Effect of Adoption Pattern of Fertilizer Technology on Small Scale Farmer's Productivity in Boluwaduro Local Government

OLAGUNJU, Funke Iyabo and SALIMONU, Kabir Kayode

Department of Agricultural Economics and Extension
Ladoke Akintoala University of Technology
P.M.B 4000 Ogbomoso, Oyo State, Nigeria
Correspondence E-mail: olagfunk@yahoo.com

ABSTRACT: The use of appropriate land improvement / intensification technology seems to offer an opportunity to substantially increase farm production and income levels. Traditionally, Nigerian farmers have been using fertilizer primarily on commercial / export crops, but in recent years, an increasing quantity of fertilizers is being used on such food crops as rice, maize, wheat, yams and cassava. The study investigated the factors determining the adoption pattern of fertilizer technology on small scale farmer's productivity in Boluwaduro Local Government Area. The specific objectives are to identify the socio economic characteristics of small scale farmers, to determine the factors affecting the intensity of use of fertilizer technology among the small scale farmers, to analyze and compare the gross margin of fertilizer users and non fertilizer users. Multistage sampling technique was used to select 65 respondents for fertilizer users and 55 respondents for non users from three (3) randomly selected towns and the needed data were collected with the means of structured questionnaire. The analytical techniques used were Descriptive, Gross margin and Tobit Regression Analysis. The results indicated that the average farm size of the respondents was about 2.4 hectares, with some having just about 0.47ha. The average capital and labour input per hectare were about ₦24, 242.25 and ₦32, 953.72 respectively. The result further indicated that the gross margin of fertilizer users is greater than that of non-fertilizer user and this implies that the use of fertilizer is profitable. Currently, the average amount of fertilizers applied by the farmers is less than the recommended dosage and that there is about 53% chances that an average small scale farmer would adopt the use of fertilizers. The expected level of adoption of fertilizers by those farmers on the limit E (Y) is 39.94, which implies that new adopters are expected to use about 40% of the recommended dosage of the appropriate fertilizer grade. Also, for farmers above the limit, the expected level of production E(Y*) of the recommended dosage of the appropriate fertilizer formulations is about 72%. A number of factors significantly influenced the fertilizer adoption decision of the farmers, namely, Distance (in km) of the farmers house from the fertilizer selling depot ($p<0.05$), Number of years of formal education of the farmer ($p<0.05$), fertilizer price /50kg bag ($p<0.01$), Number of contact with extension agents ($p<0.01$).

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1 INTRODUCTION

Fertilizer use is crucial for sustainable intensification and for raising farm productivity under increasing land constraints and declining soil fertility. Fertilizer is one of the critical inputs used in improving smallholder food and agricultural productivity. Trends in fertilizer use are all the more worrying because without significant increases in the use of chemical fertilizers it will not be possible for the production of food and fiber to keep up with demand from a rapidly growing population. Organic matter from manure and crop residues has an essential role to play in increasing land productivity, but it cannot provide the supply of nutrients (N, P, K) needed to maintain even current low levels of production (Kelly et al. 1998, Yanggen, et al., 1999).

The Nigerian agricultural sector is dominated by small scale farmers. This group of farmers plays a very important role in food and fibre production. This claim was supported by Olayemi and Ikpi 1995 who stated that small scale farmers dominated the agricultural economy of Nigeria because they account for 81 percent of all farm holdings in the country using, traditional hoes, cutlasses and oxen-plough culture. The small scale farmers usually cultivate small acreages of land. The reasons for this include among others, lack of adequate capital, education, extension services, storage and marketing facilities as well as efficient use of agricultural inputs such as improved seeds, chemicals and fertilizers. According to FAO (2002), the per capita food production in Nigeria as a whole has shown a downward trend. This was attributed to

continuous cropping on the same soils without adequate fallow periods resulting into infertile soils that need to be replenished by fertilizers.

