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Cocoa Research Innovations and Output in Ghana

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Abstract
Cocoa Research Institute of Ghana (CRIG) has introduced a number of innovations to increase cocoa yield per hectare. The main objective of the study was to determine the impact of intensity of adoption of these innovations on cocoa output. A sample of 600 cocoa farmers was selected through a multi-stage sampling technique for the study. An interview schedule was used to gather data and OLS was used to estimate the impact of intensity of technology adoption on output. Results of the study indicated that output of cocoa had positive relationship with household size, farm size, education, membership of association, credit access and technology adoption. It is recommended that COCOBOD should provide training to farmers, increase the number of extension officers and encourage farmers to join farmer associations. Also, financial institutions should make credit accessible to farmers.
Keywords: Cocoa, Research, Innovations, Technology, Adoption, Output

1. 0 Introduction

The agricultural sector, with cocoa being the most dominant, contributes significantly to the Ghanaian economy. Agriculture's contribution to Gross Domestic Product (GDP) in 2013 was 21.3% (ISSER, 2014). The contributions of cocoa, timber and non-traditional exports to total foreign exchange earnings in 2013 were 32%, 3.1% and 20.1% respectively (ISSER, 2014). According to Ghana Statistical Service (GSS, 2014) about 794,129 households are involved in cocoa production.

Despite the significant contribution of cocoa to the Ghanaian economy, the sector faces a number of challenges which have resulted in Ghana losing its position as the world's first exporter of cocoa to Cote d'Ivoire. According to Appiah (2004) output level of 560,000 tonnes in 1965 which was highest at that time declined to its lowest of 154,000 metric tonnes in the 1980s before it started increasing again.

Commenting on yield of cocoa in Ghana, Dormon, Huis, Leeuwis, Obeng-Ofori and Sakyi-Dawson (2004) indicated that generally yields of cocoa are lower in Ghana than in other major producing countries and that whilst average cocoa yield per hectare in Malaysia and Cote d'Ivoire is 1,800 Kilograms and 800 kilogram respectively it is only 360 kilograms per hectare in Ghana. They gave reasons for the low productivity as poor farm maintenance practices, planting low-yielding varieties, and the incidence of pests and diseases.

To address some of the challenges facing the cocoa sector, the government of Ghana introduced two important cocoa technology based initiatives in 2001 which embodied the various innovations introduced by the Cocoa Research Institute of Ghana (CRIG). These initiatives were the Cocoa Pest and Disease Control (CODAPEC) and Cocoa High Technology (Cocoa Hi-Tech).

Even though the innovations or technologies introduced by CRIG have potential of increasing output, some cocoa farmers are not taking advantage of these technologies. Aneani, Anchirinah, Owusu-Ansah and Asamoah (2012) in their study of adoption of some cocoa production technologies by cocoa farmers in Ghana estimated adoption rates for control of capsids with insecticides, control of black pod disease with fungicides, weed control manually or with herbicides, planting hybrid cocoa varieties and fertilizer application as 10.3%, 7.5%, 3.7%, 44% and 33% respectively.

2.0 Objectives of the study

The general objective of the study was to estimate the effects of intensity of adoption of cocoa research innovations and other farmer characteristics on output. The specific objectives were to:

i. identify factors which affect output of cocoa in Ghana.
ii. determine the impact of intensity of adoption of technologies on cocoa output.

3.0 Review of related literature

3.1 *Technology and innovation*

According to Rogers (2003) technology and innovation are often used interchangeably. He defines technology as a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving an outcome. He explained rate of adoption as the relative speed with which an innovation is adopted by members of a social system. He identified the variables that determine the rate of adoption of innovation as perceived attributes of innovation; types of innovation decision; communication channels; nature of social

system and extent of change agent's promotion efforts.

Feder, Just and Zilberman (1985) observed that agricultural technology adoption has long been of interest to social scientists because of its importance in increasing productivity and efficiency. They indicated that in developing countries, adoption started after the Green Revolution in Asian countries and since then several studies have been undertaken in Asia, Africa and Latin America to assess the rate, intensity and determinants of adoption. They gave the factors which affect technology adoption as farm size, risk and uncertainty, human capital, labour availability, credit constraint, land tenure system, supply constraint and aggregate adoption over time.

