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Evaluation of Coffee (Coffea arabica L.) on Raw and Cup Quality Aspect Under the Canopy of Cordia africana and Erythrina Abyssinica Shade Trees Effect in Arsi Golelcha District, Ethiopia

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Abstract
Coffee is shade tolerant and traditionally grown under shade trees in complex agroforestry systems, thereby providing production quality, a safe haven for biodiversity and sustaining other ecosystem services. Ecological and economical significance of coffee production with shade has an advantage for universal entry as a good opportunity to improve sustainable development through natural conservation and financial target. Coffee plantation with shade trees is important to improve raw and cup coffee quality which is based on sensory attributes that were evaluated by descriptive sensory analysis of free choice. 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 (under the canopy of Erythrina abyssinica and Cordia africana trees) on raw and cup quality of coffee (Coffea arabica L.) and to get best coffee shade trees and 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 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 trees 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 shade tree. The outcome had a significant value at ($p<0.05$) and highly significance value at ($p<0.01$) between and within the treatments. Statistically significant comparison differences were observed between shaded and unshaded as well as within shaded effect based on the parameters across PAs. Integration of shade in coffee farming system created creditable promising in producing of quality of organic coffee. Coffee 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 coffee 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 trunk. Average result of both PAs' coffee parameters; the greater value of screen size of coffee beans; 9.1% and 7.7%, shape and make of beans; 1.08 and 1.085, aromatic intensity; 0.47 and 0.035, aromatic quality; 0.38 and 0.33, acidity; 0.5 and 0.5 and body of coffee beans; 0.53 and 0.57 than open areas were detected under the canopies of Cordia africana and Erythrina abyssinica shade trees, 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 vital signal of the treatment's means difference were indicated between shaded and unshaded rather than within shaded means variation at most treatments' parameters.
Keywords: Coffee-based agroforestry system, Coffee shade value and Coffee quality attribution.

1. INTRODUCTION

1.1. Background and Justification

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). The value of coffee for producers' country about $ 14 billion annual income generator and more than 18 countries, including Ethiopia, export coffee product to more than 165 countries providing a livelihood for an estimate of 100 million people around the world (ICO, 2001). 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 which is contributing about 4.2 percent of total world coffee production since Ethiopia is the birthplace of *Coffea Arabica* (AfDB, 2010).).

Coffee Quality is described as a set of inherent characteristics of a product to fulfill requirement of customers and other interested parties (ISO, 2000). The definition of coffee quality and the attributes considered have been evolved varies along the production-to-consumer chain. At the farmer level, coffee quality is a combination of production level, price and easiness of culture; at the exporter or importer level, coffee quality is linked to bean size, lack of defects and regularity of provision, tonnage available, physical characteristics and price; at the roaster level, coffee quality depends on moisture content, stability of the characteristics, origin, price, biochemical compounds and organoleptic quality (Leroy *et al.,* 2006). It should be noted that each consumer

market or country may define its own organoleptic qualities; at the consumer level: coffee quality deals with price, taste and flavor, effects on health and alertness, geographical origin, environmental and sociological aspects (ISO, 2000). More specifically, ISO (2004a) defined a standard for green coffee quality (ISO 9116 standard) as, it requires several pieces of information, like the geographical and botanic origins of the coffee, the harvest year, the moisture content, the total defects, the proportion of insect-damaged beans and the bean size. These ISO standards define methods of measurements for several of these qualities such as, defects, moisture content, bean size, some chemical compounds and preparation of samples to perform cup tasting. Coffee quality is conformance with requirements or fitness for use in which the parties involved in the industry (customer, processor, supplier, etc) should agree on the necessities and the requirements should be clear to all stake holders involved in the process (QSAE, 2000).

Coffee production with shade is one of the best instances of agroforestry practices of organic farming system in Ethiopia. It is a worldwide issue given attention to sustain and restore nature. 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 (Mark, 2005). The Shade tree improves genetic resource of Coffea arabica, biodiversity and ecological management strategy. Additionally, 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 nutrient unless and other-wise roots damage leaves abscise and branch dies back to the petiole (Yunianto, 1986).

Shade tree enables coffee berries to be matured with better bean filling in merit attribute of coffee quality such as bean size, aroma, flavor, odor, acidity, etc and shade improved the appearance of green and roasted coffee beans as well as the acidity and body of the brew, especially for those produced in suboptimal (low altitude) coffee production zones, by promoting slower and balanced filling and uniform ripening of berries (Muschler, 2001). The function of shade trees are developing periscarp and perisperm tissue, vital syntheses of sucrose and phosphate enzymes in which higher peak of action in building up endosperm bandannas in order to sense in mature coffee beans which is being improve organoleptic coffee quality (Steiman,2003; Geromele *et al.,* 2008). Shade tree has a great advantage on coffee value for price determine and quality analysis therefore, worldwide influence in coffee price directly coincide with its quality. Shaded systems are known to produce higher quality coffee beans which is increasing the acceptability of specialty coffee markets (Muschler, 2001; Vaast *et al.,* 2006). Since the specialty coffee market has doubled over the last decade and is expected to keep growing price premiums received by small scale farmers as a result of environmental certification thus, can play an important role in raising farmers' incomes (Lyngbæk *et al.,* 2001; Jha *et al.,* 2014). Additionally, there are so many factors to be coffee quality attributer rather than management, genetic and geographical location such as post harvesting, pre-harvesting and processing condition are also an influential factors (Mohammedsani, 2014).

Accordingly, shade tree reduced the vapor pressure between the interior of the leaf and the atmosphere to minimize high leaf temperature (Chege, 2011). Since coffee had been found in the forest, it naturally needs shade for sustained production of coffee yield and for its overall health (Ferrell and Cockerill, 2012). Shade tree improves coffee production moderately for a long period of time and it reduces evapotranspiration that favor condition of microorganism activation 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.

However, population number is increasing; it is creating cultivable land shortage. As many coffee grower farmers, by abandoning their traditional coffee growing system, have begun integrating food crops with coffee plants without shade tree, especially on coffee farm in Hararghe zones' (McARC, 2005). This lately adapted system made farmers expose their coffee plants to intensive use of chemical fertilizers, insecticides, herbicides and fungicides which resulted in coffee plants; over bearing problem and branch dieback which is resulted for less coffee quality production (Osman, 2001).

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. Therefore; the study was carried out in order to evaluate the effect of shade tree on coffee (*Coffea arabica* L.) at raw and cup quality aspect. In doing so, importance of the study was indicated the following points: (a) to be magnify understanding of government and other stockholders towards certification approach and (c) to be a base-line study for further scientific research extension to promote the recommended technologies 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.

