Adoption Status and Factors Determining Coffee Technology Adoption in Jimma Zone, South West Ethiopia

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Abstract

Jimma zone is one of the most potential coffee producing areas in Ethiopia. The livelihood of the farmers is mainly depend on coffee production. However, majority of them are smalholders characterized by traditional farm management system and limited use of coffee production technology. The aim of this study was to assess the adoption status of different coffee technologies in Jimma zone and to identify the determining factors of coffee technology adoption in the area. In the study, 393 respondents were involved and the adoption status of six selected coffee technologies, namely: the adoption of improved coffee variety, stumping, pruning, fertilizer, shade and mulching was investigated. Accordingly 67.4 % of the sample respondents did not use improved coffee variety. Similarly 45.8%, 31%, 53.4%, 4.1% and 25.7% of the farmers have not yet started to use stumping, pruning, fertilizer, shade tree and mulching, respectively. The factors influencing the adoption of each of these technologies were analyzed by using binomial regression model. As a result, age was found to be significant and negatively correlated with adoption of improved coffee variety. Sex of the farmer was the second variable which was found to be significant and had a negative correlation with mulching practice. Educational status was the other important factor which was found to be significant and had a positive correlation with adoption of the improved coffee variety, stumping technology and using shade tree. Family size was also found to be significant and had a positive correlation with using of stumping technologies, pruning, fertilizer application, mulching and shade trees. Dependency ratio, which was significant and showed a negative correlation with stumping and fertilizer application, was found to have a positive correlation with pruning. Likewise coffee farm size was found to be significant and had a negative correlation with improved coffee variety, fertilizer and mulching but it had a positive significant correlation with stumping. The coffee growing experience of the farmers was also significant and had a negative correlation with stumping, pruning and fertilizer. Moreover development agent support had a significant positive correlation with adoption of improved coffee variety, stumping, pruning, fertilizer application and mulching. Market distance was a factor that had a negative correlation with adoption of improved coffee variety, stumping, shade and mulching. Cooperative membership also showed a significant and negative corelation with improved coffee variety and pruning. Credit on the other hand was found to have a positive correlation with fertilizer application and was negatively correlated with the adoption of pruning practice and mulching. The total income of the household was found to be significant and had a positive correlation with adoption of improved coffee variety, pruning, using fertilizer and using of shade tree and training was also found to have a positive relationship with adoption of improved coffee variety, stumping technology, pruning practice, using shade tree and mulching.

Keywords: Coffee, adoption, technology, production, smallholder

INTRODUCTION

Ethiopia's economy is mainly based on agriculture contributing 43% of GDP, 70% of exports and 85% of employment (UNDP, 2014). Plantation crops such as tea, coffee, tobacco, oil crops and cotton, fish farming, horticulture and floriculture like fruits, vegetables and flowers, livestock and poultry, forestry and forest by-products are some parts of the sector. Among these, coffee production is the most important part of the agricultural sector which plays a significant role in Ethiopia's economy by accounting 45 to 50% of Ethiopia's total export earnings (Feleke, 2018)

According to ICO (2011), Ethiopia is a leading Arabica coffee producer in Africa, ranking the fifth largest Arabica coffee producer worldwide and tenth in coffee export that generates about 25–30 percent of the country's total export earnings. Its total coffee production and export, respectively, increased by 107% and 226% for the crop year 2009/10 and 2010/11. In 2014, coffee accounted for 25.8% of the total export earnings, providing income for about 8 million smallholder farming households (NBE, 2014). However, further growth became limited by poor management, ageing trees, erratic weather. Its exports in the second month of coffee year 2018/19 were 17.6% lower than in November 2017, reaching 233,458 bags. However, this follows increased exports in October 2018, bringing total exports in the first two months of 2018/19 to 597,160 bags, an increase of 6.6% compared to 2017 (ICO, 2018).

According to Moat et al. (2017), coffee has a great economic, environmental as well as social significance to Ethiopia. 400,000 ha of the country is covered by Arabica and other types of coffee and the total coffee production is about 200,000 tons of clean coffee per year. The livelihood of 15 million people is directly or indirectly belongs to the coffee value chain (Sihin et al., 2013). Even though the country has a good potential to increase coffee production and productivity as it is endowed with suitable elevation, temperature, soil fertility and sufficient rainfall in coffee growing areas of the country, 95% of the country's total production is largely produced by smallholder farmers on average farms of less than 2 hectares. As a result, the average yield per hectare remains very low stagnating at 0.7–0.8 MT per hectare (Sihin et al., 2013).

