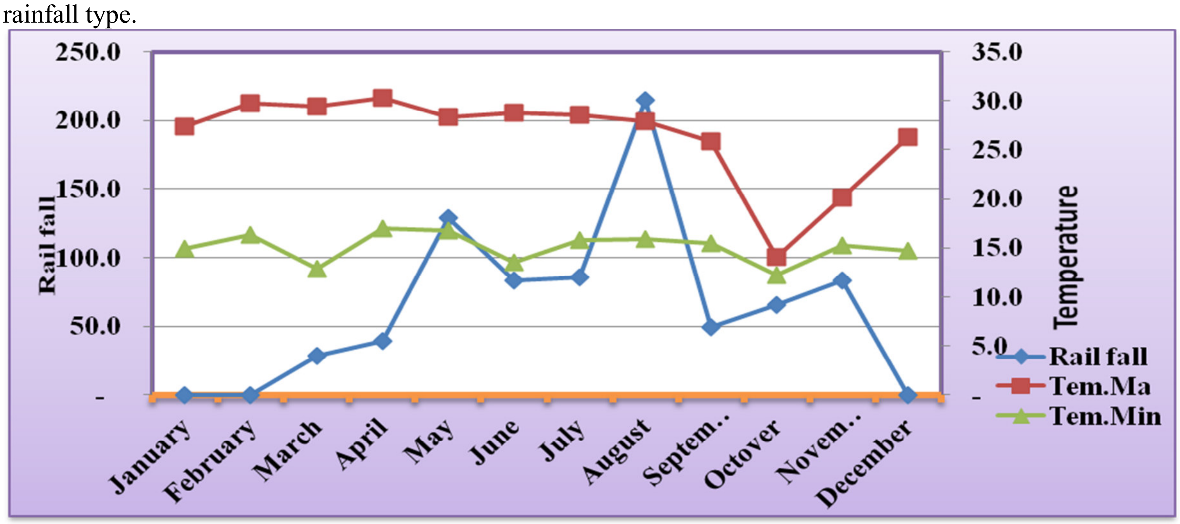

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Figure 2. Rain fall and Temperature data of Arsi Golelcha District, 2015 GC

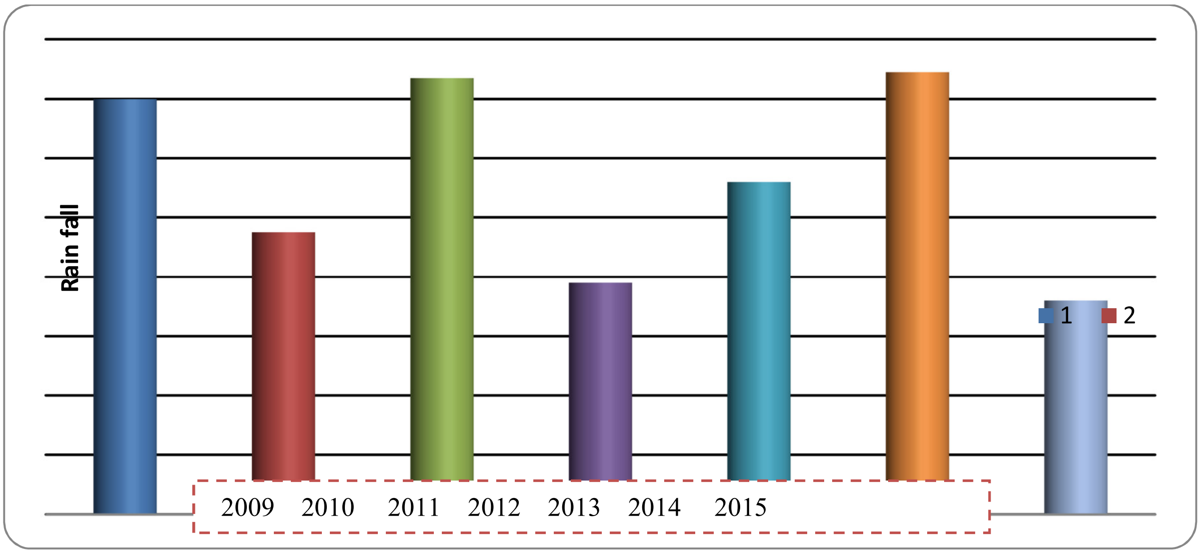

Figure 3. Seven years (2009-2015) Rain fall data of Arsi Golelcha District (Source: Metrology station of Arsi Golelcha District)

2.1.3. Land use/land cover

Coffee is one of the main crops in the district. *Khat* and fruits are important cash crops. Out of the total area of the district, 20.6% is arable or cultivable, 21.7% is for pasture, 27% is covered with forest and shrubs, and the remaining 30.7% is considered swampy, mountainous or otherwise unusable. Golelcha has an estimated population density of 94.7 people per square kilometer. From a total area of 1,818.120 square kilometers, the general soil of the district cambi-sol which is the best for agricultural purpose (Oromia livelihood Profile, 2006).

