HiLL PUBLISHING

International Journal of Food Science and Agriculture, 2023, 7(1), 105-111
https://www.hillpublisher.com/journals/jsfa/
ISSN Online: 2578-3475
ISSN Print: 2578-3467

Composition of Shade Tree Species in Coffee (*Coffea arabica* L.) Farms at Western Oromia

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How to cite this paper: Hika Bersisa. (2023) Composition of Shade Tree Species in Coffee (*Coffea arabica* L.) Farms at Western Oromia. *International Journal of Food Science and Agriculture*, 7(1), 105-111.
DOI: 10.26855/ijfsa.2023.03.015

Received: February 28, 2023
Accepted: March 26, 2023
Published: April 25, 2023

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Abstract

Ethiopia has the longest tradition of coffee production and consumption in the world with inimitable coffee ceremony. Different authors testimony's revealed as Ethiopia is the first and fifth largest Arabica coffee producer in Africa and world, respectively. Survey was conducted in East Wallaggaa coffee growing areas of western Oromia to identify currently utilized tree species as coffee shade. Stratified random sampling method was used. Three Peasant associations per district and 5 farms per district were used for the achievement of the work. Totally 90 representative coffee farms were assessed. GPS, car dashboard to measure distance interval in km, structural questionnaire and the like were utilized for data collection. Data was analyzed using descriptive statistics. Advanced books were used in order to refer the scientific name, common name, species and families of trees. About fifteen trees species were registered across surveyed coffee growing areas. Those tree species were categorized under 15 and 9 tree species and families, respectively. More than 3 tree species were utilized as coffee shade tree with a single coffee farm. Across surveyed area, this much 67% of household were used more than 4 tree species, while 37% were used 2 type of tree species. According to the survey result 3 legumes tree species and 15 none legumes species including 2 fruit tree, 3 timber tree and 3 locally available were identified across surveyed area. Depending on their canopy diameter, tree species were categorized into 3 kindly, large, medium and small canopy diameters. Among these high percent of assessed tree species were characterized with medium canopy followed by small and large canopy diameter. The study has suggested that, the detail research should be made regards to selection of proper and multipurpose tree species to be used as coffee shade tree.

Keywords

Coffee Shade, tree species, *Coffea arabica* L., canopy diameters, legumes species, none legumes species

1. Introduction

Coffee production in the form of agro-forestry practices is the most important management approach to improve the livelihoods of the farming community. Ethiopia is an important country in coffee production, so trees commonly used for provision of coffee shade are widely retained/planted and integrated in farming systems for both shade and for their socio-economic roles [1]. The preferred 'shade' species are morphologically characterized by whorled and spreading crowns which regulate the interception of sunlight for healthy coffee growth, while contributing leaf litter for fast decomposition. Coffee is shade-tolerant plant and is mainly grown under shade trees in complex agro-forestry systems. Agro-forestry technologies range from traditional to recent practices such as home gardens, improved fallows, multipurpose trees, plantation-crop alley cropping, and others [2]. Specifically coffee shade agro-forestry technology is a

traditional and complex agro-forestry system, where coffee is associated with various other species in different storeys (or "levels"). This provides ecologically and economically sustainable use of natural resources. According to [3] coffee is a shade-loving plant and the shade trees reduce the stress of coffee (*Coffea* spp.) by ameliorating adverse climatic conditions and nutritional imbalances. The previous work done had revealed that [4] added that coffee agro-forestry technology has many benefits in the economy and supports the households' needs of medicine and timber. Soil fertility will be improved by the agro-forestry practices, especially when nitrogen-fixing plants are added to the production system. The trees also contribute to the reduction of soil erosion and to the carbon sequestration.

Ecosystem services such as pollination, pest control, climate regulation, and nutrient sequestration are generally greater in shaded coffee farms, but many coffee-growing regions are removing shade trees from their management [5]. In the last two decades, the value of shade-grown (or simply shade) coffee farms for biodiversity conservation and ecosystem service provision has gained widespread attention from the public and scientific communities [6]. In this short time span, global coffee distribution patterns and local coffee management practices have exhibited dramatic changes, with major implications for ecology and livelihoods.

Shade trees reduce the stress of coffee (Coffea spp.) by ameliorating adverse climatic conditions and nutritional imbalances. For example, shade trees buffer high and low temperature extremes by as much as 5 °C and can produce up to 14 Mg ha^{-1} yr^{-1} of litter fall and pruning residues, containing up to 340 kg N ha^{-1} yr^{-1}. However, N2 fixation by leguminous shade trees grown at a density of 100 to 300 trees ha^{-1} may not exceed 60 kg N ha^{-1} yr^{-1}. Shade tree selection and management are potentially important tools for integrated pest management because increased shade may increase the incidence of some commercially important pests and diseases (such as *Phythphora palmivora* and *Mycena citricolor*) and decrease the incidence of others (such as *Colletotrichum gloeosporioides* and *Cercospora coffeicola*).