Adesina et.al. (1997) asserted that under this situation the use of appropriate land improvement / intensification technology seems to offer an opportunity to substantially increase farm production and income levels. Traditionally, Nigerian farmers have been using fertilizer primarily on commercial / export crops, but in recent years, an increasing quantity of fertilizers is being used on such food crops as rice, maize, wheat, yams and cassava. It has been discovered that there is inadequacy of the nutrient elements which improve plant growth and development in the soil. Since then materials that will supply the inadequate nutrient elements have been produced technologically. Despite the effort of government to make these materials available for the farmers to use, the crop productivity is still not high. The causes of these menace may be traced to the adoption patterns of the technology i.e. fertilizer which demands critical study in order to proffer lasting solutions. This study is necessary to be carried out because of the fact that there is increase in the production of fertilizer and crop yield is still not high. Therefore, it is glaring that high productivity is the function of the use of new innovations like fertilizer technology. It is pertinent to study some factors that determine the adoption pattern of this technology.

Despite the alarming general trends and patterns, there is evidence of large differences among farmers in adoption and use of fertilizer, even in a given agro climatic zone and on a given crop, let alone among zones in a given country or sub region of Africa. It is our belief that by studying what is known about the factors that are eliciting these diverse responses to fertilizer technologies, one can develop a better understanding of the types of policies and investments most likely to stimulate fertilizer demand in the future. It is strongly believed that this study will bring about the understanding of factors that determine the adoption pattern of fertilizer technology. It will also correct the attitude of the farmers towards the adoption of the fertilizer technology. This is due to the fact that a problem known is half solved; therefore, once those factors are identified it will be easier to work on them. The ultimate significance of this study will be that of improvement in crop productivity.

The main objective is to determine the factors affecting the adoption pattern of fertilizer technology in Boluwaduro Local Government Area of Osun State. The specific objectives are to:

1. Identify the socio-economic characteristics of small scale farmers.
2. Determine the factors affecting the intensity of use of fertilizer among small scale farmers.
3. Analyse and compare the gross margin of fertilizers users and non-users.

2 Hypotheses of the Study

1. There is no significant relationship between the socio-economic characteristics of small scale farmers and the adoption pattern of fertilizer technology among small scale farmers.
2. There is no significant difference between the gross margin of fertilizers users and non users.

3 Theoretical model

Adoption of fertilizers by farmers like many other farm technologies is subject to two response choices, namely; non-adoption and adoption. While the process of adoption of innovation goes through a sequence from the awareness to actual adoption stages, the target farming population will be divided into two groups, those not adopting and those adopting the innovation at the end of the process. In communicating the appropriate fertilizer formulations for small scale production, optimum quantities per unit of land area of the appropriate grades are usually indicated particularly, for cassava and maize production, average optimum application rate of about 400 kg per hectare of N P K fertilizers with varying grades depending on soil zones is recommended. The response of the famers to this technology fell into two categories viz, non- adoption (do not apply fertilizer) and adoption (applying varying quantities of the fertilizers). These responses or levels of adoption can be expressed in terms of their percentage of the recommended optimum dosage such that; non-adoption is equivalent to zero percentage adoption and adoption implies varying percentage adoption range of greater than zero percent.

It is assumed that farmers are rational in their decision and respond to their circumstances in a consistent utility- maximizing way. This implies that the level of adoption of fertilizer usage would normally not exceed the optimum dosage. However, it is not unusual to find some farmers who apply the fertilizers in excess of the recommended optimum dosage. To this extent, the response of the farmers fall into the range of lower limit of adoption of zero percent and continuous percent levels of adoption above the limit. This indicates some form of censoring resulting in mass points of observation at the low end called the limit value and continuous values above the limit. This suggests that the model proposed by Tobit is appropriate for analyzing the fertilizer adoption by famers. Tobit proposed a limited dependent variable model, later called the Tobit model to handle dependent variables which are combinations of those

cases, which have mass points at the low end called the limit value and continuous values above the limit.

The Tobit model is appropriate in this study since the dependent variable is the quantity of fertilizer used expressed as a percentage of the optimum dosage; thus, the dependent variable must be between 0 limit and continuous levels of adoption above the limit. A particular technology is adopted when the expected utility from using it exceeds that of non- adoption. Though it is not observed directly, the utility (U_{ij}) for a particular farmer (i) to use a particular technique (j) can be defined as a farm-specific function (Hi) of some vector of technology associated characteristics (X,), plus a error term with zero mean and constant variance (e_{ij}) thus:

$$U_{ij} = e_j F_i(H_i, X_i) + e_{ij} \times j = 1,2,...,I = 1,...,n \qquad (1)$$

