International Scholars Journals

African Journal of Agricultural Economics and Rural Development ISSN 2375-0693 Vol. 6 (2), pp. 604-612, February, 2018. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

The decision to control cocoa capsids with capsicides: The case of cocoa producers in the Sekyere Area, Ashanti Region, Ghana

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Accepted 11 February, 2018

The cocoa capsid is a critical pest in Ghana. Uncontrolled it can cause up to about 30 percent cocoa yield loss, directly affecting the livelihoods of about 800,000 cocoa farmers in southern Ghana. This study uses a logit model to estimate the magnitudes of the effects of the factors that influence the adoption of capsicide by cocoa producers in the Sekyere Area, Ashanti Region, Ghana. It uses a survey data collected by the Ghana Sustainable Cocoa Competitive Systems, Accra, Ghana, on active cocoa producers in the study area in the 2006/2007 cocoa production season. Our results show that producer's farming experience, producer's engagement in off-farm economic activities, producer's access to credit, extension visit, cocoa output, producer's age, and membership in a farmers' group are likely to influence cocoa farmers' decision to adopt capsicide. The results could help Ghana manage cocoa capsid efficiently.

Keywords: Cocoa, Capsid Bugs, Capsicide, Chemical Control, Logit Model.

INTRODUCTION

Ghana is among the top ten producers of Cocoa in the world. Domestically, the crop generates approximately 25 percent of Ghana's total foreign exchange earnings annually (Essegbey & Ofori-Gyamfi, 2012). Moreover, at the sectoral level, cocoa offers a livelihood to nearly 800,000 farm families spread over the southern belt of Ghana (Kolavalli & Vigneri, 2011). Therefore, it is not surprising that cocoa is the lifeblood of the Ghanaian economy (Osei, 2007).

An important pest to cocoa production in Ghana is cocoa capsid, which is reported to cause about thirty percent of cocoa yield loss annually (Dormon et al., 2007). The most important species of the cocoa capsid bug in Ghana are *Distantiella theobroma* (Distant), *Sahlbergella singularis* (Haglund) and *Holopelti s*sp. (Adu-Acheampong et al., 2006; Dormon et al., 2007). The feeding of cocoa capsid bug creates lesions on the plant's pods, stems, and leaves, which makes the crop susceptible to fungal infections such as cocoa black-pod (Dormon et al., 2007). There are various ways to control cocoa capsid bug, including biological, cultural, chemical (mainly capsicides), and Integrated Pest Management Practices (IPM) control methods. In most West African countries, chemical control is the most effective approach (Jonny, et al., 2003). Currently, chemical control of cocoa capsid is the official position of the government of Ghana, through the nation-wide Cocoa Diseases, and Pests Control Program (CODAPEC). However, the continued use of the pesticide on cocoa farms can potentially pose significant problems to soil health, other beneficial insects, and human health. For instance, cocoa has a high butter con-

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tent which could absorb the active ingredients of pesticides and other agrochemicals (Afrane & Ntiamoah, 2011). Consumers can have adverse health effects, when they consume products, such as chocolates or cocoa powder, derived from "pesticide contaminated cocoa."

Although, other non-chemical methods of controlling pesticides (such as integrated pest management) are currently encouraged among cocoa producers in Ghana, chemical control of pests continues to be the preferred method by producers and the government, at least in the short-term (Afrane & Ntiamoah, 2011). However, as pressures from the Codex Alimentarius Commission of the FAO/WHO, and importing countries, such as Europe and the U.S for Ghana to regulate the use of pesticides in cocoa production increase, Ghana might shift to more environmentally sustainable way of cocoa production such as Integrated Pest Management (IPM) of capsid.

In the short-term, it could be challenging for the government of Ghana to move producers away from using pesticides, to environmentally benign and sustainable non-chemical methods, such as IPM. Another problem is that most farmers use pesticides in a way that do not meet the recommended application rates (Dormon et al., 2007). A short-term solution would be a policy that encourages and educate producers to use pesticides at the right dosage and time. Such a plan could allow Ghana to increase the export revenue of cocoa by meeting the standards set by the Codex Alimentarius Commission of the FAO/WHO with regards to the sale of "certified cocoa" on the world market.

For stakeholders in the cocoa sector, in particular, Ghana's Cocoa Board, to be successful at designing policies to change producers' behavior towards the "right" use of pesticides, it is imperative for them to understand producers' behavior concerning the chemical control of capsids. A relevant question to ask would be: What are the factors that could motivate cocoa producers to use pesticides (capsicide)? This study addresses this issue. Therefore, the objective of this study is to identify the critical factors and the magnitude of their effects on the chemical control of capsid bugs by cocoa producers in the Sekyere Area, Ghana. This is the first study that has investigated producers' behavior concerning the chemical control of capsid in Ghana.

