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Factors Influencing Choice of Pesticides Used by Grain Farmers in Southwest Nigeria

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Abstract
Pesticide use in agriculture has caused a lot of rising concerns about the safety of residues in food and water, as well as other potential health and environmental risks. There is need therefore to determine the factors that influence farmers' choice of pesticides for post-harvest grain storage. This study therefore examines the factors influencing the choice of pesticides used by grain farmers in South-Western, Nigeria. Data for this study were collected using multi-stage sampling techniques and a total number of 192 respondents were sampled. The tools used for analysis include descriptive statistics (used to profile the socio-economic characteristics of the respondents) and probit model (used to determine the factors influencing the choice of pesticides by the grain farmers). Results from this research indicates that majority (69.79%) of the grain farmers had formal education, with above 10 years of farming experience (96.88%) and within the age bracket of 30 years and above (95.83%). The probit results also shows that the age of household head, education, farming experience, price of grains and quantity of grains consumed were significant factors that influences the choice of pesticides used by the grain farmers in the study area. It was recommended that farmers should be educated on the use of pesticides to avoid hazards.
Keywords: Pesticide, choice, grain farmers, Probit model, South-West.

1. Introduction

Long term post-harvest protection of stored grains against pests remains the primary constraint to maintenance of sufficient food supplies for global needs. Modern methods of food grain treatment using insecticides and fumigants to check post-harvest losses during storage are highly expensive (White and Leesch, 1995). Apart from being expensive, these treatments due to their residual effects are toxic and continuous applications of such chemicals leads to environmental pollution and health hazards, besides developing resistance in organism (Subramayam *et al.*, 1995).

Upadhyay *et al., 2011* stated in their work that insect pests, which cause damage to stored grains include beetles (Coleoptera) and moths (Lepidoptera). Of which beetles are far more diversified and highly destructive stored grain insects in comparison to moths. Both grubs and adult insects attack the stored food material while among the moth, only the caterpillars are harmful life stage that causes damage. Besides, there are certain insect pests which do not bread in stored grain but their presence in the stores is harmful because they generate filth and nuisance. They do not cause large damage to food grains but create noxious smell and debris. These insects are cockroaches, ants, crickets, silverfiches, pscolids and termites. Few mites also cause infestation in grain flour and other stored products. Food grains are also infested in the field by a number of insect pests, but only few of them reach to store houses and cause severe grain infestation. The overall damage caused by these insect pests, worldwide is estimated to be 10-40% annually. There is therefore an urgent need to control stored grain insect in order to maintain stored quality (Upadhyay *et al., 2011*). Effective preservation of both food grain quality and quantity in Africa, however, remains greatly limited by post-harvest destruction due to insect pest attack (Mailafiya *et al.*, 2014).

Insect infestation causes qualitative and quantitative losses of food commodities and changes the chemical composition thereby affecting the nutritive value of the produce (Swaminathan, 1977). Due to the significant increase in the human population and the consequent increase in the amounts of food and grains produced, many small scale farmers adopted the use of pesticides as a means of pest control. Inorganic pesticides are generally neurotoxins and a single dose may cause permanent damage (Cunningham *et al*., 2003). Examples of inorganic pesticides commonly used by grain farmers include apron plus, acetellic powder, phostoxin, pest off, vector 85 etc. organic pesticides, on the other hand, are primarily plant extracts. Examples include neem extracts, pyrethium flower, garlic or onion extracts, wood ash, citrus rinds etc. Increased pesticide use has contributed to the modernization of agriculture (Whittaker *et al*., 1995)

Pesticide use in agriculture, however, has also caused rising concerns about the safety of residues in food and water, as well as other potential health and environmental risks (Whittaker *et al*., 1995). Exposure to pesticides poses serious dangers to human health particularly that of farmers (Hossard *et al*., 2014). In the work of Bahlai, *et al.* (2010) on Choosing Organic Pesticides over Synthetic Pesticides, they found out that organic insecticides did not offer significant protection of crop yields compared with the untreated control, and were least selective in that they killed both aphids and the natural control insects. The synthetic insecticides were the most selective – even the least selective synthetic insecticide, dimethoate, was still more selective than the organic insecticides. The researchers suggest that certain organic management practices are not necessarily more environmentally sustainable than conventional systems. An integrated pest management approach might be more suitable, as such a system is flexible enough to include whichever practices have the smallest environmental impact. From this research, it has been proven that synthetic pesticides are highly toxic to non-target organisms and put adverse impacts on the environment. Hence, their use should be restricted to minimum. Thus, insect pests have developed resistance to many commercially available synthetic pesticides (Zettler, 1990 and White, 1995). Therefore, alternative methods of control are being searched in form of bio-organic pesticides.

