Factors affecting the adoption of botanical extracts as pesticides in cowpea production in northern Ghana

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ABSTRACT

Cowpea is an important crop among the farm households of northern Ghana. It provides a cheap source of plant protein and bridges a hunger gap that is known to exist between the time when most crops are planted and the time when major crops are harvested. However, the cultivation of cowpea is constrained by several factors, with pests and diseases being the most serious constraints. Some technologies have been transferred to farmers over the years to enable them cope with these production constraints. The use of synthetic pesticides in pest control raises concern for human health and environment safety. However, a long history of use of botanical extracts and herbs in African cultures is available for protecting crops and stored products, as well as for medicinal and veterinary purposes. In recent decades, the use of botanical extracts in pest control has received a lot of emphasis in research and development. This paper examined the factors influencing the adoption of botanical extracts as pesticides in cowpea production. Analysis of farm data showed that the socio-economic characteristics provided a more satisfactory explanation of the adoption pattern. Three principal but interrelated factors were of particular importance: the level of education of the household head and the size of one's farm and access to labour were relatively important in influencing decision to adopt; besides, high labour requirement by farmers for preparing and applying the botanical extracts make the technology less attractive to farmers with larger farm sizes. Therefore, the results suggest that increased adoption of the technology can be fostered by targeting education toward farmers who have had some formal education, and with smaller farm sizes. Industrial production of botanical extracts, to reduce the drudgery of its production and use by individual farmers, could speed up adoption.

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Introduction

Cowpea is an important crop among the households of northern Ghana. It provides a cheap source of protein for the households and helps in bridging a hunger gap that exists between the time crops are planted and the time when most new crops are harvested (Langyintuo *et al.*, 1995). The crop is also important in providing a source of cash income as well as improving soil fertility through nitrogen fixation and incorporation of the residue after harvest. Despite the benefits enumerated above, the production of cowpea in northern Ghana is faced with several constraints. Some constraints mentioned by farmers include lack of access to improved seeds, insect pest infestation, access to markets for cowpea grain, and liquidity constraints. Insect pest infestation stands out as the most important constraint to cowpea production in northern Ghana. Farmers use pest control methods recommended to them either through extension or research. Over 50 per cent of farmers use chemicals to control aphids alone (Abatania, Gyasi & Terbobri, 1999). This situation suggests a widespread use of chemical pesticides in northern Ghana.

In recent times, concern for environmental safety and human health has led to recommendations on the use of botanical extracts as pesticides (Singh & Sexana, 1999). Insecticides from neem extracts have demonstrated activity against over 400 species of insects, including those that attack cowpea (Singh & Sexena, 1999). The use of neem extracts in particular has been recommended to farmers. The extent of use of the botanical extracts has been limited.

This study, therefore, aimed to find out the factors affecting the adoption of botanical pesticides in northern Ghana.

Materials and methods

Study area

The study was carried out in northern Ghana, which comprises three administrative regions (Northern, Upper East and Upper West regions) of the country. The three regions together have a land area of 97,700 km^2, which constitute 40 per cent of the total land area of Ghana (MOFA, 1997). The area falls within the Guinea and Sudan Savanna vegetation zones of the country. The average annual rainfall of the area ranges from 900 to 1,500 mm. The rainfall period starts in April and ends in October, followed by a dry season from November to March. Dominant naturally growing tree species in the area include shea nut *(Butruspermum* spp.), dawadawa (*Parkia* spp.), ebony (*Diospiros mespiliformis*), and baobab *(Adansonia digitata)*.

The soils of northern Ghana are predominantly Savanna glysols and Savanna ochrosols from sand stone parent material (Donhauser, Baur & Langyintuo, 1994). Sand and gravel contents are generally high in the top layer of these soils. The soils are low in nitrogen, while the available phosphorus poses the most serious limitation to crop production. Potassium is usually available in sufficient quantities (NAES, 1987/88).