LITERATURE REVIEW

Recent literature on technology adoption has identified farm size, risk and uncertainty on output following adoption, human capital, labor availability, credit constraint, land tenure and supply constraints as critical factors influencing a farmers' decision to adopt an agricultural technology (Feder et al., 1985; Sunding & Zilberman, 2001). For instance, the uncertainties of crop yield following adoption of an agricultural technology and the initial fixed costs of adoption explain the differential adoption rates observed between large and small farms (Feder & O'Mara, 1981). Also, information gained by learning and observing from neighbors and/or friends who have experimented with the technology before, and access to extension information, is reported to reduce farmers' uncertainties about yields from agricultural technologies, leading to adoption (Feder & O'Mara, 1981; Feder et al., 1985; Mignouna et al., 2011; Beaman et al., 2015). Membership to a farmers' group leads to the adoption of agricultural technologies because of the positive effect of learning from other members. It is shown that membership to professional bodies or groups can positively influence the adoption of farm technologies by individual members (Nzomoi, et al., 2007).

Higher education, a proxy for human capital, is critical in determining the adoption rates of new agricultural technologies in developing countries (Feder et al., 1985; Mignouna et al., 2011; Okunlola et al., 2011). Again, external or off-farm income has a positive effect on adoption, through offsetting the adverse impact of inadequate credit (Tovignan et al., 2004; Reardon et al., 2007). Varying agroclimatic zone and topography also have differential effects on adoption across different agro-ecological zones (Sunding & Zilberman, 2001; Nzomoi et al., 2007). Distance is a major obstacle to the adoption of agricultural technologies in developing countries (Feder et al., 1985). More specifically, distance to input shops, output markets, the nearest city, and other geographic locations have a negative impact on the adoption of agricultural technologies (Feder et al., 1985).

Further, there is a theoretical relationship between land security and land investment (Martin et al., 2008). When agents have secured land rights, they are more likely to undertake long-term land-improving investments to improve the productivity of their lands investment (Martin et al., 2008). Also, secured land rights make it possible for owners to use their land as collateral to access credit which can be used to improve agricultural productivity through the acquisition of the essential agrarian investments (Feder & Noronha, 1987; Gershon & Feeny, 1993). It is therefore very likely that farmers who own their lands will adopt technologies that will enhance their farm productivity and profits.

MATERIALS AND METHODS

This section highlights the conceptual framework followed in this study which addresses the central problem facing producers, whether they should control capsids with chemicals (capsicides) or not? Also, in this section the econometric model used to achieve the objective of this study, the statement of hypotheses and description of data, as well as the sources of the data used are discussed.

CONCEPTUAL MODEL

A fundamental assumption in this study is that a cocoa farm has already been established, and the majority of all cocoa trees are of fruit-bearing age. This assumption is warranted because all the respondents in the cocoa survey have fruit bearing cocoa trees. A producer would choose to control capsid to maximize the expected utility of the net farm profits obtained from cocoa production in multiple cocoa production seasons, all things being equal. Therefore, the producer's capsid control choice problem is intertemporal.

The decision to use capsicides to control capsids or not would depend on the potential benefits and costs associated with the technology (Foster & Rosenzweig, 2010). For each production season, the apparent benefit to the cocoa producer from using capsicides is the possible increased of cocoa revenue through increased cocoa yield. Moreover, a producer would incur the unit cost of capsicide for capsid control. It is a variable cost, which increases directly with the extent of use of the chemical. The degree of capsid infestation could affect the extent of use of capsicides. Among others, additional costs associated with capsicide application might include the cost of renting spraying machines, cost of labor to spray the chemical.

The overall anticipated utility from adopting capsicide is a function of net-present profit net indirect cost of capsicide use. Net-present profit is the present value of the future stream of profits (cocoa revenue minus the cost of cocoa production) discounted to the current time using an interest rate, r. The indirect costs are the environmental cost and human health cost associated with capsicide use. Intrinsically, a producer compares the expected utility from potentially using capsicides to that of its alternatives, including a no action. Assuming a risk averse producer, the expected utility the producer obtains from a capsid control method is captured by von Neumann-Morgenstern utility function, U, which is increasing in net-present value of farm profit net the indirect cost of a capsid control method (Chevalley, 2007). Following the random utility framework, it is expected that a producer would choose a capsid control alternative, if it gives the highest expected utility compared to its option (Cameron and Trevedi, 2005).

