Socio-Economic Factors Influencing the Use of Botanicals in Cocoa Pest Management

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Abstract

A combination of botanicals and natural components to manage pests and diseases of crops offers considerable promise for increasing income and sustainability of farmers in developing countries. It nonetheless remains unclear whether these techniques lend themselves easily to adoption by smallholder farmers. Using cross sectional data applied to probit model, this study finds that preparation constraints limit many farmers' adoption of alternative pest management techniques. The size of the farm owned by a farmer, educational qualification, household size, farming experience and social group participation all had a significant positive effect on the likelihood of adoption. This study helps to close the "feedback loop" from farmers back to researchers and others attempting to disseminate the technology, and by doing so, should contribute to faster and more widespread uptake of this technology.

Keywords: adoption, probit, Siam weed, Neem, Tobacco

Introduction

Pest and disease control constitutes one of the most important aspect of crop production and protection for increase income and sustainability of farmers' livelihood as well as national income for agrarian economy. It therefore seems intuitive that stakeholders should invest in managing pest and disease of crop. It has been estimated that about 125,000- 130,000 metric tons of pesticides are applied every year to achieve that in developing country like Nigeria (Asogwa and Dongo, 2009). However, the continuous use of synthetic chemicals to manage the pests and diseases of crops is generally fraught with problems of undesirable side effects and food chain involvement. Many pesticides pose substantial short and long term health risks (Rahman, 2003) occupational and health hazards (Sosan et al. 2010), substantial environmental damage/ contamination (Conway and Pretty, 1991), secondary pest outbreak (Tijani and Omondiagbe, 2006). The adverse health effects include a series of chronic end points including cancer (Settimi et al. 2003; Alanvanja et al. 2004).

Due to the aforementioned problems, usage of synthetic pesticides is not economical and sustainable for small scale farmers indicating a need for effective, alternative pest management methods devoid of the adverse effects. Botanicals such as neem trees (*Azadiracta indica*), Siam weed (*Eupatorium odorata*) and tobacco (*Nicotiana tabacum*) have been reported to play an important role in the development of such strategies. These alternative methods involve the combination of these botanicals with other materials such as ashes and water.

Adejumo (2005) investigated protection strategies for major diseases of crops and reported that local herbs and constituents of plant materials offer cheap and safer control for those categories of farmers who cannot sustain the high cost of synthetic pesticides. In Kenya, Mugisha-

Kamatenesi et al. (2008) reported that the subsistence farmers preferred using botanical pesticides rather than synthetic ones mainly because of the latter's adverse effects such as safety, cost and crop failure. Abedi and Bedragheh (2011) asserted that indigenous knowledge is a principal factor at the field of research of sustainable development, decreasing poverty, local participation in farming activities and rural development programs which develops and produces appropriate technology, self-reliance of rural societies and country.

Inspite of the growing literature on the use of botanicals to manage pests and diseases of crops, there is dearth of literature on the level of adoption of the method by the farmers. (Provide citations) This is a crucial issue because one major criterion for assessing the suitability of a new technology or an innovation in an area is the level of its adoption among the target group, which establishes the extent of its compatibility with existing and local system. Apart from improving the efficiency of technology generation, studies on adoption of agricultural technology provide bases for assessing the effectiveness of technology transfer as well as its suitability to local environment (CIMMYT, 1993; Inaizumi et al. 1999). Adoption studies are also important when analyzing innovation diffusion processes both at local and regional levels and is expected to supply crucial information on the patterns of adoption and identify who is by-passed by the innovation, explains income distribution of rural households (Le Gal et al. 2011; Ding et al. 2011). Hence, this study seeks to analyse the factors driving the use of botanicals by farmers in the quest to manage pests and diseases of crops.

Since adoption of agricultural production technologies in developing countries is influenced by a wide range of economic, social, physical as well as technical aspects of farming, it is important to understand the role of these factors to ensure the development of sustainable technologies and the design of successful development projects.

According to Rogers (1995), the adoption of an innovation goes through a decision-making process beginning with awareness, then the formation of positive or negative attitudes, and finally deciding whether to adopt the technology. Each stage of this process is influenced by various factors, including: household factors (socio-economic, resource base and outside contacts), community factors (access to extension, education, market, infrastructure, indigenous knowledge and ecological factors), and institutional factors (extension services, training and material support, through government and national/local NGOs). Understanding who adopters are can assist in repacking the technology to meet the need of the potential producers as well as put in place other key services that would enable the users to sustain their level of production.