2.2. Site Selection

The study was conducted in Golelcha District at two PA (Mine Golelcha/Jingadibu and Baqayisa/ Laftorifenso). From the selected PA, three villages were assigned from each PA. Then the study was under taken on three farmer’s field from each village. To do this procedure, simple reconnaissance survey was applied in order to select villages and farmer’s field for further analysis. The farmer’s field was taken, as a representative across PAs over location with similar management practice; elevation and slope were considered for both under shade and out of shade effect of farm fields.

2.3. Data to be collected

Soil sample data were collected from field. The data of selected physicochemical properties of soil samples were identified after laboratory analysis. Finaly, the data of treatments were collected after software analysis for conclusion and recomendetion of research get.

2.4. Sampling and Processing Techniques

2.4.1. Soil sampling

To take soil samples; circumstance of the shade tree, optimum level of shade effect and distance from the shade tree trunk for each shade tree species were considered in order to evalute the impact of coffee shade trees on selected physicochemical property of soil through comparison of shaded and unshaded part of coffee farmes. To do this procedures,three distance layers were engaged under one coffee shade tree species that (1, 3 and 6m) away from the shade tree trunk under the canopy and >25m away from shade tree trunk out of the canopy. Each distance was separately taken as a plot which had a circumstance on its contour line from four directions (north, south, west and east). Soil sample of (0.25kg) each was collected from each sample layers with 0-30cm soil depth and one core of bulk soil were taken from each distance layer of shaded effect and out of shaded effect areas. Then, each soil sample tagged and merged to be one composite sample of disturbed soil and one core sample of undisturbed bulk soil from each layer were collected. Three composite samples and three core samples of soil under canopy effect and one composite sample and one core sample of soil outside of the canopy effect for each shade tree species were taken. The soil samples were eighteen composites and eighteen core samples under both shade tree species effect and six composites and six core samples out of shade tree effect from three farmer’s field, respectively. Overall, twenty-four composite samples and twenty-four core samples of soil from one PA, and forty-eight composite samples and forty-eight core samples of soil were collected from two PAs.

2.4.2. Soil sample processing

Effect of soil physical and chemical properties on soil parameters had been computed. The soil samples were analyzed based on chemical and physical properties of a given soil at Haramaya University in soil laboratory center. Among the soil physical properties; soil particle size distribution was analyzed using the Bouyoucos hydrometer method (Bouyoucos, 1962) after dispersing the soils with sodium hexameter phosphate ($NaPO_3$). Soil bulk density, from undisturbed soil sample, was determined using the core method after drying the soil samples in an oven at 105°C to a constant weight (Black, 1965). The core sampled soils were oven dried and the bulk density (Bd) was calculated by dividing the mass of the oven dry soil (g) by the respective volume (cm^3) as it exists naturally under field conditions.

The following soil chemical properties were analyzed for this study; organic carbon of the soils was determined following the wet digestion method as described by Walkley and Black (1934) while percentage organic matter of the soils was determined by multiplying the percent organic carbon value by 1.724. Total nitrogen (N) was determined using micro-kjeldahl digestion, distillation and titration procedure as described by Sahlemedhin and Taye (2000). Available phosphorus was determined using spectrophotometer after extraction of the soil samples with 0.5M sodium bicarbonate ($NaHCO_3$) solution at pH 8.5 following the Olsen extraction method (Olsen *et al.,* 1982). Soil (pH) was measured potentiometrically in the supernatant suspension of a 1:2.5 soil to water ratio using a pH meter (Thomas, 1996). For the determination of CEC, the soil samples were leached with 1N ammonium acetate solution and washed with ethanol (97%) to remove excess salt followed by leaching with sodium chloride to displace the adsorbed (NH+4). The quantity of ammonia was then measured by distillation and taken as CEC of the soil Chapman (1965); Rhoades (1982). Exchangeable potassium (K) was determined from the extract of 1M ammonium acetate at pH 7.0 with flame photometry instruments.

2.5. Sample Procedure and Experimental Design

The design was arranged with factorials in (RCBD) for soil samples' parameters by three replications for each treatment. Two shade tree species and four distance layers under each shade tree were taken as treatments of the study. Soil sample parameters: physical properties (texture and bulk density) and Chemical properties (pH, Total Nitrogen, available Phosphorous, Exchangeable potassium (K), Organic carbon, and Captions Exchange Capacity) were used.