This decision-making process is latent, and not observable to the researcher. The mathematical formulation of the decision-making process of the method regarding the control of capsidis: Let D^* be a latent variable that underpins the latent decision making process regarding capsid control:

$$D^*_{ij} = E(U(NP\pi_{ij} - IC_{ij}) = V_{ij}(x_i;\beta) + \varepsilon_i \quad (1)$$

$$i = 1,\dots,N$$

$$j = \begin{cases} 1 \text{ if chemical control(capsicide)} \\ 0 \text{ otherwise, including no action} IPM \end{cases}$$

$$NP\pi_{i1} = \sum_{t=1}^{T}(1+r)^{-(t-1)} * [\varphi_1 * f_t(z_{it};\omega) - C_t(z_t) - IC_{i1}]$$
(2)

$$NP\pi_{i0} = \sum_{t=1}^{T}(1+r)^{-(t-1)} * [\varphi_0 * f_t(.\, z_{it};\omega) - C_t(z_t)] \quad (3)$$

where D^*_{ij} is a latent decision-variable for the ith producer and jth capsid control method; E: is the expectation operator; $NP\pi_{ij}$ is net-present profit (net-present revenue – net-present cost) for the ith producer and the jth capsid control method; IC_{ij} the indirect cost to the ith producer and jth capsid control method (assumed to be zero for non-chemical control methods); $V_i(x_i;\beta)$ is the deterministic component of expected utility: x_i is the farm and producer characteristics of the ith producer, β is a set of parameters that are associated with x and that determines $V_i(x_i;\beta)$; ε_i is the stochastic component of expected utility; t is production season and T is the end of production seasons; N is the sample size; r is market interest rate assumed to be constant across production seasons; φ_1 & φ_0 are yield-augmenting effects of capsicide and other control methods, respectively, on cocoa production function $f_t(.\, z_{it};\omega)$; z_{it}&ω are vectors of production inputs and other site specific and spatial field attributes, respectively; and $C_t(.)$ is the total cost of production associated with production inputs z_t.

As noted earlier, the producer would choose a control method that gives him/her the highest expected utility. In this regard, three possible scenarios can be discussed. First, compared to other capsid control methods, it could be that the yield-augmenting effect of capsicide use is substantial to cause the revenue from using capsicide to be significantly higher than the sum of the variable cost of using capsicide and related indirect costs. That is the net-present profit net indirect cost for chemical control might be more significant than other capsid control methods, including no action alternative. This situation is possible because there is evidence to show that chemical control of capsid is very effective, and could prevent about 30 percent cocoa yield loss associated capsid infestation. Also, the government of Ghana frequently subsidizes the cost of cocoa inputs, including capsicide to producers; in some cases, cocoa inputs are distributed freely to producers. These support to producers might reduce the cost associated with the chemical control of capsid. Again, cocoa producers might not able to identify all the indirect costs related to capsicide use.

Second, compared to chemical control, the expected utility of not using capsicides could be significantly higher than that from chemical control. It could be possible, if the potential cost reductions from capsicide use are considerably higher than the cost of non-chemical control of capsids, including no action. Also, the indirect cost of capsicide use is not existent in the case of non-chemical control of capsid. In addition to the above cost conditions, the second scenario is possible if the yield-augmenting effect of other control methods is not significantly different from that of capsicide use. In summary, the net-present profit net indirect cost for nonchemical control could be higher than that of chemical control.

The third scenario could arise when the expected utility from using capsicide and not using it are the same. In this case, producers would be indifferent between the two methods. Producers might choose a way based on the convenience of controlling capsid but not on economic consideration. For purposes of this study, the outcome of situation three (the indifferent case) is assumed to be the same as the outcome of scenario 1.

ECONOMETRIC MODEL

Based on the three scenarios described above, a cocoa producer would reveal his/her adoption state to the researcher. The adoption variable, y, for the ith producer is defined as:

$$y_i = \begin{cases} 1 \text{ if } D^*_{i1} \geq D^*_{i0} \\ 0 \text{ otherwise} \end{cases} \quad (4)$$

Therefore, the probability that a producer chooses capsid control is:

$$\Pr(y = 1) = \Pr\{D^*_{i1} \geq D^*_{i0}\} = \Pr\{\varepsilon_{i0} - \varepsilon_{i1} < V_{i1}(z;\beta) - V_{i0}(z;\beta)\} = F(z;\beta) \quad (5)$$

where Pr is a probability operator, $F(z;\beta)$ is a cumulative distribution function associated with the probability of choosing the information alternative j.