Shade appears to impart its greatest benefit in coffee bean flavor for plants growing in suboptimal and heat-stressed growing regions, where shade can bring environmental conditions closer to ideal levels [7]. This suggests that shade may be particularly important for maintaining coffee quality in the context of climate change, especially in regions with expected temperature increases in future climate scenarios. Reduction in the quantity and quality of transmitted light and hence avoidance of over-bearing. Shade reduces nutritional imbalances and dieback also [8].

Despite the largest share in export and economic contribution, numerous constraints have been mentioned that affect the production and utilization of coffee. Among these lack of utilization of proper tree species for coffee shade is one of the bottle neck in coffee industry. Many of Ethiopian coffee growers have been used different tree species for coffee shade with the same farm. These tree species are include legumes species and none legumes species like timbers, fruit, shrubs and another locally available tree species. Legumes trees provides different function for coffee farm, while serving as shade, nitrogen fixer and their leaf litter used as mulching and improving soil organic matter, which accumulatively provide sustainable increasing of coffee production and productivity. This may be result in sustainable fluctuating of coffee production and productivity. While, this diversity is good in the management of coffee pests' via generating natural enemies and predators, it develop variation in light transmission, rain flash distribution, air temperature, nutrient added to soil and another micro and macro climate which finally result in unsustainable of both quantity and quality of coffee bean. Using trees belongs to legumes species have more advantage than none legumes tree species. Therefore, the objective of this work was to assess tree species currently utilized as coffee shade tree in western Oromia.

2. Materials and Methods

Survey was conducted in six districts (Sasiga, Limmu, W/Tuka, Sibu Sire, Gudeya Bila and Digga) of East Wallaggaa zone, Oromia region during 2020 and 2021. Three Peasant associations per district and five farms per district were used for the achievement of the work. Totally 90 representative coffee farms were assessed. During the survey work materials like GPS, car dashboard in order to measure distance interval in km, structural questionnaire and the like were utilized to collect the most important data. Data was analyzed using excel sheet and SPSS for descriptive statistics. Advanced books were used in order to refer the scientific name, common name, species and families of trees.

3. Results and Discussions

3.1 Taxonomy and the excellence of identified shade tree species

Fifteen tree species belongs to ten families were identified across surveyed areas. Among these family Fabaceae and Euphorbiaceae found with 3 species, while the remaining are occurred with single species (Table 1). The identified locally and nationally known and the recommended coffee shade trees were placed with their scientific, common and local name (Table 1). The well-known and dominant shade trees reported from Ethiopia embody genera like *Albizia*, *Acacia*, *Bersama*, *Cordia*, *Croton*, *Dracaena*, *Entada*, *Erythrina*, *Ficus*, *Leucaena*, *Millettia*, and *Syzygium* [9]. At commercial level family Fabaceae is more known and recommended as coffee shade tree in terms of permanent and temporary followed by Euphorbiaceae, Boraginaceae and Moraceae. Whereas, the remaining species utilized as coffee shade tree

where they are available. Among Fabaceae family, species *Acacia abyssinica and Albizia gummifera* and Sesbania sesban *were* found more in surveyed area followed by *Senna petersiana*. *Acacia abyssinica* is considered to be the most favourable tree species for coffee shade in south-western Ethiopia [10] with *Ficus vasta* appreciated for its' large canopy [11]. According to the earlier studies [12-13], *Acacia abyssinica*, *Albizia gummifera*, *Millettia ferruginia*, *Croton macrostachyus* and *Sesbania sesban*, although *Cordia africana* and *Ficus* were also found growing in home gardens for providing shade for underneath crops including coffee.