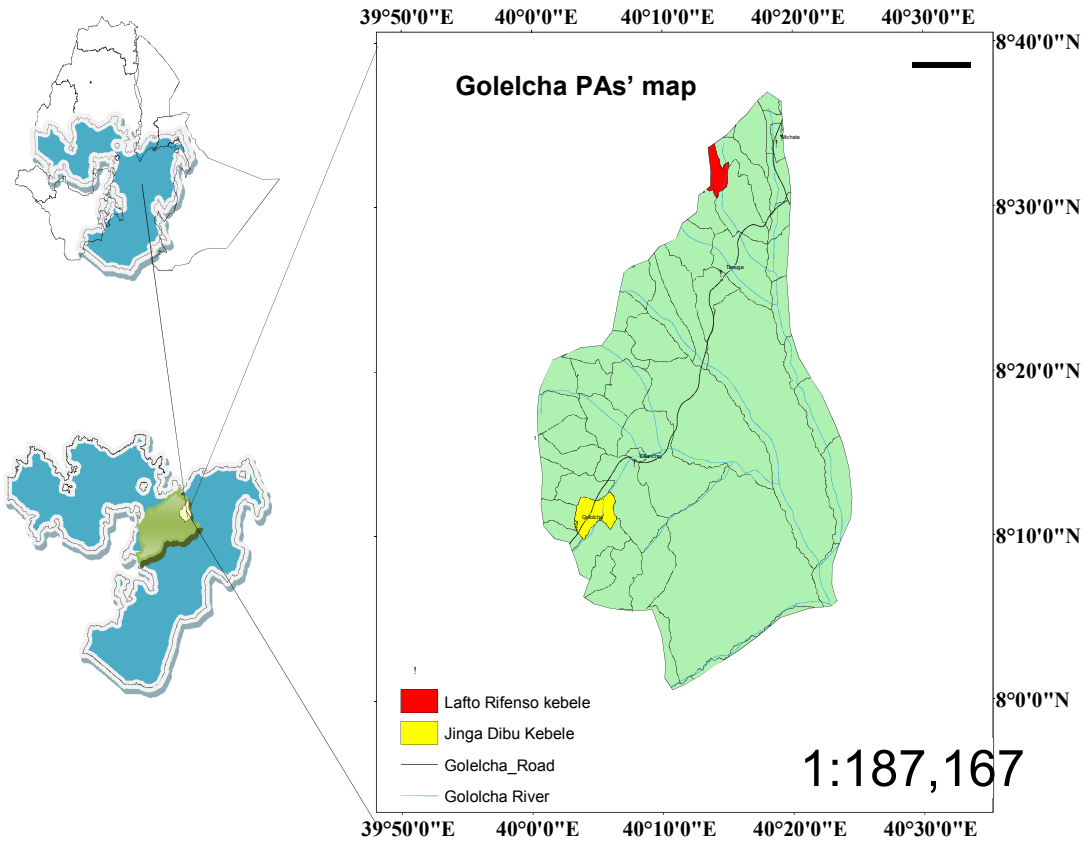

Figure 1 Study area map of Arsi Golelcha district (Source: Ethio-GIS lab in Haramaya University

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 a bimodal rainfall type.

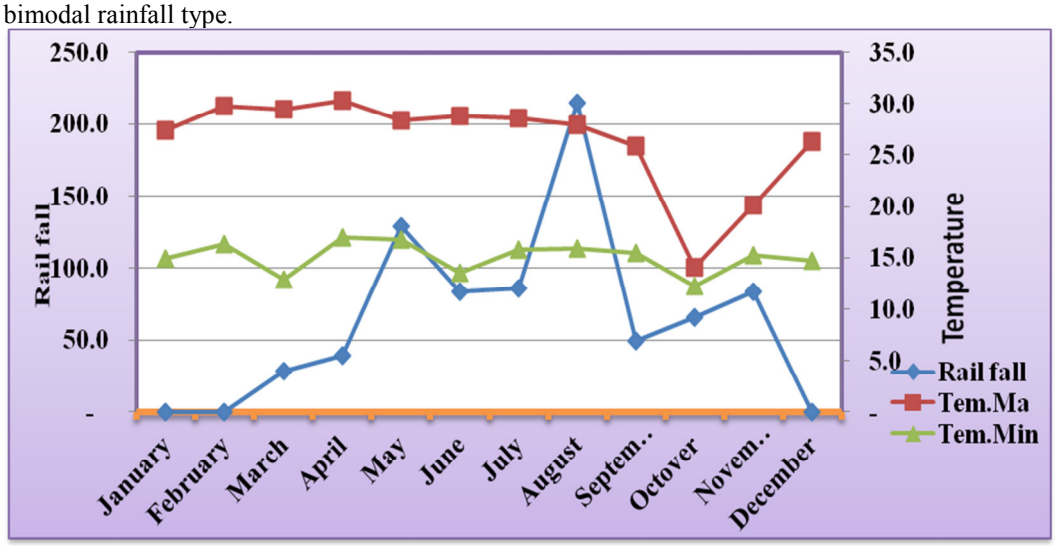

Figure 2. Rain fall and Temperature data of Arsi Golelcha District, 2015 GC

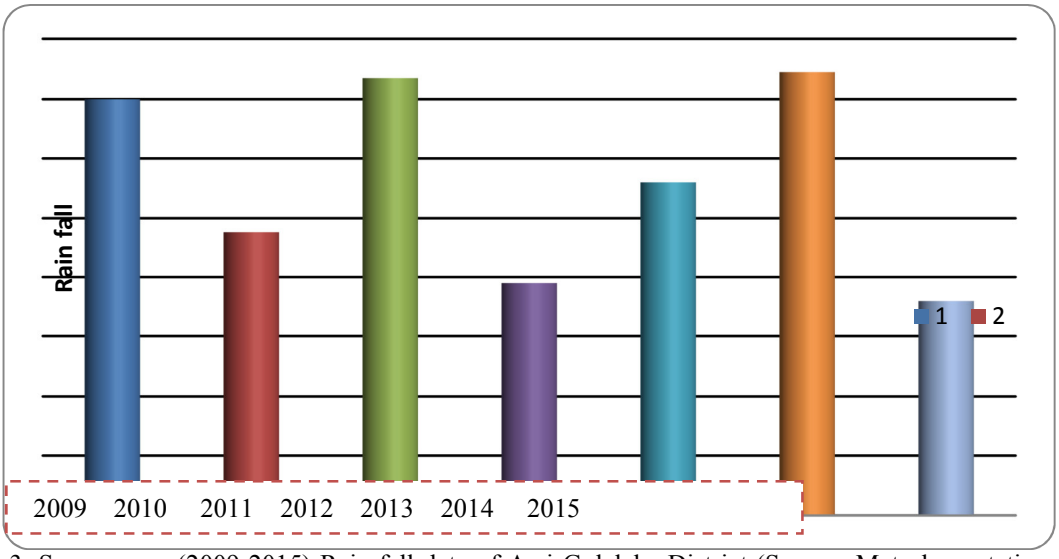

Figure 3. Seven years (2009-2015) Rain fall data of Arsi Golelcha District (Source: Metrology station of Arsi Golelcha District)

2.1.3. Land use/land cover

Coffee is one of the main crops in the district. *Kha*t 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 unshaded and shaded coffee plantations.