Nowadays, many institutions at the national and international level are paying attention to new coffee production technologies and how agricultural innovations in general can best be nurtured. Innovation is very essential to provide some of the answers required to adapt to a fast-changing world. The flow of new technologies is widely recognized to be a fundamental determinant of one's country over all development and for agriculture in specific. Different studies have demonstrated that the differences in the nature, speed and extent of technological change can be explained through a systemic understanding of the national context within which that innovation and technological change occurs (Watson et al., 2014).

Jimma zone is one of the potential coffee growing zones in Ethiopia. According to Samuel et al. (2018), the share of coffee income from total income in coffee producing districts of Jimma zone is 77% and share of land allocated to coffee crop in these areas is more than 69%. This shows that coffee is the base of livelihood for most of the farmers in the area. Out of the 40–55 thousand tons of coffee which is annually produced in the zone, about 28–35 thousand tons is sent to the central market, while the remaining is locally consumed and it covers a total of 21% of the export share of the country and 43% of the export share of the Oromia Region (JZARDO, 2008).

Currently the coffee sector is suffocated with different problems. The system of coffee farm management and agronomic practices are mostly traditional. Low income from coffee production and farm land competition of khat (*Catha edulis*) with coffee production are some of the problems that can be seen in the study area. One of the most important means of decreasing the consequence of these problems and improving coffee production and productivity is the development and adoption of new coffee production technology. Expansion and adaptation of new coffee technologies can help in improving the quality and productivity of coffee which can bring a greater economic efficiency and growth in the national economy. In relation to this, many researches have been conducted in different studies but the aim of most of them was focused on how to develop different coffee production technologies and how to expand improved coffee varieties for major coffee growing areas of the country. In this regard persistent studies that illustrate the adoption status of the disseminated technologies are very important that needs more prominence. Therefore, this study was designed to assess farmers' status of coffee technology adoption in Jimma zone and to identify the different factors that can determine the coffee technology adoption decision of the farmers in the area.

MATERIALS AND METHODS

Study Area

The study was conducted in Jimma zone which is located 355 km to the south west of Addis Ababa. The zone is characterized by a tropical highland climate with heavy rainfall, warm temperatures and a long wet period. The mean annual rainfall ranges between 1,200 mm and 2,500 mm. Coffee is produced in 13 of 18 districts of Jimma zone. It is the major contributor to the socio economic well-being of the farmers in the zone.

Manna is one of the major coffee producing districts in Jimma zone, which is located at 368 km south west of Addis Ababa and 20 km west of Jimma town. It is the smallest district in the zone and it is found in the central part of the zone. According to the information that is found from Jimma zone agricultural office, it has an area of 480 km^2 and has one urban center, Yebu town, the district capital. It lies between 1,470 and 2,610 m asl. and the area is classified in to *dega* (cool zone) (12%), *woinadega* (sub-tropical zone)(63%) and *kolla* (tropical zone) (25%) agro-climatic zones. The mean minimum and maximum temperatures are 13.0°C and 24.8°C, respectively.

Sampling Techniques

In order to achieve the objectives of this study a multistage sampling technique was used. At the first stage, Manna woreda was selected purposively based on the criteria of area coverage and as major coffee producing area of Jimma zone. In the second stage, 4 kebeles or administrative units: namely Gubebikila, Dabesa, Somodo and Bilida were selected using a random sampling technique. Finally, 393 households were selected as sample respondents from the total 22,596 coffee growers in the district using the calculation formula of Taro (Yamane, 1967).

$$n = \frac{N}{1 + N\,(\varepsilon)^2}$$

Where:
n = sample size required
N = number of people in the population
ε = allowable error (%)

Data Collection Methods

Both primary and secondary data were used for this study. Primary data related to

personal, socioeconomic, technology and coffee innovation-specific variables and other relevant data were collected. Quantitative primary data were collected using household survey, in which the household heads or the coffee producers were asked the questions. Qualitative primary data were collected using key informants where knowledgeable people and coffee production experts in the area were asked on different issues relevant to the study. On the other hand, secondary data were obtained from published and unpublished sources which were found from the internet and different offices in Jimma zone such as Jimma agricultural research center, Jimma zone coffee and tea authority and agricultural office of Manna woreda in Jimma zone.

The primary data was collected using interview schedule and it was collected by visiting each one of the sample households and personal observation was also used as means of verifying the data collected by enumerators. Group discussion and individual interviews were held to have reactions of the farmers concerning their detail experiences and their perceptions of coffee production technologies and their priority problem. Information from Manna woreda (district) experts of the agricultural office and key informants is also accompanied.

Data Analysis

The binary logistic regression model which was illustrated by Gujarati (1995) was selected to analyze factors affecting coffee technology adoption. The dependent variable of the study is a dichotomous variable, which takes a value of 1 if the farmer adopts the technology and 0 if not. So the important explanatory variables which potentially affect the decision of coffee technology adoption are identified using this model. Other important qualitative and quantitative analytical techniques were also used to achieve the remaining objectives.