According to Rick and Higgins (2008), the following insect-management tactics should be considered for preventing infestations of insects in stored grains. If successful management is achieved with these tactics, fumigation of grain can be avoided.

- Sanitation (cleanup of old grain and grain debris)
- Empty-bin spray with an insecticide
- Empty-bin fumigation, primarily to control insects in the sub-floor plenum
- Storing clean, dry grain
- Treating grain with a protectant insecticide
- Aeration to cool the grain to prevent insect feeding and reproduction
- Regular measurement of grain temperature and sampling for insects

Post-harvest grain losses are the loss of grains (quality and/or quantity) between the moment of harvest and consumption of the crop. Reduction in food losses are sometimes considered as the 'third dimension' to the world food supply equation, that is, in addition to increase in food production and increases in population (Toma, Fansler and Knipe, 1990). Insect pests are one of the major organisms that are responsible for reduction in quantity, quality and germination potential of seeds that are stored. Post-harvest cereal grain losses to insect pests in small-farm tropical agriculture can exceed 30% because of lack of good storage facilities and the high humidity prevalent in the tropics, especially Nigeria (Ramputh *et al*., 1999).

Joseph *et al*. (2012) found out in their studies that proper post-harvest management, especially the use of the small scale metal silo, contributes to better quality of grains, less pesticide usage and can accelerate agribusiness, therefore directly contributing to rural development and poverty reduction. However, not much effort has being invested in reducing post-harvest food losses especially in staple cereals like maize and legumes, even after many studies have shown that it offers an essential way of increasing food availability without the need of other resources. FAO (2011) estimated that, 1 out of every 5 kilos of grain produced in Sub Saharan Africa is lost to pests and decay. This lost food is enough to feed 48 million people for 12 months and is valued at around $4 Billion or ½ annual grain imports to Africa. This means that a reduction in grain losses could have an immediate and significant impact on people's livelihoods.

Consumers' perception of quality is influenced by the product's intrinsic attributes as well as by extrinsic indicators and cues provided by the seller of the product (Caswell *et al*., 2002). Therefore, this paper aims at analyzing the factors that influence the choice and use of pesticides by grain farmers in South-western Nigeria.

2. Conceptual/Theoretical framework

2.1 Theory of choice

Rational choice theory, also known as choice theory or rational action theory is the main theoretical standard in the currently-dominant school of microeconomics. The most fundamental decision unit of microeconomic is the consumer, in this case the farmer. Rational choice theory is a basis for understanding and often formally modeling social and economic behavior (Lawrence and Easley, 2008). The basic idea of rational choice theory is that patterns of behavior in societies reflect the choices made by individuals as they try to maximize their benefits and minimize their costs. In other words, people make decisions about how they should act by comparing the costs and benefits of different courses of action for example, what type of storage techniques to use and what type of pesticides to use. Choice models are developed from economic theories of random utility. Qualitative choice analysis methods are used to describe and/or predict discrete choices of decision-makers or to classify a discrete outcome according to a host of regressors. Farmers choose the alternative that is expected to give them the utmost satisfaction in terms of postharvest technologies (Carling 1992; Coleman, 1973).

This paper makes use of an economic choice model, in which a farmer decides on which pesticides to use while weighing its costs against the utility gain he expects from it. Several empirical studies have tried to capture the influence of socio-economic variables on farmers' adoption decision. In most cases, the use of probit or logit model is applied (Rahm and Hufman, 1984; Hailu, 1990; Kebede et al., 1990; Adesina, 1996). In these models, farmers are assumed to make adoption decisions based upon an objective of utility maximization (Nkamleu et al, 2000). A probit model was developed to examine the relationship between socio-economic characteristics and the use of pesticides in agriculture. This according to Nayga (1996) is affected by the level of information acquired through experience. Previous studies in Sub-Saharan Africa suggest that information acquisition and the eventual practice (adoption) behaviour are influenced by various individual characteristics (Adesina, 1996; Nkamleu *et al*., 1998).