2.3. Data to be collected

Data of coffee production: Raw and cup coffee quality such as screen size, color, odor (raw coffee quality) and aromatic intensity, aromatic quality, acidity, astringency, body, bitterness, flavor and over all quality (cup coffee quality) were collected.

2.4. Sampling and Processing Techniques

2.4.1. .Coffee Shade Trees Selection

Targeted shade tree species (*Cordia africana* and *Erythrina abyssinica*) having dbh ≥20cm size, height of ≥5m length, and the shaded and unshaded coffee plantation, which have similar branch and crown on the same gradient and elevation that seven to ten years old and ≥ 3m height were selected purposively from three villages and three farmers' fields as replication for each PA.

2.4.2. Coffee beans sampling

Coffee plants which originated under shade influence and spread over the three distance layers, that are 1, 3 and 6m away from the shade tree trunk and those which originated out of shade influence 25m away from the trunk were selected respectively. Thus were four coffee plants in all (West, East North and South) direction of coffee plating areas at each distance layer (1, 3 and 6m) away from the shade tree trunk, and four unshaded coffee plants, 25m away from shade effects were purposively selected and assigned for sample collection .

The coffee trees were selected based on canopy coverage of the shade tree and proportionality of coffee bean with equal range of all shade trees to count and measure coffee beans. Then, six coffee branches were selected and 2 coffee branches were marked from the lower, middle and upper stick branch from west and east directions for each sample coffee plants at each distance layer. 5 kg of fully ripe coffee cherry beans were collected from one layer and taken to be as one coffee sample from each distance layer (Siles et al., 2010; Bote and Struik, 2011). The same procedure was followed for both shade tree species on each farmer's fields that eight coffee bean samples from one replication/ farmers' field under both shade tree species and twenty-four

coffee bean samples from three farmers' field in one PA, and over all forty-eight coffee bean samples were collected across PAs, respectively. The harvested coffee bean was dried until a constant moisture content of 12%. Dry coffee beans were weighted using digital measuring balance on basis of 1000 seed weight from shaded and unshaded coffee plants under each shade tree species from each study area of farmers' field in each distance layers from each coffee bean samples (Siles et al., 2010; Bote and Struik, 2011).

2.4.3. Coffee cherries drying process

The oldest and simplest method producing' natural' coffee is 'sun drying' that has been adopted throughout all coffee growing areas in Ethiopia, and in Arsi Golelcha this system was the only processing method. The cherries were spread out evenly on mesh wire to dry in the sun. Each sample cherries were dried until the recommended moisture content of 11-12% was attained. Then after, the sample cherries were hulled with mortar as farmers have been practicing carefully and cleaned. Finally, the green coffee beans were labeled and packed in transparent polyethylene bags where berries stabilize their moisture content and quality attribute. The packed dry coffee bean was then transported to Jimma Agricultural Research Center for determination of the coffee quality.

2.4.4. Coffee beans' Sample process

The packed and collected samples were prepared using proper method of processing and arbitrary code (identity letter) was assigned to secure unbiased judgment. The packed dry coffee bean samples were transferred to coffee quality laboratory at Jimma Agriculture Research Center to evaluate the quality, based on screen size, color, odor (raw coffee quality) and aromatic intensity, aromatic quality, acidity, astringency, body, bitterness, flavor and overall quality (cup coffee quality) attributes.

2.4.4.1. Screen size of coffee beans

Bean sizes were determined by conventional screen analysis of perforated plate screen sizes of 14 with respective whole diameter of 5.55mm (Wintgens, 2004). 300g of each coffee samples were replicated three times and measured using digital beam balance.

The coffee beans were graded by 'size using standard screen' that have different screen size, with 'round holes' as defined by (ISO, 1991). The normal sizes of coffee beans were remained over the screen in order to determine their normality percentage while undervalued and broken beans were separated from each sample. Finally, the defect count percentage was recorded as per national fixed standard (JARC, 2008).

2.4.4.2. Raw coffee quality grade evaluation

During physical quality analysis; 300g of green bean was used for each sample for their qualities attribute such as 'shape and make', color and odor. These quality attributes were measured according to the Ethiopian standard (ES, 2001; ECX, 2009). Based on raw quality parameters' grading was done in account of 40% as per (JARC 2008) and shown in (Table 4).

2.4.4.3. Aroma and cup quality grade evaluation

Three cups per treatment in three replications were prepared for each tasting session. The cup quality had been carried out by a panel of Jimma Agricultural Research Center panelist who formed a team of trained, experienced and certified quality Graders and Cuppers in order to get aroma and cup quality values in account of 60%. In this case, three experienced tasters participated in a panel to evaluate coffee bean samples' aroma and taste characteristics of each treatment of coffee brew involving olfaction, gestation, and mouth feel sensation. For each sample using the round soup spoon raise six to eight cc of liquid to just in front of the mouth and forcefully slurp the liquid. Aroma was evaluated by sensation. The aroma was obtained from gasses that brewed coffee released.

The released gasses were inhaled through the nose by sniffing and briskly/quickly aspiring, the coffee. In this way, spread evenly over the entire surface of the tongue. Sensory evaluation was done using the following quality criteria in scale range of (, color, odor, aromatic intensity, aromatic quality, acidity, astringency, body, bitterness, flavor and overall quality) value that described under (Table 2). Based on these measures, a scale comprising point that ranged from 1-15 was used. The least point on the scale is (0) corresponding to the total absence and the highest point is (15) corresponding to the presence of decisive factor in the given scales of cup coffee quality attributers (Table 2).

The sensation was obtained from the gases released from roasted and ground coffee beans as aromatic compounds. In order to evaluate sample of ground coffee quality, the gasses were inhaled through the nose with sniffing/smelling aroma and the inhaling process revealed the nature of coffee bean taste /typicity moca and slightly spicy nature (Table 4) ware showed at the 2nd distance layer across PA under both shade trees influence.

2.5. Sample Procedure and Experimental Design

The design was arranged with factorials in (RCBD) for coffee 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. The coffee sample parameters: coffee quality such as physical bean characteristics, raw quality (color, shape and make, and odor) brewing analyses (cup qualities) ware utilized.

2.6. Data Analysis

Coffee quality aspect such as raw and cup coffee qualities were compared between shaded and open areas effect as well as between shade tree species effect. After laboratory processing, the results of coffee parameters were analyzed by statistical software in order to get mean value difference. The result of Coffee quality (raw and cup quality) were summed up and the total values of each treatment was graded statistically. Generally, analysis of variance (ANOVA) was done to determine differences among the mean of the treatments (between tree species and between shaded and unshaded parts of the results) with respect to coffee parameters 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). Interaction and combination effect of the treatments' parameters were identified across PAs. The mean value of significant comparison at t-Test (0.05) was computed between shaded and unshaded, and between shade tree species effect of treatments' parameters based on the distance layers.