Based on Gujarati (1995), the functional form of logistic model is specified as follows:

$$\pi(x) = E(Y = f/x) = 1$$

$$\pi(x) = E(y = 1/x) = 1 + e^{-(Bo + BiXi)} \quad \ldots \ldots (1)$$

The probability that a farmer adopts coffee technology is expressed as follow:

$$\pi(x) = \frac{1}{1 + e^{-zi}} \quad \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

Where $\pi(x)$ = is a probability of adopting coffee technology ranges from 0 to 1, Zi = is a function of n-explanatory variables (x) which is also expressed as:

$$Zi = Bo + B_1X_1 + B_2X_2 + \ldots + BnXn$$

Table 1. The independent variables of the study

Notation	Variable name	Description	Variable type/criteria
Y	Adoption of coffee production technology	Farmer's adoption of coffee production technology	Dummy: 1 if adopted, 0 not adopted
X1	Age	Respondent's age	Continuous variable
X2	Gender	The Farmer's gender	Dummy: 1=male, 2=Female
X3	Education	Educational status of farmers	Categorical variable: 1=Non-formal 2=Primary, 3=Secondary, 4=College/University
X4	Family size	The number of family members	Continuous variable
X5	Dependency ratio	The ratio of inactive labor force to the active labor force	Continuous variable
X6	Coffee farm size	Total coffee farm size	Continuous variable
X7	Coffee growing experience	The coffee growing experience of the farmer in years	Continuous variable
X8	Frequency of DA (Department of agriculture) contact	Frequency of farmers contact with development agent	Independent variable 1 = often, 2 = sometimes, 3 = always 4 = none
X9	Tenure security	Tenure security for the farmer.	Dummy: 1 secured, 2 not secured
X10	Market distance	The distance of the market from the farmer's house	Continuous variable
X11	Cooperative membership	Farmers' cooperative membership	Dummy: 1 if yes, 2 otherwise
X12	Credit	Farmer's access to credit	Dummy: 1 have access,2 no access
X13	Total income	The annual income of the farmer.	Continuous variable
X14	Training	Famer's access to training	Dummy: 1 if yes, 2 otherwise

Where X1 = age of household head, X2 = sex of household head, X3 = educational status of household head, X4 = family size, X5 = dependency ratio, X6 = coffee farm size, X7 = coffee growing experience, X8 = DA (Department of Agriculture) support, X9 = tenure security, X10 = market distance, X11 = cooperative membership, X12 = credit, X13 = total income, X14 = training, Bo = intercept, B1, B2....... Bn = are slopes of the equation in the model. Table shows the detail of the explanatory variables.

The probability for not adopting is as follow:

$$1 - (x) = \frac{1}{1 + e^{zi}} \quad \text{.............................. (3)}$$

$$\frac{\pi (x)}{1-\pi (x)} = \frac{1 + e^{zi}}{1+ e^{-z}_{i}} = e^{zi} \quad \text{...................... (4)}$$

$\pi (x) / (1 - \pi (x))$ is the odds ratio in favor of coffee technology adoption. It is the ratio of the probability that a household will adopt coffee technology to the probability that it will not adopt.

Therefore we can get the following

$$Li = \ln\left[\frac{\pi (x)}{1-\pi (x)}\right] = Zi \quad \text{.......................... (5)}$$

$$Zi = Bo + B1X1 + B2X2 + \text{...........} + BnXn$$

Li =   log of the odds ratio, which is not only linear in Xi but also linear in the parameters.

Xi =   Vector of relevant explanatory variables.

Changing an independent variable in this case, is predicted to change the probability that a given farmer adopts the technology, and this will be helpful to forecast the probability of achieving coffee technology adoption.

RESULTS AND DISCUSSIONS

The status of coffee technology adoption in Jimma zone and the influence of different demographic, socio-economic and institutional factors on the adoption and use of the existing coffee technology are discussed consecutively. Out of the recommended coffee technologies in the area only improved coffee variety use, stumping, pruning, fertilizer, shade and mulching were included as there was no observed significant difference among the respondents in using other technologies. The dependent variable in this case is a dichotomous variable, which takes a value of 0 if the farmers do not adopt the technology and 1 if they adopt the technology.

In this study, sample respondents were composed of both male and female house-hold heads. Table 2 shows that 83 percent of the respondents are male and only 17% of them are female. This indicates that most of the farmers who are growing coffee in the study area are male or male headed house-holds. According to Ragasa *et al.* (2013), this is usually because of the difference between male-headed households and female headed households in accessing agricultural exten-sion service, agricultural inputs and tech-nologies. In addition most females when they become widow or divorce, they usually rent their land as they lack labor and the same is true for most of the rural females in the study area.