Where 1 represents adoption of the new technology and 0 represents continued use of the old technology. The i^{th} farmer adopts j = 1 if $U_i1 > U_i0$. Farmer-specific characteristics include such variables as their social standing in society, participation in field-days, agriculture training workshops and on farm trials and contact with extension agents etc, while technology- specific characteristics include the impact of the technology on yield, availability of the technology on the farmer's farm or in the immediate neighbourhood, convenience in use, cost of adoption of the technology. The utility of adoption U_{ij} can be inferred from farmer's continuous choice over a predefined interval (intensity of adoption). This justifies the use of Tobit model, as has been applied in previous studies of agricultural technology adoption. This method enables one to estimate the likelihood of adoption and the extent (i.e. intensity) of adoption of a technology.

The lower-limit Tobit model following from Femandez-Cornejo and McBrid (2002) can be represented as:

$$y_i^* = \beta X_i + \in_1 \qquad (2)$$

Where: y_i^* is a latent variable (unobserved for, values smaller than 0) representing the use of the technology; X is a vector of independent variables, which includes the factors affecting adoption (inclusive of farm/farmer and technology-specific characteristics); β is a vector of unknown parameters and $\in_i$ is a stochastic error term assumed to be independently and normally distributed with zero mean and constant variance and $i = 1,2,...,n$, (n is the number of observations). Denoting Y_i (the level of adoption of fertilizer by the farmer) as the observed dependent (censored) variable, as applied by Oladele (2005) fall into the range.

$$Y_i = \begin{cases} 0 if\ Y_i^* \le T \\ Y_i^* if\ 0 < Y_i^* < 1 \\ 1 if\ Y_i^* > T \end{cases} \qquad (i=1,...,n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Unlike traditional regression coefficients, the Tobit coefficients cannot be interpreted directly as estimates of the magnitude of the marginal effects of changes in the explanatory variables on the expected value of the dependent variable. Each marginal effect in a Tobit equation includes both the influence of the explanatory variable on the probability of adoption as well as on the intensity of adoption. As Adesina and Baidu-Forson (1995) indicated, the (marginal) effect accounts for the simultaneous affects on the number of adopters and the extent of adoption by both current and new adopters. To decompose the relevant effect of changes in explanatory variables on the dependent variable, the McDonald and Moffit (1980) decomposition is employed as follows:

$$E(y) = F(z)E(y^*) = x\beta F(z) + \sigma f(z) \quad (4)$$

$$E(y^*) = x\beta + \sigma f(z)/F(z) \quad (5)$$

Where,

$E(y)$ index **es of** expected value of the level of technology adoption. It indicates the level of adoption expected to be made by new adopters of the technology. $E(y^*)$ gives the expected value of the level of adoption by those who are already using the technology, α: is the constant term in the Tobit estimate; $\beta_{I:}$ are the coefficients of the independent variables; F(z): is the cumulative standard normal distribution function. It predicts the probability of adoption of technology given the mean value of the explanatory variables. That is the percentage change of a technology being used by new adopters. The derivatives of $E(y)$ with respects to X_i yields

z, given as $\left(\alpha + \sum_{i=1}^{n} X_i \beta_i\right)/\sigma$ is the z-score for an area under the normal curve, evaluated at the mean values of X_i;

$$\frac{\delta E(y)}{\delta x_i} = F(z)\frac{\delta E(y^*)}{\delta x_i} + E(y^*)\frac{\delta F(z)}{\delta x_i} \quad (6)$$

and multiplying both sides of equation (6) by $X/E(y)$ and following from LeClere (1994) result in the estimation of elasticity of expected use intensity and the elasticity of adoption probability thus.

$$\frac{\delta E(y)}{\delta z_i}\left(x/y\right) = Fz\frac{\delta E(y^*)}{\delta x_i}\left(x/y\right) + E(y^*)\frac{\delta F(z)}{\delta x_i}\left(x/y\right) \quad (7)$$

After some algebraic transformations, the following expression result:

$$\frac{\delta E(y^*)}{\delta x_i} = \beta[1 - z(\frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2}) + z\frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2})] \quad (8)$$

Where; $\beta[1 - z(\frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2})]$ is the elasticity of expected use intensity and

$\beta z(\frac{f(z)}{F(z)} - \frac{f(z)^2}{F(z)^2})$, is the elasticity of probability of adoption.

