



Economics of Insecticides Usage among Cowpea Farmers in Kaduna State, Nigeria

**R. A. Omolehin^{1*}, S. S. Adeola¹, Ben Ahmed¹, E. O. Ebukiba²
and O. B. Adeniji³**

¹*Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Nigeria.*

²*Department of Agricultural Economics and Extension, University of Abuja-Nigeria.*

³*Department of Agricultural Economics and Extension, Federal University of Technology, Minna-Nigeria.*

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ABSTRACT

This study carried out an economics of insecticides usage among cowpea farmers in Kaduna State. Specifically, the study estimated insecticides marginal productivity; the degree of response of demand for insecticides to changes in its prices and the return to cowpea production due to insecticides usage. A multi-stage sampling technique was used to select 150 cowpea farmers who used insecticides in controlling pest in cowpea production in the study area. Information collected includes those of inputs quantities and prices as well as quantity of cowpea output and its farm prices. The logistic specification of the damage control model and its corresponding demand function were used to estimate insecticides marginal productivity and the degree of demand's response to changes in insecticides prices respectively. A budgetary analytical model was used to estimate the return to cowpea production. The study showed that insecticide marginal value product was ₦310.06 and the ratio of MVP to insecticide price was 0.48. This is an indication that insecticides were not efficiently utilized. The demand elasticities for the various insecticides were greater than unity indicating that demand for insecticides used in cowpea production in the area studied was own price elastic. The study also found that a return of ₦787.52 per hectare was obtained due to insecticide usage.

Keywords: Cowpea; farmers; damage; insecticides; usage; elasticity;

1. INTRODUCTION

In West Africa and many parts of the world, Cowpea (*Vigna unguiculata* (L) Walp) is an important grain legume (Singh et al., 2002). The crop is very unique as an important source of food, income and fodder. It has high potential to increase income of both farmers and traders, being widely consumed and traded outside the producing localities (Owoade et al., 2004). Nigeria, being the largest producer of cowpea in the world accounts for about two million metric tonnes which is about 50% of the world production output (Singh et al., 2002). However, the continued cultivation of cowpea as a profitable agribusiness enterprise is being threatened by a number of problems which include those of pests and diseases. Singh and Allen (1980), and TJRI (2009) identified various kinds of pests and diseases that have led to a considerable decrease in the output of cowpea. Effective control of these pests and diseases require the use of chemical pesticides which level of use has been found to depend on its price, risk, credit availability and cropping pattern (Sukume, 1999).

Insecticides are agro-chemicals (pesticides) that are used for crop protection. They are substances intended to prevent, destroy, repel or control any animal pest or diseases caused by micro organisms as well as weeds (Dugje et al., 2009). Tijani and Oshotimehin, (2007) posited that pesticides are protective resources which are unique and differ from other productive resources. This is because they do not affect productivity directly but are applied to eliminate those factors that directly reduce productivity. For a good result in cowpea production, pest control is a major task. Even though efforts are being intensified to reduce the amount of chemical insecticides used in the control of pests through the introduction of integrated pest management, insecticides use in cowpea production has been reported to be skyrocketing dramatically (IITA, 2003). This goes in line with the assertion of Davies (1992) that "pesticide treatments are likely to remain the most important component of crop protection programs for the foreseeable future in agriculture even in the face of new methods of pest management exploiting genetic resistance in plants and biological control". It is therefore obvious that the use of pesticides in cowpea production is inevitable if success must be recorded among small scale farmers who control the bulk of domestic output.

A report given by NFRA (2008) revealed that the total land area cultivated by small holder farmers and their output of cowpea in Kaduna State, Nigeria has dropped drastically in recent times. The low yield obtained in most cowpea producing areas of West Africa is largely due to field insect pests which feed on reproductive plant parts causing most economic damage thereby necessitating appropriate control measure (Karungi et al., 2000). Effective control of pest infestation on cowpea can only be achieved through the use of convectional insecticides. The efficacy of pesticides (which include insecticides) depends mainly on their level of use which in turn depends on their market prices. Prices are particularly important since most of the pesticides are imported into the country (Tijani and Oshotimehin, 2007). With the low exchange rate of the Nigerian currency against major currencies of the world, the prices of the pesticides are becoming comparatively high. It is expected therefore that farmers would respond to changes in prices by adjusting the level of use of the resource alongside changes in its market prices. Lagoke (1982) has attributed the low output per hectare of cowpea to the attack of pest and diseases.