2.6. Data Analysis

The collected and processed soil data were compared between shaded and open areas effect as well as between shade tree species effect based onsoil parameters. After laboratory processing, the results of soil parameters were analyzed by statistical software in order to get mean value difference. Generally, analysis of variance (ANOVA) was done to determine differences among the mean of the treatments (between shade tree effects and between shaded and unshaded parts of the results) with respect to selected soil physicochemical properties through SAS software program (SAS, 2002 v.9.1) following the General Linear Model (GLM) procedure.
The means that showed significant differences in F-test were separated by least significant difference (LSD) at (0.05 and 0.01) level, which used to multiple comparison procedures (Zar, 1996).

3. ESULTS AND DISCUSSIONS

3.1. Effect of Shade Trees on Physicochemical Properties of the Soil

3.1.1. Effects of shade trees on soil physical properties

3.1.1.1. Soil texture

The present study indicated that the mean value of silt particles under shade tree was greater than that of soil in open area in both PAs (Table 4). The highest value of silt content under both shade trees canopy zone was recorded at the 1st distance layer in JingadibuPA, while in Laftorifenso PA, the highest value of silt content was observed under the 2nd distance layers under both shade trees. The other soil textures were not observed significant difference rather than silt contents that availability of silt particle showed significant difference ($P<0.05$) between distance layers and shade tree species (Table 4).

As the size of mineral particle in a soil was readily subjected to change due to shade tree effect, textural class of a given soil makes its own general picture of the soil physical property and textural class (Prasada and Power, 1997) it shows that (Table 1). The results that different from the present study were reported by Abebe *et al*. (2001); Tadesse *et al*. (2001); Kamara and Haque (1992) about soil textures due to shade effect, there was no significant difference under and outside the canopy of Faidherbia albida, Milletia ferrugenia and *Cordia africana* trees, respectively in Ethiopia.

Hassen (2010) had reported a similar finding to this study that was in contrast of sand and clay but the silt content under the tree canopy zone of Erythrina abyssinica and Faidherbia albida was higher than that of open area by 21, 15 and 10%, at 0.5, 1.5 and 3m distance respectively. These variations may be credited to increase biological activity which might have enhanced weathering process and favorable moisture provision under the tree canopy. The soil under the shade has high soil micro-organisms and decomposers which may enhance soil silt contents. The other soil particles didn't show more significant difference under and outside the shade effect. Sand and clay particles can be changed duo to parent materials condition rather than simple effect within a short period of time such shade effects.

Table 1: Influence of tree species and distance from the trunk on soil texture contents (%)

Treatments		Laftorifenso PA				Jingadibu PA			
Tree	Distance	Sand%	Clay%	Silt%	Textural class	Sand%	Clay%	Silt%	Textural class
		Mean±Std				Mean±Std			
	1m	58.7±1.76	28.3±1.81	13± 2.09	SCL	74±1.51	9.5±1.01	16.5±0.92	SL
Cordia africana	3m	58±1.76	28±1.72	14±1.11	SCL	75.2±1.46	9.6±0.84	15.2± 0.92	SL
	6m	58.6± 1.41	28.2±1.45	13.2±0.35	SCL	75.4±0.75	9.8±0.74	14.8± 0.77	SL
Without-T	25m	59.3±1.93	28.4± 2.07	12.3±2.17	SCL	74.5±0.75	10.4±0.46	15.1± 0.50	SL
Erythrina byssinica	1m	58.7±1.35	27.7 ± 0.88	13.6±0.83	SCL	74±1.37	9.8±1.16	16.2±1.13	SL
	3m	58±1.56	28±1.07	14 ±1.32	SCL	75.4± 1.32	9.7± 0.99	14.9±1.13	SL
	6m	59.2±1.21	28.1± 0.80	12.7±0.56	SCL	75.2±0.61	10.4±0.89	14.4±0.98	SL
Without-T	25m	59.4± 1.73	27.8± 1.42	12.8±2.38	SCL	75.3± 0.61	10.4±0.61	14.3± 0.71	SL
LSD (0.05)		1.6	1.7	1.3	-	1.3	0.9	0.8	-
CV (%)		2.3	5	7	-	1.4	7.2	4.8	-

SCL=sandy clay loam, SL=sandy loam

3.1.1.2. Bulk density

The bulk density of the soil was significantly ($p<0.05$) affected with tree species by the distance from the tree trunk within both PAs. The lowest mean value of bulk density was under Cordia africana and Erythrina abyssinica shade tree species than out of shade effect. Nevertheless the highest mean value of bulk density was at 4th layer; which was out of shade effect across PAs. In general, the bulk density of the soil increased significantly with the distance away from the shade tree trunks (Table 1). Similar report was given by Tadesse et al. (2001) and Abebe (2001) under the canopy of Millettia ferruginea tree species effect; bulk density of soil was less than open areas.