A type 1 extreme value distribution is assumed for the cumulative distribution function in equation (5) (Cameron & Trivedi, 2005). Therefore, a logit model can be used to explain the probability that a producer will use capsicide to control capsids. The logit model assumes that the explanatory variables used in this model are exogenous.

Moreover, a white heteroscedastic consistent estimator (robust) is used with STATA version 14, to mitigate the potential adverse effect of a non-spherical variance-covariance structure of the regression error term (Cameron & Trivedi, 2005). Not correcting for heteroscedasticity does not affect the consistency of the parameter estimates but produces unreliable standard errors (Cameron & Trivedi, 2005). Also, non-corrected standard errors are estimated to compare with robust standard errors, to check for the seriousness of a potential heteroscedastic problem.

Variance inflation factors (VIF) of the covariates in the model will be used to check for multicollinearity. Variance inflation factors greater than ten suggest the variables are causing multicollinearity in the model (Cameron & Trivedi, 2005). Multicollinearity inflates the variance (or standard errors) of the estimates, which in turn could affect the inferential power of tests (Cameron & Trivedi, 2005). Moreover, this study uses the link-test procedure to test for model misspecification. This analysis answers the following question, is the logit model the correct model? In other words, the analysis is based on the notion that a correctly specified regression model should not have additional covariates that are significant by chance. This analysis/test is conducted using the “linktest” routine in STATA 14.

Statements of Hypothesis and Description of Variables

Some variables are expected to influence the decision-making process of the producer regarding the control of capsid. That is whether to use chemical control (capsicide) or not? The supposed influence of a variable in the decision-making process of the producer is conditional on other variables held constant.

Age is a continuous variable. It is expected to have a negative a priori effect on producers’ decision to use capsicide. In most cases, senior producers have shorter planning horizons and might be less inclined to use new agricultural technologies. Older producers might be inclined to use older techniques handed down from their parents to control capsids.

Compared to women, male producers are more likely to use capsicide. It is because in most cases males are the heads of households in Ghana. This position allows them to control family resources. The freedom and independence to manage family resources will enable them to buy and use capsicide if they want to. Gender is a dummy variable which takes a value one if the producer is male and 0 otherwise.

Farm size is a proxy for wealth. A wealthy producer would have the ability to buy and use capsicide. For this reason, it is expected to have a positive a priori effect on capsicide use. Farm size is a continuous variable. Similarly, the cocoa output is expected to have a positive a priori effect on capsicide use. Cocoa output (bags) is a continuous variable. Also, access to credit is expected to have a positive a priori effect on capsicide use. Producers who have access to credit will have the ability to buy and use capsicide. Access to credit is a dummy variable which takes on a value one if the producer has obtained a loan before from a financial institution, and 0 otherwise.

The government of Ghana’s official policy regarding the control of cocoa capsid is through capsicide. This planis implemented through extension services department of Ministry of Agriculture. Therefore, it is expected that producers who have access to extension officers concerned about cocoa capsid are supposed to use capsicide. This variable is a dummy variable which takes on a variable one if the producer has access to extension officers’ visits to discuss cocoa capsid, and 0 otherwise.

Farming experience could have a positive or negative a priori effect on capsicide use. It depends on the prior of the producer on cocoa capsids. Producers would be expected to use capsicide if capsids have had a significant adverse effect on previous cocoa yields. This variable is a continuous variable.

Producers who own their farm might have an incentive to invest in their farming enterprise. For this reason, producers who own their farms might are expected to use capsicide. On the contrary, a producer who does not own a farm might not have the motivation to invest in the farming enterprise. This variable is a dummy variable which takes on a value one if producer owns his/her farm and 0 otherwise.

Producers who have off-farm employment are more likely to have the ability to buy and use capsicide. However, when the producer is more devoted to the off-farm work, it is possible he/she might be less inclined to use capsicide. This variable is a dummy variable which takes on value one if producers have off-farm employment and 0 otherwise.

Membership to a producers' group is expected to have a positive a priori effect on capsicide use. Members ofa producers' group learn from each other about their experiences about cocoa capsids. Also, such groups invite extension officers to talk about essential cocoa topics, such as cocoa capsids. This variable is a dummy variable which takes on a value one if producer belongs to such a group and 0 otherwise.

Literacy is a dummy variable, which takes on a value one if the producer has formal education and 0 otherwise. Educated producers are expected to have the ability to process information and seek for new information themselves. Such producers are expected to use capsicide using the right dosage.