3. Result and discussion

3.1. Coffee Production in raw beans Quality Aspects

3.1.1. Influence of shade tree species and distance from tree trunk in screen size of coffee beans

The mean value on available coffee fruits' 'screen size' observed a highly significant difference ($p<0.01$) between shade tree species effect and between distance layers' effect only in Laftorifenso PA (Table 4). The highest mean value on the given treatment's parameter was displayed at 1^{rst} distance layer under both shade trees species, while the lowest mean value on the given parameter was displayed at the end distance layer in unshaded coffee plants in Laftorifenso PA. In Jingadibu PA, the highest mean value on the given parameter was equally displayed under both shade trees effect at all distance layers but the lowest mean value on the given parameter was observed at the end distance layer away from the shade trees trunk in unshaded coffee plants (Table 1).

Coffee bean size is unified criteria for conducting coffee business within the international market which based on physiological fitness of coffee fruit through main factors such as management, shade and species and geographical varies (Agwanda *et al.* 2003). Similarly, bold and medium bean size has a particular importance for roasters, as uniform bean size could be produced uniform roast (Yigzaw, 2005; EAFCA, 2008). Additionally, Barel and Jacquet (1994) supported that roasting uneven sized beans cannot produce uniform roast, because of the smallest tend to burn and the largest tend to be under-roasted. Thus, this trend to be reduced final quality of the brew.

According to Hernández (1995) reported that insignificant differences between bean sizes of shaded and unshaded coffee. In the contrast, the other investigation accounted by Guyot *et al.* (1996) was, shade have positive effects on coffee bean size.

Generally, the result of this study was showed that the shade to be a significant value for coffee beans' size under the comparison of shaded coffee versus unshaded coffee plants in the study area and its rate was based on description of the scale in (Table 2).

3.1.2. Influence of shade tree species and distance from tree trunk in shape and make of coffee beans

In this study, the mean value of treatments observed to have significant difference ($P<0.05$) between shade tree species effect across PAs in the availability of shape and make of raw coffee quality test. The highest mean value of the given treatments' parameter was observed under *Erythrina abyssinica* shade tree influence at the 2nd layer and the lowest mean value of the given treatments' parameter was displayed at the end distance layer away from the shade tree trunk in unshaded coffee plants across PAs but under *Cordia africana* shade tree's effect without mean difference was displayed between shaded and unshaded effect only in Laftorifenso PA.

According to Bote and Struik (2011), research report, shaded coffee resulted in heavier and larger coffee beans and a good "shape and make" than unshaded coffee fruits, mainly due to its effect on temperature and the duration of the ripening period. This research report, confirmed with the present study, under both shade tree species' effect with distance intervals.

3.1.3. Influence of shade tree species and distance from tree trunk in color of coffee beans

The mean value of treatments indicated significant difference ($P<0.05$) between shade tree species and between and within distance layers away from shade tree trunks to open areas' effect on the availability of color at raw coffee quality test across PAs. The highest mean value on the treatments' parameter was observed at the 2nd distance layer under both shade trees species in Laftorifenso PA, while the lowest mean value of the given treatments' parameters was observed in unshaded coffee plants. In Jingadibu PA, the highest mean value was observed under both shade trees species at the 2nd and the 3rd distance layers, while the lowest mean value on the given parameter was observed at the end distance layers in unshaded coffee plants.

Color is the visual appearance of the brewed cup of coffee. Ones' aspect of visual appearance indicates color and the direct effect of caramelization power of the sugar beans based on roasting degree. The roasting degree also depends on the size and 'shape and make' of green coffee beans. So the shade may have an influence

on color availability indirectly hence and Categories of the rate of results were found under the rooted in its referred scales similarly in (Table 2).

Table 1. Influence of shade tree species and distance from tree trunk in raw coffee beans quality value

Treatments		Laftorifenso PA Mean+ Std (*Y*±**x**)			Jingadibu PA Mean+ Std (*Y*±**x**)		
Tree species	distance (m)	screen size of coffee beans quality (%)	s and m of coffee beans quality	color of coffee beans	screen size of coffee beans quality (%)	s and m of coffee beans quality	color of coffee beans
Cordia africana	1m	0.95 ±0.03	12 ±0.83	12.3±0.25	0.9±0.02	12±0.3	12.2±0.2
	3m	0.93 ±0.03	13 ±0.77	12.4±0.26	0.9±0.01	13±0.4	12.3±0.2
	6m	0.92± 0.03	12 ± 0.57	12.1±0.39	0.9±0.01	12±0.4	12.3±0.3
Without-T	25m	0.86 ±0.01	12± 0.61	11.8±0.24	0.8±0.01	12±0.3	11.6±0.1
Erythrina abyssinica	1m	0.92 ± 0.03	12± 0.71	12.1±0.35	0.9±0.01	13±0.3	12.3±0.3
	3m	0.90± 0.03	12± 0.64	12.2±0.36	0.9±0.01	13±0.4	12.4±0.3
	6m	0.89±0.03	12 ±0.44	11.9 ±0.49	0.9±0.01	13±0.4	12.4±0.3
Without-T	25m	0.84± 0.02	12± 0.48	11.6±0.34	0.8±0.01	12 ±0.3	11.7±0.2
LSD (0.05)		0.01	0.7	0.3	0.01	0.2	0.3
CV (%)		1.1	4.8	2.3	1.3	1.6	1.8

Scale of Shape and make:- v. good=15; Good =12; Fair good=10; Average=8; Mixed =6; Small =4"
Scale of Color:-Bluish =15; Grayish =12; Greenish =10; Coated =8; Faded=6; White =4"
**s and m= shape and make of coffee beans;* Without-T=without shade trees
** Y±x ; y=means' value; x = standard division; LSD=least significant difference ;CV=coefficient of variance*

3.2. Coffee Production in cup Quality Aspects

3.2.1. Influence of shade tree species and distance from tree trunk in aromatic intensity of coffee beans

The mean value of treatments showed significant difference (P<0.05) between shade tree species and between and within distance layers of shaded versus unshaded areas' effect in the availability of aromatic intensity at cup coffee quality test across PAs (Table 3). The highest mean value of aromatic intensity was observed under both shade trees species at the 2nd distance layers across PAs, while the lowest mean value of the given parameters was also displayed at the end distance layer in unshaded coffee plants across PAs (Table 2).

