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ADOPTION OF IMPROVED AGRICULTURAL TECHNOLOGIES BY COCOA FARMER AND EFFECTS ON FARM INCOME: EVIDENCE FROM ONDO STATE, NIGERIA

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ABSTRACT
The adoption of new agricultural technology that could lead to a significant increase in agricultural production and productivity can be realized when yield increasing technologies are widely used and diffused. This study aimed at identifying the determinants of agricultural technology adoption decision and examining the effects of adoption on farm income. Multi-stage sampling technique was used to collect primary data from 200 cocoa farmers. Data collected were analyzed using descriptive statistics, Probit and Ordinary Least Square (OLS) regression models. The study revealed that adopters of the improved technologies are more educated, had larger hectares of farm-land and cultivated more land than the non-adopters. Most of the non-adopters were older with larger household size. The probit model identifies the determinants of improved technology adoption to include age, household size, education, membership of farmers' association, farm size influenced adoption decisions of improved technologies. The regression result also revealed that agricultural technology adoption had a positive and significant effect on the income of adopters by increasing their farm income.

INTRODUCTION

Agriculture has been a cornerstone in Nigeria economy and a major source of income to about 90% 0f rural dwellers. With the abundance of human and natural resources, Nigeria rural sector accommodates 70% of the nation's population and employs about 75% of the labour force as well as contributes 40% of the nation's GDP. Despite its significant contribution to the life of the people, majority of Nigerians are faced with poverty (Igbalajobi *et al*, 2013). Indeed, agriculture is central to the livelihood of most people that live in rural areas whose population accounts for more than half of the world's population. Productivity increases in agriculture can reduce poverty by increasing farmers' income, reducing food prices and thereby, enhancing increments in consumption.

The improved agricultural technology can be defined as the sustainable production by which the farmer increases and maintains productivity, through soil fertility maintenance at levels that are economically viable, ecologically sound and culturally acceptable using efficient management of resources (Aneani, 2012). The adoption of new agricultural technology such as the high yielding varieties (HYV), fertilizers, pesticides etc could lead to significant increases in agricultural productivity and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (World Bank, 2008). Studies that show a positive impact of the adoption of agricultural technologies include; Winters *et al.* (1998) and Dejanvry and Sadoulet (1992), Mendola (2006), Kijima *et al* (2008), Adekambi *et al* (2009). Agricultural research and technological improvements are therefore crucial to increase agricultural productivity and thereby reduce poverty and meet demands for food without irreversible degradation of the natural resource base. Agricultural research and technological improvements are also crucial in reducing poverty (Solomon (2010); Solomon *et al*, 2011). The role of agricultural technologies and innovations in alleviating and reducing poverty and contributing to economic development has been well documented (Just and Zilbermann, 1988, Binswanger and von Braun, 1991). The benefits of adopting new technologies and innovations are viewed directly through productivity increases that can translate into higher farm incomes and food security. Indirect benefits can accrue to other farmers and consumers through lower food prices, increase in food availability, accessibility and consumption and potentially non-farm employment (de Janvry and Sadoulet, 2001; Pervez et al. 2018).

Adoption of technologies occurs in an innovation-decision process that consists of a series of actions and choices over time through which individuals or other decision-making units evaluate a new idea and decides whether or not to include the innovation into existing practices (Rogers, 1995). It has been greatly demonstrated that technology uptake is a major contributory factor to increased agricultural productivity (Semana, (1999); Doss and Morris (2001); Neupane, *et al*., 2002; Marenya and Barrett, (2006); Kiptot, *et al*., (2007). Therefore, evaluation studies of technology adoption provide evidence-based information that is useful in decision making as well as in designing effective intervention programmes and projects in agriculture. They enable the enactment of a feedback mechanism in which lessons learnt from implementation of programmes, can be used in future, to support development objectives (Thornton, *et al*., 2003)

For a technology to be adopted by farmers, it must be affordable. Affordability does not end at an initial cost of the technology. It also includes repairs and maintenance cost, availability of personnel to operate or manage the technology and the impact of the technology either to the environment or the immediate user. Planting of hybrid cocoa seedlings, use of agro-chemicals, pruning and fermentation were cocoa technologies adopted by the farmers.