Major crops grown in the area include maize, yam, sorghum, millet, rice, and cowpea as subsistence crops; and groundnut and cotton as the main cash crops. Cropping systems in a particular area are defined by crops that occupy a larger cultivated area relative to other crops in cultivation. Where crops are planted in mixtures, the cropping system is defined by the crop having the highest relative population density in the plant stand. On this basis, cropping systems in the Northern Region are mainly yam and maize-based; in the Upper West and Upper East regions, they are mainly sorghum, millet and cowpea-based.

Data collection

Data were collected from farm household surveys through informal and structured questionnaire interviews. Sub-samples of 5 to 10 farm household heads (depending on the population of the village) were randomly selected from villages, including those that were exposed to farmer field school activities in northern Ghana, through the PRONAF project. A total of 169 heads of farm households were interviewed using a structured questionnaire. The questionnaire covered socio-economic characteristics of the household, an inventory of cowpea technologies available and also being adopted by farmers, the impact of cowpea on household income, and trends in cowpea income distribution within the household. Other areas covered by the surveys were the relative ranking of cowpea (compared to other crops) in terms of the annual area under cultivation, relative ranking in annual production, and its relative ranking in nutrition and food security. This paper focuses on the aspect of the survey that deals with the adoption of improved cowpea technologies (botanical extracts).

Conceptual model

A probit model was used to determine the importance of the factors that affect the adoption of botanical extracts used as pesticides in Ghana. Farmers have been encouraged to use botanical pesticides in place of chemical pesticides because of the dangers posed in using the latter. Given that the factors influencing the adoption of these botanical pesticides are unknown, this study contributes to establish them.

The probit model was found to be the appropriate model for this type of study. The model has found wide application in published reports (Rahm & Huffman, 1984; Hailu, 1990; Kebede, Gunjal & Coffin, 1990; Adesina, 1996). It is generally assumed that farmers' response to innovation adoption is individualistic, and the decision to adopt is dichotomous between two mutually exclusive alternatives; that is, the individual chooses either to adopt or not to adopt. It is usually assumed in these models that farmers make adoption decisions based on utility maximisation as an objective.

Let adoption of botanical extracts be defined as 'f'; where f=1 for adoption, and f'= 0 for non-adoption. The underlying utility function, which ranks the preference of the i^{th} individual, is assumed to be a function of farmer-specific characteristics, 'X' (independent variables linked to characteristics which may include age, sex, and household size of farm households) and an error term with a zero mean and constant variance:

$U_{i1}(X) = \beta_1 X_i + \varepsilon_{i1}$ for adoption and

$U_{i0}(X) = \beta_0 X_i + \varepsilon_{i0}$ for non-adoption, where

β is a matrix of coefficients

X is a matrix of independent variables

ε is an error term

Given that the utilities are random, the i^{th} farmer would choose the alternative 'adoption' if and only if $U_{i1} > U_{i0}$. Therefore, for the i^{th} farmer, the probability of adoption is given by:

$$\wp(1) = \wp(U_{i1} > U_{i0})$$

$$\wp(1) = \wp(\beta_1 X_i + \varepsilon_{i1} > \beta_0 X_i + \varepsilon_{i0})$$

$$\wp(1) = \wp(\varepsilon_{i0} - \varepsilon_{i1} < \beta_1 X_i - \beta_0 X_i)$$

$$\wp(1) = \wp(\varepsilon_i - \beta X_i)$$

$$\wp(1) = \Phi(\beta X_i)$$

It is vital to screen the traditional and improved varieties for their agronomic, physical and chemical properties to find out the grain quality and its suitability for specific uses.

$$\Phi_f(\beta X_i) = \int_{-\infty}^{\beta X_i} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-t^2}{2}\right) dt$$

The last equation can then be estimated using the probit technique (Goldberger, 1964; Dagenais, 1969; Judge *et al.*, 1985). Though this model assumes normal distribution of the sample, its use with large samples is justified even when the underlying distribution of the sample is not normal (Pindyck & Rubinfeld, 1991).