Table 1. Importance and botanical class of identified tree species in studied coffee growing areas

Family	Common name	Scientific name	Local name in Afaan Oromo	Excellence
Asteraceae	bitter leaf	*Vernonia amygdalina*	Eebicha	Local
Fabaceae	peacock flower	*Albizia gummifera*	Muka arbaa	National
Boraginaceae	Sudan teak	*Cordia africana*	Waddeessa	National
Euphorbiaceae	Rushfoil or croton	*Croton macrostachyus*	Bakkaniisa	National
Moraceae	fig tree	*Ficus vasta*	Qilxuu	National
Euphorbiaceae	castor bean	*Ricinus communis*	Qobboo	National
Fabaceae	flat top acacia	*Acacia abyssinica*	Laaftoo adii	National
Anacardiaceae	mango	*Mangifera indica*	Maangoo	National
Fabaceae	monkey pod	*Senna petersiana*	Somboo	Local
Rosaceae	African cherry	*Prunus africana*	Hoomii	Local
Fabaceae	hummingbird tree	*Sesbania sesban*	Sasbaaniyaa	National
Cannabaceae	white stinkwood	*Celtis africana*	Cehii	National
Euphorbiaceae	Chinese tallowood	*Sapium evaptrcum*	Bosoqaa	Local
Bignoniaceae	African tulip tree	*Spathodea nalotica*	Ispaatoodaa	Exotic species
Lauraceae	butter pear	*Persea Americana*	Avokaadoo	National

3.2 Distribution of tree species in coffee growing areas of Western Oromia

Out of identified tree species *Croton macrostachyus* (16.09%) was dominantly distributed in all study areas followed by *Albizia gummifera* (15.22%) and *Cordia Africana* (14.78%). While fruit crops like *Mangifera indica* and *Persea Americana* (6.96%), *and Acacia abyssinica* (9.13%), *Ficus vasta* (7.83%) have been found moderately in some coffee farms. trees with too low dominance were *Prunus Africana* and *Celtis Africana* (1.3%) followed by *Spathodea nalotica* (2.17%), *Sapium evaptrcum* and *Vernonia amygdalina* (3.48%) (Table 1**)**. In the previous study [12], similar report was done related to the occurrence of these tree species in Manasibu district of West Wallaggaa zone.

Table 2. Frequency and rank of tree species in study area

Tree species	Frequency	% of frequency	Rank
Vernonia amygdalina	8	3.48	11
Albizia gummifera	35	15.22	2
Cordia Africana	34	14.78	3
Croton macrostachyus	37	16.09	1
Ficus vasta	18	7.83	5
Caster bean	9	3.91	9
Acacia abyssinica	21	9.13	4
Mangifera indica	16	6.96	6
Senna petersiana	9	3.91	7
Sasbania sasbin	16	6.96	10
Prunus africana	5	1.30	16
Celtis Africana	5	1.30	15
Sapium evaptrcum	8	3.48	13
Spathodea nalotica	3	2.17	14
Persea Americana	8	3.48	12

3.3 Occurrence and richness of the identified tree species across surveyed areas

There is a variation among tree species richness' from place to place. Across surveyed area, tree species *Vernonia amygdalina, Albizia gummifera, Cordia Africana, Croton macrostachyus, Caster bean, Acacia abyssinica* and *Sasbania sasbin* were recorded in all surveyed areas, while the remaining species were recorded in one and more than one study area (Table 3). Relatively, closely related richness value was recorded with both *Albizia gummifera* and *Acacia abyssinica* the surveyed area (Table 3). While, the far apart value was recorded with tree species *Spathodea nalotica, Sapium evaptrcum, Celtis Africana, Prunus Africana* and followed by *Persea Americana* and *Mangifera indica* (Table 3).

Table 3. Occurrence and richness of the identified tree species per study area areas during 2021

Tree species	% of richness per districts					
	Diggaa	Limmu	G/Bila	Sasiga	Sibu/Sire	W/Tuka
Vernonia amygdalina	8.82	29.41	20.59	8.82	17.65	14.71
Albizia gummifera	18.60	20.93	23.26	16.28	4.65	23.26
Cordia africana	16.28	9.30	11.63	27.91	9.30	25.58
Croton macrostachyus	5.45	18.18	12.73	27.27	12.73	23.64
Ficus vasta	0	0	11.11	66.67	11.11	11.11
Caster bean	22.73	13.64	18.18	18.18	13.64	13.64
Acacia abyssinica	40.74	14.81	14.81	11.11	3.70	14.81
Mangifera indica	50	11.11	11.11	0	16.67	11.11
Senna petersiana	5.88	17.65	5.88	35.29	35.29	0
Prunus Africana	0	0	0	100.00	0	0
Sasbania sasbin	23.08	15.38	15.38	7.69	15.38	15.38
Celtis africana	0	0	0	100.00	0	0
Sapium evaptrcum	0	0	0	0	0	100.00
Spathodea nalotica	0	0	0	0	0	100.00
Persea Americana	50.00	37.50	12.50	0	0	0