Age is one of the demographic factors that is useful to describe the respondents and helps to provide trace about their age structure (Shryock *et al.*, 1973). Accordingly in this study the respondents were grouped into five different age groups. The result shows that only 2% of the farmers have an age less than 25. Farmers with age of 25–34 were 16.5%. The largest proportion of the respondents was between 35–44 years that is 30%. 24.9% of the farmers are found under 45–54 age category. The remaining 26.5% of the farmers have an age above 55.

Table 2. The demographic and socio-economic characteristics of the respondents

	Frequency	Relative frequency %
Sex		
Male	326	83.0
Female	67	17.0
Age (years)		
< 25	8	2.0
25 – 34	65	16.5
35 – 44	118	30.0
45 – 54	98	24.9
55+	104	26.5
Level of education		
Non-formal	106	27.0
Primary	247	62.8
Secondary	16	4.1
College/University	24	6.1
Religion		
Muslim	289	73.5
Orthodox	100	25.4
Protestant	4	1.0
Family size		
1 – 5	192	48.9
6 – 10	197	50.1
11 – 15	4	1.0
Marital status		
Single	19	4.8
Married	351	89.3
Divorce	4	1.0
Widow	19	4.8
Coffee growing experience (years)		
< 5.00	4	1.0
5.00 – 9.00	32	8.1
10.00 – 14.00	59	15.0
15.00 – 19.00	54	13.7
20.00+	244	62.1
Annual income (ETB)		
<25000	266	67.7
25000 – 50000	90	22.9
50000 – 75000	30	7.6
75000 – 100000	3	0.8
>100000	4	1.0
Total	393	100

The role of education in adoption process is well known as it enhances the capacity of individuals to obtain, process, and utilize information from various sources. According to Ghimire *et al*. (2015), the more educated the farmer is, the more likely he/she will adopt new ideas as he or she can process information more rapidly than others. In this study 27% of the respondents have no any formal education and majority of the farmers that means 62.8% of the respondents have attended primary education. While 4.1% have attended secondary education and 6.1% are college/university graduates.

In regard to their religion, 73.5 percent of the respondents were Muslim and 25.4% of them were Orthodox. The remaining 1% are Protestant. The result also shows that 48.9 percent of the respondents have family size of 1–5 while 50.1% and 1% have family size of 6–10 and 11–15 respectively. The martial status of the respondents is also presented on Table 2. Accordingly, 89.3% of the respondents are married and 4.8% of the respondents are single. 1% of them are divorced and the remaining 4.8% are widowed.

The majority of the respondents have a good coffee growing experience. Around 62.1% of them have been growing coffee for more than 20 years and only 1% of them have been growing coffee for less than five years. 8.1%, 15%, and 13.7% of the respondents have 5–9, 10–14, and 15–19 years of growing coffee experience, respectively.

The annual income of the respondents ranges from <25000 ETB which is 67.7% to>100000 ETB that is 1% of them. The others 22.9%, 7.6% and 0.8% of the farmers have an annual income of 25000–50000 ETB, 50000–75000 ETB and 75000–100000 ETB, respectively. Therefore the annual income of the majority is very low.

Adoption Production Technologies

Coffee technology adoption in the study area involves the use of different technologies and practices recommended by Jimma Agricultural Research Center and Jimma University. These include the use of improved variety, seeding rate, fertilizer rate, pruning, spacing, compost application rate, stumping, recommended frequency of weeding and other many technologies. Therefore, a significant development of a farmer's coffee production

and productivity depends on their adoption of these technologies. Out of these recommended coffee technologies in the area, only adoption of improved coffee variety, stumping, pruning, fertilizer, shade and mulching were included as there was no significant difference in using other recommendations among the respondents and the adoption status of these selected technologies in the study area is presented below.

The farmers were asked whether they are growing improved coffee variety or not and 67% of the respondents were responded as they are using improved coffee variety even though there is a difference in the area coverage among them. This difference is because of their varying land holding and stage of an individual in the adoption process. Therefore, in this study all farmers who are using improved coffee variety are considered as adopters and the non-adaptors are those who are not using improved coffee variety.

Coffee stumping technology is one of the important coffee technologies that need to be used fully in order to alleviate the declining of production due to age of coffee trees (Mulugeta, 2009). It is practiced by cutting of the entire tree down to a level of about 40–50 cm above the ground. It is possible to left two branches or stems as needed. It is known that old wood and dense canopies slow down cherry development and encourage disease so stumping helps in improving this problem. Compared with replanting, stumping is cheaper and it also takes shorter time to give good production. 54.2% of the farmers, who practice stumping in the study area, are stumping their coffee plant on rotational basis rather than all trees at ones. The remaining 45.8% of the farmers are not practicing stumping.