3.2 Cocoa industry of Ghana

3.2.1 *Trends of cocoa output in Ghana*

Cocoa was introduced to Ghana in the late 19th century (Acquaah, 1999) and the production of the crop has undergone a series of major expansions and contractions. Ruf and Siswoputranto (1995) suggest that cycles are intrinsic to cocoa production because cocoa is influenced by environmental factors such as availability of forest land; ecological factors such as deforestation, outbreaks of disease, and geographic shifts in production; and economic and social factors such as migration. They identified four distinct phases with regard to cocoa production in Ghana. These phases are: introduction and exponential growth (1888–1937); stagnation followed by a brief but rapid growth following the country's independence (1938–64); near collapse (1965–82); and recovery and growth or expansion, starting with the introduction of the Economic Recovery Program (1983 to present). According to Vigneri and Santos (2008) growth in cocoa production became more pronounced starting in 2001, possibly driven by a combination of record-high world prices, increased share being passed onto farmers, and a set of interventions such as mass spraying programs and high-tech subsidy packages to promote the adoption of higher and more frequent applications of fertilizer rolled out by COCOBOD.

3.2.2 *Cocoa Research Institute of Ghana*

According to Acquaah (1999), the Cocoa Research Institute of Ghana (CRIG) was set up in June 1938 as the Tafo Central Cocoa Research Station and was assigned clear goals within the Gold Coast Department of Agriculture to investigate the pest and disease problems of cocoa in order to maintain production in the Eastern Region. In 1944 the Research Station was upgraded to West Africa Cocoa Research Institute (WACRI) and the objectives were widened to include the disease and pest problems of cocoa in West Africa and also to investigate soil fertility and agricultural practices with a view to increasing yield. The name was changed to CRIG when Ghana attained independence in 1957. Since 1966 CRIG's research mandate has been further widened to include coffee, kola, sheanut and now cashew.

Appiah (2004) and information from CRIG website (http://crig.org.gh/) enumerated some of the innovations introduced into the cocoa industry as:

i. Characterisation of swollen shoot disease as caused by a virus, discovery of mealy bugs as vectors of the virus and control of the disease by eradication.
ii. Isolation and characterisation of Cocoa Swollen Shoot Virus (CSSV) and development of diagnostic methods.
iii. Introduction and testing of Amazon cocoa.
iv. Development of early bearing and high yielding WACRI Series II hybrids by crosses between Amelonado and Amazon Cocoa.
v. Understanding of the relationship between cocoa shade, nutrition and yield.
vi. Development of agronomic packages guaranteeing yield over three tonnes per hectare.
vii. Mass hand pollination of clonal seed gardens for large scale production of seed pods.
viii. Understanding of cocoa fermentation and flavour chemistry.
ix. Short-term control of a severe type of black pod disease, and
x. Production of pectin, alcohol and alcoholic beverages, animal feed, jelly, soap and cosmetics as by-product from cocoa waste.

Based on the findings of CRIG, the government initiated two programmes namely Cocoa High Technology (Cocoa Hi-Tech) and Cocoa Pest and Disease Control Programme (CODAPEC) to improve cocoa yield and for that matter impact on the socio-economic conditions of farmers. The "High Technology" of cocoa production is defined as the sustainable cocoa 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 resources (Appiah, 2004).

The Cocoa High Technology Programme (Hi-tech) programme emphasizes the use of fertilizer and proper farm management practices to achieve higher cocoa yield. However, to enable maximum utilization of the fertilizer the programme holistically consists of other four components namely cultural maintenance, application of fungicides, application of insecticides and harvesting, fermentation and drying technologies in addition to the fertilizer application component. Two main types of fertilizer formulations are used in the Hi-Tech Programme.

These are granular fertilizers and liquid fertilizers.