The factors that influence the adoption of modern agricultural production technologies are broadly categorized into economic factors, social factors and institutional factors. The economic factors include farm size, cost of technology or modernization, expected benefits from the adoption of the technology, and off-farm activities. The social factors that influence probability of adoption of modern agricultural production technologies by farm households include age, level of education and gender. Institutional factors include access to information and extension services. The farmers require knowledge on the skills, techniques and the ability to use resources in the most efficient and effective ways, minimizing waste and loses so as to achieve the best.

Cocoa (*Theobroma cacao* L.) originated from the upper Amazon region of South America from where it spread to different parts of the world. (Osun, 2001). Originally, cocoa was mainly cultivated in the

tropical rainforests in South America. Cocoa production expanded rapidly in Africa and by the mid-1920s, West and Central Africa (WCA) became the main producer. Cocoa grows naturally in tropical rain forests. This habitat provides heavy shade and rainfall, uniform temperature and constant relative humidity and is typically only found within 10º of the equator. WCA produces about 70% of world cocoa. About 90-95% of all cocoa is produced by smallholders with farm sizes of two to five hectares (ICCO, 2007). Cocoa is dependent on natural resources and unskilled or semi-skilled low-cost labour rather than technology as the dominant portion of its total cost. (Bedford, 2002). In Africa, cocoa production is dominated by four countries. Côte d'Ivoire and Ghana produce approximately 41% and 17% of the world output respectively. The other two important producers are Cameroon and Nigeria, each contributing approximately 5% of the world cocoa production.

Cocoa is a major economic tree crop in Nigeria. Between 1950 and 1960, cocoa was the highest source of foreign exchange in the country (Oyedele, 2007). Cocoa cultivation gained prominence rapidly in Nigeria such that by 1965, Nigeria became the second-largest producer in the world. However, in recent times, Nigeria has slipped from being the world's second-largest producer to the fourth position. Ranking on the top of the 10 countries with significant global production of cocoa in Côte d'Ivoire, followed by Ghana and Indonesia, and Nigeria ranked fourth (UNECA, 2013). Following the investments in the oil sector, the 1970s and 1980s saw a constant economic down turn and decline in cocoa production in the country. Despite the launch of the Structural Adjustment Programme (SAP) in 1986 and overall economic liberalization policy, cocoa production is still primarily managed by smallholders with low use of both inputs and product enhancing agricultural techniques (Idowu, 2007).

Cocoa is an important generator of income for most rural farmers in Nigeria especially in the Southwestern states and serves as a backbone for their livelihood. The production of cocoa is largely dominated by smallholders who operate at very low levels of productivity. Diseases and pests attacks, declining soil fertility, poor agronomic practices, use of low yielding varieties, limited access to credit as well as inadequate infrastructure constitute major constraints to productivity (Appiah, 2000). Agboola and Ochigbo (2011) claimed that cocoa and cocoa preparations contributed $533.4 million to Nigeria non-oil export earning between January and June 2011, while Agbota (2013) claimed that cocoa contributed $900m to Nigeria's economy in 2012. In addition, Ndubuto *et al* (2010) opined that Nigeria has a comparative advantage in the production and exportation of cocoa, thus adoption of improved cocoa technology is expected to raise cocoa production in Nigeria and make the country the leading producer of cocoa in the world.

The Nigerian cocoa economy has a rich history which is well documented in the literature. The contributions of cocoa to the nation's economic development are vast and have been reported by many authors (Olayide, 1969; Folayan, *et al* 2006). Moreover, with the discovery of oil and gas, the contribution of agriculture to the overall economic growth has declined from 70 per cent at independence to about 25 per cent in the mid-1970s (the oil boom period). In spite of this sharp decline, agricultural sector accounts for about 80 per cent of the active labour force (CBN, 2007). In like manner, cocoa industry began to deteriorate. It is obvious that increased productivity in the cocoa industry is paramount to improvement in rural standards of living.