Input shop availability is a dummy variable, which takes on a value one if the producer has an input shop in his/her locality and 0 otherwise. Given that a producer has the financial means, input shop availability is expected to have a positive a priori effect on capsicide use.

The government of Ghana sometimes spray capsicide on cocoa farms free for producers nationwide. This exercise is implemented under the Cocoa Disease & Pest Control Program (CODAPEC). It is expected that producers who have benefitted from the CODAPEC in the past might be less inclined to use capsicide. Such producers might believe that they could benefit from the program again in the future.

Sources and Data Collection

The study uses a survey data collected by the Ghana Sustainable Cocoa Competitive Systems, Accra, Ghana, on active cocoa producers in the Sekyere Area, Ashanti, Ghana. The survey was conducted in the 2006/2007 cocoa production season. The unit of analysis was the individual cocoa farmer in the study area. A multi-stage cluster random sampling procedure was used to select 184 cocoa producers from the Sekyere Area, Ashanti Region, and Ghana. At the first level, three districts from the Sekyere area were chosen purposely, because of their relative importance to cocoa production in the region. These districts are Afigya Sekyere, Sekyere West, and Sekyere Central. At the second level, one town was purposively selected from each district based on their relative importance to cocoa production. The towns are Wiamoase in the Afigya Sekyere district, Yonso in the Sekyere West district, and Kwaman town in the Sekyere Central district.

In selecting the farmers, that is the third level of the sampling procedure; announcements were made to cocoa farmers through public address systems (PAS) for a meeting in the selected towns/villages. The present study also made use of contacts already established by the local Ministry of Agriculture in contacting the farmers. A forum was then created in the selected towns/villages to serve as a platform where the project was introduced to the farmers. In these hearings, discussions were undertaken about cocoa capsid and the need to control it. The farmers were particularly encouraged to tell the project about their experiences on cocoa capsid. They were also invited to make suggestions concerning the factors they see as necessary and likely to influence them to use capsicide and spray right (twice or more). Out of the list of farmers provided by the extension officers in each town/village, a simple random procedure was then used to select a sample size of 184 farmers for the project. The selected respondents were distributed as follows; Afigya Sekyere (60), Sekyere Central (77) and Sekyere West (47). After data cleaning, a final sample size of 151 cocoa producers is used for this study.

The distribution of producers who used capsicide (adopters) is different from non-users (non-adopters) in some key variables (Table 1). The variables are farm size, farming experience, engagement in off-farm economic activities, membership of a farmers' group, literacy, access to credit, cocoa output and beneficiary of cocoa mass spraying (once). The means of these variables are significantly different between the two groups, using the T-test statistic (Table 1).

On the average, adopters of capsicide have larger farm sizes (above 2 acres more), have more farming experience (about 3 years more), engage more in off-farm economic activities, have more cocoa output (about 6 more bags), benefited more from cocoa mass spraying, are less inclined to be members of a farmers' group, have less input shops in their localities, have more access to credit, and are more literate. But, with regards to the other variables in Table 1, the two groups are not different from each other significantly. Table 1 is shown below:

RESULTS OF LOGIT MODEL

The coefficients in the model are jointly significant at the 1 percent level (at a Wald chi-square of 48.4 with 14 degrees

Table 1. Descriptive Analysis and Test of Means between groups.

	Did not use capsicide		Used Capsicide			
Variable	Mean(o)	SE	Mean(1)	SE	T-test: D =Mean(0) –Mean(1)	Hypothesis
AGE	59	1.9	58	1.2	0.772	Ho: D=0; H1: D<0
GENDER	0.63	0.07	0.63	0.04	0.033	Ho: D=0; H1: D<0
FARMSZ	4.8	3.5	6.72	0.42	-2.64***	Ho: D=0; H1: D<0
EXTVT	0.58	0.07	0.58	0.04	-0.09	Ho: D=0; H1: D<0
FARMOW	0.86	0.05	0.85	0.027	0.1	Ho: D=0; H1: D<0
FARMEXP	17	1.73	20	1.15	-1.53*	Ho: D=0; H1: D<0
ENGOTHER	0.6	0.069	0.8	0.04	-2.6***	Ho: D=0; H1: D<0
MEMFGP	0.75	0.06	0.51	0.045	3.15***	Ho: D=0; H1: D>0
LITERACY	0.6	0.07	0.75	0.04	-1.96**	Ho: D=0; H1: D<0
ACCDT	0.15	0.05	0.38	0.04	-3.33**	Ho: D=0; H1: D<0
INPUTSA	0.73	0.06	0.61	0.04	1.61**	Ho: D=0; H1: D>0
OUTPUT	5.23	0.9	11	1.04	-4.2***	Ho: D=0; H1: D<0
BENMS1	0.22	0.06	0.33	0.04	-1.45*	Ho: D=0; H1: D<0
BENMS2	0.42	0.07	0.43	0.04	-0.13	Ho: D=0; H1: D<0