The reason for the higher bulk density with increasing distance from the tree trunk might be due to higher organic matter accumulation, resulting in lower bulk density. However; the results of all bulk density shown in the treatments were found under very low rate, relatively there was a variation between shaded and unshaded effect based on FAO (2006a) soil rating description.

3.1.2. Effects of shade trees on chemical properties of the soil

3.1.2.1. Soil pH

In this study, the mean value of soil pH was higher under selected shade tree canopies than that of soil in open field across PAs. Under the canopy of both shade tree species, the highest mean value of soil pH was observed at 1^{rst} distance layer in JingadibuPA (Table 2). In Laftorifenso PA, the highest mean value of soil pH was observed under the canopy of *Cordia africana* shade tree at 2^{nd} layer, while under shade tree canopies, it was observed at the 1^{rst} distance layer, and the least mean value of soil pH was observed in open area across PAs (Table 2). Probability level of soil pH mean value showed highly significant difference ($P<0.01$) between shade trees species effect and significance differences ($P<0.05$) between shaded and unshaded soil effect in both PAs (Tables 4).

This study's result was in line with the result reported by Havlin *et al*. (1999) where in Laftorifenso PA, the pH value of soil on a given parameter was ranged from strongly acidic to moderately acidic, whereas in Jingadibu PA, the result was from moderately acidic to slightly acidic. This value was within the range of optimum soil pH for crop production (Table 2).

The investigation of soil pH under tree canopy versus open area has been reported by different researchers at different areas. According to Havlin *et al*. (1999), for example the soil was moderately acidic with mean pH 5.3-5.9 under canopy and very strongly acidic in open area with mean of pH 5.1. Abebe *et al.* (2001) reported that soil pH decreased with the distance from the tree trunk significantly under *Cordia africana* tree in Bako area. Similarly, Kamara and Haque (1992) reported a significant variation in soil pH horizontally under Faidherbia albida tree canopies.

In contrast to this, Jiregna *et al.* (2005) reported that there was no significant difference in soil pH under the canopies of *Cordia africana* and Croton macrostachyus compared to the open area. They are not reported that disproved the idea that lower soil pH value had been found defiantly from shaded areas of the coffee farms (Siles *et al.,* 2010; Souza *et al.,* 2012).

3.1.2.2. Organic Carbon

Organic carbon content of the soil under the canopy zone as well as in open area of both PAs showed significant difference ($p<0.05$) between distance layers and highly significant difference ($p<0.01$) between shade tree species in Laftorifenso PA, whereas in Jingadibu PA, a highly significant difference ($p<0.01$) was observed between distance layers as well as between shade tree species effect (Tables 4) The highest mean value of organic carbon was observed under both shade tree species at 2^{nd} layer but the least mean value was in the open soil across PAs (Table 2).

This result was confirmed with the result of Nyberg and Högberg (1995); Tadesse *et al.* (2000); Abebe *et al.* (2001); Kamara and Haque (1992) and Zebene *et al.* (2007). In contrast, Landon (1991) reported that organic carbon content of the soil both under the canopy zone and in open area was rated very low.

A slow but sure significant reduction in soil organic carbon was observed with increased distance away from the tree trunk starting from 2nd detachment interval towards open area with the exception of the 1rst detachment interval which had less organic carbon content than the 2nd detachment interval with regardless of the tree species and sites (Table 2). The variation of organic carbon content along distance from the 2nd layer towards an open area was quite reasonable as the higher contents of organic carbon under the tree canopies was due to higher accumulation of the litter falls and dead roots from the tree but in the case of the 1rst layer's distance of organic carbon contents was less than the 2nd layer across PAs. This result materialize may be due to lateral roots influence which was found in the nearest circumstance of shade tree trunk. As a result of this, organic carbon contents might be utilized highly by a dense lateral roots.

3.1.2.3. Total nitrogen contents

Mean value of total nitrogen content showed highly significant difference ($P<0.01$) between shade tree species and between distance layers across PAs. Total nitrogen concentration under the canopy of *Erythrina abyssinica* at all the three distances was higher than that of *Cordia africana* across PAs (Table 4). The highest value of total nitrogen concentration was observed at the second layer and the least value of total nitrogen was also found at open area across PAs respectively (Table 2).

Significant variation in total nitrogen between shade tree canopies and open area was also reported by different authors. Tadesse *et al.* (2001) noted that total nitrogen decrease with distance from *Millettia ferruginea* tree. Similarly, Yeshanew *et al.* (1999) and Abebe *et al.* (2001) reported that total nitrogen content was significantly higher under the canopy relative to the control under *Croton macrostachyus* and *Cordia africana*, respectively. The total nitrogen content for both canopy zone and open area rated medium according to (Landon, 1991).