The mean value of treatments showed significant difference (P<0.05) between shade tree species and between and within distance layers of shaded versus unshaded areas' effect in the availability of aromatic intensity at cup coffee quality test across PAs. The highest mean value of aromatic intensity was observed under both shade trees species at the 2nd distance layers across PAs, while the lowest mean value of the given parameters was also displayed at the end distance layer in unshaded coffee plants across PAs (Table 2). Aromatic intensity, the gaseous natural chemical components of roasted and brewed coffee is given off when coffee is roasted and brewed. Aroma is a responsible for all coffee flavor attributes. The shade may have indirect effect on availability of aromatic intensity.

According to results' discussion was stated at different tables in this study, the shade trees have a direct and indirect effect on coffee production through the process with buffering the physiological part of coffee plants, from natural phenomenon. Thereby the coffee beans made uniform bean size due to indirect effect of shade trees and the rate of parameter was based on its description of the scale in (Table 2).

3.2.2. Influence of shade tree species and distance from tree trunk in aromatic quality of coffee beans

The mean value of treatment observed to have significant difference (P<0.05) between shade tree species, and between as well as within distance layers away from the shade tree trunks towards open area under both shade tree species across PAs (Table 3).

The highest mean value of treatment was recorded from the 2nd distance layer under both shade trees species, while the lowest mean value of the given treatments' parameter was recorded at the end distance layers in unshaded coffee fruits across PAs (Table 2). Aromatic quality indicates smell of the liquor sensed either by direct inhaling of the vapors arising from the cup or by nasal perception of volatile substance evolving in the mouth found as multiple aromatic compounds' quality. The 2nd distance of coffee beans' result designated to have typicity values of the given parameter to be 'slightly moca and spice' perfume by professional cup liquor panelist of (JARC, 2008) group and the rate of parameter was based on its description of scale in (Table 2).

3.2.3. Influence of shade trees and distance from tree trunks on acidity of coffee beans

The mean value of treatment effect observed to be significant difference (P<0.05) between shade tree species, and between as well as within distance layers away from shade tree trunk towards open area, in the availability of acidity at cup coffee quality test across PAs (Table 3).

The highest mean value of acidity was recorded at the 1rst distance layer under both shade tree species, while the lowest mean value of the given parameter observed under the end distance layers in unshaded coffee plants across PAs (Table 2). Lower soil pH and high acidity of cup coffee had reported defiantly from shaded areas of the coffee farm than open areas (Siles et al., 2010; Souza et al., 2012). According to Agawanda (1999), acidity of coffee cup tests are reliable and suitable quality attributes that can be used as selection criteria for the genetic improvement of the overall liquor quality had got from shaded coffee beans than unshaded beans.

In contrast, the result of soil analysis parameters in this study indicated that when distance from the tree trunk under shade increased linearly; it increased the value of soil pH starting from the 2nd distance layer. This result implies that pH value was higher under the shade, likewise the value of acidity percentage in cup quality test also higher than open area. This relation may be, due to high pH value under the shade, which influences acidity of coffee bean cup quality test under the canopies (Alemayehu D, 2017) MSc Thesis. Acidity indicates the bitter or acidic balance that a sweet caramelic after taste which could be affected by roast degree and phonology of coffee fruit that means shade may have indirect effect on coffee cup quality test.

3.2.4. Influence of shade trees and distance from tree trunks in astringency of coffee beans

The mean value of treatment observed to have significant difference ($P<0.05$) between shad trees species n the availability of astringency at coffee cup quality test only in Laftorifenso PA. However, the mean value of treatments effect of distances layers away from shade tree trunks under both shade tree species had no significant difference ($P>0.05$) (Table 3). The highest mean value of unshaded effect was greater than shaded ones under both shade tree species at 1rst, 2nd and 3rd layers by 0.22%, 0.17% and 0.22% in Laftorifenso PA. In Jingadibu PA, the mean value of unshaded effect was higher than shaded one by 0.4%, 0.3% and 0.3% under *Cordia africana* shade tree, while under *Erythrina abyssinica* shade trees' effect ware higher by 0.5%, 0.4% and 0.4%, respectively (Table 2).

The higher content of astringency of the coffee beverage may be due to higher content of sucrose and chlorogenic acid in green coffee beans based on its size and ripping paired. This chlorogenic acid is reduced to organoleptic quality especially under unshaded beans than shaded ones (Morais *et al*., 2006). Shade tree play a great role in producing heavier and larger coffee beans size which is depends on temperature effect and the duration of ripening period to have quality physiological fitness of coffee beans (Siebert, 2002). So in this study the higher value of astringency was observed under unshaded part of coffee plants (Table 2) and the rate of parameters ware based on scale description in (Table 2).

3.2.5. Influence of shade tree species and distance from tree trunk in bitterness of coffee beans

The mean value of treatments effect did not show significant difference ($P>0.05$) in the availability of bitterness at the given treatments' parameter between shade tree species and distance layers only in Laftorifenso PA. In Jingadibu PA, the mean value of treatments showed significant difference ($P<0.05$) between shade tree species and between as well as within distance layers in the availability of bitterness effect (Table 3).

The highest mean value of treatment observed at the 1rst and the 2nd distance layers under both shade tree species in Jingadibu PA, while equally rated at every distance layers under both shade trees species effect in Laftorifenso PA. The lowest mean value of the given parameter was observed at open areas across PAs (Table 2). In Jingadibu PA, the mean value of treatment was exceeded than that of open areas' result at 1rst, 2nd and 3rd distance layer, beneath *Cordia africana* and *Erythrina abyssinica* shade trees effect by 0.4%, 0.4% and 0.3%, and 0.5%, 0.5% and 0.3%, respectively (Table 2).

The higher content of bitterness of the coffee beverage may be due to higher content of sucrose and chlorogenic acid in green coffee beans based on its size and ripping paired. This chlorogenic acid optimally influences organoleptic quality especially under unshaded than shaded ones (Morais et al., 2006). In this study, the highest value of bitterness ware observed under the shade trees effect, than that of unshaded coffee beans' quality. This may be due to its size and ripping paired beside other factors and the rate of parameters ware based on description in (Table 2) scale rages.

3.2.6. Influence of shade tree species and distance from tree trunk in body of coffee beans

The mean value of treatment effect had no significant difference ($P>0.05$) in the availability of body at cup coffee quality test between shade tree species effect and between as well as within distance layers away from both shade tree trunks towards open area in Laftorifenso PA (Table 3). In Jingadibu PA, the mean value of treatment effect to have significant difference ($P<0.05$) in the availability of body at cup coffee quality test between shade tree species effect and between as well as within distance layers away from both shade tree trunks towards open area (Table 3). The highest mean value of treatments' parameter was observed under both shade trees species at the 2nd distance layers, while the lowest mean value was observed at the end distance layer away from both shade tree trunks in open beans at Jingadibu PA (Table 2). Available of body in a cup of coffee quality test indicates viscosity or thickness of coffee brewed. It is the physical property of beverage that the result in tactile sensations perceived on the skin in the mouth during and after ingestion based on beans quality (JARC, 2008).