Pruning is the other important practices in the management of coffee plant. It helps to regulate production and stretch the lifespan of a coffee tree by reducing the occurrence of pests and diseases (Anzueto *et al.*, 2005). In addition to this if the farmers do not practice pruning, their coffee tree grow brunches all over the place and it becomes weak and ages very quickly. Thus for better result, the coffee tree must be pruned. In this study 61% of the respondents have adopted pruning practices while 39% of them have not yet started to practice pruning.

Using chemical fertilizer in combination with compost of decomposed coffee husk and manure improves the activity of micro-organisms and improve the property of the soil (Dzung, 2013). It is used for optimal by improving the yield performance of the coffee trees. In the study area 85% of the respondents use fertilizer for their coffee tree and the remaining 15% do not use fertilizer.

Naturally coffee is a shade loving plant so it has to be planted with certain trees. Shade trees help as wind breakers to protect the coffee trees and protect it from extreme sunshine by decreasing temperature, humidity, and solar radiation fluctuations (Lin, 2007). They can also help in recovering soil nutrients and in providing organic matter or manure when the leaves of the shade tree fall and rot. This organic matter improves the soil texture and water retention thus availing the much needed water to the coffee. On the other hand if leguminous species are used as shade trees they are good sources of nitrate for the coffee plant. Majority of the farmers in the study area plant coffee tree with a shade tree. Accordingly 92 % of the respondents use shade trees for their coffee farm and only 8% of the respondents have replied as they are not using shade trees.

Mulching is the process of covering the soil to avoid water loss through evaporation and to make more favorable conditions for plant growth, development (Shruti *et al.*, 2018). Most famers use coffee pulp as an

Table 3. The adoption status of six coffee production technologies in the study area

Type of technology	Coffee farmers responses to adoption category			
	No of adopters	No of non-adopters	% of adopters	% of non-adopters
Improved coffee variety	128	265	32.6	67.4
Stumping	213	180	54.2	45.8
Pruning	271	122	69.0	31.0
Application of fertilizer	183	210	46.6	53.4
Using shade tree	377	16	95.9	4.1
Mulching	292	101	74.3	25.7

ideal mulching material because it protects the soil from erosion. Mulching is highly recommended and it is a very important practice after a coffee tree is planted because it protects the soil and retains water and helps to keep the roots moist. It also keeps weeds out to help prevent root competition and prevents soil compaction. In regard to this, in the study area 74.3% of the farmers have adopted the practice and the other 25.7% are not using mulching. Generally the adoption status of the technologies is summarized in Table 3.

Factors Determining Technologies Adoption

The logit model is used to see the relative influence of different explanatory variables on the adoption of certain coffee technologies in the area. The dependent variable in this case is a dichotomous variable which takes a value of 0 if the farmers did not adopt the technology and 1 if they adopt the technology. Accordingly, improved coffee variety, stumping, pruning, fertilizer application, using shade tree and mulching are the chosen recommended coffee technologies for this analysis. Other technologies are not included because there is no considerable difference in using them among the farmers. The various factors that are assumed to have influence on the dependent variables are grouped into three broad categories as socio-demographic factors, economic factors and institutional factors. The socio-demographic factors that are assumed to influence the dependent variable include age,

gender, education level, family size, dependency ratio, and experience of coffee production. Economical factor includes household income and farm size. The institutional factors include availability of credit, contact to DA (Department of Agriculture), distance from the nearest market, the land tenure system and access to training. Therefore, the influence of these variables on the adoption of each coffee technology is presented as follows in Table 4.

Age is found to be significant and negatively correlated with adoption of improved coffee variety ($\beta = -0.031**p < 0.05$). This implies that younger farmers are more likely to adopt improved coffee variety compared to the older farmers. This might be because of the risk averting behavior of older farmers which makes them to be reluctant to adopt new ideas and new technologies. In other side, the younger farmers usually have good exposure to new ideas and information. In addition they have a tendency to be more innovative than older farmers. This result coincides with the finding of Paul *et al.* (2017), Neupane *et al.* (2002) and Odera *et al.* (2000) but it contradicts with the finding of Kariyasa & Dewi (2013).