Generally, the variation between shaded and unshaded mean value of total nitrogen might be due to high accumulation of organic matter under the tree canopy and fixation of atmospheric nitrogen with the tree species.

3.1.2.4. Available phosphorus

The results of this study revealed that availability of phosphorus in both areas under both shade tree species canopy and horizontal distance starting from the first layers to the end layers (open area) with a stepwise increasing outcomes available P (Table 2). Available phosphorus content showed highly significant difference ($P<0.01$) between shade tree species and between distance layers effect across PAs (Table 2). The highest mean value of phosphorus availability was observed in open area but the least value of phosphorus availability was noted at the 1rst layers under both shade tree species across PAs, respectively (Table 2).

This result coincide with Powlsn (2011) finding that the variation between shaded and unshaded effect might be resulted in increased fixation by Iron and Aluminum oxides, destabilization of the soil structure and reduced soil biological activity. In the contrary, Kho *et al.* (2001) reported that the phosphorus availability in the soil was estimated to be almost 30% higher under *Faidherbia albida* tree canopy than open field. A Similar report by Souza *et al.* (2012) that the phosphorous availability under coffee shade tree was higher than that of open coffee areas.

The increment of horizontal variation from tree trunk to the open area may be due to less and less mobility of the phosphorus available in the soil and it may be long lasting characteristics before changes to other forms which need high source of decomposers in addition to lateral root characteristics.

3.1.2.5. Cation exchange capacity

The result of CEC showed a highly significant difference ($P<0.01$) between shade tree species and between distance layers across PAs correspondingly (Table2). The highest mean value of CEC was observed at the 2nd distance layer away from both shade tree trunks and the least mean value of CEC was also noted in the open area across PAs (Table 2).

According to Landon (1991) report, the Cation exchange capacity of the soil under the canopy was very higher than that of the samples from the open area. The other findings were reported by Abebe *et al.* (2001), Tadesse *et al.* (2001) and Yeshanew *et al.* (1998) under *Cordia africana*, *Millettia ferruginea*, and *Croton macrostachyus*, respectively, showed that CEC had significant increments under the tree canopy compared to outside the canopy area.

Under both shade tree species across PAs, as compared to open area significant decrease in the values of CEC was seen starting from the 2nd layer distance towards an open area. This was quite reasonable perhaps due to higher organic matter accumulation under the tree canopies than the open fields. This implies that, the release of more cat ions to the soil through mineralization effect with increasing negative charges in the soil. As the amount of organic matter in the soil increased, the total negative charge in the soil increased which in turn increased the CEC of the soil; this relationship was also observed in the present study.

3.1.2.6. Exchangeable potassium

The result showed a highly significant variation ($p<0.01$) in exchangeable potassium as it is affected by both shade tree species and distance layers across PAs (Table 4). The highest mean value of exchangeable potassium was indicated at the 2nd layer under both shade trees effect and the least mean value of exchangeable potassium was designated in the open area across PAs respectively (Table 2).

The mean value of exchangeable potassium at 3m and 6m away from the shade tree trunk under *Cordia africana* canopy exceeded that of the exchange in open area by 0.2 and 0.1cmol (+)/kg, while the mean value under Erythrina abyssinica canopy was greater than in the open area by 0.17, 0.19 and 0.1cmol (+)/kg in Laftorifenso PA. Similarly; in JingadibuPA, the value of exchangeable potassium at the same distance, under *Cordia africana* canopy was greater than the one in open area with 0.17, 0.18 and 0.1 cmol (+)/kg and under Erythrina abyssinica it was better than the open area with 0.18, 0.19 and 0.11cmol (+)/kg respectively.

On the other hand, the exchangeable potassium content of both canopy zone and open area was rated high according to (Landon 1991) investigation which was in contrast to this study.

Commonly, Interaction effect showed highly significant difference (P<0.01) between shade tree species as well as between and within distance effect across PAs and combined analysis of variance between PA showed highly significance difference (P<0.01) for almost all on the results of coffee's parameters likewise across PAs (Table 3).

Figure 1: The process of Soil sample taken from farmers' field and taken processed in Haramaya University soil laboratory for further analyzetion