***,**,* denotes significance at 1 percent, 5 percent, and 10 percent, respectively. Stata command for the T-testis: ttest "variable," by(CAPUSE) unequal. The independent variables and CAPUSE are defined in Table 1.Ho and H1 denote the null and alternative hypotheses, respectively.

of freedom). It means that the model is significant in explaining the probability that a producer would use capsicides to control cocoa capsid bugs. Also, the estimated model has a prediction accuracy of 79.4 percent. The probit model results (after multiplying the coefficients by a factor of 1.6) confirms the findings of the logit model. Multicollinearity is not a problem in the model because the variance inflation factors of the covariates are below 6.It means that the standard errors of the parameter estimates are not inflated.

The study reports the results of the marginal effects of the covariates on the probability of a producer using cocoa capsicides. The direction of effects of the significant variables (at least at 10 percent significance level) are reported. The magnitude of their marginal effects are discussed under the discussion section of this study. The model results (Table 2) show that producer's farming experience (1 percent), producer's engagement in off-farm economic activities (10 percent), producer's access to credit (1 percent), extension visit (10 percent), and cocoa output (5 percent) have significant and positive effects on the probability that a producer would use cocoa capsid, as expected a priori. The values in parenthesis are the significance levels of the estimated effects. Also, as expected, producer's age has a 5 percent significant negative impact on the likelihood that a producer would use cocoa capsid. Membership of a farmers' group has a 1 percent significant negative effect on the probability that producer would use capsicide.

DISCUSSION OF RESULTS

A producer who has access to credit is about 29 percent more likely to use capsicide. This impact is significant at the 1 percent significance level. Access to credit makes funds available to the farmer and could increase the probability of the farmer buying capsicide to use on their farms. Access to credit has been noted by other researchers to influence the adoption of agricultural technologies (Zegeye, 2001; De Groote, Doss, Lyimo, Mwangi, & Alemu, 2002;Mohamed &Temu, 2008).

A one-year increase in a producer's farming experience could increase the likelihood of him/her using capsicides by 0.9 percent, at the 1 percent significant level. Farming experience shows the prior knowledge of cocoa producers regarding the control of cocoa capsid bugs, as well as their effect on cocoa yield. The devastating impact of capsid on cocoa yield is a common problem in Ghana. It is likely that producers might have prior negative experiences (reduced cocoa yield resulting from capsid infestation) from capsid bug infestation. Therefore, it is not surprising that farming experience would have a positive effect on the likelihood that a producer might use cocoa capsicides to avert possible reduced yields from capsids. Other studies have shown that farming experience has a positive impact on the adoption of agricultural technologies (De Groote et al., 2002).

Input shop availability has a significant (10 percent) positive effect on the probability that a producer would use capsicides; but, its marginal impact is not significant at the 10 percent level. This variable could improve a producer's access to an agricultural input (regarding availability). Also, it could reduce the real cost of capsicides by avoiding or reducing the transportation cost that can occur from buying them from another town. Many studies have shown that the cost of agricultural inputs and their availability could affect the adoption of agricultural technologies (Makokha et al. 2001; Wekesa et al. 2003).

Table 2. Model Results.

	Logit Model Results					**Probit Model Results**	
Dependent Variable:			Robust	Marginal Effects	M.E. Std. Error		Robust
CAPUSE	Coefficient	Standard Error	Standard Error	(M.E.)	(Delta-Method)	Coefficient	Standard Error
AGE	-0.063**	0.028	0.025	-0.008**	0.003	-0.037**	0.014
GENDER	-0.460	0.527	0.540	-0.060	0.070	-0.274	0.294
FARMSZ	0.033	0.079	0.087	0.004	0.011	0.018	0.045
EXTVT	1.200*	0.701	0.709	0.157*	0.090	0.695*	0.385
FARMOW	-0.074	0.583	0.547	-0.010	0.071	-0.057	0.316
FARMEXP	0.069***	0.026	0.022	0.009***	0.003	0.041***	0.013
ENGOTHER	0.950*	0.556	0.575	0.124*	0.075	0.589*	0.319
MEMFGP	-2.249***	0.608	0.595	-0.294***	0.066	-1.325***	0.326
LITERACY	0.160	0.601	0.548	0.021	0.072	0.120	0.311
ACCDT	2.227***	0.662	0.629	0.291***	0.074	1.320***	0.336
INPUTSA	1.057*	0.601	0.608	0.138	0.077	0.626*	0.335
OUTPUT	0.107**	0.048	0.051	0.014**	0.007	0.063**	0.027
BENMS1	0.692	0.696	0.704	0.091	0.093	0.442	0.386
BENMS2	-0.236	0.637	0.623	-0.031	0.081	-0.135	0.349
Constant	1.397	1.922	1.959			0.754	1.082
Sample size	151						
Likelihood Ratio Test (Chi-Square, 14df)	48.4						
Pseudo R-square	28%						
Correctly Predicted	79.4%						