The cocoa disease and pest control programme (CODAPEC) is a national pest and disease control programme initiated by the government in 2001 to address the decline in cocoa production. The programme aims at assisting farmers to maintain their farms and includes weeding twice or thrice in a year; general pruning and pruning of mistletoes and choppons and spraying against diseases and pests twice or thrice in a year.

CRIG's research innovations indicate that a farmer has to follow prescribed agricultural practices to achieve the increase in output. These practices include maintenance of the farm by weeding at least twice in a year, pruning semi parasitic mistletoe plant from the cocoa trees and cutting down cocoa trees affected by swollen shoot virus disease. To improve soil fertility, the farmer has to apply fertilizer in prescribed quantities. The farmer has to spray fungicides in right quantities to control black pod disease and spray insecticides to control insects such as black ants, stem borers, mealy bugs, termites and red ants. Ripe cocoa should be harvested; fermentation should be between six and seven days and should be turned twice on the third and fifth days. The cocoa should be dried daily in the sun on raised mats and should be properly dried before they are put in sacks for sale.

3.3.3 ***Impact of technology adoption on output***

A number of studies have been conducted to determine the impact of technology adoption on output of a number of crops. For example, El-Osta and Morehart (1999) used data from the 1993 Agricultural Resource Management Study to examine the impact of technology adoption on production performance of a sample of dairy farms and Islam (2002) used a time series database on major cereal production in Bangladesh.

In the cocoa industry, Edwin and Masters (2003) estimated the yields gains attributable to the breeding of new cocoa varieties in Ghana. Results from their study showed that cocoa yield increases with fertilizer use.

Teal and Vigneri (2004) analysed the evolution of cocoa production growth in Ghana in the 1990s. In particular, they examined the impact of subsidies on inputs supply and the possible role of technical change in effecting rises in cocoa production. Their results showed that the increase in household output had been very modest and that while the effect of liberalisation had been to raise the price of inputs, the contribution of such inputs to cocoa production had increased both relative to land and very substantially relative to labour. They found no evidence that reforms had led to innovation in techniques which raised total factor productivity.

In a similar study, Vigneri (2008) investigated the factors that accounted for increased cocoa output in Ghana between 2002 and 2004. Data for the study was from the Ghana Cocoa Farmers Survey (GCFS) conducted in 2002 and 2004. The study estimated a standard Cobb-Douglas production function with three conventional inputs: land, labour, and non-labour inputs (fertilizer, insecticides, and agricultural equipment), a number of household characteristics which have important effect on the level of cocoa production and rainfall. Results of the study indicated that three key causes of the output boom were increase in labour input, the dramatic rise in the use of fertilizer and good weather.

To study the impact of access to credit on technology adoption and its impact on productivity, Opoku, Dzene, Caria, Teal and Zeitlin (2009) investigated the impact of a private sector initiative [Cocoa Abrabopa Association (CAA)] in Ghana's cocoa industry. The study was part of the Ghana Cocoa Farmers Survey 2008. CAA provided inputs to farmers based on the Hi-Tech package developed by CRIG on credit to groups of farmers. It was expected that the farmers who adopted the Hi-tech would have increased output. Results of the study indicated that there was large evidence of agronomic and economic returns to participation in the programme as output increased by 638.5 Kg relative to the 435 Kg they estimated would have been output levels had farmers not participated in the programme. The study however indicated that there was high dropout rate in spite of the large returns. The reasons for the high dropout rate were not provided.

Another study on the relationship between hybrid cocoa and land productivity of cocoa farmers in the Ashanti region of Ghana was conducted by Wiredu, Mensah-Bonsu, Andah and Fosu (2011). Results of the study indicated that in addition to the use of hybrid cocoa varieties, land size, labour, age, nativity, participation in cocoa programs and engagement in secondary income activities are shown to be significant determinant of land productivity in the two models. Household size is shown to be significant when adoption is introduced as a choice variable. When adoption is introduced as a proportion of land allocated to cocoa hybrid, the number of extension contacts is shown to be significant. Gender, education, membership of farmer based organizations, credit and social amenities did not significantly affect land productivity in cocoa based production system. Labour positively affected productivity.