Empirical model

Given the importance attached to the use of botanical extracts used as pesticides, an empirical probit model was estimated to establish the factors influencing their adoption. Based on existing knowledge of smallholder decision-making processes (Little *et al.*, 2000), six factors were hypothesised to influence farmers' decision to adopt or not to adopt botanical pesticides in cowpea pest control. Tables 1 and 2 summarise the hypothesised variables and descriptive statistics of the variables included in the empirical model. The dependent variable is whether or not the farmer uses botanical extracts in cowpea pest control. The variable is given by BOTADOPT, which takes on the value of 1 if the farmer adopted botanical extracts; and 0, otherwise. The farmer-specific socio-economic explanatory variables are age of the farmer (AGE), level of education (EDUC), household size (HHSIZE), extension contact (EXTN), access to non-farm income (NFINCOME), and farm size (FSIZE) as a proxy for access to farmland. The cursory review of the data suggested that in northern Ghana cowpea is largely cultivated by males or male-dominated households. As a result, sex was not used as explanatory variable. A discussion of the expected signs for the coefficients of independent variables included in the model is provided below.

AGE is a variable that measures the age of the farmer. It is often presumed that younger farmers, being more adventurous and with a longer planning horizon, are more inclined to accept innovations than older ones. Hence, age of the household head (AGE) is hypothesised to have a negative influence on adoption.

It has been argued that education enhances one's ability to receive, decode, and understand information (Schultz, 1975); and is also generally used to capture the effects of differing managerial capabilities. It is, thus, commonly argued that educated individuals are more likely to adopt new technologies or are more likely to be early adopters or both. For the adoption of botanical extracts in place of chemicals, educated farmers are more likely to understand and appreciate the hazards of using chemicals and, hence, would shift from chemicals to botanical extracts. Therefore, higher level of adoption would be positively related to the producer's level of education.

People with non-farm income have the means to procure purchased inputs that the adoption of a new technology may require. Thus, earning of NFINCOME is also assumed to have a positive influence on the adoption of botanical extracts. The EXTN reflects access to extension services by respondents. It is agreed that access to extension enhances the adoption of new technologies. The EXTN is positively related to adoption. The HHSIZE measures household size. A large family often has many working members. Owing to the high labour demands for applying botanical extracts, the larger the household (other things being constant) the higher the probability of adoption. A positive relationship is, therefore, expected between HHSIZE and BOTADOPT. The FSIZE is a measure of access to farmland by households. Households with larger farm sizes are also likely to have larger cowpea fields. As cowpea farm size increases, the labour intensive nature of using botanical extracts would be a disincentive to their adoption. Thus, it can be stated that households with larger cowpea farms are likely to shift away from botanical extracts in favour of chemicals. Therefore, a negative relationship is expected between FSIZE and BOTADOPT.

Results and discussion

Three of the six factors included in the model were found to be significant in influencing farmers' decision to adopt or not to adopt botanical extracts in cowpea pest control. The model has good predictive power, predicting 85 per cent of adopters or non-adopters correctly. All the predictor (independent) variables had the expected signs of the coefficients (Table 3). The analysis of the farm data showed that sources of knowledge, through which the technology has been disseminated (farmer field school, number of extension contacts), could not provide enough information to influence adoption. However, household size, access to farmland, and level of education of the head of household were found to significantly influence the adoption of botanical extracts as pesticides. Household size was significant at the 5 per cent level with a positive relation to the adoption of botanical pesticides; which suggests that larger households are more likely to adopt botanical pesticides, a situation that conforms to *a priori* expectation. The use of botanical pesticides is known to be more labour intensive than the use of chemical pesticides. Larger households are likely to have the needed labour (other things being equal) to adopt these botanicals compared to smaller households. Thus, consistent with evidence from similar studies on technology adoption (Adesina & Baidu-Forson, 1995; Feder & Umali, 1993), the study showed that technologies that exert pressure on scarce resources are less likely to be adopted by resource-poor farmers. Farm size was significant at the 1 per cent level with a negative relationship

TABLE 1

A Description of Factors and Their Expected Influence

Factor (variable)	*Description*	*Expected influence*
AGE	Age of head of household (number of years)	Negative
EDUC	Educational status of head of household: 1 = educated 0 = No education	Positive
NFINCOME	Access to non-farm income: 1 = has access 0 = has no access	Positive
EXTN	Access to extension on cowpea, defined as the number of extension visits/season	Positive
HHSIZE	Household size, as a proxy for availability of family labour (number of persons)	Positive
FSIZE	Farm size (ha), as a proxy for access to farmland	Negative