3.4 Type and contributions of tree species utilized as coffee shade in study areas

Among identified tree species served as coffee shade tree in surveyed area, % of them were categorized under edible fruit trees, while % were timber tree, % wooden and % were shrubs tree. Among edible fruit mango was utilized more than avocado in many surveyed villages and coffee farms. In case of timber trees *Cordia Africana* was served more when compared with others like *Prunus Africana*, *Sapium evaptrcum* and *Persea Americana*. Whereas Croton macrostachyus used more as compared with other wooden trees like *Albizia gummifera, Acacia abyssinica, Ficus vasta*, *Senna petersiana* and *Spathodea nalotica*. Shrubs trees *Vernonia amygdalina*, Caster bean and *Sasbania sasbin* were used in dispersal manner across surveyed areas.

On other hand the more dominantly found tree species in surveyed area were none legumes followed by legumes one. This indicate existence of limitation with awareness and knowledge on the utilization of appropriate coffee shade tree either the permanent or the temporary one at surveyed areas. In whatever coffee production system coffee plants/mother tree need more external production inputs like additional nutrient, weed management, insect pest management, disease management, mulching material in order to encourage the productivity of the crop. But, if over majorly leguminous trees species identified as coffee shade tree used, they could be highly contribute those cost of production for external inputs through adding nitrogen to soil, balancing soil temperature and air atmosphere/micro climates, adding organic matter to soil and a mass of leaf litter to be used as mulching material and play also in suppressing of weed. So using leguminous coffee tree species is more desirable and advisable than utilization of none leguminous tree species as coffee shade tree.

Trees also improve soil fertility through nitrogen fixation and the addition and decomposition of nutrient-rich litter [13]. Recently, it has been reported that in a managed natural plantation forest at Yayu, southwestern Ethiopia, more than 40% of the important shade trees were legumes, *i.e*., species of *Albizia*, *Acacia*, and *Millettia* [14]. More precisely, the addition of nitrogen to coffee systems by leguminous shade trees has been reported in many countries.

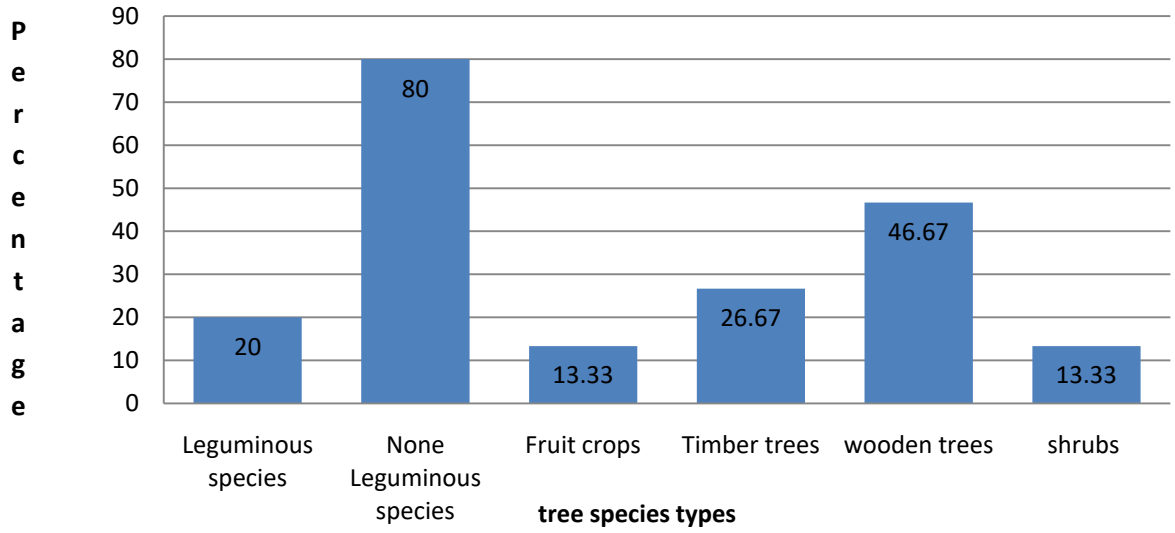

Figure 1. Types of tree species served as coffee shade in surveyed area and their contribution.

3.5 Canopy nature and degree of identified tree species in surveyed areas

Different tree species characterized with various trunk diameter. Some of identified tree species across surveyed area were found with medium canopy size and followed by large and small canopy diameter (Figure 2). Most of wooden tree and timber trees were characterized with large canopy size, whereas few of timber trees and shrubs were exhibited with medium and small canopy diameter (Table 4). In other hand, some of legumes species were fall in both large and small canopy size, while none legumes tree species were dominated with three canopy size (Table 4).