According to Agawanda (1999), body of coffee cup tests are reliable and suitable quality attributes that

can be used as selection criteria for the genetic improvement of the overall liquor quality had got from shaded coffee beans than unshaded beans. Shade alter directly and indirectly organoleptic result in coffee quality aspect beside to other factors that dark roast enhance the body while light roast emphasize acidity (Muschler, 2001; ITC, 2002). The study was also confirmed the above ideas that the higher mean value of the given treatments' parameter was observed under the shaded coffee plants' beans (Table 2) and the rate of parameter s ware submitted by description of (Table 2) scale rages.

3.2.7. Influence of shade tree species and distance from tree trunk in Flavour of coffee beans

The mean value of treatments indicated significant difference ($P<0.05$) in the availability of flavor at cup of coffee test between shade tree species and between as well as within distances layers away from shade tree trunks versus open areas' effect across PAs (Table 3). The mean value of flavor at cup quality test that influenced by distance under both shade tree canopy was higher than that of open area at the 1^{rst}, 2nd and 3rd distance layer by 0.8%, 0.7% and 0.9% in Laftorifenso PA. In Jingadibu PA, the mean value of the given treatment was influenced by distance under the canopy, greater than open area by 0.3%, 0.4% and 0.5%, under *Cordia africana* shade and 0.2%, 0.3% and 0.4% under *Erythrina abyssinica* shade effect (Table 2).

Flavor is the simultaneous sensation in the test of aroma and taste. Coffee aroma is composed of the gaseous natural chemical components of roasted and brewed coffee beans, which escape as vapors after the coffee grounds are brewed. The perfume of the ground roasted coffee before water is added, it gives fragrance/aroma and one can smell the aroma, evaluate the body then perceive the taste and flavors (Muschler, 2001). The higher mean value of treatments' parameter was observed under the shade, while the lowest mean value was observed under unshaded coffee plants under both shade trees across PAs (Table 2). This may be due to indirect effect of shade trees and the rate of parameters ware submitted by description of (Table 2) scale rages.

3.2.8. Influence of shade trees and distance from tree trunk in overall quality of coffee

The mean value of treatments observed highly significant difference ($P<0.01$) between shade tree species effect on availability of 'overall quality' of cup coffee test across PAs (Table 3). The mean value of treatment observed significant difference ($P<0.05$) between and within distance layers away from shade tree trunk to open area effect on availability of the given treatments' parameter across PAs (Table 3). The highest mean value of the given treatments observed at the 2nd distance layers under both shade tree species effect across PAs, while the lowest mean value of the given treatments was also observed at the end distance layers in which unshaded coffee beans across PAs (Table 2).

The total quality of coffee, based on overall quality attributes was used to determine quality potential (Muschler, 2001). The higher value of the given treatments' parameter was observed under the shade trees effect under both shade tree species across PAs, the lowest value of the given parameter was observed in unshaded areas (Table 2). This happen may be due to the above reasons that were stated similarly in the quality attributer parameters and the rate ware submitted by description of (Table 2).

Table 2. Influence of shade tree species and distance from tree trunk in cup quality of coffee beans

Treatments		Laftorifenso PA Mean ± Std ($Y\pm x$)								Jingadibu PA Mean ± Std ($Y\pm x$)							
Tree species	Distance (m)	Aromatic intensity of cup coffee beans' quality	Aromatic quality of cup coffee beans'	Acidity of cup coffee beans' quality	Astringency of cup coffee beans' quality	Bitterness of cup coffee beans' quality	Body of cup ' coffee beans quality	Flavor of cup coffee beans' quality	overall cup quality of coffee beans'	Aromatic intensity of cup coffee beans quality	Aromatic quality of cup coffee beans' quality	Acidity of coffee beans' quality	Astringency of coffee beans' quality	Bitterness of cup coffee beans' quality	Body of cup coffee beans' quality	Flavor of cup coffee beans' quality	overall cup quality of coffee beans'
Cordia africana	1m	4.1±0.2	3.9±0.2	7.2±0.4	4.3±0.2	4.6±0.2	7.12 ±0.20	7.2 ±0.3	7.0±0.9	3.9±0.3	4.2±0.1	7.5±0.2	4.2±0.2	4.6±0.1	7.2±0.3	7.1±0.3	7.1±0.4
	3m	4.2±0.5	4.1±0.4	6.9±0.3	4.3±0.2	4.6±0.2	7.12± 0.21	7.1± 0.2	7.2±0.9	4.1±0.2	4.3±0.1	7.3±0.1	4.3±0.3	4.6±0.1	7.3±0.3	7.2±0.3	7.7±0.3
	6m	4.1±0.1	3.8±0.3	6.8±0.3	4.3±0.2	4.5±0.2	7.17± 0.24	7.3 ±0.4	7.1±0.6	3.9±0.2	4.2±0.1	7.2±0.2	4.3±0.2	4.5±0.1	7.2±0.2	7.3±0.3	7.3±0.3
Without-T	25m	3.8±0.2	3.7±0.2	6.6±0.3	4.5±0.2	4.4±0.2	6.57± 0.12	6.4±0.2	6.4±0.4	3.6±0.1	3.7±0.1	6.8±0.1	4.6±0.1	4.2±0.0	6.7±0.2	6.8±0.2	6.9±0.4
Erythrina abyssinica	1m	4.1±0.2	3.9±0.23	7.1±0.3	4.1±0.1	4.6±0.2	7.12 ±0.16	7.1 ±0.1	6.8±0.2	3.9±0.4	4.2±0.1	7.6±0.4	4.2±0.2	4.6±0.1	7.3±0.3	7.2±0.2	7.2±0.3
	3m	4.1±0.1	4.1±0.24	6.9±0.2	4.1±0.2	4.6±0.2	7.12 ±0.16	7.0 ±0.1	7.2±0.2	4.1±0.3	4.2±0.1	7.3±0.2	4.3±0.2	4.6±0.1	7.5±0.4	7.3±0.2	7.5±0.12
	6m	4.0±0.1	3.8±0.28	6.8±0.2	4.1±0.1	4.6±0.2	7.17 ±0.20	7.2 ±0.3	7±0.19	3.9±0.3	4.1±0.2	7.3±0.3	4.3±0.1	4.4±0.1	7.3±0.3	7.4±0.2	7.1±0.2
Without-T	25m	3.8±0.1	3.7±0.21	6.5±0.1	4.3±0.1	4.5±0.1	6.57 ±0.08	6.3±0.1	6.3±0.7	3.6±0.2	3.7±0.1	6.9±0.3	4.7±0.1	4.1±0.0	6.8±0.2	7±0.2	6.9±0.3
LSD(0.05)		0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.1	0.2	0.2	0.1	0.3	0.2	0.3
CV (%)		4	4.1	2.9	3	4	2.6	3.2	3	6	2.8	2.3	3.8	1.4	3.4	2.6	3.7