Sex is the second variable which is found to be significant and has a negative correlation with mulching practice ($\beta = -0.733*$, $p < 10\%$). This variable is not correlated with other technologies. The result reveals that female farmers do not usually practice mulching compared to their male counterparts. This clearly displays the existing gap among male headed and female headed

Table 4. The results of econometric model

Factors	Improved coffee variety		Stumping		Pruning		Fertilizer		Shade		Mulching	
	Cfc	(Sig)	Cfc	(Sig)	Cfc	(Sig)	Cfc	(Sig)	Cfc	(Sig)	Cfc	(Sig)
Age	-0.031 **	(0.008)	-0.013	(0.265)	0.006	(0.650)	0.013	(0.266)	-0.008	(0.832)	-0.002	(0.884)
Sex	0.135	(0.759)	0.075	(0.856)	-0.111	(0.796)	-0.036	(0.926)	1.526	(0.205)	-0.733 *	(0.097)
Education	-0.120 **	(0.010)	-0.090 *	(0.053)	-0.005	(0.930)	-0.056	(0.208)	0.293 **	(0.032)	-0.042	(0.380)
Famy size	-0.002	(0.976)	0.262 ***	(0.000)	0.159 **	(0.011)	0.157 ***	(0.004)	0.410 **	(0.011)	0.120 **	(0.044)
Dep Ratio	-0.019	(0.861)	-0.377 **	(0.036)	0.212	(0.257)	-0.420 **	(0.011)	-0.341	(0.217)	-0.106	(0.537)
Cofarmsiz	-0.465 **	(0.030)	0.400 *	(0.084)	-0.192	(0.410)	-0.682 ***	(0.002)	-0.380	(0.611)	-0.575 **	(0.024)
Farmexp	0.019	(0.206)	-0.026 *	(0.082)	-0.039 **	(0.023)	-0.030 **	(0.037)	0.060	(0.189)	-0.004	(0.787)
DAsuport	0.614 *	(0.092)	2.106 ***	(0.000)	1.834 ***	(0.000)	0.774 **	(0.020)	-1.152	(0.256)	1.503 ***	(0.000)
Tensecury	0.667	(0.289)	-1.032 **	(0.050)	-0.389	(0.432)	-0.378	(0.428)	-19.95	(0.998)	-0.531	(0.352)
MarkDis	-0.034 ***	(0.000)	-0.018 ***	(0.000)	0.004	(0.353)	0.000	(0.948)	-0.039 ***	(0.000)	-0.010 **	(0.013)
Copmem	1.162 **	(0.011)	-0.634	(0.148)	1.085 **	(0.022)	-0.327	(0.404)	1.874	(0.101)	-0.299	(0.504)
Credit	-0.396	(0.177)	-0.372	(0.185)	-0.921 ***	(0.003)	0.897 ***	(0.002)	1.748	(0.138)	-0.657 **	(0.024)
Totincome	0.000 *	(0.071)	0.000	(0.321)	0.000 ***	(0.000)	0.000 ***	(0.005)	0.000 *	(0.053)	0.000	(0.785)
Training	0.603 **	(0.039)	1.059 ***	(0.000)	1.140 ***	(0.001)	0.436	(0.127)	1.934 **	(0.023)	1.167 ***	(0.000)
Constant	3.132	(0.042)	6.027	(0.000)	5.355	(0.001)	4.754	(0.000)	2.000	(1.000)	3.302	(0.021)

Notes: *** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

households in terms of adopting mulching practice and this might be related with lack of time and freedom to participate in different training programs. This makes them not to know the importance of some technologies like mulching. This result is in line with finding of Okon & Idiong (2016). On the other hand the study conducted by Morris & Doss (2001) show that there is no significant relationship between sex of the household head and adoption behavior.

Educational status of the farmer is the third variable which is found to be significant and has a positive correlation with adoption of improved coffee variety ($\beta = 0.120**$ p < 0.05), adoption of stumping technology ($\beta = 0.090*$ p $< 10\%$) and using shade tree ($\beta = 0.293**$ p <0.05). The result implies that when the farmers are more educated, they are more likely to adopt these coffee production technologies in the study area. This might be because of being literate would improve access to information which is disseminated by different sources. They can also easily understand the importance of the technologies better than the illiterate farmers. This result supports the finding of Ghimire *et al.* (2015), Yitayal (2004) and Degu (2012). In contrary the study conducted by Uematsu & Mishra (2010) shows a negative influence of farmer's formal education towards the adopting behavior of farmers.

Family size is the other important factor which is found to be significant and has a positive correlation with using of stumping technologies ($\beta = 0.262***$ p < 0.01), pruning ($\beta = 0.159**$ p < 0.05), fertilizer application ($\beta = 0.157***$ p < 0.01), mulching ($\beta = 0.120**$ p < 0.05) and using of shade trees ($\beta = 0.410**$ p < 0.05). This might be because of more labor gained from a large family size which is considered to lead the farmers to the adopting process of the technologies. Compared to small size of family, a large family size provides the necessary labor force which is needed in the adoption process of the technologies. In other way the additional income from their labor invested in other activities and their incentive to produce more output on their coffee farm makes farmers with a large family size to adopt more technologies than the others. This result is in line with other findings such as Allahyari *et al.* (2016), Mignouna *et al.* (2011) and Amsalu *et al.* (2008), who have also reported a positive relationship of family size with the adoption tendency of farmers.