The summation of the elasticity of expected use intensity and that of the probability of adoption gives the total elasticity.

4 METHODOLOGY

The study area is Boluwaduro Local Government Area of Osun State. The local government is surrounded by Boripe Local Government Area, Ila Local Government Area and Odo-otin Local Government Area all of Osun state. The headquarters of the Local Government is located at Otan Ayegbaju, which can be reached along Ikirun-Ila Orangun road. Cross sectional data were collected during the field survey of 120 small scale farmers selected through multi-stage selection process and covered the 2009 cropping season. The target population was small scale farmers who produce cassava and maize.

In the first stage of the sampling, simple random sampling technique was employed to select three towns out of five towns that constitute the local government area. In the second stage, a list of farmers was collected from Farmers Association, where purposive sampling technique was used to select fertilizer users and non-fertilizer users separately. In the last stage, simple random sampling technique was used to select 65 respondents from the fertilizer users and 55 respondents from non-fertilizer users which later resulted into 120 respondents' altogether. Primary data were collected through the use of well structured interview schedule according to the objectives of the study. Data collected relate to input-output of the farmers and their farm characteristics, with particular emphasis on their management of soil fertility. Also of importance were the farmer's socio-economic characteristics as they relate to their farming activities. The structured interview schedule covered four sections namely; socio-economic characteristics of small scale farmers, factors affecting the intensity of use of fertilizer among small scale farmers, gross margin of fertilizer users and non users and constraints encountered by the fertilizer and non fertilizer users. The variable is the percentage of recommended dosage of fertilizer used by the farmers. The dependent variable was regressed against proxies for various factor hypothesized to influenced the producer's adoption decision. The parameter estimates were estimated using Minimum Likelihood (ML) methods. The definitions, measurement and *apriori* expected effects of the independents variables on the adoption of fertilizers are as shown in Table 1.

5 DATA ANALYSIS AND DISCUSSION OF FINDINGS

The summary statistics of the basic socio-economic characteristics of the famers are presented in Table 2. On the average, the famers were about 47 years of age with a range of 22-68 years. The average family size was about 7, with some families having as many as 16 members, while a few had just 6 members. Majority of the famers had formal education ranging from incomplete primary education to tertiary education. On the average they had about 9 years of formal education. The average farm size of the respondents was about 2.38 hectares, with some having just about 0.47 hectares. The famers can be said to be mainly smallholders. They cultivate on the average about 2 plots at the same time. Many of them plant multiple crops; with an average of about 3 crops per plot. Average capital and labour input per hectare were about ₦24, 242.25 and ₦32, 953.72 respectively. The farmers used on the average, about 29kg of fertilizers per hectare which is less than the recommended dosage of about 400 kg per hectare. Many of the farmers however, do not use fertilizers at all. The mean value of farm output was about ₦84, 262.68per hectare. The average net farm income of about ₦27, 066.71 per hectare was made. Also, the volumes of credit used by the famers were about 36% of total cost of production, with many of the farmers using no credit at all for their fanning activities. The inability of many of the farmers to use credit has been identified by Olagunju (2007) as a factor responsible for limiting them to using less capital intensive and traditional methods of farming.

Table 3 shows the Tobit coefficients, the standard errors, t-ratios and their levels of significance as well as mean values of explanatory variables. All the coefficients had the hypothesized signs, with distance to fertilizer depot, fertilizer selling price per unit, age, farming experience of the head of the farm family and number of years of fallow of farm land having negative signs. These imply that a unit decrease in the distance to the nearest fertilizer selling depot, unit selling price and fallow of farm land would bring about increased adoption and intensity; of use of fertilizer by the small scale farmers in the study area. Proximity to fertilizer selling depot determines the transportation costs involved in the use of the input. The cost of transporting fertilizers, being bulky products

determines the extent to which famers most of who are low income earners can use them.