***, **, * denote significance at 1, 5 and 10 percent, respectively; the average marginal effects were calculated using the delta method. Stata estimation command: *logit CAPUSE "independent variables".* The probit model follows the same command but uses probit instead of logit. The Heteroscedastic consistent estimator command is done by appending vce(robust) to the *logit* or *probit* commands.

Again, increasing levels of cocoa farm output could translate into a better financial position for the cocoa farmer, all things being equal. A unit (1 bag) increase in cocoa output could increase the probability of the producer using capsicides by 1.4 percent. Similarly, a farmer earning off-farm income is expected to have a better financial position and could increase the likelihood of him/her adopting cocoa capsicides by 12.4 percent. Also, off-farm income can substitute for borrowed capital and could help producers with credit constraints access agricultural technologies (Reardon et al. 2007; Diiro et al. 2013).

Famer's age has a significant (5 percent) adverse effect on the likelihood that a producer would use capsicide by about 0.7 percent. Compared to older producers, young producers have a more extended planning horizon, are less risk-averse and are more daring to try out new technologies (Mauceri et al. 2005). Membership of farmers' group has a significant (1 percent) adverse effect on the likelihood that a producer would use capsicide by 28 percent. The result is contrary to expectations, and the results obtained in other adoption studies (Zegeye, 2001). A possible explanation for this contradiction is that some members of these farmer groups (for instance older farmers) might have negative peer influence on potential adopters.

CONCLUSION

The cocoa capsid is an important pest of cocoa that causes up to 30 percent cocoa yield loss in Ghana. The official government of Ghana's policy is to use chemicals (capsicide) to control the pest; because its control through chemical means has proven to be the most effective method of controlling this pest. It would be in the country's interest to regulate the use of pesticides, including capsicide, in cocoa production to meet the demands of international conventions. This study contributes to the understanding of cocoa producers' behavior towards the chemical control of capsid. It identified producers' age, extension visit, farming experience, access to credit, membership to a farmers' group, input shop availability in the farmer's locality, engagement in off-farm economic activity, and farm output as having significant effects on the probability that a producer would use capsicide on their farms.

In the short-term, policymakers could use the results of the study to design appropriate policies to target producers who would be more likely to use capsicide and educate them to use it according to the recommended practice. In the medium to long-term, the results of this study could benefit the government of Ghana and other stakeholders interested in promoting the use of appropriate agricultural technologies, such as integrated pest management. For instance, an environmental NGO could use the results of this study to target producers who are likely to use pesticides and try to shift them to good ecological alternatives through education and incentives.

ACKNOWLEDGEMENT

The authors thank the Department of Agricultural and Applied Economics, Texas Tech University for their support, financial and material, towards this article. We also thank K Yerfi Fosu and Ghana Sustainable Cocoa Competitive Systems Project, Accra, Ghana, for the data used in this article.

REFERENCES

Adu-Acheampong, R., Padi, B., Ackonor, J., Adu-Ampomah, Y., & Opoku, I. (2006). Field performance of some local and international clones of cocoa against infestation by mirids. Global Approaches to Cocoa Germplasm Utilization and Conservation, 50, 187.

Afrane, G., & Ntiamoah, A. (2011). Use of pesticides in the cocoa industry and their impact on the environment and the food chain Pesticides in the Modern World-Risks and Benefits: InTech.

Beaman, L., BenYishay, A., Mugruder, J., & Mobarak, A.M. (2015). Can network theory based targeting increase technology adoption. Yale University, June (mimeo).

Cameron, A. C., & Trivedi, P. K. (2005). Microeconometrics: methods and applications: Cambridge university press.

Chevalley C. (2007). Theory of games. Theory of games and economic behavior (60th Anniversary Commemorative Edition).