Materials and Methods

This study was carried out in Osun State. The state is located in south-western Nigeria, and lies within latitude 7.0^o and 9.0^o N and longitude 2.8^o and 6.8^{o}E. The state covers a total land area of approximately 8, 602 km^2. It is characterized by two-peak rainfall regimes, which range from 1125mm in derived savannah to 1475 mm in the rain forest belt. The mean annual temperature ranges from 27.2^{0}C in the month of June to 39.0^0 in December. The state comprises three agro- ecological zones: rain forest (Ife/Ijesa), derived savannah (Osogbo) and savannah (Iwo) zones. The state vegetation is characterized by secondary forest and in the northern part, the derived savannah mosaic predominates.

The soil type of the study area belongs to the highly ferruginous tropical red soils associated with basement complex rocks. As a result of the humid forest cover in the area, the soils are generally deep and are of two types, namely, deep clayey soils formed on low smooth hill crests and upper slopes; and the sandy hill wash soils on the lower slopes. The well drained clay soils of the hill crest and slopes are very important, because they provide the best soils for cocoa and coffee cultivation in the state. The lighter loams are more suitable for cultivating the local food crops, such as yam, cassava and maize.

Data for the study were collected in 2009/2010 cropping season using structured questionnaire. A multistage sampling procedure was employed. Cocoa farmers in the study area were purposively selected. The farmers were then stratified into two strata: adopters of botanical method and non-adopters. A total of 150 farmers were randomly selected from each categories using lottery draw method. In all, 300 farmers were sampled; however, only 274 were used for analysis, while 26 were rejected for inconsistency and inadequate information. Data collected were analysed using both descriptive statistics and probit model.

The Probit Model

The probit model is used to explain the behaviour of a dichotomous dependent variable. The general form of the probit model is:

$$P_i^* = f(\beta' X) = 1/[\exp(-\beta' X)]$$

The original functional relationship is specified as

$$Y_i^* = \beta_0 + \Sigma\beta_i X_{ij} + u_i$$

where Y_i^* is not observed, i.e., a latent variable. In this study, the dependent variable is dichotomous, taking a value of 1(one) if a farmer has adopted and 0(zero) otherwise. A number of demographic, social and economic factors were hypothesized to influence the adoption decision. Most of these hypothesized factors were motivated from previous adoption studies. A dummy variable is observed, Yi, i.e., whether the respondent is adopting the technology or not, and defined it as:

$Y_i = 1$ if $Y_i^* > 0$

= 0 otherwise

The marginal effects were computed using the equation

$$\delta P/\delta X_{ij} = \beta_j P_i(1 - P_i)$$

The model relating to the adoption is specified as follows;

$$P_i = f(b_0 + b_1x_1 + b_2x_2 + \cdots b_{11}x_{11})$$

where

P_i = adoption status measured as dummy (1=adoption, 0 = non adoption)

$b_0 \ldots b_{13}$ = parameters to be estimated.

X_1 = Gender of respondent (dichotomous)

X_2 = Age in years

X_3 = Marital status (continuous)

X_4 = Education (number of years of formal education)

X_5 = Household size (number)

X_6 = Farm size (ha)

X_7 = extension contact (1=yes, 0=no)

X_8 = Off farm employment (1=yes, 0=no)

X_9 = Accessibility to the technology inputs (1=available, 0=not available)

X_{11} = Participation in community groups (Continuous)

X12 = There is no "membership" as a variable in this model. Define and include membership variable since it was significant according to Table 4. Or is participation in community groups the same as membership?

A Priori Expectations

The rationale for inclusion of these factors was based on *a priori* of agricultural technology adoption literature (Cite literature not table). The effect of age on the decision to adopt an innovation may be negative or positive. Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk and adopt new technology because of their longer planning horizons. The older the farmers, the less likely they are to adopt new practices as he gains confidence in his old ways and methods. On the other hand, older farmers may have more experience, resources, or authority that may give them more possibilities for trying a new technology. Thus for this study, there is no agreement on the sign of this variable as the direction of the effect is location- or technology- specific (Bekele and Drake, 2003; Alcon et al. 2011).

Table 1 Description, measurement and '*a priori*' expectations of the study variables.