The effect of the distance to fertilizer selling depot contradicts the findings of Adanikin (2008) who obtained positive effects on the probability and intensity of adoption of agricultural technologies. He concluded however that the farmers seemed indifferent to distance to input sources provided they obtained the type and quantity they needed at affordable prices. In other words, he was of the view that it is the total cost of purchases rather than the distance to input source that matters. The effects of age and number of years of farming experience bring to bear the conservative attitude of many famers towards the adoption of new faming innovations. With experience and age, many famers stick to the old ways of farming rather than trying new techniques, probably due to their risk averse tendencies. On the other hand, farm size, level of formal education of the head of the farm family, number of instructional contacts the farmer had with extension agents, ratio of credit to total cost of production, degree of farm enterprise commercialization, membership of farmers' associations, knowledge of fertilizer use and application as well as ratio of non-farm to total annual income of farmers had positive signs, implying direct effect on the probability of adoption and intensity of use of fertilizer by the farmers. Specifically, these imply that a unit increase in the farm size. level of formal education of the head of the farm family, number of instructional contacts the farmer had with extension agents, ratio of credit to total cost of production, decree of farm enterprise commercialization and ratio of non-farm to total annual income of farmers would bring about increased adoption and intensity of use of fertilizer among the farmers. Also, membership of farmers association brings about increased awareness on the part of the farmers regarding existing and new farming technologies. With increased awareness of the availability of improved farm inputs coupled with information on their applicability, the level of adoption and intensity of use of fertilizer would increase. These views have also been expressed by Chukwuji and Ogisi (2006).

Cultivation of large farm sizes makes it more economical for farmers to apply fertilizers. Also, the larger the size of farm cultivated and therefore output produced, the more commercialized the farm would be. Increased level of education of farmers and contacts with extension agents lead to increased knowledge of input uses and their application because ignorant of the uses and abuses of inputs in crop production could discourage farmers from using them. These findings are in line with the reports of Daramola and Aturamu (2000) who noted that contacts with extension agents as well as acquisition of formal education exposes the farmers to the availability and technical-know-how of innovations and increases their desirability for acquiring them. The high and positive effect of off-farm incomes on the adoption indices of the farmers is an indication that they need improved financial bases in order to adopt better farming technologies.

Availability of off-farm incomes is an indication of farmer's involvement in non farm economic activities, with complementing income effects on farming activities. The incomes generated serve to ferry the farmers over the periods waiting for their crops to mature. The incomes also help the farmers to acquire the necessary farm inputs. Daramola and Aturamu (2000) however, reported opposite effects and pointed out that high proportion of off-farm relative to farm income suggests that incomes from farm investments are not enough to encourage farmers to take on some risks and adopt. It is obvious therefore that making the rewards from farm investments attractive through appropriate policies would discourage farmers from going into off-farm economic activities so as to increase the efficiency of farming activities. The financial bases of the farmers can also be increased through policies aimed at making them have easier access to production credit at affordable prices so as to increase their ability to purchase and use fertilizers. Credit availability to farmers is a measure of his financial worth and that most of them can not adopt any innovations when their purchasing power is ineffective. In Table 3, the last column gives the product of the Tobit coefficients and the mean values of the explanatory variables which when divided by the standard error of the model (σ) resulted in the z value of 0.18195. The predicted probability of adoption of fertilizer given as the cumulative distribution function F(z) 0.5299. This indicates that there is about 53% chances that small scale farmer would adopt the use of fertilizer. The expected level of adoption of fertilizers by those farmers on the limit E(Y) is 39.94, which implies that new adopters are expected to use about 40% of the recommended dosage of the appropriate fertilizer formulations for their production. Also, for farmers above the limit, the expected level of production E(Y*) of the recommended dosage of the appropriate fertilizer formulations is about 72%.

Table 4 presents the first order derivatives of Tobit function, the marginal effects and the elasticity estimates. The signs of the coefficients of elasticities of adoption intensities and probabilities of adoption with respect to the explanatory variables follow those of the individual Tobit coefficients estimated. However, elasticities are interpreted in absolute terms, with the signs only indicative of direction of their effects. The results indicate that fertilizer selling price per 50kg bag exhibited the highest elasticity of all the explanatory

variables with coefficients of about 1.01 and 1.36 in absolute terms for adoption intensity and probability of adoption respectively. These imply that a 10% reduction in the unit selling price of fertilizers would lead to about 10% increase in the intensity and 14% increase in the probability of adoption of fertilizer usage by the farmers respectively. In other words, current users of fertilizers will increase their level of usage by about equal proportion for a given percentage in the unit selling price of fertilizers. Similarly, the probability that more farmers would adopt the use of fertilizer would increase by about one and a half times for a given percentage reduction in the unit selling price of the input.