3. Methodology: Sampling and Analytical Technique

The study was carried out in two states of South-Western Nigeria. South Western Nigeria lies between longitude 2°45E, latitude 9°30N in the North and longitude 6°15E, latitude 4°5 south of the equator. The total land area is approximately 11500sq.km. The area is bounded in the North and East by River Niger, in the South by the Atlantic Ocean and in the West by Republic of Benin. The study was conducted in Oyo and Osun states, Nigeria. Multi- stage sampling technique was employed in choosing the sample size. The first stage involves random selection of two agricultural zones among other zones in the study areas in each state. The second stage involves random selection of two local government areas in each zone per each state and this was follow by randomly selecting two villages per local government area. One hundred and ninety two (192) respondents were selected using probability proportionate to farmers in each village as contained in Agricultural Development Programme (ADP) household lists.

3.1. Model Specification

Probit model was used in this research work. A probit model is a popular specification for an ordinal or a binary response model which employs a probit link function. This model is most often estimated using standard maximum likelihood procedure, such an estimation being called a probit regression. Probit models were introduced by Chester Bliss in 1935, and a fast method for computing maximum likelihood estimates for them was proposed by Ronald Fisher in an appendix to the same article.

Probit model was used to identify the factors influencing the choice of pesticides by farmers and it is represented as:

$$Y = \alpha_0 + \sum_{i=1}^{n} \alpha_i X_i + e$$

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + e_i$$

Where:
Y = vector of dependent variable (1 for use of inorganic pesticides; 0 for use of organic pesticides);
X = vector of explanatory variables (predictors);
α = Probit coefficients;
e_i = random error term.

The explanatory variables X included in the model are:
AGE (X_1) = age of farmers (in years)
ED (X_2) =Educational level of farmers (in years)
FE (X_3) = Farmers' years of experience (in years)
QH (X_4) = Quantity of grains harvested (kg)
QS (X_5) = Quantity of grains stored (kg)
PR (X_6) = Price of grains (naira)
QC (X_7) = Quantity of grains consumed (kg)
CP (X_8) = Cost of pesticides (in naira)
The apriori expectation of the probability of a respondent using pesticide is stated as:

$\partial Y/\partial X_{2,}\ \partial Y/\partial X_3,\ \partial Y/\partial X_{4,}\ \partial Y/\partial X_{5,}\ \partial Y/\partial X_6 > 0$ while

$\partial Y/\partial X_1,\ \partial Y/\partial X_{7,}\ \partial Y/\partial X_8 < 0.$

This means that education, years of farming experience, quantity of grains harvested, quantity of grains stored and price of grains are expected to be positively significant while age of respondents, quantity of grains consumed and cost of pesticides are expected to be negatively significant.

4. Results and Discussion

4.1. Socioeconomic Characteristics of Respondents with Respect to Type of Pesticides Used

4.1.1 Gender

The gender distribution of respondents in relation to type of pesticides used is shown in Table 1. From the result given, it is seen that there are more male in the study area than female. 21.82% of the male respondents use organic pesticide while 78.18% use inorganic pesticide. Amongst female respondents, 29.63% uses organic pesticides while 70.37% uses inorganic pesticide. This shows that the use of inorganic pesticide is prevalent in the study area.

Table1: Gender of respondents

Gender	Organic	Inorganic	Total
Male	36 21.82 81.82	129 78.18 87.16	165 100.00 85.94
Female	8 29.63 18.18	19 70.37 12.84	27 100.00 14.06
Total	44 22.92 100.00	148 77.08 100.00	192 100.00 100.00

Source: Field Survey (2010).

4.1.2 Education

A large number of the respondents were found to have secondary education. In this group, 13.56% of the farmers use organic pesticide while 86.44% uses inorganic pesticide. Also 36.21% of farmers without education use organic pesticide and 63.79% uses inorganic pesticides. The post-secondary school category has the lowest number of farmers with 18.18% using organic pesticides and 81.82% uses inorganic pesticides.