In a study to analyze the efficiency of resource utilization in cocoa production of cocoa farmers in Ghana Aneani, Anchiranah, Asamoah and Owusu-Ansah (2011) used a random sample of 300 farmers selected from the Eastern, Ashanti, Brong-Ahafo, Central, Volta and Western regions using the multi stage sampling approach. Results of the regression analysis indicated that household size, cocoa farm size, quantity of insecticides, quantity of fungicides, and quantity of fertilizer significantly affected cocoa production.

In a related study, Kyei, Foli and Ankoh (2011) analysed the factors that affect the technical efficiency of cocoa farmers in the Offinso district in Ghana. Results of the study indicated that labour force had a negative

relationship with output. Also modern equipment and age of trees had a strong negative correlation with output. The results suggest that in the study area cocoa productivity could be enhanced by improving technical efficiency.

Richman (2012) investigated the drivers of technical efficiency among cocoa farmers in Ghana using a panel data for the period 2001/02 to 2005/06 cocoa seasons. The study concludes that among other factors the quality of farm maintenance, farmer's educational status, fertilizer intensity and the use of farm inputs will improve technical efficiency while farm level events warps efficiency.

4.0 Methodology

4.1 *Research design*

The survey method was used to collect primary data for the study. This method was used because of the wide area the study covered. Primary data was collected through the use of interview schedule. The questions covered personal, socioeconomic, institutional and other relevant variables.

4.2 Study areas

The study was conducted in five regions namely Eastern, Central, Brong Ahafo, Ashanti and Western where cocoa is grown. Volta region was left out because according to COCOBOD (2011) output of cocoa from that region is less than one percent of the total national output.

4.3 Study population

The population for the study was all cocoa farmers in Ghana. According to the report of the Ghana Statistical Service (2014), cocoa supports more than 794,129 smallholder households and the number of cocoa farmers in estimated at 350,000. These farmers are found in all the cocoa growing regions. They consisted of male and female, literate and non-literate farmers of diverse background and ages.

4.4 Sampling procedure

The multi-stage stratified sampling technique was used in selecting 600 farmers for the study. The first stage involved selection of districts from the regions and two districts from each region were selected making a total of 10 districts. The districts selected were Nkawie and Konongo in the Ashanti Region; Goaso and Dormaa in the Brong Ahafo Region; Assin Fosu and Twifo Praso in the Central Region; Koforidua and Asamankese in the Eastern Region; and Tarkwa and Sefwi Bekwai in the Western Region. The second stage involved the selection of villages or communities through simple random sampling and 10 villages were selected from each district. The third stage involved the selection of farmers and six (6) farmers were selected from each village making a total of 600 farmers.

4.5 Survey instrument and procedures for data collection

The instrument for the study was interview schedule. The questions in the interview schedule were developed based on the kind of information required for the analysis. It contained both closed and open-ended questions. Some questions were on Likert scale to enable respondents rank certain items or variables. The interview schedule was divided into eight sections as follows: Section one dealt with farmer characteristics; section two considered farm characteristics; section three had questions on social participation; section four sought respondents' knowledge about cocoa research innovations; section five treated questions related to technology adoption; section six treated questions on measurement of intensity of technology adoption; section seven dealt with output of cocoa; and section eight dealt with credit access.

4.6 Test of reliability of instrument and pilot study

To test the reliability of the questions in the interview schedule, the services of cocoa extension officers were solicited. They reviewed the questions to ascertain whether they would elicit the type of responses expected. After that a pilot study was carried out.

Twenty (20) farmers purposively selected from the New Juabeng District were used for the pilot study. This district was selected due to its nearness to Akim Tafo where the Cocoa Research Institute of Ghana (CRIG) is located. The results of the pilot study led to a modification of a few questions to make them clearer. The data from the pilot study was analysed using SPSS (Statistical Package for Social Sciences). A reliability coefficient of 0.90 was obtained which was good.