Other variables that showed high elasticities were age of farmers with 0.56 and 0.78, distance of fertilizer selling depot with about 0.70 and 0.11, farm size with about 0.04 and 0.06 as well as farmers level f education with about 0.03 and 0.04 coefficients in absolute term for intensity and probability of adoption of fertilizer usage by the farmers respectively. These indicate that a percentage reduction in the mean age of the farmers can result in adoption intensity and the probability of more farmers adopting the use of fertilizers by about 0.6% and 0.8 %, respectively. Also, a reduction in the distance to fertilizer selling depot and increase in farm size as well as farmers' level of formal education by 1% would increase intensity and probability of adoption of fertilizer usage by the farmers by about 0.70, 0.11, 0.04 and 0.06% as well as 0.03 and 0.04% respectively. These results indicate that younger farmers are more likely to adopt the use of fertilizers than older ones. Similarly, it appears that most farmers who are willing to adopt the use of fertilizers are unable to do so due to the long distances they have to travel with the attendant high transport cost to purchase the inputs. In the same manner, creating more conducive atmosphere for educated people to go into farming would increase the adoption of fertilizers thereby leading to increased yield per land area. For all variables, the elasticity coefficients for probability of adoption were higher than those of intensity use. This implies that the effect of adjustments in the explanatory variables would be felt more by non – adopters who would be motivated to become adopters by changes in the prevailing constraining factors. Fernandez-Cornejo and McBrid (2002) had observed that adoption of agricultural technologies is more responsive to policy adjustment at the innovation stage but declines as intensity of the diffusion increases.

5.1 Analysis and Comparism of the Gross Margin of Fertilizer Users and Non Users

Table 5 shows that about 32% and 63% of fertilizer users and non-fertilizers users earn less than ₦15, 000 as gross margin from crop produced per hectare. The mean value of the gross margin of crop produced/Ha by fertilizer users was ₦22, 660.15, while the mean value of the gross margin of crop produced/Ha by non fertilizer users was (₦32, 432.27). In comparison, higher proportion (63.3%) of non - fertilizer users earn ≤ ₦15, 000 while about 32% of fertilizer users earn the same amount. This means that there is difference in the gross margin of fertilizer users and non-users as expected. This further shows that appropriate use of fertilizer is more profitable.

5.2 Test of Hypotheses

Hypothesis 1: There is no significant relationship between the socio economic characteristics of small scale farmers and the adoption pattern of fertilizer technology among the small scale farmers. Table 6 shows that there is a significant relationship between age, sex, education, marital status, farm distance, experience, household size and the adoption pattern of fertilizer technology among small scale farmers at 99% significant level. This indicates that the variables can determine the adoption pattern of fertilizer technology

Hypothesis II: There is no significant difference between the gross margins of fertilizer users and non users. Table 7 reveals that there is a significant difference in the gross margins of fertilizer users and non users at (95%) significant level.

This shows that gross margin of fertilizer users is different from that of non fertilizer users.

Table 1: Descriptions, measurement and expected signs of variables for Tobit regression analysis on fertilizer adoption

Variables	Definitions and Measurements	Apriori expectations
Adoption	The quantity of fertilizer used by a farmer as percentage of the recommended dosage	
Independent Variables		
DIS	Distance (in km) of the farmers house from the fertilizer selling depot	Negative
PRI	Unit selling price of 50kg bag of the fertilizer (in Naira)	Negative
SIZ	Farmers' farm size (in hectares), being the sum of the current cassava and maize farm plots cultivated by the farmer	Positive
EDU	Number of years of formal education of the farmer, with the more the number of years, the higher the level of education expected to be acquired	Positive
EXT	Contact with extension against, measured as the average number of contacts a farmer had during the current and immediate past farming years.	Positive/Negative
AGE	Chronological age of the head of the farm family	Positive
CRD	The amount of production credit used by the farmer expressed as a percent of the total of production as a percent of total farm output	Positive
COM	The degree of commercialization of the farm investment, measured as the quantity of cassava tuber and maize output sold as a percent of total farm output	Positive
ASS	Membership of small farmer Association (Dummy with 1 if yes and 0 otherwise)	Positive
NAI	Estimate of non-farm income expressed as a percentage of farmer's total annum income (in Naira). It is a measure of farmers' involvement in off-farm economic activities	Positive/Negative
KNG	Knowledge of fertilizer uses and application (Dummy with 1 if yes and 0 otherwise)	Positive
EXP	Number of years of farming experience of the head of farm family	Positive/Negative
FAL	Fallow periods of cassava/maize farm plots (years)	Negative

Source: field survey, 2009

Table 2: Summary Statistics of the basic socioeconomic characteristics of the farmers (N = 120).