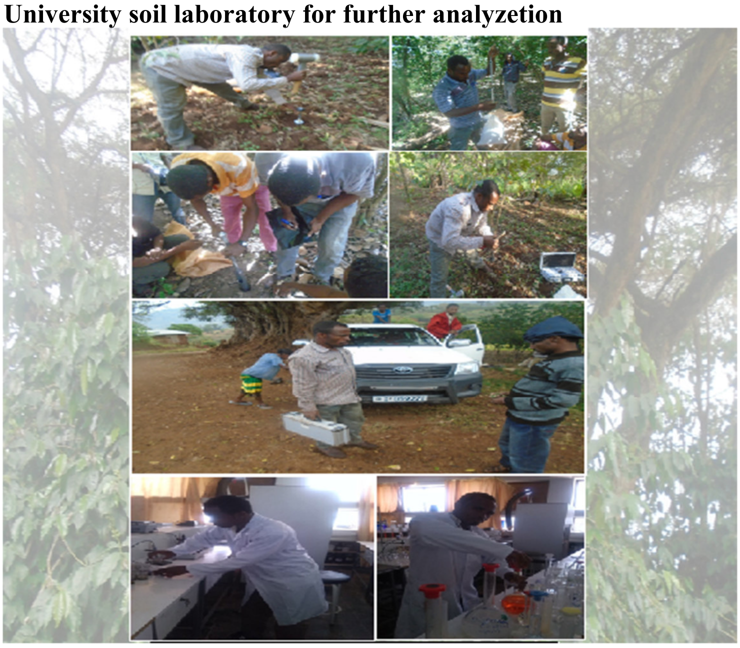

Table 2: Influence of shade tree species and distance from tree trunk on soil chemical properties' value

Treatments		Laftorifenso PA Mean±Std							Jingadibu PA Mean±Std						
Tree species.	Distance (m)	Bulk density	soil pH	OC (%)	total N (%)	P(PPM)	CEC (meq/100g)	Ex.K (cmol (+)/kg		soil pH	OC (%)	total N (%)	P(PPM)	CEC (meq/100g)	Ex.K (cmol (+)/kg
Cordia africana	1m	0.6±0.04	5.3±0.34	2.2± 0.1	0.21 ±0.1	20.2 ±1.2	19 ±1.37	0.45 ±0.2	0.6±0.05	6.5± 0.22	3.1± 0.2	0.3± 0.02	19.5±1.0	25.6±4.2	0.6±0.4
	3m	0.5±0.03	5.7 ±0.34	3 ±0.37	0.27 ±0.2	16.9 ±03.5	30.7± 4.0	0.64 ±0.03	0.5±0.04	6.4 ±0.22	3.3±0.4	0.4 ±0.02	19.6 ±1.2	29.6±3.4	0.6±0.4
	6m	0.5 ±0.04	5.6 ±0.38	2.7±0.1	0.25 ±0.1	19.32 ±2.5	28.02±2.5	0.55 ± 0.2	0.5± 0.05	6.3 ±0.20	2.9±0.3	0.3 ±0.03	21.2±1.5	24.6±3.8	0.5 ±0.5
Without-T	25m	0.6 ±0.04	5.2 ±0.39	2.2±0.1	0.21 ±0.1	20.94 ±2.0	20.3±2.13	0.45 ±0.3	0.6± 0.03	5.9 ±0.12	3.1± 0.2	0.2±0.2	24.3± 0.7	18.1±2.6	0.5 ±0.2
Erythrina abyssinica	1m	0.6 ±0.05	5.8 ±0.31	2.9±0.3	0.26 ±0.1	17.6 ±2.5	26.2 ±.01	0.58 ±0.1	0.5 ±0.05	6.6±0.20	3.4 ±0.3	0.3±0.2	20.5±1.4	27.9±3.8	0.6±0.2
	3m	0.5 ±0.02	5.6 ±0.18	3.1± 0.4	0.28 ±0.2	18.9 ±3.2	28.7± .69	0.60 ±0.1	0.5 ±0.05	6.5 ±0.20	3.6± 0.5	0.4 ±0.2	20.6± 1.5	31.9±2.9	0.6 ±0.3
	6m	0.5 ±0.02	5.5 ±0.22	2.9±0.2	0.26 ±0.2	21.3 ±2.1	26.1±1.11	0.51 ±0.1	0.5± 0.06	6.5±0.18	3.2±0.4	0.3 ±0.3	22.2± 1.8	26.9±0.4	0.5 ±0.2
Without-T	25m	0.6 ±0.02	5.1 ±0.23	2.3 0.2	0.22 ±0.1	22.9 ±1.6	18.3±0.8	0.41 ±0.1	0.6 ±0.04	6.0±0.10	2.5±0.3	0.2 ±0.2	25.2 ±1.0	20.4±2.2	0.4 ±0.1
LSD(0.05)		0.04	0.3	0.3	0.02	0.8	1.9	0.06	0.05	0.2	0.2	0.02	0.4	0.9	0.06
CV (%)		6.4	4.7	8.5	8.5	3.6	6.7	10	7.2	2	6	8	1.6	3	8.7

Table 3: Significance level of F value for different soil parameters with respect to distance from the tree trunks and tree species in Golelcha District (Combined analysis of variance across PAs).