Cocoa production in Nigeria is retarded by the declining productivity of the existing old cocoa trees. For example, Fasina *et al*, (2001) and CRIN, (2003) showed that most of the cocoa trees in the country have almost attained 30 years of age with diminishing production trend. These old trees

coupled with their susceptibility to pest attack are responsible for decline in the quality and quantity of cocoa production in the country.

This study, therefore, describes the socio-economic characteristics of the respondents in the study area, identifies the determinants of agricultural technology adoption decision and examines the effects of adoption on farm income.

METHODOLOGY

The Study Area

The study area is Ondo State in South-Western Nigeria. It was one of the seven states created on 3rd February 1976. The state consists of eighteen Local Government Areas. The choice of the study area was born out of its prominence in cocoa production. About 60% of the nation's cocoa output is produced in Ondo State (IITA, 2007).

Agriculture (including fishing) constitutes the main occupation of the people of the state. Ondo state is the leading cocoa producing a state in Nigeria. Other agricultural crops grown in the state include yams, cassava, kolanut, cocoyam and palm produce. Farming in the state is characterized by small farm sizes, inadequate supply of modern farming inputs, poor state of rural infrastructure, ageing farmers and cocoa trees, significant post-harvest losses, dependence on rain for farming, and lack of interest among youths in agricultural activities.

Sampling Method and Data Collection

A well-structured questionnaire was used to collect primary data from 200 cocoa farmers using a multi-stage sampling technique. At the first stage, four notable cocoa-producing Local Government Areas (Ile oluji, Akure South, Ondo East and Idanre) out of a total of fifteen cocoa-producing LGAs in Ondo State. The second stage involved the random selection of five communities from each of the selected LGAs while the third stage involved the random selection of ten respondents from the selected communities. Data collected were analyzed using descriptive statistics, Probit and Ordinary Least Square model.

THEORETICAL MODEL AND EMPIRICAL SPECIFICATION

In this study, regardless of the intensity and quantity of technologies being used, a farmer was taken as an adopter if he or she sows any improved variety, uses the recommended fertilizers and pesticides. The dependent variable, technology adoption has a binary nature taking the value of 1 for adopters (HYV, fertilizer and pesticide) and 0 for non-adopters. In this regard, an econometric model employed while examining probability of farm household's agricultural technology adoption decision was the probit model. Often, probit model is imperative when an individual is to choose one from two alternative choices, in this case, either to adopt or not. Hence, an individual i makes a decision to adopt HYV, fertilizer and pesticide if the utility associated with the adoption choice (V_{1i}) is higher than the utility associated with decision not to adopt (V_{0i}). Hence, in this model there is a latent or unobserved continuous variable that takes all the values in (-∞, +∞). These two different alternatives and respective utilities can be quantified as: $Y_i^* = V_{1i} - V_{0i}$ (Koop, 2003 and Kassa *et al.* 2014). The econometric specification of the model is given in its latent as:

$$Y_i = \begin{matrix} 1 & Y_i^* \geq 0 \\ 0 & Y_i^* \leq 0 \end{matrix}$$

Where Y_i takes the value of 1 for adopters and 0 for non-adopters

$$Y_i^* = x\beta_i + u_i \quad (1)$$

Where u/x is a normally distributed error term.

Form the observed or latent model specification, the utility function depends on household-specific attributes *X* and a disturbance term $u$having a zero mean:

$U_{i1}(X) = \beta_1 X_i + u_{i0}$ for adopters (2)

As utility is random, the *i*th household will adopt if and only if $U_{i1}>U_{i0}$. Thus, for the household *i*, the probability of adoption is given by:

$$P(1) = U_{i1}>U_{i0} \quad (3)$$

$$P(1) = P(\beta_1 X_i + u_{i1} > \beta_0 X_i + u_{i0}) \quad (4)$$

$$P(1) = P(u_{i0} - u_{i1} < \beta_1 X_i - \beta_0 X_i) \quad (5)$$

$$P(1) = P(u_i < \beta X_i \quad (6)$$

$$P(Y_i = 1) = \varphi(-X'_i\beta_1 / \boldsymbol{\sigma}) \quad (7)$$

Where, $P(1)$ is the probability of adopting improved seedlings, fertilizer and pesticide

$\boldsymbol{\varphi}$ is the cumulative distribution function of the standard normal distribution