Variable	Mean	Standard deviation	Minimum	Maximum
Age (Years)	47.17	6.2	22	68
Family size (No)	7.23	4.72	6	16
Formal Ed. (Years)	9.41	4.32	0	18
Farm size (ha)	2.38	1.94	0.47	7.37
No. of farm plots maintained	2.2	0.41	1	5
No of crops produced	3	0.18	1	5
Capital input (₦*)/ha	24,242.25	6228.10	27,566.40	46,340.50
Labour input (₦)/ha	32,953.72	9340.60	5135.30	65,358.30
Fertilizer input (kg/ha)	29	8.41	0	56
Ratio of credit to total production cost	0.36	0.19	0	0.89
Value of farm output (₦)/ha	84,262.68	5,237.12	16,653.16	106,445.54

*Note: One USA Dollar is equivalent to about 145 Nigerian Naira for 2009 average exchange rate. Source: Authors' survey data, 2009

Table 3: Total coefficient, standard errors, t-ratios, level of significance and means of variable

Variable	Coefficients	t-ratio	Level of significance	Mean of variable	Mean multiplied by coefficient
Constant	364.4725	8.3340	0.0000***	1.00	364.47
Distance of fertilizer purchasing depot (DIS)	-0.3200	-2.6810	0.0197**	35.33	-11.31
Fertilizer price/50kg bag (PRI)	-0.0242	-6.1310	0.0000***	4385.12	-106.12
Farm size (SIZ)	2.0236	1.2270	0.1342	2.48	5.02
Farmer's level of formal education (EDU)	0.5323	2.0910	0.0571**	8.47	4.51
No of contacts with Extension agents (EXT)	0.8712	1.8720	0.0821*	3.48	3.03
Age of farmer (AGE)	-2.0201	-6.6290	0.0000***	41.76	-84.36
Credit of total cost (CRD)	2.0275	0.6560	0.6203	0.34	0.68
Degree of commercialization (COM)	15380	0.4210	0.7156	0.38	0.58
Farmer's Association (ASS)	0.3374	0.1261	0.8213	0.47	0.16
Ratio of Non-farm to total annual income (NAI)	4.1210	0.9520	0.3061	0.21	0.86
Knowledge of fertilizer use and application (KNG)	0.8974	0.7083	0.4497	0.67	0.60
Farming experience (EXP)	-0.1032	-0.5030	0.6149	8.90	-0.92
Fallow period of farm lands (FAL)	-0.4972	-1.8760	0.3248	2.68	-1.33
$X\beta = 32.0004521$, $\sigma = 175.87342$, $Z = X\beta/\sigma = 32.0004521/175.87342 = 0.18195$					
$E(Y) = 39.9357023$, $E(Y^*) = 71.8453290$, Note: *** = 1%, ** = 5% and * = 10% level of Significance, source: Authors: Survey data, 2009					

Table 4: Partial Derivatives and Estimates of elasticities and intensities of adoption

Variables	Coefficient	Partial derivative $\frac{\partial E(y)}{\partial x_i}$	Partial derivative $\frac{\partial E(y^*)}{\partial x_i}$	Partial derivative $\frac{\partial F(z)}{\partial x_i}$	Elasticity of Adoption $\frac{\partial F(z)}{\partial x_i}\frac{x}{F(z)}$	Elasticity of intensity $\frac{\partial E(y^*)}{\partial x_i}\frac{x}{E(y^*)}$
Constant	364.4725	112.1682	108.7418	1.2342	1.4986	2.0465
Distance of fertilizer purchasing depot (DIS)	-0.3200	-0.1387	-0.1549	-0.0013	-0.0744	-0.1127
Fertilizer price/50kg bag (PRI)	-0.0242	-0.0314	-0.0231	-0.0014	-1.0145	-1.3575
Farm size (SIZ)	2.0236	0.7816	0.6733	0.0200	0.0414	0.0568
Farmer's level of formal education (EDU)	0.5323	0.2102	0.1799	0.0041	0.0324	0.0363
No of contacts with Extension agents (EXT)	0.8712	0.2587	0.2295	0.0038	0.0217	0.0282
Age of farmer (AGE)	-2.0201	-0.7468	-0.7346	-0.0089	-0.5626	-0.7646
Credit of total cost (CRD)	2.0275	1.0667	1.0579	0.0138	0.0052	0.0073
Degree of commercialization (COM)	1.5380	0.5835	0.5716	0.0058	0.0019	0.0043
Farmer's Association (ASS)	0.3374	0.1310	0.1264	0.0014	0.0005	0.0011
Ratio of Non-farm to total annual income (NAI)	4.1210	0.6857	1.6528	0.0217	0.0063	0.0078