Soil parameters	Laftorifenso PA			Jingadibu PA			PA effect	Interaction effect		
	Tree effect	Distance effect	Interaction Effect	Tree effect	Distance effect	Interaction Effect		Tree* PA effect	Distance * PA effect	Tree * Dist. *PA effect
pH	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
OC(%)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Av.P(ppm)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
CEC(meq/100g)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TN(%)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Exch.K(cmol(+)/kg	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
SILT(%)	0.0001	0.0001	0.008	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Bd (gcm^{-3})	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

"Ert.=Erythrina abyssinica; Cor=Cordia africana; PA=peasant association, pH=soil pH, OC=organic carbon, Av. P=available phosphorus, CEC=Cation exchange capacity, Bd=bulk density and Exch. k=exchangeable potassium, and TN=total nitrogen.

Table 4**.** Mean values for physicochemical property of the soil as influenced by distance from the trunk of *Cordia africana* and *Erythrina abyssinica* shade trees in coffee fields at Laftorifenso and Jingadibu PA, Golelcha District

Soil parameters	Trees	1m		3m		6m		Open area	
		LPA	JPA	LPA	JPA	LPA	JPA	LPA	JPA
pH	*C. africana*	5.31	6.50	5.67	6.40	5.57	6.32	5.18	5.89
	E. abyssinica	5.79	6.62	5.55	6.52	5.45	6.45	5.05	6.01
	*Mean**	**5.55 a**	**6.56a**	**5.61b**	**6.46b**	**5.51 b**	**6.38b**	**5.11c**	**5.95c**
OC (%)	*C. africana*	2.20	3.09	3.00	3.33	2.74	2.90	2.17	2.21
	E. abyssinica	2.96	3.39	3.13	3.62	2.87	3.20	2.30	2.50
	*Mean**	**2.58 b**	**3.24b**	**3.07 a**	**3.47a**	**2.81b**	**3.05c**	**2.23c**	**2.35d**
Av.P (ppm)	*C. africana*	20.21	19.50	16.99	19.58	19.32	21.20	20.94	24.25
	E. abyssinica	17.55	20.49	18.98	20.57	21.30	22.19	22.93	25.24
	*Mean**	**18.9 c**	**20.00c**	**17.98d**	**20.08c**	**20.31b**	**21.70b**	**21.93a**	**24.74a**
CEC (meq/100g)	*C. africana*	18.50	25.58	30.67	29.63	28.02	24.63	20.27	18.13
	E. abyssinica	26.20	27.88	28.70	31.93	26.05	26.93	18.30	20.43
	*Mean**	**22.35b**	**26.73b**	**29.68a**	**30.78a**	**27.03b**	**25.78c**	**19.28c**	**19.28 d**
N (%)	*C. africana*	0.21	0.25	0.27	0.27	0.25	0.25	0.21	0.21
	E. abyssinica	0.26	0.26	0.28	0.28	0.26	0.26	0.22	0.22
	*Mean**	**0.24b**	**0.25b**	**0.27a**	**0.28 a**	**0.25b**	**0.26 b**	**0.21c**	**0.22c**
Exch.K (cmol(+)/kg	*C. africana*	0.45	0.63	0.64	0.64	0.55	0.56	0.45	0.46
	E. abyssinica	0.58	0.63	0.60	0.64	0.51	0.56	0.41	0.45
	*Mean**	**0.52 b**	**0.63a**	**0.62a**	**0.64a**	**0.53b**	**0.56b**	**0.43c**	**0.45c**
SILT (%)	*C. africana*	13.25	15.25	16.42	15.25	16.17	14.25	13.17	12.50
	E. abyssinica	16.42	15.08	16.42	15.08	16.17	14.08	13.17	12.33
	*Mean**	**14.83a**	**15.17a**	**16.42 a**	**15.17a**	**16.17a**	**14.17b**	**13.17 b**	**12.42c**
Bd (gcm^{-3})	*C. africana*	0.63	0.56	0.53	0.53	0.54	0.53	0.61	0.60
	E. abyssinica	0.55	0.53	0.52	0.50	0.54	0.50	0.61	0.57
	*Mean**	**0.59b**	**0.54 b**	**0.52c**	**0.51 c**	**0.54c**	**0.51c**	**0.61a**	**0.59 a**

" Letters that 'a'; 'b' ;'c' and 'd' refers significance difference at (p<0.05) and (p<0.01) level in horizontal direction based on shade tree and distance effect, and similar letters are indicated non-significance difference at a given level" and ' C. africana =Cordia africana; E. abyssinica=Erythrina abyssinica '
*" *= mean value; pH=soil pH; OC=organic carbon; Av. P=available phosphorus; CEC=Cation exchange capacity; Bd=bulk density; Exch. k=exchangeable potassium; LPA=Laftorifenso PA and Jingadibu PA*