$\boldsymbol{\beta}$is the parameters that are estimated by maximum likelihood

X' is a vector of exogenous variables that explains the adoption of improved seedlings, fertilizer and pesticides (age of respondents, education, farm size, membership of cooperative society, access to credit, etc). Therefore, on the basis of the three dependent variables indicated: Improved seedling fertilizer and pesticide, probit model was applied independently for each binary dependent variable; given below

$$IMPSEEDADOPT = \delta_0 + \delta_1 AGE + \delta_2 EDUC + \delta_3 HHSIZE + \delta_4 LANDTEN + \delta_5 MBERASS + \delta_6 ACCESS + \delta_7 FARMSIZE + \delta_8 YRSEXP + \delta_9 YIELD$$

$$FERTADOPT = \delta_0 + \delta_1 AGE + \delta_2 EDUC + \delta_3 HHSIZE + \delta_4 LANDTEN + \delta_5 MBERASS + \delta_6 ACCESS + \delta_7 FARMSIZE + \delta_8 YRSEXP + \delta_9 YIELD$$

$$PESTADOPT = \delta_0 + \delta_1 AGE + \delta_2 EDUC + \delta_3 HHSIZE + \delta_4 LANDTEN + \delta_5 MBERASS + \delta_6 ACCESS + \delta_7 FARMSIZE + \delta_8 YRSEXP + \delta_9 YIELD$$

Given the above three dependent variables, to estimate the magnitude of parameters or variables basically to put clearly the percentage probability of adoption, the marginal effect of variables was calculated. Marginal effect of a variable is the effect of unit change for that variable on the probability of $P(Y = 1/X = x)$, given that all other variables are constant. The marginal effect is expressed as:

$$\frac{\partial P(Y_i=1/X_i)}{\partial X_i} = \frac{\partial E(Y_i/X_i)}{\partial X_i} = \varphi(X'\beta)\beta. \quad (8)$$

To examine the effect of agricultural technology adoption on farm income, Ordinary Least Square (OLS) regression model was employed. The rationale was due to the continuous nature of the dependent variable, farm income. According to Gujarati (2006), with the assumption of a classical linear model, OLS estimators are unbiased linear estimators with minimum variance and hence they are Best Linear Unbiased Estimators. Hence, its specification is given below using similar independent variables used in the probit model above.

$$Y = \beta_0 + \beta_1 X_i + U_i \quad (9)$$

Where, *Y* is the dependent variable (farm income), *X* is a vector of explanatory variables, $\boldsymbol{\beta}$ is a vector of estimated coefficient of the explanatory variables and u_i indicates disturbance term which is assumed to satisfy all OLS assumptions (Gujarati, 2006).

$$Farminc = \beta_0 + \beta_1 AGE + \beta_2 EDUC + \beta_3 HHSIZE + \beta_4 LANDTEN + \beta_5 MBERASS + \beta_6 ACCESS + \beta_7 FARMSIZE + \beta_8 YRSEXP + \beta_9 YIELD$$

Where Farming is the continuous dependent variable indicating farm income

RESULTS AND DISCUSSION

It is believed that the socio-economic characteristics of respondents described in the table below are relevant in providing information about the general features of the area under investigation.

Age is very important in agricultural production as it affects the attitude to work on the farm and efficient utilization of resources. The age of a farmer determines ability to adopt innovations. The distribution of age of respondents as revealed in Table 1 shows that 42.5% of the cocoa farmers in the study area are within the age range of 51 and 60 years, the mean ages of the adopters and non-adopters were 54.26 and 56.14 respectively. Most of the non-adopters were older than the adopters. The t-value was 1.386 which is statistically insignificant. This shows that there is no significant difference in the mean age of the adopters and non-adopters. The findings revealed that majority of the respondents were old. This is in line with Amos (2007) who found that an average cocoa farmer in Ondo State is old and concluded that young farmers are more receptive than older

ones as the older ones are not always ready to part with the old techniques for new ones. This finding also agrees with the findings of Oseni and Adams (2013) and also with that of Nmadu *et al*. (2015) that an average cocoa farmer in Ondo State is old.