4.7 Administration of interview schedule for the main study

Extension officers employed by COCOBOD were used to interview the farmers. The extension officers were selected based on recommendation from officers from CRIG who had been working closely with these extension officers. The questions were asked in the local language and so there was the problem of exact translation of the

scientific terminologies into the local language. However because cocoa extension officers were used they were able to explain things to the farmers.

4.8 Data analysis

The assistance of officers in the Ghana Statistical Service was solicited and the information in the completed interview schedules was captured with the use of software called Census and Survey Processing System (CS Pro). The information was then exported to the Stata software for analysis. The descriptive statistics such as mean and standard deviation were obtained using appropriate commands in the Stata software. Also regressions were run using the appropriate commands based on the models to be estimated.

4.9 Intensity of adoption

Intensity of adoption measures the degree or extent of adoption of a technology. Intensity of adoption has been measured in several ways in literature. Nkonya, Schroeder and Norman (1997) measured the intensity of adoption as the number of hectares planted with improved seed or the amount of input applied per hectare. Mensah-Bonsu, Sarpong, Alhassan, Asuming-Brempong, Egyir, Kuwornu and Osei (2011); Paxton, Mishra, Chintawa, Roberts, Larson, English, Lambart, Marra, Larkin, Reeves and Martin (2011); and Masuki, Mutabazi, Tumbo, Rwehumbiza, Mattee and Hitabu (2006) defined intensity as the number of technologies adopted. Other researchers such as Kaguongo, Ortmann, Wale, Darroch and Low (2010); Nchida, Ambe, Nathalie, Leke, Che, Nkwate, Ngassam and Njualem (2010); and Asfaw, Shiferaw, Simtowe and Haile (2011) defined intensity of adoption as the proportion of area under the improved varieties.

In this study intensity of adoption was measured following the example of Opare (1980) using a scale 1 to 5. Farmers ranked the intensity of adoption of the various cultural practices such as weeding, spraying insecticides, fertilizer application, among others, as follow: very low (1), low (2), moderate (3), high (4) and very high (5). This scale was used in computing the intensity of adoption of a particular cultural practice and the result was expressed as a percentage.

4.10 Empirical model

Based on the literature reviewed, the model estimated to assess the impact of intensity of adoption of the recommended practices on output was as stated in equation 1**.**

$$Output = \beta_0 + \beta_1 Age + \beta_2 hhsize + \beta_3 farmsize + \beta_4 primedu + \beta_5 midedu + \beta_6 \sec edu + \beta_7 Tertedu + \beta_8 hirelab + \beta_9 Nonhiredlab + \beta_{10} ownlab + \beta_{11} memasso + \beta_{12} freqadvice + \beta_{13} credit + \beta_{14} Intense + \varepsilon \quad \text{..... (1)}$$

The expected signs of the coefficients are:

$\beta_1 < 0$; $\beta_2 > 0$; $\beta_3 > 0$; $\beta_4 > 0$; $\beta_5 > 0$; β_6, > 0; $\beta_7 > 0$; $\beta_8 > 0$; $\beta_9 > 0$; $\beta_{10} > 0$; $\beta_{11} > 0$; $\beta_{12} > 0$; $\beta_{13} > 0$; $\beta_{14} > 0$

Where: *Output* is total cocoa output by each farmer, *Age* is farmer's age; *hhsize* is household size; *farmsize* is the size of the cocoa farm in acres; *primedu* refers to primary education; *midedu* is junior secondary/middle school education; sec*edu* is secondary education; *Tertedu* is tertiary education, *hirelab* is the number of hired labour; *Nonhiredlab* is number of non-hired labour; *ownlab* refers to farmer's own labour; *memasso* is membership of a farmer based association; *freqadvice* is frequency of advice received from extension officers; *credit* is access to credit, *Intense* is intensity of adoption of cocoa research innovations; and ε the error term.

4.10.1 Measurement of variables in the model

The descriptive statistics of variables in the model are presented in Table 1.