The broad objective of this study is to examine the economics of insecticides use among cowpea farmers in Kaduna state. The specific objectives are to:

- (i) estimate the production function and marginal value products from the usage of insecticides in controlling pests in cowpea production,

- (ii) estimate the demand functions and price elasticity of demand for the different insecticides used for cowpea production and
- (iii) estimate the financial returns (profitability) from insecticide usage in cowpea production.

According to Chambers and Lichtenberg (1994), existing empirical information on pesticide productivity and pesticide demand is at best inadequate. Information about the degree of responsiveness to changes in the market price of pesticides by farmers is an important one, which will help the policy makers and researchers in their policy recommendations. Also, earlier studies in cowpea production in the area have not taken into cognizance the uniqueness of insecticides as a protective production resource differing from other productive resource. This study is justified on the above premises.

1.2 Conceptual Frame Work

All marginal product estimates of pesticides before 1986 use the standard Cobb-Douglass production function. In a 1986 analysis, Lichtenberg and Zilberman argued that the single equation Cobb-Douglass model may not be appropriate because it leads to overestimation of the marginal product of pesticides and to address this problem, they introduced a different model of the pesticide yield relationship. This approach proposes a damage abatement model. Essentially, the approach considers the effects of pests on yield separately from the effect of pesticides on pests (Anna et al., 2007). One key feature of the damage control model is the distinction between inputs in standard factors of production and damage control agents. This distinction is important because control agents like pesticides and biological control do not enhance productivity directly as standard inputs do but contribute indirectly to the actual output by preventing output losses.

Lichtenberg and Zilberman (1986) noted that damage abatement function may not only include damage control agents, but also other variables which affect the damage abatement effort. Thus, exogenous variables such as weather conditions and the state of nature interacting with pest prevalence could be included in the function but are ignored since they are considered to be uncontrollable.

From the characterization of actual output as a combination of potential output and the quantity lost that production (Q) can be characterized as a function of productive inputs, Z, and damage abatement G(X)

$$Q = F[Z, G(X)] \dots \dots \dots (1)$$

The abatement function G(X) can be defined as the proportion of the destructive capacity of the damaging agent eliminated by the application of a level of control agent X. This definition suggests that the abatement function will possess the properties of a probability distribution. It will be defined on the (0,1) interval with G=1 denoting complete eradication of the destructive capacity and G=0 denoting zero elimination i.e., maximum destructive capacity; it will be monotonically increasing and it will approach a value of unity as damage control agent X increases. That is $G(X) \rightarrow 1$ as $X \rightarrow \infty$. The derivative of G with respect to X, $G_x(X) = g_x$, represents the marginal damage control effectiveness or marginal productivity; simply the density of G(X).

The production function F (●) is assumed to possess the standard properties of production functions notably concavity in (Z, G). When the destructive capacity of damaging agent is

completely eliminated, losses will be zero and actual output will equal potential output, that is potential output can be expressed as $F(Z, 1)$. When $G=0$, $F(Z, 0)$ denotes the output obtainable under maximum destructive capacity that is minimum actual output.

Assuming that the output elasticity of abatement, G , and all other inputs, Z are constant and that the elasticity of substitution differs only negligibly from one over the relevant range, then the Cobb-Douglass specification;

$$Q = e^{\alpha} Z^{\beta} [G(X)]^{\gamma} e^{\mu} \dots\dots\dots(2)$$

represents the underline production function and the random error associated with it. This as argued by Lichtenberg and Zilberman gives a better estimate of abatement agent rather than using X instead of abatement function $G(X)$ in Cobb-Douglass $Q = \alpha + Z\beta + \gamma X + V$ Where β and γ are the parameter estimates of the productive inputs and protective inputs respectively, Z are the productive inputs and X the damage control agent.

1.2.1 Hypothesis

The null hypothesis for this study is:

H_0 : the ratio of revenue to pesticide price does not affect pesticide use level.