Table 1: Socio-Economic Characteristics of Respondents

Variables	**Adopters**		**Non Adopters**		**Pooled**	
Age	Freq	%	Freq	%	Freq	%
< 40.00	9	7.4	9	11.5	18	9.0
41.00 - 50.00	32	26.4	14	11.5	46	23.0
51.00 - 60.00	57	47.2	28	38.5	85	42.5
61.00 - 70.00	18	14.9	21	25.0	39	19.5
71.00+	5	4.1	7	13.5	12	6.0
Mean	54.26		56.14		55.00	
T-Test	1.386					
Gender						
Male	102	84.3	63	79.7	165	82.5
Female	19	15.7	16	20.3	35	17.5
Household size						
≤ 5	47	38.8	29	36.7	76	38.0
6 - 10	72	59.5	48	60.8	120	60.0
>10	2	1.7	2	2.5	4	2.0
Mean	6.08		6.37		6.19	
T-Test	1.593					
Cooperative Society						
No	0	0	73	92.4	73	36.5
Yes	121	100	6	7.60	127	63.5
Years of Farming Experience						
< 10.00	11	9.0	9	11.4	20	10.0
11.00 - 20.00	74	61.2	38	48.1	112	56.0
21.00 - 30.00	23	19.0	15	19.0	38	19.0
31.00 - 40.00	10	8.3	15	19.0	25	12.5
41.00+	3	2.5	2	2.5	5	2.5
Mean	20.54		20.61		21.36	
T-Test	1.582					
Farm Size(Hectare)						
< 2.00	79	65.3	56	70.8	135	67.5
2.01 - 4.00	32	26.4	19	24.1	51	25.5

4.01 - 6.00	6	5.0	4	5.1	10	5.0
6.01+	4	3.3	0	0	4	2.0
Mean	2.50		2.12		2.35	
T-Test	0.516					
Access to formal credit						
No	63	52.1	78	98.7	141	70.5
Yes	58	47.9	1	1.3	59	29.5

Gender distribution of respondents, as shown above, reveals that majority (82.5%) of the cocoa farmers in the study area were male out of which 84.3% were adopters and 79.7.2% were non-adopters. This implies that men dominate cocoa production among adopters and non-adopters in the study area. The female farmers have their own roles to play, especially in the maintenance and processing of cocoa beans as reported by Adetunji *et al.* (2007). These findings agree with Oseni and Adam (2013) who reported that more male was involved in cocoa production in Ondo State.

Household size has a great role to play in family labour provision in the agricultural sector (Sule, *et al.,* 2002). Table 1 revealed that the majority (60%) of the cocoa farmers in the study area had household sizes between six and ten out of which 59.5% were adopters and 60.8% were non-adopters. The mean of the household size of both adopters and non-adopters were 6.08 and 6.37 respectively. This means that the non-adopters have relatively large household size than the adopters. This implies that the farmers in the study area have a fairly large household which could probably serve as an insurance against short-falls in supply of farm labour. The t-value was 1.593 which is statistically insignificant. This shows that there is no significant difference in the mean of the household size of the adopters and non-adopters.

The table above also indicates that the majority (63.5%) of the farmers in the study area were members of cooperative societies. All the adopters belong to cooperative societies while only 7.6% of the non-adopters are members of cooperative societies. This implies that membership in cooperative society aid participation in new innovations introduced to the farmers in the study area. According to Yahaya and Omokhaye (2001), the social involvement of cocoa farmers through their participation in farmers' co-operatives will enhance diffusion of information among the farmers. Also, it is essential that cocoa farmers be involved in social organizations as it will enhance their access to government assistance in form of loan and other benefits.

Farming experience is an important factor determining both the productivity, adoption of technology and the production level in farming (Oseni and Adams, 2013). Table 1 reveals that the majority 56% of the respondents had farm experience between 11 and 20 years. The mean years of farming experience of both the adopters and non-adopters were 20.54 and 22.61 respectively. This implies that the latter had more farming experience than the former, which is an indication that they have been in the production for many years. Generally, it would appear that up to a certain number of years, farming experience would have a positive effect; after that, the effect may become negative. The negative effect may be derived from ageing or reluctance to change from old farm practices and techniques to those that are modern and improved. The t-value was 1.582 and was statistically insignificant. This shows that there is no significant difference in the mean of the years of experience of the adopters and non-adopters.