Knowledge of fertilizer use and application (KNG)	0.8974	0.3264	0.3248	0.0036	0.0028	0.0062
Farming experience (EXP)	-0.1032	-0.0528	-0.0524	-0.0006	-0.0062	-0.0076
Fallow period of farm lands (FAL)	-0.4972	-0.2619	-0.2608	-0.0020	-0.0074	-0.0115

Source: Survey Data, 2009

Table 5: Distribution of Respondents Based on Gross Margin of Cassava/ Maize Produced/ha

Gross margin of crops produced (₦)	Fertilizer users		Non Fertilizers users	
	Frequency	Percentage	Frequency	Percentage
≤15,000	19	31.7	38.0	63.3
16,000-20,000	6	10	16	26.7
21,000-25,0000	17	28.3	6	10
26,000-30,000	16	26.7	0	0
≥30,000	2	3.3	0	0
Total	**60**	**100**	**60**	**100**

Source: Field survey, 2009.

Table 6: Relationship between the Socio Economic Characteristics and the Adoption Pattern of Fertilizer Technology of Small Scale Farmers.

Paired Differences	
Characteristics	T- values
Age	43.139***
Sex	19.718***
Education	17.647***
Marital status	25.088***
Farm distance	12.484***
Experience	14.954***
Household size	22.527***

*** Significant at 99% (2-tailed).
Source: Field Survey, 2009.

Table 7: Difference between the Gross Margin of Fertilizer and Non Users

Paired Differences	
Variables	T-values
Gross margin of fertilizer users and non-user	-2.325**

Significant at 95% (2-tailed).
Source: Field Survey, 2009.

6 Conclusion

The study was based on small scale farmers in Boluwaduro local government area of Osun state vis a vis their adoption of fertilizers. Specifically, the study investigated the probability and intensity of adoption, gross margin of both fertilizers and non fertilizers. A Tobit model was used to analyse the cross sectional data collected from a random sample of 120 farmers selected by means of multistage random sampling technique during the 2009 cropping season. The results indicated that the average farm size of the respondents was about 2.4 hectares, with some having just about 0.47ha. They cultivate on the average, 3 plots at the same time. The average capital and labour input per hectare were about ₦24, 242.25 and ₦32, 953.72 respectively.

The result further indicated that the gross margin of fertilizer users is greater than that of non-fertilizer user and this implies that the use of fertilizer is profitable. The result further indicate that currently the average amount of fertilizers applied by the farmers is less than the recommended dosage and that there is

about 53% chances that an average small scale farmer would adopt the use of fertilizers. The expected level of adoption of fertilizers by those farmers on the limit E(Y) is 39.94, which implies that new adopters are expected to use about 40% of the recommended dosage of the appropriate fertilizer grade. Also, for farmers above the limit, the expected level of production E(Y*) of the recommended dosage of the appropriate fertilizer formulations is about 72%.

A number of factors significantly influenced the fertilizer adoption decision of the farmers, namely, Distance (in km) of the farmers house from the fertilizer selling depot ($p<0.05$), Number of years of formal education of the farmer ($p<0.05$), fertilizer price /50kg bag ($p<0.01$), Number of contact with extension agents ($p<0.01$). These imply that policies that would make fertilizers affordable by the famers at close distances and those that would encourage young people into crop production as well as increased education of farmers would encourage increased adoption of fertilizer to boost. The extension agents must intensify their efforts in training adequate contact farmers who are literate with high social participation and highly devoted people.

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