Table 2: Education Status of respondents

Education	Organic	Inorganic	Total
No education	21 36.21 47.73	37 63.79 25.00	58 100.00 30.21
Primary school	11 20.75 25.00	42 79.25 28.38	53 100.00 27.60
Secondary school	8 13.56 18.18	51 86.44 34.46	59 100.00 30.73
Post secondary school	4 18.18 9.09	18 81.82 12.16	22 100.00 11.46
Total	44 22.92 100.00	148 77.08 100.00	192 100.00 100.00

Source: Field Survey (2010).

4.1.3 Age

Most farmers in the study area are between the ages of 40 and 49 years while age group 15 to 29 has the least number of farmers. In relation to pesticides use, 62.50% of the respondent within ages 15 to 29 years use organic pesticide and 37.50% use inorganic pesticide. For farmers between 30 to 39 years, 18.75% use organic pesticides while 81.25% use inorganic pesticide. Furthermore, among farmers with ages 40 to 49 years, 22.00% use organic pesticides with 78.00% using inorganic pesticides. For ages 50 to 59 years, 18.37% use organic pesticides whereas 81.63% use inorganic pesticide. Also for farmers between the ages of 60 to 69, 22.50% use organic pesticides while 77.50% use inorganic pesticides. For farmers between ages 70 and above, 30.77% use organic pesticides and 69.23% use inorganic pesticide.

Table 3: Age of farmers

AGE	Organic	Inorganic	Total
15 – 29	5 62.50 11.36	3 37.50 2.03	8 100.00 4.17
30 – 39	6 18.75 13.64	26 81.25 17.57	32 100.00 16.67
40 – 49	11 22.00 25.00	39 78.00 26.35	50 100.00 26.04
50 – 59	9 18.37 20.45	40 81.63 27.03	49 100.00 25.52
60 – 69	9 22.50 20.45	31 77.50 20.95	40 100.00 20.83
≥70	4 30.77 9.09	9 69.23 6.08	13 100.00 6.77
Total	44 22.92 100.00	148 77.08 100.00	192 100.00 100.00

Source: Field Survey (2010).

4.1.4 Years of Farming Experience

Most farmers in the study area have between 20 to 29 years of farming experience. For farmers that have between 1 to 9 years of farming experience, 16.67% use organic pesticides whereas 83.33% use inorganic pesticide. Amongst farmers with 10 to 19 years of farming experience, 24.39% use organic pesticides while 75.61% use inorganic form of pesticides. For the group 20 to 29 years, 25.58% use organic pesticides and 74.42% use inorganic pesticide. For farmers with 30 to 39 years of farming experience, 25.00% use organic pesticides while 75.00% use inorganic. Furthermore, 16.67% of farmers with 40 to 49 years of experience use organic and 83.33% use inorganic pesticides respectively. Lastly, for farmers with 50 and above years of experience, 23.08% use organic while 76.92% use inorganic pesticides.

Table 4: Farming experience of farmers

Years of faming experience	Organic	Inorganic	Total
1 – 9	1 16.67 2.27	5 83.33 3.38	6 100.00 3.13
10 – 19	10 24.39 22.73	31 75.61 20.95	41 100.00 21.35
20 – 29	11 25.58 25.00	32 74.42 21.62	43 100.00 22.40
30 – 39	10 25.00 22.73	30 75.00 20.27	40 100.00 20.83
40 – 49	6 16.67 13.64	30 83.33 20.27	36 100.00 18.75
≥50	6 23.08 13.64	20 76.92 13.51	26 100.00 13.54
Total	44 22.92 100.00	148 77.08 100.00	192 100.00 100.00

Source: Field Survey (2010).

4.2. Determinants of the Factors Influencing Choice of Pesticides Use.

Probit model was used in determining the factors affecting use of organic and inorganic pesticides by farmers. Organic pesticides took the value of 0 while inorganic pesticides took value of 1. The result shows that the chi-square (123.8) is significant with a p- value of 0.000. Out of the variables use, five were found to be significant. These significant variables are age of household head, education (ED), farming experience (FE), price of grains (PR) and quantity of grains consumed (QC).