TABLE 2

Descriptive Statistics of Hypothesised Variables

Factor (variable)	*Minimum*	*Maximum*	*Mean*	*Frequency*
AGE	19	79	45	
HHSIZE	2	56	13	
FSIZE	0.8	35	5.6	
NFINCOME	0	1		37
	1			63
EXTN	0			5
	1			95
EDUC	0			59
	1			41

to the adoption of botanical pesticides. Thus, suggesting that farmers with smaller farms are more likely to adopt the technology. As the area cropped to cowpea increases, the tendency is to move away from botanical pesticides in favour of chemical pesticides in view of labour and time considerations. However, this result is inconsistent with existing knowledge about the relationship between farm size and technology adoption (Feder, 1980; Feder & O'Mara, 1981; Just & Zilberman, 1983). In most reports, farm size has emerged as an important surrogate for many factors (including access to credit, capacity to bear risk, access to inputs, wealth, and access to information) underlying the high likelihood for new technology adoption to begin with larger farmers. The apparent deviation from the norm can be attributed to the fact that, unlike other types of technologies (e.g., high-yielding varieties, complementary inputs such as fertilizer), the actual physical technology (for botanicals) demands more of the farmers own inputs (labour to mobilize the local resources and extracting the bio-pesticide, among others, before application). It implies that more physical efforts and management capacity are required, making the use of botanicals less attractive to larger farmers.

Years of formal education were consistent with traditionally expected effect (Tables 1 and 3). The education variable was significant at the 10 per cent level with the expected positive relationship.

TABLE 3

Probit Model Estimates for Botanical Pesticide Adoption

Predictor variable	*Coefficient*	*STD error*	*Coef./SE*	*P*
Constant	-1.44153	1.30412	-1.11	0.2690
AGE	0.00974	0.01631	0.60	0.5503
HHSIZE	0.06329	0.03201	1.98	0.0480**
NFINCOME	0.14857	0.45733	0.32	0.7453
EXTN	0.58292	0.95269	0.61	0.5406
FSIZE	-0.81030	0.13825	-5.86	0.000***
EDUC	0.23184	0.13259	1.75	0.0804*

* = significant at 10% ** = significant at 5% *** = significant at 1%
Cases included 165 Missing cases 4
Proportion of category 0 correctly classified 0.865
Proportion of category 1 correctly classified 0.836
Overall proportion correctly classified 0.855

Consistent with published reports, through education's positive influence on ability to perceive, identify, acquire, process new information and respond to new events (Shultz, 1975), highly skilled farmers are seen as the first adopters of technologies. Therefore, one might infer that the low level of education among the farmers in the region was a barrier to adopting botanical extracts as pesticides in cultivating cowpea.

The above results may be used to arrive at certain policy decisions. However, efforts at increasing the adoption of botanical pesticides must consider the three important factors of household size, access to farmland, and level of education of heads of household. In this regard, larger households, households with less access to farmland, and educated heads of household should be targeted.

Conclusion

This study examined the effects of socio-economic and structural factors on adopting botanicals as pesticides in cultivating cowpea in northern Ghana. The analysis of the farm data showed that adopting the technology was directly influenced by three interrelated factors: level of education, farm size, and access to farm labour. The results suggest that the years of education attained by the farmer significantly influence adoption decision. It was also showed that farmers with smaller farms are more likely to adopt botanical extracts as pesticides in cowpea production in northern Ghana. Moreover, the high labour farmers require for preparing and applying the botanical extracts make the technology less attractive to farmers with larger farm sizes.

Therefore, the results suggest that increased adoption of the technology can be fostered by targeting education toward farmers who have had some formal education, and with smaller farm sizes. In particular, policy incentives that would stimulate industrial production of botanical extracts as pesticides in Ghana, to reduce the drudgery of its production and use by individual farmers, could speed up adoption. Second, farmer education (through increased resources to research and extension for conducting demonstrations on effectiveness of botanicals as pesticides) can enhance widespread adoption to ensure environmentally sustainable cowpea production in Ghana.

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