Variable	Measurement	Expected sign
	Dependent variable	
Adoption	Dummy (1 for adopters; 0 otherwise)	
	Independent variables	
Age	Years	+/-
Education	Years	+
Household size	Number of people living under the same roof	+/-
Farm size	Hectares (ha)	+
Off farm income	Naira (1N = $153)	+

Education was hypothesized to positively influence the adoption of a new intervention. Education increases the ability of farmers to obtain, analyze and interpret information. Studies (e.g. Nchinda et al. 2010; Alcon et al. 2011) indicated positive relationship between education and technological adoption. Off farm income was hypothesized to influence adoption positively. It is generally considered to be capital that could be used either in the production process (is off farm income not cash?) or processing process or other activities within the household. These variables are known to influence the adoption of an innovation positively (Negatu and Parikh, 1999). Family size has an unclear relationship with technology adoption. Larger family size among smallholder farmers is generally associated with the availability of labour force for timely farm operations including indigenous technology. However in some cases, the variable has a negative relationship with adoption because of increased consumption pressure associated with large family (Mignouna et al. 2011). It is therefore difficult to predict this variable 'a priori' in this study.

Previous studies have found a positive relationship between farm size and technological adoption (Oluch-Kosura et al. 2001; Bekele and Drake, 2003). In many cases, large farm size is associated with increased availability of capital, which makes investment in innovation methods more feasible. For this analysis, farm size is included as the total cropland available to the farmer. A positive relationship was hypothesized with adoption of an alternative pest management practices.

Results and Discussion

A summary of the socioeconomic characteristics of the sampled respondents in the study area revealed that actual mean estimates for socio-economic variables did not show much variation between adopters and non-adopters (See Table 2). However, there were significant differences (P<0.05) between the adopters and non-adopters' household size, farm size and years of farming experience. .

There were no significant differences between the age and years of education of the two different groups of farmers. Members of both groups in the study area were ageing and had little western education. The mean household size of adopting households was comparatively low and statistically different to that of non-adopters of an alternative pest management method. The average household size was 6 for adopters and 8 for non-adopters which implies that the cocoa farmers have relatively large family size in the study area.

Farm size of adopters and non-adopters of an alternative pest management method significantly differed. The adopters had average cocoa farm size of 6.85 hectares while the non-adopting farmers had average of 4.87 hectares. The mean farm size for all the respondents was 5.87 ha.

Years of farming experience was found to be statistically different between the two groups of farmers. Also, the descriptive results indicated that the farmers had long years of experience in cocoa farming. The average year of experience was 25.34 and 29.18 for adopters and non adopters, respectively.

Table 2 Socioeconomic characteristics of respondents.

Variable	Adopters N=137	Non-adopters N=137	All samples N=374	T-value
Age (year)	57.9	57.16	57.53	1.656
Household size	6.18	8.11	7.14	-5.854***
Farm size (ha)	6.85	4.87	5.87	8.251***
Farming experience (year)	25.34	29.18	27.26	-5.770***
Level of education	2.48	2.50	2.49	-0.078
Income (₦)	801,000	562,000	682,000	7.420***
Yield/ha	40.07	28.12	34.10	-8.053***

Source: Data analysis, 2010
* means significant at 5% level

The average year of experience for all the respondents was 27.26. The level of education for the two groups of farmers was low and statistically insignificant. The results also showed a statistically significant difference between yields per hectare of the farmers belonging to different adoption status. The average net yield per hectare of the adopters and non-adopters equals 2003.5 kg and 1406.28 kg respectively. The findings reveal a statistically significant difference in the income of the adopters and non-adopters. The income represents the total revenue generated from the sales of the cocoa in the cropping season.

The analysis of the rate of adoption of the alternative pest management method is presented in Table 3. The results showed that 37.2% of adopters of botanicals use Siam weed (*Eupatorium odoratum*), 24.1 percent use Tobacco (*Nicotiana tabacum*) while the 38.7 per cent use Neem (*Azadiracta indica*). The result indicates that both the use of Neem and Siam weed is the most popular among the adopters of botanical method.

Table 3 Rate of adoption of an alternative pest management method.

Alternative methods	Frequency	Percentages
SWSS	51	37.2
TSS	33	24.1
NSS	53	38.7
Total	137	100

Source: Data analysis, 2010

Estimated Results of the Probit Model

Results of the probit model are presented in Table 4. The diagnostics tests such as Pseudo R^2, Likelihood Ratio, Chi-Square and estimated value for the Log-likelihood functions are also reported in the table. All the explanatory variables accounted for about 58% of the variations in the probability that a farmer would decide to adopt the alternative pest management method. The overall fit, expressed by the likelihood test, is high and significant. This demonstrates that the variables included in the model are relevant influences of the adoption decisions of the sampled cocoa farmers regarding the alternative pest management method in the study area. The respondents' years of education, household size, participation in community groups, farm size were all significantly related to the probability of adoption by the respondents (Table 4). In binary models, the coefficients (βs) cannot be interpreted as the marginal effects on the dependent variable (Greene, 1994; Gujarati, 2007). Therefore, marginal effects were computed, as the percentage change in the probability of adoption associated with a unit change in an explanatory variable.