Table 1: Descriptive statistics for variables

Variable	Description	Obs.	Mean	S. dev	Min	Max
Adopt	Level of Adoption	600	0.68	0.47	0	1
Output	Cocoa output in Kg	600	771.67	298.48	188	1875
lnyield	Log of Output	600	6.57	0.4	5.24	7.54
Age	Age of farmer (years)	600	50.12	11.4	22	72
Hhsize	Household size	600	4.53	0.73	2	7
Farmsize	Farm size in Acres	600	4.9	1.15	2	10
Noedu	No formal Educ. (1/0)	130	0.22	0.41	0	1
Primedu	Primary education(1/0)	116	0.19	0.39	0	1
Midedu	JSS/Middle School(1/0)	302	0.5	0.5	0	1
Secedu	SSS/Tech/Trg Coll(1/0)	48	0.08	0.27	0	1
Tertedu	Tertiary (1/0)	4	0.01	0.081	0	1
Credit	Credit Access(1/0)	600	1.29	0.46	0	1
Hirelab	Hired labour	600	3.74	1.41	0	9
Nonhiredlab	Non-Hired Labour	600	2.93	2.3	0	8
Ownlab	Own labour(1/0)	600	0.66	0.47	0	1

The average age of farmers was 50.12 years. Household size measured the number of people living in a family and the average was 5 per household. This agrees with the findings of the GLSS (2008) and Hainmuelier et al (2011). The average farm size was 4.9 acres and agrees with the finding of Hainmuelier et al (2011). Farmers with no formal education were 130. Majority of the farmers had middle school or junior secondary school education. The total number of farmers who had secondary and tertiary education was 52 which constituted about 9 per cent of the total respondents. Educational standard of most cocoa farmers can therefore be considered to be low.

The intensity of adoption measured the degree to which the farmers had adopted the CRIG recommended technologies. About 173 of the respondents did not adopt any of the technologies recommended by CRIG. 22.8% of the respondents had adoption rates of between 71 and 80 per cent. Those who had adoption rates of between 81 and 100 per cent constituted about 18.1 per cent. The rates were higher than Aneani et al (2012) who had adoption rates of between 0 and 44 per cent. It is however worth noting that the methodologies employed are different and that might have accounted for the differences in the adoption rates.

4.11 Results of estimation of the impact of intensity of adoption on output

The results of the OLS estimation of equation have been presented in Table 2. The dependent variable was log of yield per acre (*Output*). The R^2 of 0.8791 means that the explanatory variables are able to explain about 87.9 per cent of the changes in the dependent variable, output. The t statistics were used to test the significance of the individual variables.

Table 2: OLS regression results for impact of technology adoption and other farmer characteristics on cocoa output

Output	Coef.	Std. Err.	t	P>t	[95%	Interval]
Age	-0.5802	0.3983	-1.46	0.146	-1.3625	.2021
HHsize	17.0569	9.9076	2.89	0.004	5.4541	28.6596
Farmsize	173.5620	3.8078	45.58	0.000	166.0834	181.0406
Primedu	29.7319	13.8116	2.15	0.032	2.6055	56.8584
Midedu	34.8798	11.2775	3.09	0.002	12.7306	57.0291
Secedu	20.4951	17.9494	1.14	0.254	-14.7580	55.7481
Tertedu	17.5929	53.5549	0.33	0.743	-87.5905	122.7763
Hiredlab	3.3596	2.8233	1.19	0.235	-2.1854	8.9047
Nonhiredlab	3.5571	3.1753	1.12	0.263	-2.6792	9.7933
Ownlab	-1.0371	9.8389	-0.11	0.916	-20.3610	18.2868
Memasso	25.3524	9.8189	2.58	0.010	6.0679	44.6370
Frqadvice	1.0214	3.7435	0.27	0.785	-6.3309	8.3738
Credit	35.5275	9.8724	3.60	0.000	16.1379	54.9171
Intense	5.0769	0.1408	36.06	0.000	4.8004	5.3535
Constant	-472.363	42.0414	-11.24	0.00	-554.9334	-389.7926

No. of observation = 600; F(14,585) = 303.72; R^2 = 0.8791; Root MSE = 105.04

4.12 Discussion of results

The variables which significantly affected the output were household size, farm size, education, membership of association, credit access and intensity of technology adoption.