2. MEHODOLOGY

The study was conducted in Kaduna state, Nigeria. The state is in the Northern part of Nigeria and is located between latitudes $10^{\circ} 20^1$ N to $10^{\circ} 33^1$ N and longitudes $7^{\circ} 45^1$ to $7^{\circ} 75^1$ E (Wikipedia March, 2008). It shares common borders with Abuja in the south-east, and six other states namely; Katsina, Kano, Zamfara in the North, Nassarawa, and Plateau in the North-East and Niger in the North-West. The hottest months are March-April while the coldest are December- January. Rainfall is heaviest in the south, and decreases northwards with an annual mean rainfall varying from 942mm to 1000mm. The rainfall lasts from May till October (NAERLS, 2002). The people of the state are mainly engaged in agricultural production activities with the main crops being Maize, Sorghum, Millet, Rice, Cowpea, Ground-nut, Yam and Sugar cane. The National population commission puts the projected population of the state for 2010 at 6,066,562 peoples (NPC, 2006). Kaduna state has a land area of about 46,053Km².

Primary data were used for this study. The data were collected by interview method with the aid of a well structured questionnaire administered to cowpea farmers using multistage and random sampling procedures. In the first stage, three Local Government Areas (Giwa, Kudan and Sabon Gari) were purposively selected from the 23 LGA in the state based on their level of involvement in cowpea production in the state. In the second stage, three villages were randomly selected from each of the selected LGA. These include: Zabi, Hanwa and Ugwan Nashuka in Sabongari LGA; Giwa, Yakawada and Doka in Giwa LGA and Jaja, Hanyin Makada and Honkuyi in Kudan LGA. In the final stage, 150 cowpea farmers were randomly selected and interviewed for the study.

2.1 The Damage Control Model

A damage control production function by Lichtenberg and Zilberman (1986) begins with a multi-factor production function mathematically expressed as

$$Q = f(Z_1, Z_2, Z_3, Z_4, Z_5 \dots Z_n) + U \dots \dots \dots (3)$$

Where Q equals the quantity of output in Kgha⁻¹, Z₁-Z_n = input used in production purposes. They argued that damage control agents such as insecticides have no direct relationship with output as specified by the equation above. Their argument is based on the work of Feder, (1979) who stated that the output realized from a production process in which damage agents are present is assumed to be given by

$$Y = \pi - D \dots \dots \dots (4)$$

Where Y is equal to output realized, Π equals to potential output and D equals to quantity lost due to pest attack. The quantity D depends on the pressure of pests. A rational farmer applies pesticides so that D can be reduced as much as possible while Y is increased. The increased in Y therefore depends on the amount of pest the insecticide is able to abate. This established the indirect relationship between the output and the insecticide as other productive inputs do.

If the insecticide used is denoted by X, ψ(X) is the percentage of insect killed and an additive error ε is included. Then yield can be written as

$$Y = \pi - D[1 - \psi X] + \varepsilon \dots \dots \dots (5)$$

It is on the basis of equation (5) that Lichtenberg and Zilberman proposed their damage control model (LZ model). The relationship between output and pest level is given by:

$$Q = f(Z, B) \dots \dots \dots (6)$$

Where Q= output, Z= productive inputs used and B = the pest pressure. Also,

$$B=B(X, B_0) \dots \dots \dots (7)$$

X being the level of protective input used and B₀ the uncontrolled pest level. Lichtenberg and Zilberman (1986) therefore proposed a production function which recognized the abatement function of the damage control agents like pesticides among other variable inputs. The model is stated as:

$$Q = \alpha Z \beta [G(X)]^\gamma \dots \dots \dots (8)$$

Where Q = output realized from cowpea production (Kg), α= constant of the model, Z = productive inputs used, X= damage control agent (insecticides in litres) and β and γ are positive parameters estimated.

G(●) is the proportion of the capacity of the damaging agent abated by the use of

X; 0<G(X)<1. Explicitly, LZ model is given by:

$$Q = \alpha_0 + \beta_1 Z_1 + \beta_2 Z_2 + \dots \beta_4 Z_4 + G(X) + \mu \dots \dots \dots (9)$$

Where: Z₁ = farm size in hectare, Z₂ = fertilizer (SSP) in Kgha⁻¹, Z₃ = quantity of labour (hired + family) used in mandays, Z₄= quantity of cowpea seed used in Kgha⁻¹, X= quantity of

insecticides used measured in litres/ha and μ = white noise error term. Equation (9) was estimated.