Years of education were statistically significant and positively related to the probability of adoption at the 5% level. The result showed that a one unit increase in the years of education cocoa farmer is likely to increase the probability of adopting the alternative pest management method by 13 percent. This implies that educated farmers have the ability to acquire, synthesize, and quickly respond to disequilibria, thereby increasing the probability of positively adopting an innovation. This finding is consistent with those of Asfaw and Admassie (2004) and Lemchi et al. (2005).

The social capital proxy by the membership of farmers' organizations was statistically significant and positively related to probability of adoption at 5% level of significance. This means membership of a particular farmer's organization increased the probability of adoption by 8 per cent**.** As more households joined social groups, adoption and the use of the alternative pest management method increased. Household size was statistically significant but negatively related to the probability of adoption of the alternative pest management method. The negative sign of the household size is consistent with *a priori* expectations of the subsistence requirements of the households. The result showed that a one unit increase in household size of cocoa farmer would decrease the probability of adopting indigenous pest control method by 13 percent. Owu (1995) asserted that this variable has a negative relationship with adoption since increased household size increases consumption pressure. This explanation is particularly more plausible for innovation on tree crops such as cocoa with a relatively long production cycle.

Farm size of the household was positive and had statistically significant influence on the adoption of the alternative pest management method. The result

Table 4 Estimated Probit model results of adoption.

Variables	Coefficient	Standard error	*z*- Value	Marginal effect
Age	57.4982	0.082057	1.61	0.0132035
Education	2.49817	0.0294301	4.29***	0.1267962
Gender	1.16117	0.1469537	-0.03	-0.0042338
Household	7.14286	0.0314953	-4.13***	-0.133164
Membership	6.23443	0.0244152	3.44***	0.0842144
Farm size	5.84615	0.0385716	5.28***	0.2021456
Offfarm income	1.64835	0.1009746	0.94	0.0947142
LR chi2(10)	220.08			
Prob > chi2	0.0000			
Log likelihood	-79.189638			
Pseudo R^2	0.5815			
Number of obs	273			

Source: Data analysis, 2010
* means significant at 5% level

showed that a one unit increase in farm size is likely to increase the probability of adopting indigenous pest management method by 20 percent. The effect of farm size suggests that farmers who hold large farms are more likely to invest in adoption of the alternative technology. This agrees with the argument that larger farm owners have more flexibility in their decision-making, greater access to discretionary resources, and more opportunity to use new practices on a trial basis with more ability to deal with risk (Nowak, 1987).

Age of household head was not statistically significant at the 5% level though it had the expected positive sign. Other studies had also found age to be statistically insignificant in influencing adoption. Gender was not found to be statistically significant in influencing the alternative pest management method adoption decision. This implies that the adoption of the alternative method was not associated with the gender of the farmer. This finding agrees with Doss and Morris (2001). Off farm income was also not found to significantly influence the adoption of at 5% level. This finding could be attributed to the nature of cocoa farm enterprise as a tree crop. To earn income from cocoa, a relatively long period of time is needed to transform the product to a marketable produce unlike food crops.

Conclusions

Pest management using botanical method is an increasingly adopted practice in Nigeria. Based on the findings of this study, there is little variation between most socioeconomic characteristics of adopters and non adopters of botanical with the exception of household size and farm size which show significant difference. This leads to our conclusion that non adopters of botanicals are characterized by larger household size but lower farm size. Further, Farmers in the study area have adopted a range of indigenous pest management technologies. Although the range of adoption varies from one household to another for several reasons, indigenous technologies based on *Azadiracta indica* (neem) and *Eupatorium odorata* (Siam weed) are the most adopted respectively. Findings from probit model lead to the conclusion that education, social capital and farm size have a significant positive impact on the probability of adopting botanicals to manage pests and disease of cocoa crop. Thus, the development of innovations and technologies that possess desirable attributes that fit into the peoples' farming systems, and which present alternatives to negative social, economic and environmental effects for trial are of crucial importance in decisions regarding technology, transfer and sustainability of improved agricultural productivity.

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