The land-holding capacity of the respondents as presented in Table 1 which shows that majority (67.5%) of the respondents had farm size below 2.0Ha out of which there are 65.3% adopters and 70.9% non-adopters. Hence, the farmers are predominantly small scale farmers. The mean value of adopters and non-adopters were 2.50 and 2.12 respectively. This suggests that the farmers had a relatively small size of farm which could be as a result of land fragmentation caused by land tenure system. These findings agree with that of Oluyole *et al.*, (2015) that cocoa farmers are predominantly small scale farmers. The t-value was 0.516 and statistically insignificant. This shows that there is no significant difference in the mean of the farm size of the adopters and non-adopters.

Table 1 also presents the result of access to formal credit by the farmers. From the result, 70.5% of the respondents did not have access to formal credit while only 29.5% had access. About 47.9% and 1.3% of the adopters and non-adopters respectively had access to formal credit. It can be deduced that lack of access to formal credit by the respondents could be as a result of small farmland holding capacity. However, farmers can be encouraged in their production by granting them access to formal credit.

DETERMINANTS OF AGRICULTURAL TECHNOLOGY ADOPTION DECISIONS OF RESPONDENTS

The factors that influenced the adoption of improved cocoa technologies were examined using the binary probit regression model. Farmers who had adopted at least one of the improved technologies were classified as adopters and those that were using traditional or old technologies were classified as non-adopter (Awotide *et al*, 2012). As stated in the model specification, three dependents variables (adoption of improved seedling, adoption of fertilizer and adoption of pesticide) where similar independent variables were identified and used. An estimate of the probit regression model for the three dependent variables and Marginal effects after probit estimation are presented in tables 2, 3, and 4 below.

The regression result shows that membership of an association, access to credit, farm size and yield had a positive and significant relationship with adoption of improved seedlings while age carried a negative sign, indicating a negative relation with adoption decision of improved seedlings. However, for fertilizer adoption, positive and significant relationship was found with membership of association, farm size and yield whereas distance to market carried a negative sign. Likewise, for pesticides adoption, membership of association, access to credit, farm size and yield had a positive and significant relationship while distance to market carried a negative sign.

Age was found to be statistically significant at 5% level and negatively related to improved seedling adoption decision. Hence, as age increases by one year, all things being equal (citrus paribus), the probability of adopting improved seedlings by cocoa farmers would decrease by 0.85%. This implies that as farmers grow older, they would become too reluctant and conservative in adopting improved seedlings as the older ones are not always ready to part with the old techniques for new ones. This finding also agrees with the findings of Oseni and Adams (2013) and Nmadu *et al*. (2015). Age was not found to be a determinant factor of fertilizer adoption and pesticide adoption decisions but had negative relationship with them.

The implication of membership of farmers' association on adoption of improved seedlings, adoption of fertilizer and adoption of pesticide decisions were all positive and significant at 1% level. Farmers who were cooperative members had 15.2%, 36.0%, 39.5% higher probabilities of adopting improved cocoa seedlings, fertilizer and pesticides respectively than their counterparts who are not members of

cooperatives. It could be deduced as the farmers get more committed to their associations, the more they would readily adopt technologies introduced through the association. This finding agrees with that of Adeniyi (2014).

It is worth to note that, access to credit is an important factor affecting technology adoption especially among smallholder farmers as the adoption of new technology with complementary inputs require considerable amount of capital for purchase of modern agricultural inputs. Access to credit was significant at 5% and 10% significance level, respectively in determining the adoption decision of improved seedlings and pesticides. In line with this, farmers who had access to formal credit, keeping other variables constant, would have 10.9% and 8.4% higher probability of adopting improved seedling and pesticide respectively unlike those that do not have credit access. This suggests that farmers who have access to formal credit are more probable to adopt improved technologies that could increase crop yield than those who have no access to formal credit (Saleem *et al.*, 2011, Akudugu *et al*. 2012).