Different forms of $G(\bullet)$ exist as alternative relationship between damaging capacity and the level of control agent. Assuming a logistic damage control function and the neo-classical profit maximization objective on the part of the farmers, Lichtenberg and Zilberman derived the following specification for the abatement function

$$G(X) = 1/[1 + \exp(\mu - \sigma X)] \dots \dots \dots (10)$$

The logistic production function specification of the LZ model obtained by substituting the value of $G(X)$ in equation 10 into equation 9 is therefore

$$Q = \alpha + Z\beta - \gamma \ln[1 + \exp(\mu - \sigma X)]^{-1} \dots \dots \dots (11)$$

The corresponding demand function is

$$X = \frac{\mu}{\sigma} + \frac{1}{\sigma} \ln \left[\frac{PQ}{W} - \frac{1}{\gamma\sigma} \right] \dots \dots \dots (12)$$

This can be further expressed as

$$X = a_0 + a_1 \ln \left[\frac{PQ}{W} - \frac{1}{\gamma\sigma} \right] \dots \dots \dots (13)$$

Where $a_0 = \frac{\mu}{\sigma} + \frac{1}{\sigma}$ and $a_1 = \frac{1}{\sigma}$

Lichtenberg and Zilberman further assumed that $\frac{1}{\sigma}$ is sufficiently small enough to make the proper specification of the pesticide demand a linear function of $\frac{PQ}{W}$ where P =Price per kilogram of cowpea, Q= quantity of cowpea harvested per hectare and W=cost of insecticides per litre in Naira.

The marginal value products for the insecticide were estimated by the following equations:

$$MVP = MPP \times P \dots \dots \dots (14)$$

$$MPP = \gamma \alpha X^{\gamma-1} \dots \dots \dots (15)$$

Where: MPP= marginal physical product, MVP= the marginal value product, γ = the constant of the function

α = The coefficient of the insecticide variable and X= insecticide variable in the functions

2.1.1 Net returns

Following the entomological society of Canada (1988), and Tijani (2006) the following equations were used to estimate net returns derived from applying insecticides in pests control in cowpea production: This was used to approximate financial advantage (net returns) derived from the use of chemical control . The model is in the form

$$N = \left[\left(\frac{1}{100+1} \right) (Q)(P) \right] - \left[(PC)(L) \left(\frac{1}{100+1} \right) (Q) \right] \dots \dots \dots (16)$$

Where

I = Efficacy (percentage increase in marketable yield due to pest control)

Q = yield in Kg⁻¹

P = price of cowpea in ₦ Kg⁻¹

PC = pest control cost (pesticide plus application cost per hectare)

L = Number of application per cropping season

N = Net returns of cowpea farmers (gross margin per treated hectare to farmers derived from pest control in ₦Ha⁻¹)

T= Total net returns to cowpea farmers

3. RESULTS AND DISCUSSION

3.1 Effect of Insecticides Use on Cowpea Output

Table 1 shows the result from the estimated coefficients of the Logistic production function in equation (9). The result shows that insecticide usage (variable X) in cowpea production was statistically significant at 5% level and has positive effect on the output. Thus insecticide has a direct positive relationship with output and the damage agent. The higher the pest pressure, the higher the level of insecticides a farmer is expected to use.

Table 1. The coefficients of the Logistic production functions

Coefficient	Logistic	T-values
Constant (α)	1.15 ^{***} (0.119)	9.7
Land (Z_1)	0.79 ^{***} (0.040)	19.71
Fertilizer (Z_2)	-0.008 ^{***} (0.002)	-3.0
Labour (Z_3)	0.110 ^{***} (0.046)	2.37
Seed (Z_4)	0.044 ^{***} (0.009)	4.89
Pesticide(X)	0.065 ^{**} (0.323)	2.01

^{***}Significant at 1% level, ^{**}Significant at 5% level, ^{*}Significant at 10% level, St-Error in parentheses

Furthermore, the result presented on Table 2 shows that the marginal value product of insecticide was ₦310.06 while the ratio of MVP to factor price of insecticides was 0.48. This is an indication that insecticides were inefficiently used by the farmers. A ratio of less than unity signifies an overuse of the resource or high factor cost in relation to the product market price. This result agrees with the findings of Mshelia and Kwanga, (2006) but inconsistent with the findings of Alimi (1999) which had earlier indicated that insecticides were not overused. This inconsistency might be possible if insecticides prices are high in the study area since the two studies cited were carried out at different times and in different ecological zones of Nigeria.