Dependency ratio is the other factor which is found to be significant and has a negative correlation with stumping ($\beta = -0.377**$ p < 0.05) and fertilizer ($\beta = -0.420**$ p < 0.05) but it is found to have a positive correlation with pruning ($\beta = 0.212*$ p < 0.05). Adoption of stumping

technology generally requires more active labor inputs so large number of dependency ratio may prevent its adoption. Besides, it may not be available for the farmers who have high number of non-active family members as it is difficult for them to afford the cost of fertilizer. This confirms the findings of Atinkut *et al.* (2017), Ouma *et al.* (2002) and Keil *et al.* (2005) who have revealed that availability of labor in the family or lower dependency ratio increases the adoption tendency of farmers.

Coffee farm size has also found to have significant and negative correlation with improved coffee variety (β = -0.465** p < 0.05), fertilizer (β = -0.682*** p < 0.01) and mulching (β = -0.575** p < 0.05) but it has a positive significant correlation with stumping (β = 0.400* p < 10%). The result reveals that farmers who have larger coffee farm size have more likely to stump their old coffee plants. These farmers are usually characterized by their willingness to take the risk and costs associated with stumping of old coffee trees like losing of yields for two or more years. In other hand the farmers with larger coffee farm size are reluctant to adopt new coffee variety and using of fertilizer. This might be due to their secureness to get enough income from their large coffee farm. This result is consistent with the result of Okon & Idiong (2016) who have also shown the negative correlation of farm size with farmers' adoption decision. Onyewaku & Mbuba, (1991) have also confirmed that increase in farm size might not lead to adoption of the technology. In contradiction to this, the studies conducted by Gebrezgabher *et al.* (2015), Chukwuji & Ogisi (2006), and Uaiene *et al.* (2009) show the positive influence of farm size in the adoption decision of farmers.

Coffee growing experience is another important variable that has relationship with adoption of coffee production technologies. It is found to be significant and has a negative

correlation with stumping (β = -0.026* p < 10%) pruning (β = -0.039** p < 0.05) and fertilizer (β = -0.030** p < 0.05). This might be because of the unwillingness of old farmers as they are generally the ones who have a good coffee growing experience in traditional way and in regard to adopting new production technologies they are usually reluctant compared to the young farmers. This result is in line with the work of Carrer *et al.* (2017), where they have revealed that farmers experience had a negative effect on the adoption behavior of farmers. On contrary to this, in the study conducted by Egge (2005), farm experience was found to be an important factor that affects farmers' innovation adoption behavior positively.

DA (development agent) support is also found to be significant and has positive correlation with adoption of improved coffee variety (β = 0.614* p < 10%), stumping (β = 2.106*** p < 0.01), pruning (β = 1.834*** p < 0.01), fertilizer (β = 0.774** p < 0.05), mulching (β = 1.503*** p < 0.01). Farmers who had more frequent contact with development agents were more likely to adopt coffee production technologies as compared to farmers who had less contact with development agents. Therefore, DA support has an important role in the process of coffee technology adoption. This result supports the study conducted by Sánchez-Toledano *et al.* (2018), where development agent support through effective extension contact is found to be positive determinant factors of the adoption behavior of farmers. Other studies which were conducted by Goswami *et al.* (2016), Tefera *et al.* (2016), Tadesse (2008), Akudugu *et al.* (2012), have also revealed a positive significant influence of good extension agency with frequent development agents support contact on the adoption behavior of farmers.

Market distance is also found to be significant and has negative correlation with adoption of improved coffee variety (β =

0.034*** p < 0.01), stumping (β = 0.018*** p < 0.01), shade (β = 0.039*** p < 0.01) and mulching (β = 0.010** p < 0.05). This negative relationship between distance of the residence of the farmers and adoption of these coffee production technologies might be because of low access to technology related information and high transportation cost because of the distance. This is consistent with the work of Han *et al.* (2018) and Shiferaw & Tesfaye (2005) where they have found the negative impact of market distance on the adoption of behavior of farmers.

Cooperative membership was significant and has positive relation with improved coffee variety (β = 1.162** p < 0.05) and pruning (β = 1.085** p < 0.05). The result shows that farmers who are a member of cooperative are usually adopt the recommended technologies compared to the non-members. This might be because of their exposure to information which enables them to be more aware of coffee production technologies and new recommended practices compared to the non-members. It also facilitates discussion and information exchange among the farmers that can inspire them to adopt the technologies. This result confirms the finding by Wang *et al.* (2016), Okon *et al.* (2016) and Ajayi *et al.* (2003) where all have shown the positive relationship of farmers membership with their adoption decision.