In addition, farm size was found to be statistically significant in determining the adoption of improved seedlings, fertilizer and pesticides all at 1% significance level. As expected, farmers with larger farms appear to use more modern inputs, keeping other factors constant. Such farmers have 11.2%, 14.0% and 16.8% higher probability of adopting improved seedling, fertilizer and pesticide compared to farmers with smaller farm sizes.

The regression result reveals that yield positively affects the adoption of improved seedlings, fertilizer and pesticides which were all statistically significant at 1%. This implies that additional increase in the yield obtained by the farmers will increase the probability of adopting adopt improved seedlings, fertilizer and pesticides by 0.08%, 0.07% and 0.16% respectively. This also means that adoption of improved technologies could lead to increase in crop yield hence result to increase in farm income.

Distance to the market, though not determining improved seedling adoption decision, was found to be negatively related with adoption of both fertilizer and pesticide and statistically significant at 5% and10% level of significance respectively. Accordingly, as the distance to the market increases by one kilometer, assuming other factors are constant, the probability of adopting fertilizer and pesticides respectively, would decrease by 2.9% and 2.3%.

Effect of Agricultural Technology Adoption on Farm income

Table 5 below shows the effect of agricultural technology adoption mainly improved seedlings, fertilizer and pesticides on farm income. The OLS regression model was used for analysis and the result is shown below.

Table 2: Determinants of Improved Seedling Adoption Results from Probit Model

Variables	Improved Seedling				
	Coef.	**SE**	**Z**	**P>|z|**	**Marginal Effect**
Age	-0.04158	0.021821	-1.91	0.057**	-0.0085
Household size	-0.00486	0.095604	-0.05	0.959	-0.00099
Education	0.020858	0.030616	0.68	0.496	0.004262
Membership of association	0.745982	0.253196	2.95	0.003***	0.152443
Access to credit	0.537881	0.253302	2.12	0.034**	0.109917
Farmsize	0.548218	0.127346	4.3	0.000***	0.11203
Years of farming experience	0.010101	0.027194	0.37	0.710	0.002064
Yield	0.004007	0.000731	5.48	0.000***	0.000819
Land tenure	0.123714	0.273719	0.45	0.651	0.025281
Distance to market	-0.06561	0.057731	-1.14	0.256	-0.01341
_Cons	-1.66821	0.92909	-1.8	0.073	
Log likelihood	-72.2373				
Number of obs	200				
LR chi^2	75.96				
Prob > chi^2	0.0000				
Pseudo R^2	0.3446				

Note: * = Significant at 1%, ** = Significant at 5%, * = Significant at 10%**

Source: Data Analysis, 2017

Table 3: Determinants of Fertilizer Adoption Results from Probit Model

Variables	Fertilizer				
	Coef.	**SE**	**Z**	**P>|z|**	**Marginal Effect**
Age	-0.0082	0.018642	-0.44	0.660	-0.00209
Household size	-0.13377	0.083925	-1.59	0.111	-0.03417
Education	-0.03465	0.027586	-1.26	0.209	-0.00885
Membership of association	1.409454	0.235713	5.98	0.000***	0.360034
Access to credit	0.024548	0.223902	0.11	0.913	0.006271
Farmsize	0.549699	0.134377	4.09	0.000***	0.140416
Years of farming experience	-0.01639	0.022687	-0.72	0.470	-0.00419
Yield	0.002971	0.000712	4.17	0.000***	0.000759
Land tenure	0.072856	0.235532	0.31	0.757	0.018611

Distance to market	-0.11444	0.054757	-2.09	0.037**	-0.02923
_Cons	-0.50974	0.872274	-0.58	0.559	
Log likelihood	-89.2795				
Number of obs	200				
LR chi^2	93.56				
Prob > chi^2	0.0000				
Pseudo R^2	0.3438				