4.2.1 Age of Household Head

Age of household head was found to be negatively significant at p = 0.05. A year increase in the age of farmers will cause 0.004 decreases in the use of inorganic pesticides. This follow the apriori expectation that increase in age will reduce the use of pesticides. This could be attributed to the fact that the productivity of old household head will decline as they get old thereby impacting on their food security status. This result is in agreement with Agboola (2004) who claimed that increase in age decreases food security. However, it may also be that younger farmers are more likely to adopt new technologies and/or are more likely to be early adopters (Alavalapati *et al*., 1995). Young people have more energy, and it's more important for them to invest in the long-term productivity.

4.2.2 Educational Level

Also a year increase in education (ED) will cause 0.010 increases in the use of pesticides. This follows apriori expectation since increase in years spent in school is expected to lead to increase in the use of pesticides. A commonly stated proposition is that educated farmers are more likely to adopt new technologies and/or are more likely to be early adopters (Falusi, 1974/5; Norris and Batie, 1987; Rahm and Singh, 1988; Kebede *et al*., 1990). It is hypothesized that education is positively related to pesticides use.

4.2.3 Farming Experience

An additional year to farming experience (FE) will cause 0.0036 increases in the use of pesticides and this also follows the apriori expectation. This result is expected because a more experienced farmer is likely to have higher productivity and hence be able to provide more food for his household members. Also, to many analysts it seemed reasonable to assume that individuals act according to behavioral rules: they choose among a limited number of objectives from their realm of experience by a finite process of thought that may appropriately be described by "rules of thumb" (Dasgupta, 1993).

4.2.4 Price of Grains

Furthermore, a naira increase in the price of grains (PR) will cause 0.00004 increases in the use of pesticides. This follows the apriori expectation because an increase in the price of grains will make farmers store more when grains are cheap in order for them to sell during lean periods. This implies greater use of pesticides. Studies have indicated that farmers store their produce for different reasons which include provision of planting materials, controlling supply of food for later consumption and produce quality improvement. (Anyim, 1991)

4.2.5 Quantity of Grains Consumed

A kilogram increase in the quantity of grains consumed (QC) will bring about 0.0002 decreases in the use. This also follows apriori expectation because increase in the quantity consumed will cause decrease in the quantity stored and a further decrease in the use of pesticides.

Table 5: Probit result on the use of pesticides

Pesticides	Coefficient	P values	Marginal effect
Age	-0.0467	0.03**	-0.00422
Education level	0.1128	0.00***	0.01021
Farming experience	0.0402	0.05**	0.00363
Quantity harvested	0.0013	0.24	0.00011
Quantity stored	-0.0010	0.35	-0.00009
Price of grains	0.0004	0.00***	0.00004
Quantity consumed	-0.0025	0.06*	-0.00022
Cost of pesticides	-0.0026	0.34	-0.00023
Constant	-1.03	0.15	
Chi-square	123.8***		
Log likelihood	-41.5		

Source: Field Survey (2010)

*Sample size =192, ***= significant at 0.01%, **= significant at 0.05%. *= significant at 0.1%.*

5. Conclusion

The study was carried out in two states of south-western Nigeria. The states were chosen because they are major producers of grains. The objective of the study is to determine the factors that influence the use of particular type of pesticides by grain farmers. Probit regression model was used as a statistical tool in achieving this objective. The probit regression was done to analyze binary response between the use of organic and inorganic pesticides.

Out of the independent variables use, five were found to be significant. These are age of household head, education (ED), farming experience (FE), price of grains (PR) and quantity of grains consumed (QC). From the empirical findings it can be concluded that the decision of farmers to use either organic or inorganic pesticides is influenced by age of household head, farming experience (FE), price of grains (PR) and quantity of grains consumed (QC). Furthermore, educational level was found to be important in the use of pesticides. This indicates a need to educate farmers on the use of pesticides in order to avoid problems such as contamination of grains and other hazards. Also, the storage and preservation of grains and pulses is only valuable in meeting food storages, if after storage the harvested produce is still fit for human consumption and poses no health hazard.

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