Credit is another factor which is found to have a significant and positive correlation with using of fertilizer (β = 0.897*** p < 0.01) and it is negatively correlated with the adoption of pruning practice (β = -0.921*** p < 0.01) and mulching (β = -0.657** p < 0.05). It is found to be an important factor for adoption of fertilizer. Credit is usually the source of finance for the medium and lower income households to buy inputs like fertilizer. With regard to adoption of pruning and mulching, credit has negative correlation and this implies that farmers who have access to credit are less likely to invest in the adoption of coffee production technologies because of the risk to invest in coffee production technologies and the borrowed money has to be paid back by any means. The positive correlation of credit with adoption is in agreement with the study conducted in Ghana by Djokoto *et al.* (2016), where access to credit was found to have a positively influence in the adoption decision of cocoa technology. In addition Liu *et al.* (2018), Gockowski & Ndoumbe (2004), Simtowe & Zeller (2006) and Minyahil (2008) also show the same positive influence of credit on farmers adoption decision.

Total income of the household is another variable which is found to have a significant and positive correlation with adoption of improved coffee variety (β = 0.000* p < 10%), pruning (β = 0.000*** p < 0.01), using fertilizer (β = 0.000*** p < 0.01) and using of shade tree (β = 0.000* p < 10%). This suggested that the increased income of the farmers contributed to the better adoption of these technologies and those farmers with limited incomes are reluctant to adopt new recommendations and technologies due to the risks of possible low gain and they cannot also afford the expenses of the technologies. This is in line with the finding of Goswami *et al.* (2016), where the annual income of the farmers in West Bengal is found to have a positive significant influence on their adoption behavior. In addition the studies conducted by Alam (2015), Gebresembet (2008), and Gebregziabher (2014) also show the same result.

The result illustrates that training is significant and has a positive relationship with adoption of improved coffee variety (β = 0.603** p < 0.05), adoption of old coffee stumping technology (β = 1.059*** p < 0.01), pruning practice (β = 1.140*** p < 0.01), using shade tree (β = 1.934** p < 0.05) and mulching (β = 1.167***

p < 0.01). The positive correlation of training with the adoption of these technologies suggests that, farmers who participate in different training programs have good knowledge of coffee production technologies and they get information about the importance of adopting coffee production technologies. The same result is revealed in the study conducted by Han (2018) and Wang (2016) where they have found a significant positive influence of training on farmers' adoption behavior. In addition Rezadoost *et al.* (2014), have also highlighted the importance of farmers training in the adoption process of different innovations.

From the results in general it is recommended that, in spite of generating new coffee production technology, attention has to be given to the adoption of these technologies. Therefore, being aware of the potential influencing variables and implementing different interventions as well as improving the existing system, it is very important to achieve broad adoption of coffee production technologies in order to enhance the production and quality of coffee in the area.

CONCLUSIONS

In this study, the coffee technology adoption status of farmers in Jimma zone was assessed and 67.4 %, 45.8%, 31%, 53.4%, 4.1%, and 25.7% of the respondents were not yet adopted the improved coffee variety, stumping, pruning, fertilizer, shade tree and mulching, respectively. As a result age was found to be significant and negatively correlated with adoption of improved coffee variety. Sex of the farmer was the second variable which was found to be significant and had a negative correlation with mulching practice. Educational status of the farmer was the other important factors which was found to be significant and had a positive correlation with adoption of improved coffee variety, adoption of stumping technology and

using shade tree. Family size was also found to be significant and had a positive correlation with using of stumping technologies, pruning, fertilizer application, mulching and using of shade trees. Dependency ratio, which was significant and had a negative correlation with stumping and fertilizer application, was found to have a positive correlation with pruning. Likewise coffee farm size was found to be significant and had a negative correlation with improved coffee variety, fertilizer and mulching but it had a positive significant correlation with stumping. The coffee growing experience of the farmers was also significant and had a negative correlation with stumping, pruning and fertilizer. Moreover development agent support had a significant positive correlation with adoption of improved coffee variety, stumping, pruning, fertilizer application and mulching. Market distance was the other factor that has a negative correlation with adoption of improved coffee variety, stumping, shade and mulching. Cooperative membership also found to be significant and has negative relation with improved coffee variety and pruning. Crediton on the other hand was found to have a positive correlation with fertilizer application and is negatively correlated with the adoption of pruning practice and mulching. The total income of the household was found to be significant and had a positive correlation with adoption of improved coffee variety, pruning, using fertilizer and using of shade tree and training was also found to have a positive relationship with adoption of improved coffee variety, stumping technology, pruning practice, using shade tree and mulching.

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