4. CONCLUSIONS AND RECOMMENDATIONS

The influence of Agroforestry plays a great role with different soil management systems in which physical, chemical and biological properties of a given soil is prerequisite to safeguard them before they go out of production .Ethiopia is agricultural dependent based on seasonal rain fall chancellor. Deliberate growing of shade trees on farmlands, it is an agroforestry practice, to improve soil firtility, sustain environmental biodiversity, increase productivities of production. The pressure from rapidly growing of human population has been directly and indirectly attenuation interests of natural resources. However, fertility of soil and coffee productivity under this system has not been comprehensively evaluated and properly documented. Indigenous coffee shade tree species, namely '*Erythrina abyssinica* and *Cordia africana'* were carried out on six farmers' field across PAs in order to investigate the given treatments' parameters. In the implementation of shade trees, *Erythrina abyssinica* was found to have higher significant value than *Cordia africana* shade tree with almost all soil parameters from a given results; however the dominance of the species in the coffee farm was mainly because of its economic value, farmers preferred *Cordia africana* rather than ecological services. It covered about 60% and 48% of farm-land in Laftorifenso and JingadibuPA while *Erythrina abyssinica* covered about 23% and 26% of farm-land in Laftorifenso and JingadibuPA, respectively.

Organic carbon and total nitrogen mean value in the soil is more positively and significantly increased under the shade effect than the other constraints. On the contrary, bulk density is decreasing under the shade effects. These consequences illustrate the value of organic carbon and total nitrogen in the soil is a vital factor for almost all of parameters under shaded effect. Bulk density is also another main aspect of consideration which has an influential factor over a given constraint especially under unshaded effect of soil across PAs. With the exception of available phosphorous and bulk density, all soil properties increased significantly under the tree canopy than in the open area in both PAs showing decreasing trend with increasing distance from the tree trunk. However, significant differences in all selected soil physicochemical properties were observed between tree species as well as between distance layers across PAs (Table 1, 2 and 4). The study also revealed that the fertility of the soil gradually decreased as the distance away from the shade tree trunks increased starting from the 2nd distance layer due to the inputs from *Erythrina abyssinica* and *Cordia africana* tree species. In the 2nd distance layer, the litters of trees provided were maintained and the organic matter produced as a result continued to accumulate under the canopy. The nearest and the farthest layers' result was indicated less than the 2nd distance layer in most parameters of treatments. The variation of layers' outcomes may be due to accumulation of litter falls intensity as the distance increased from the shade tree trunks and capability of lateral roots consumed the litter falls as the distance decreasing from the shade tree trunks.

In a conclusion, Golelcha's District coffee farm land features deserved an official recognition as farmers' integration of coffee with shade trees can lead to be initiator of sustainable agriculture with organic coffee producer thereby organic soil improvements which is a promoter of climatic resilience through sustainable natural resource managements. It needs such a certification because it can show how other farmers can be resilience to climate change and to sestain natural resource management in order to improved their livelihoods dependancy without jeopardize natural resource utility for the next generation.

Successively across PAs, in almost all parameters, the best results were at the 2nd layer (3m) away from the shade tree trunks. This layer was designated to have better effect than the other layers under both coffee shade effect of soil parameters. Based on the investigated effect of treatments, it can be recommended that remarkable distance of coffee seedling plating area is 3m away from the shade tree trunks under both shade tree species. However, *Cordia africana* was prevalent shade tree over most part of coffee fields. The empirical data obtained thus, confirms that the best result was found in most parameters of physicochemical property of the soil under *Erythrina abyssinica* shade tree species across PAs. Therefore, *Erythrina abyssinica* shade tree was the more recommended than *Cordia africana* shade tree based on the given results.

Convenience of shade tree which was currently being practiced in the area significantly improved coffee production, soil fertility and livelihood of the people. Therefore, the trees integration in the farming system is valuable and should be promoted by relevant stakeholders to be regarded as exemplar for farmers in neighboring districts who had been producing coffee without shade trees. This practice should be promoted in most districts of Hararghe that where coffee farmlands nearly wiped out and have been replacing with *Khat.* Although the present study indicated that a substantial contribution of coffee shade trees to soil fertility improvement, this could not be an end in itself. Much more research work needs to be done in the following hesitation area of research potential:

The further study should be conducted on nutrient dynamics under the canopy effect to determine when branch have to be pollarded for off-site uses or *in situ* soil conservation activities. Determinations of *Erythrina abyssinica* feeding habit (crude proteins and total digestible nutrients) have to be identified for sustainable animal production. Studies regarding the micro floral population associated with coffee shade trees such as Rhyzobia species and mycorrhizal fungal associations are of principal importance as the soil improvement under the tree strength if being correlated with them. The root architectures of tree and photosynthesis variation needs better investigation due to shade intensity effect.

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