Regarding this, open/large canopy tree species has being preferred more in coffee production due to their canopy to cover large area. This large canopy tree species also used for weed management in coffee farm, make balanced air atmosphere/optimum micro climate including temperature and air moisture, they produce high leaf litter which leads to high organic matter added to coffee plot. While the vise-versa was true in case of tree species riches in medium and small canopy size. In his previous work [11] reports growing of Coffee arabica under diverse and dense shade canopy, While, Ficus vasta appreciated for its' large canopy [11].

Table 4. Canopy nature identified tree species in coffee farm of study areas during 2021

No.	Tree species	Canopty natures
1	*Albizia gummifera*	large
2	*Ficus vasta*	large
3	*Acacia abyssinica*	large
4	*Cordia africana*	medium
5	*Croton macrostachyus*	medium
6	*Mangifera indica*	medium
7	*Celtis africana*	medium
8	*Senna petersiana*	medium
9	*Prunus africana*	medium
10	*Persea Americana*	medium
11	*Vernonia amygdalina*	small
12	*Ricinus communis*	small
13	*Sesbania sesban*	small
14	*Sapium evaptrcum*	small
15	*Spathodea nalotica*	small

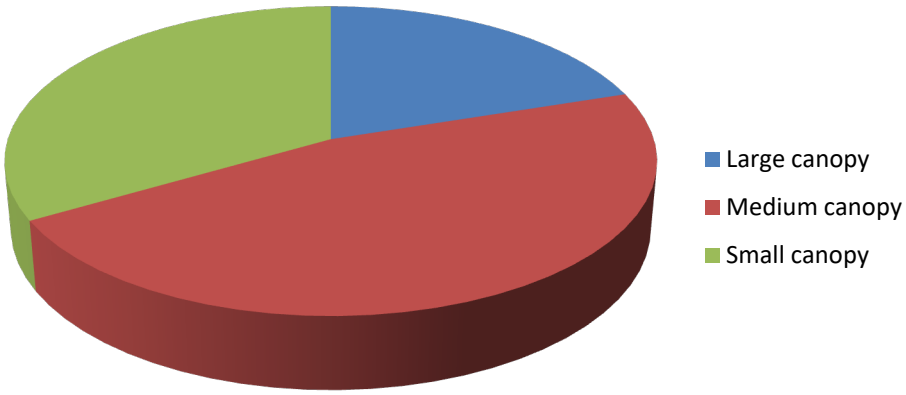

Figure 2. Canopy natures' degree of tree species in study areas during 2021.

3.6 The life cycle mode of identified tree species

Among the identified tree species 46.67% of them were belongs to permanent shade and followed by Semi permanent (40%) and temporary (13.33%) one (Table 5).

Table 5. The life cycle of tree species recorded in coffee farm during 2021

No.	Tree species	Persistency
1	*Albizia gummifera*	Permanent
2	*Ficus vasta*	Permanent
3	*Acacia abyssinica*	Permanent
4	*Cordia africana*	Permanent
5	*Croton macrostachyus*	Semi permanent
6	*Mangifera indica*	Permanent
7	*Celtis africana*	Semi permanent
8	*Senna petersiana*	Semi permanent
9	*Prunus africana*	permanent
10	*Persea Americana*	permanent
11	*Vernonia amygdalina*	Semi permanent
12	*Ricinus communis*	Temporary
13	*Sesbania sesban*	Temporary
14	*Sapium evaptrcum*	Semi permanent
15	*Spathodea nalotica*	Semi permanent

4. Conclusion and Recommendation

In Western Oromia, most of coffee growers have been used different shade tree composition. Both locally available and nationally recommended coffee tree species are identified. Among *Albizia gummifera, Acacia abyssinica, Cordia Africana, Croton macrostachyus, Ficus vasta and Sesbania sesban* are nationally recommended, while *Vernonia amygdalina, Ricinus communis, Senna petersiana, Prunus Africana, Celtis Africana,* and *Sapium evaptrcum* locally utilized tree species as coffee shade tree. Including legumes and none legumes fifteen tree species belongs to ten families were identified in study area. The identified shade tree species are varying in their canopy nature. Permanent, semi permanent and temporary shade tree were identified. Despite *Albizia gummifera* and *Acacia abyssinica* are currently

ideal coffee shade tree, further study should be made to identify comprehensive/intensive coffee shade.

5. Acknowledgment

The authors extended their thanks to IQQO who was support financially and facilitated this study. All technical staff of the coffee research case team is also appreciated for their support in data collection.

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