Note: Description of scale and definition

Scale of Aromatic intensity:-V. strong=5; strong=4; medium=3; light=2; V. light=1;Nil=0
Scale of Aromatic quality :- excellent=5; v.good=4; good=3; regular=2; Bad=1; Nil =0"
Scale of Acidity Pointed=10; M. pointed=8; Medium =6; Light =4; Lacking=2;Nil=0"
Scale of Astringency:-Nil =5; V.ligh t=4; Light=3; Medium=2;Strong =1;V.strong=0"
Scale of Bitterness:-Nil =5; V. light=4; Light=3; medium=2; Strong=1; V. strong=0"
Scale of Body (10%):-Full =10, Medium full =8, medium=6, Light =4, V.light=2, Nil =0"
Scale of Flavor (10%):-V.good=10, Good =8, Average =6, Fair =4, Bad=2, Nil=0 "
Scale of Overall cup quality (10%): Excellent=10, v.good =8, Good=6, Regular=4, Bad =2, unacceptable=0"

* *Y±x ; y=means' value; x = standard division;*
* *LSD=least significant difference; CV=coefficient of variance*
* Without-T=without shade trees

Table 3:Mean values on (*coffea arabica L.)* 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, East Arsi zone

Parameters	Shade trees	Laftorifenso PA					Jingadibu PA				
		Distance from shade tree trunks				Open area	Distance from shade tree trunks				Open area
		1m	3m	6 m	MVD		1m	3m	6 m	MVD	
Scrn in %	*C. africana*	95.00	93.0	92.00	93.3	86	0.90	0.90	0.90	0.90	0.80
	E. abyssinica	92.0	90.0	89.0	90.3	84	0.90	0.90	0.90	0.90	0.80
	Mean*	**93.5a**	**91.5b**	**90.5c**	**91.8**	**85d**	**0.90a**	**0.90a**	**0.90a**	**0.90**	**0.80b**
AI in %	*C. africana*	4.1	4.2	4.1	4.13	3.78	3.90	4.00	3.90	3.93	3.70
	E. abyssinica	3.1	3.3	3.3	3.23	3.1	3.85	4.00	3.90b	3.92	3.65c
	Mean*	**3.6b**	**4.5a**	**3.7b**	**3.68**	**3.44c**	**3.8b**	**4a**	**3.90b**	**3.93**	**3.6c**
AQ in %	*C. africana*	4	4.1	3.78	3.96	3.73	4.20	4.30	4.20	4.23	3.70
	E. abyssinica	4	4.1	3.78	3.96	3.73	4.10	4.20	4.10	4.13	3.70
	Mean*	**4b**	**4.1a**	**3.78c**	**3.96**	**3.73c**	**4.15ab**	**4.25a**	**4.15b**	**4.18**	**3.70c**
Ac in %	*C. africana*	7.2	7	6.8	7	6.6	7.50	7.30	7.20	7.33	6.80
	E. abyssinica	7.2	7	6.8	7	6.5	7.60	7.30	7.30	7.40	6.90
	Mean*	**7.2a**	**7b**	**6.8b**	**7**	**6.55c**	**7.55a**	**7.30b**	**7.25b**	**7.37**	**6.85c**
AS in %	*C. africana*	4.2	4.3	4.2	4.23	4.5	4.20	4.30	4.30	4.27	4.60
	E. abyssinica	4	4	4	4.00	4.3	4.20	4.30	4.30	4.27	4.70
	Mean*	**4.1b**	**4.2b**	**4.1b**	**4.12**	**4.4a**	**4.20b**	**4.30b**	**4.30b**	**4.27**	**4.65a**
BI in %	*C. africana*	4.5	4.5	4.3	4.43	4.6	4.60	4.60	4.50	4.57	4.20
	E. abyssinica	4.6	4.5	4.6	4.57	4.5	4.60	4.60	4.40	4.53	4.10
	Mean*	**4.55a**	**4.5a**	**4.45a**	**4.50**	**4.5a**	**4.60a**	**4.60a**	**4.45b**	**4.55**	**4.15c**
BO in %	*C. africana*	7.00	7.30	7.10	7.13	6.60	7.20	7.30	7.20	7.23	6.60
	E. abyssinica	7.10	7.20	7.10	7.13	6.60	7.30	7.40	7.20	7.30	6.80
	Mean*	**7.05a**	**7.25a**	**7.10a**	**7.13**	**6.60b**	**7.25b**	**7.4a**	**7.20b**	**7.27**	**6.70c**
FL in %	*C. africana*	7.2	7.3	7.2	7.23	6.4	7.10	7.20	7.30	7.20	6.80
	E. abyssinica	7	7.4	7.2	7.20	6.3	7.20	7.40	7.40	7.33	7.00
	Mean*	**7.1ab**	**7.35a**	**7.2b**	**7.22**	**6.35c**	**7.15b**	**7.30ab**	**7.35a**	**7.27**	**6.90c**
OAQ in %	*C. africana*	7	7.4	7.2	7.2	6.4	7.10	7.70	7.30	7.37	6.90
	E. abyssinica	7.2	7.5	7.2	7.3	6.4	7.20	7.50	7.10	7.27	7.00
	Mean*	**7.1b**	**7.45a**	**7.2b**	**7.25**	**6.4c**	**7.15b**	**7.60a**	**7.20b**	**7.32**	**6.95c**

scrnsz=screen size of green coffee; AI =aromatic intensity of cup test; AQ=aromatic quality of cup test; Ac=acidity of cup test; AS=astringency of brewed coffee; BI=bitterness of cup test; Bo=body of coffee beverage ; FL=flavor of coffee beverage; OAQ=overall quality of coffee beverage and No.=number mvd=mean value difference"

3.3. Coffee Grading Based on Raw and Cup Quality Evolution

3.3.1. Raw coffee quality evaluation

The raw coffee quality evaluation based on their "shape and make", color and odor were computed along with the set of (ES, 2001; ECX, 2009). The highest mean value of raw quality analysis was found from the 2nd distance layer in the given parameters, relatively. The summations of parameters were given its grading value as per (JARC, 2008) standard with 40% accounting shown as (Table 4) bellow.