Table 2. Estimated Marginal Product of insecticides

Logistic	
MPP	0.062
MVP	310.06
MVP/MFC	0.48

3.2 Demand Functions for Insecticides

All the respondents used insecticides to control insect pests on their farms. However, about 48% of the respondents stated that they have grown cowpea in the past without using insecticides and discovered a significant difference in the marketable quantity of cowpea realized. Majority of the respondents,(99%) obtained their insecticides from the open markets. Four different types of insecticides were used (Table 3).

Table 3. Estimated Demand Functions for different Insecticides

Insecticides used	Constant	Coefficient of Revenue/Price Ratio	R²-Adjusted
Cymbush	-1.259 (-2.569)**	1.25 (5.815)***	41.4
Karrate/Cypermethrine	-2.54 (-6.427)***	1.84 (8.43)***	71.9
Shapper plus	-1.908 (-5.473)***	1.55 (6.98)***	88
Uppercott	-2.4 (-4.736)***	1.72 (5.82)***	84

** Denotes 5% level of significance, *** Denotes 1% level of significance, t-values are in parentheses

The results of the demand equation (equation 3) are presented on table 3. The R²-adjusted ranged from 41.4% for Cymbush to 88% for Shapper plus. Thus, the revenue, insecticides cost ratio explained 41% of the demand for cymbush while it accounts for 88% of the demand for shapper plus. The hypothesis that the ratio of revenue to insecticide cost does not affect insecticides was rejected at 5% level of probability because in all the cases coefficients were statistically different from zero at 5% level of probability. It shows therefore that the quantities of all the insecticides used by the respondents were influenced by their prices. This agrees with the findings of Tijani and Oshotimehin (2007).

3.3 Price Elasticity of Demand for Insecticides

The insecticide demand elasticities were estimated and are as shown on table 4. Each of the insecticides has absolute values of elasticity greater than unity and is therefore elastic. This suggests that a 1% increase in the price of cymbush (holding product and other input prices constant) would lead to 1.63% decrease in its use. Furthermore, a 1% increase in the prices Karrate/cypermethrine, shapper plus and uppercott would lead to a decrease in their use by 4.27, 3.0 and 3.41 percent respectively. The policy implication from this result is that increase in prices of insecticides would substantially reduce insecticides usage by farmers in the study area. On the other hand, the provision of subsidy would significantly enhance insecticide usage by the farmers in cowpea production.

Table 4. Insecticides Demand Elasticity Estimates

Insecticides	Elasticity at means
Cymbush	1.63
Karrate / Cypermethrine	4.27
Shapper plus	3.0
Uppercot	3.1

3.4 Net Financial Returns from Insecticides Usage

Table 5 shows the net returns from insecticides usage derived from equation (16). The average is the percentage increase in marketable yield of cowpea as a result of insecticides usage to control pests was about 260%. It means that insect pests of cowpea of different categories were effectively controlled through the use of insecticides. The mean cost of pest control of cowpea farm was found to be ₦ 787.52 per hectare. However the cost ranges from ₦354.38 to ₦5, 709.50 per hectare. The average area of land sprayed among the cowpea farmers was 1.95ha. The average net return from cowpea farms was ₦ 48,308.8 per hectare. However, the net returns ranged from 25,933 to 417,812. The net return analysis result shows that cowpea production using insecticide was profitable.

Table 5. Summary of Profitability Analyses of Cowpea production due to Pesticide Usage

	I(%)	I/100+1	Q (tons/ha)	P(₦)	L	N(₦)
Min	15	0.130	0.33	36,000	2	11,306
Max	930.7	0.902	3.73	60,000	2	127,795
Average	260.15	0.722	1.41	49,028.71	2	48,308.8

4. CONCLUSION AND RECOMMENDATION

This study has shown that insecticides use has a positive and significant effect on cowpea grain output. In addition, land, labour, and seed have positive and significant effect on cowpea yield while fertilizer has a negative and also significant effect on yield. However, the price elasticity of demand is elastic suggesting that the price need not increase astronomically, or else, the farmers will use less of them. It was therefore recommended that federal government input policy should be such as to minimize sudden increase in prices to ensure farmers continual patronage.

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