Note: * = Significant at 1%, ** = Significant at 5%, * = Significant at 10%**

Source: Data Analysis, 2017

Table 4: Determinants of Pesticide Adoption Results from Probit Model

Variables	**Pesticide**				
	Coef.	**SE**	**z**	**P>|z|**	**Marginal Effect**
Age	-0.02365	0.022215	-1.06	0.287	-0.00444
Household size	-0.04482	0.098839	-0.45	0.650	-0.00841
Education	0.0196	0.036062	0.54	0.587	0.003677
Membership of association	2.11025	0.363985	5.8	0.000***	0.395867
Access to credit	0.450713	0.264799	1.7	0.089*	0.08455
Farm size	0.900143	0.196084	4.59	0.000***	0.16886
Years of farming experience	-0.00041	0.025535	-0.02	0.987	-7.6E-05
Yield	0.00856	0.001896	4.52	0.000***	0.001606
Land tenure	0.136114	0.265762	0.51	0.609	0.025534
Distance to market	-0.12721	0.070835	-1.8	0.073*	-0.02386
_Cons	-2.49774	1.282981	-1.95	0.052	
Log likelihood	-66.8224				
Number of obs	200				
LR chi^2	134.73				
Prob > chi^2	0.0000				
Pseudo R^2	0.5020				

Note: * = Significant at 1%, ** = Significant at 5%, * = Significant at 10%**

Source: Data Analysis, 2017

The parameter estimates of the OLS regression model for the determinants of farm income are presented in Table 5. The estimates shows that household size ($\boldsymbol{\beta}$=5590.84, p< 0.01), farm size ($\boldsymbol{\beta}$ = 35876.88, p< 0.01), yield ($\boldsymbol{\beta}$ = 325.32, p< 0.01), improved seedlings ($\boldsymbol{\beta}$ = 10575.25, p< 0.05), fertilizer ($\boldsymbol{\beta}$ = 22604.93, p< 0.01) and pesticide ($\boldsymbol{\beta}$ = 35922.69, p< 0.01) were positive and statistically

significant; while education ($\boldsymbol{\beta}$ = -1764.66 p< 0.01) was negative and statistically significant. Moreover, land tenure, membership of association and access to credit were positive and statistically insignificant while years of farming experience and distance to the market were negative and statistically insignificant.

Table 5. The Effect of Improved Technologies Adoption on Farm Income: OLS Result

Explanatory Variables	Coeff.	Std. Error	t	P>|t|
Improved Seedlings	10575.25	5076.798	2.08	0.039**
Fertilizer	22604.93	7648.934	2.96	0.004***
Pesticide	35922.69	7424.099	4.84	0.000***
Age	-404.66	433.2842	-0.93	0.352
Household size	5590.845	1898.201	2.95	0.004***
Education	-1764.66	647.4157	-2.73	0.007***
Land tenure	2604.059	7000.454	0.37	0.710
Membership of association	6682.709	6083.527	1.1	0.273
Access to Credit	1917.509	5260.383	0.36	0.716
Farm size	35876.88	2577.287	13.92	0.000***
Years of farming experience	-604.84	525.8585	-1.15	0.252
Yield	325.3234	18.2733	17.8	0.000***
Distance to Market	-389.451	1026.793	-0.38	0.705
_Cons	-16292.7	21065.11	-0.77	0.44
R-Squared	0.8278			
Adjusted R-Squared	0.8158			
F (13, 186)	68.80			
Prob > F	0.0000			
Root MSE	34592			

Note: * = Significant at 1%, ** = Significant at 5%, * = Significant at 10%**

Source: Data Analysis, 2017

The coefficient of household size was positive and statistically significant at 1%. This implies that as household member increase by one, the farm income will also increase. The coefficient of farm size was positive and statistically significant at 1%. This implies that increase in farm size tends to increase the farm income of the farmers. In other words, farm size acquired by the farmers has a significant effect on farm income. The coefficient of improved seedlings was positive and statistically significant at 5%. This connotes that as the use of improved seedling increase the farm income also increases. The coefficient of fertilizer and pesticide were positive and statistically significant at 1%. This connotes that as the use of fertilizer and pesticide increase the farm income also increases.

The coefficient of education of farmers was negative but statistically significant at 1% implying that the level of education tends to have significant effect on farm income. The coefficient of yield was positive and statistically significant at 1%. This connotes that as the yield obtained by farmers

increases, the farm income also increases.

In conclusion, the study showed that the use of improved technologies in cocoa production significantly increased farm income among the adopters than non-adopters.

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