Table 4: Standard parameters and their respective values used for unwashed coffee that raw quality evaluation values as per (JARC, 2008) standard

Treatments		Laftorifenso PA				Jingadibu PA			
Tree	Distance	Sm 15%	Col. 15%	Od. 10%	TRQ 40%	Sm 15%	Col. 15%	Od. 10%	TRQ 40%
.*Cordia africana*	1m	12.00	12.30	10.00	34.3	12.00	12.30	10.00	34.3
	3m	13.00	12.60	10.00	**35.6**	12.30	12.30	10.00	**34.6**
	6m	12.20	12.20	10.00	34.4	12.00	12.00	10.00	34
Without-T	25m	11.50	11.30	10.00	32.8	11.50	11.00	10.00	32.5
Erythrina abyssinica	1m	11.80	12.20	10.00	34	12.80	12.00	10.00	34.8
	3m	12.60	12.30	10.00	**34.9**	13.30	12.60	10.00	**35.9**
	6m	11.80	11.50	10.00	33.3	13.00	12.60	10.00	35.6
Without-T	25m	11.50	11.30	10.00	32.8	11.47	11.00	10.00	32.47

"Sm =shape and make; Col.=color; Od=odor; TRQ=Total raw quality; Without-T=without shade trees

3.3.2. Cup quality evaluation

The highest mean value of aroma and cup quality analysis value of a given parameters was found from the 2nd distance layer as were found in other parameters. Each quality attribute, after laboratory processing was subjected to statistical descriptive analysis, which was based on treatment effect. The total of raw quality (40%) and aroma and cup quality (60%) summation values ware used for final quality grading judgment in accounting of (100%) based on (ES, 2001; ECX, 2009) procedure as per (JARC, 2008) standard shown in (Table 5).

The highest quality grade range and typicity sense of 'moca' and 'spice of a given quality attributer parameters were observed at the 2nd distance layer under both shade tree effect across Pas (Table 5).

Table 5: Standard parameters and their respective values used for unwashed coffee that cup and aroma evaluation values as per (JARC, 2008) standard

Treatments		Laftorifenso PA										Jingadibu PA									
		AI	AQ	AC	AS	BI	BO	FL	OAQ	TCPQ	100%	AI	AQ	AC	AS	BI	BO	FL	OAQ	TCPQ	100%
Tree	Dist	5%	5%	10%	5%	5%	10%	10%	10%	60%		5%	5%	10%	5%	5%	10%	10%	10%	60%	
Cor.	1m	4.10	4.00	7.60	4.30	4.60	7.00	7.04	6.75	45.39	79.69	3.80	4.20	7.50	4.00	4.50	7.00	6.90	6.80	44.70	**79.0**
africa	3m	4.20	4.30	7.00	4.50	4.50	7.00	7.00	7.00	45.50	**81.10**	4.00	4.30	7.20	4.30	4.63	7.70	7.00	7.20	45.83	**80.9**
na	6m	4.00	3.60	6.60	4.30	4.60	7.40	7.80	7.60	45.90	80.30	4.00	4.20	7.20	4.30	4.60	7.30	7.30	7.80	46.70	**80.7**
wt/t	25m	3.50	3.50	6.20	4.60	4.20	6.00	5.60	5.60	39.20	72.00	3.30	3.20	6.30	5.00	4.60	6.20	6.50	6.50	41.60	**74.00**
Ert.	1m	4.00	4.00	7.20	4.00	4.60	7.20	7.20	7.09	45.29	79.29	3.80	4.20	8.00	4.30	4.60	7.50	7.20	7.20	46.80	**81.6**
abyssi	3m	4.20	4.30	6.80	4.00	4.60	7.20	7.00	7.00	45.10	**80.00**	4.50	4.30	7.20	4.30	4.60	7.80	7.50	7.30	47.50	**83.4**
nica	6m	4.00	3.60	6.80	4.00	4.60	7.00	7.00	7.00	44.00	77.3	3.80	4.00	7.00	4.30	4.60	7.00	7.60	7.50	45.80	**81.474.**
Wt/t	25m	3.40	3.50	6.20	4.60	4.20	6.00	5.60	5.60	39.10	71.9	3.30	3.20	6.30	5.00	4.60	6.20	6.50	6.50	41.60	**00**

Note

"Cor= Cordia africana; Ert=Erythrina abyssinica; wt/t= without shade tree; TCPQ=Total cup quality; AI=Aromatic intensity; AQ=Aromatic quality; AC=acidity; AS=astringency; BI=bitterness; BD=body; FL=flavors; OAQ= overall quality; TCPQ=total cup quality; JARC, 2008=Jimma Agricultural Research Center*
"The first grade coffee sample was determined as slightly moca and slightly spice flavors as per (JARC, 2008)"; "After the raw and cup quality values summed the grade range will be: 1rst grade =81-100%, 2nd grade =63-80%, 3rd grade =50-62%, 4th grade =31- 49%"

Figure 1: Dried Coffee beans were processed starting from the initial testing steps of row quality analysis to an end of cup quality analysis.

4. CONCLUSIONS AND RECOMMENDATIONS

Ethiopian coffee quality become deteriorates from time to time. As many researches indicated that this deterioration may be because of daily and annual climatic variation, pre and post harvesting method, timing and processing methods, lack of awareness etc. The climatic variability has a strong influence on coffee quality (daily and annual temperature fluctuations, hotness and coldness of weather termination and distribution of rainfall) are very important factors. Ethiopia is agricultural dependent based on seasonal rain fall chancellor. The pressure from rapidly growing human population has been directly and indirectly shrinking welfare natural resources. Deliberate growing of shade trees on farmlands, it is an agroforestry practice to improve production quality and sustain environmental biodiversity. 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 coffee 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 Jingadibu PA while *Erythrina abyssinica* covered about 23% and 26% of farm-land in Laftorifenso and Jingadibu PA, respectively.

Almost all the given coffee 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 trunk. The results also reflected that the fertility of the soil may be gradually decreased as the distance away from the shade tree trunks increased starting from the 2nd distance layer. This stipulation may be due to the inputs from *Erythrina abyssinica* and *Cordia africana* shade trees. 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 ware 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 a certification as farmers' integration of coffee with shade can lead to be initiator of sustainable agriculture, organic and quality coffee producer and promoter of climatic resilience. It needs such a certification because it can show how other farmers can be resilience to climate change and improved their livelihoods and because the practice can provide substantial ecosystem services. As many writers expressed their views that certification approach should be advanced for organic coffee growers and fair traders had to be provided different price premium which can be offer farmers distinct economic incentives so that farmers can have a unique ecological standards in order to sustain progressively. Coffee obviously has the highest share in a once country's GDP like Ethiopian. So Golelcha's district of coffee grower farmers should be motivated for their environmentally friendly practicing coffee production with shade trees implementation. This technology has to be demonstrated to farmers in other district of Hararghe and other part of Ethiopia for whom coffee without shade tree users.

Successively across PAs, in almost all parameters, the best results were found at the 2nd distance layer (3m) away from the shade tree trunks. This layer was designated to have better effect than the other layers under almost all coffee 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 coffee quality under *Erythrina abyssinica* shade tree 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 property and coffee production 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 determinations of *Erythrina abyssinica* and *Cordia africana* utilization as well as 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 which is may be good for production quality. The root architectures of tree and photosynthesis variation needs better investigation due to shade intensity effect.

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