4.12.1 ***Household size***

Results from the study indicated that the coefficient of household size was 17.05 and was significant at 5 per cent. Thus, there was a positive relationship between household size and output of cocoa. This finding agrees with the finding of Owu (1995). The possible explanation for this finding is that members of the household might have seen the need to devote much of their effort into cocoa production in order to earn a living.

4.12.2 ***Farm size***

The coefficient of *lnfarmsize* was 173.56 and was significant at 1 per cent. This shows that there was a positive relationship between farm size and output of cocoa. The finding is consistent with those of Teal and Vigneri (2004), Vigneri (2008) and Aneani et al (2011) who found positive relationship between farm size and cocoa output. The results indicate that as more and more land is put into cocoa cultivation output increases. It is however worth noting that land for cocoa cultivation is dwindling and so it is important to adopt other technologies such as fertilizer application to increase the output without increasing the size of the land under cocoa cultivation.

4.12.3 ***Education***

Education was divided into several levels such as primary education, middle school, secondary school and tertiary education. The results indicated that primary and middle school education were significant implying that farmers with a minimum of primary school education are likely to adopt the recommended, other things being equal. The finding agrees with that of Teal and Vigneri (2004) who have a positive relationship between education and output of cocoa. The reason may be that farmers with a minimum of primary school education are able to read and understand basic farming information provided by extension officers and other media as compared to those without any formal education.

4.12.4 ***Membership of association***

The coefficient for membership of association was 25.35 and was significant at 10%. Membership of an association therefore has a positive effect on output as it exposes farmers to new information and technical skills about cocoa production. This finding is consistent with the results of Kyei et al (2011) and Opoku et al (2009) who observed in their study of Cocoa Abrabopa Association (CAA), a private-sector initiative in Ghana's cocoa industry that there is evidence of large agronomic returns to participation in the programme.

4.12.5 ***Access to credit***

The coefficient for access to credit was 35.53 and was significant at 1%. The results indicate that there was a positive relationship between access to credit and output of cocoa. The finding agrees with the findings of Opoku et al (2009). Farmers require inputs such as fertilizers, fungicides and hired labour on their farms. These inputs have to be paid for but the income of farmers is seasonal. There is therefore the need for credit to finance their operations until they harvest and sell their produce. Farmers with access to credit are therefore likely to get increased output, other things being equal.

4.12.6 ***Intensity of technology adoption***

The coefficient of intensity of technology adoption was 5.076 and was significant at 1 per cent. Thus, the results indicated a positive relationship between intensity of technology adoption and output. This finding confirms the finding of Wiredu et al (2011), Donkoh (2006) and Wu (2005) who identified a positive relationship between productivity and improved technology.

5.0 Conclusion and recommendations

Adoption of cocoa research innovations has potential to significantly increase cocoa output as envisaged by the Cocoa Research Institute of Ghana. The results of this study indicate that intensity of adoption of cocoa research innovations, household size, farm size, education, hired labour, membership of association, frequency of extension advice and access to credit significantly and positively affected the output per hectare. Based on the outcome of the study the following recommendations are made:

i. COCOBOD and LBCs should educate cocoa farmers through non-formal education in the cocoa farms to enable them appreciate the importance of adopting the recommended cocoa technologies. COCOBOD, through CRIG, has developed a curriculum for training of extension officers. This curriculum should be used for Farmer Field School (FFS). By participating in FFS and other training activities, farmers have the opportunity to increase their skills and knowledge about good agricultural practices as well as responsible and safe labour practices.
ii. Credit should be made accessible to farmers. Financial institutions, Licensed cocoa buying companies (LBCs), microfinance institutions and COCOBOD should educate cocoa farmers on the requirements for accessing credit. They should also teach the farmers the need to repay facilities extended to them.
iii. COCOBOD and LBCs should encourage cocoa farmers to join producer associations, marketing associations and credit unions. Farmers need to be sensitized about the benefits of belonging to an association.
iv. The number of cocoa extension officers should be increased. This will make it possible for them to visit

the farmers regularly.

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