De Groote, H., Doss, C., Lyimo, S. D., Mwangi, W., & Alemu, D. (2002). Adoption of maize technologies in East Africa–what happened to Africa's emerging maize revolution. Paper presented at the FASID Forum V,"Green Revolution in Asia and its Transferability to Africa", Tokyo.

Diiro, G. (2013). Impact of Off-farm Income on Technology Adoption Intensity and Productivity: Evidence from Rural Maize Farmers in Uganda. International Food Policy Research Institute, Working Paper 11.

Dormon, E., Van Huis, A., & Leeuwis, C. (2007). Effectiveness and profitability of integrated pest management for improving yield on smallholder cocoa farms in Ghana. International Journal of Tropical Insect Science, 27(1), 27-39.

Essegbey, G. O., & Ofori-Gyamfi, E. (2012). Ghana cocoa industry-An analysis from the innovation system perspective. Technology and investment, 3(4), 276.

Feder, G., & Noronha, R. (1987). Land rights systems and agricultural development in sub-Saharan Africa. The World Bank Research Observer, 2(2), 143-169.

Feder, G., & O'Mara, G. T. (1981). Farm size and the diffusion of green revolution technology. Economic development and cultural change, 30(1), 59-76.

Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. Economic development and cultural change, 33(2), 255-298.

Gershon, F., Feeny, D. (1993). The theory of land tenure and property rights. The Economics of Rural Organization: Theory, Practice, and Policy. Oxford University Press, Oxford, 240-258.

Jonny, G., Barbara, J., & Julie, F. (2003). Discovery learning about cocoa: an inspirational guide for training facilitators. Cabi Bioscience, UK Centre, Oxon.

Kolavalli, S., Vigneri, M. (2011). Cocoa in Ghana: Shaping the success of an economy. Yes, Africa can: success stories from a dynamic continent, 201-218.

Makokha, S., Kimani, S., Mwangi, W., Verkuijl, H., Musembi, F. (2001). Determinants of Fertilizer and Manure Use for Maize Production in Kiambu District, Kenya. CIMMYT (International Maize and Wheat Improvement Center) Mexico.

Martin, S. W., Roberts, R. K., Larkin, S. L., Larson, J. A., Paxton, K. W., English, B. C., . . . Reeves, J. M. (2008). A binary logit estimation of factors affecting adoption of GPS guidance systems by cotton producers. Journal of Agricultural and Applied Economics, 40(1), 345-355.

Mauceri, M., Alwang, J., Norton, G. Barrera, V. (2005). Adoption of Integrated Pest Management Technologies: A Case Study of Potato Farmers in Carchi, Ecuador; Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island, July 24-27, 2005

Mignouna, B., Manyong, M, Rusike, J., Mutabazi, S., & Senkondo, M. (2011). Determinants of Adopting Imazapyr-Resistant Maize Technology and its Impact on Household Income in Western Kenya: AgBioforum, 14(3), 158-163. Hall, B. and Khan, B. (2002) Adoption of new technology. New Economy Handbook.

Mohamed K, Temu A (2008). Access to credit and its effect on the adoption of agricultural technologies: The case of Zanzibar. African Review of Money Finance and Banking: pp. 45-89.

Nzomoi, J., Byaruhanga, J., Maritim, H., & Omboto, P. (2007). Determinants of technology adoption in the production of horticultural export produce in Kenya. African Journal of business management, 1(5), 129-135.

Okunlola, O Oludare, O., Akinwalere, B.(2011). Adoption of new technologies by fish farmers in Akure, Ondo state, Nigeria Journal of Agricultural Technology 7(6):1539-1548

Osei, I. (2007). Sustainable Practices in the Global Cocoa economy–A producer's perspective. Paper presented at the proceedings of the 4th Indonesia International Cocoa Conference and Dinner.

Reardon, T., Stamoulis, K. and Pingali, P. (2007). "Rural Nonfarm Employment in Developing Countries in an era of Globalization." Agricultural Economics 37:173–183.

Sunding, D., Zilberman, D. (2001). The agricultural innovation process: research and technology adoption in a changing agricultural sector. Handbook of agricultural economics, 1, 207-261.

Tovignan, D. S., Nuppenau, E.A. (2004). Adoption of organic cotton in Benin: does gender play a role. Paper presented at the Deutscher Tropentag.

Wekesa, E., Mwangi,W., Verkuijl, H., Danda, K., De Groote,H. (2003) Adoption of Maize Technologies in the Coastal Lowlands of Kenya. CIMMYT, Mexico, D.F.

Zegeye, T. (2001). Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-scale Farmers in Yelmana Densa, and Farta Districts of Northwestern Ethiopia: CIMMYT.