American Journal of Experimental Agriculture
5(5): 466-474, 2015, Article no.AJEA.2015.046
ISSN: 2231-0606

SCIENCEDOMAIN ***international***
www.sciencedomain.org

SCIENCEDOMAIN

Adoption of Inorganic Fertilizer by Urban Crop Farmers in Akwa Ibom State, Nigeria

Nsikak-Abasi A. Etim[1*]

[1]Department of Agricultural Economics and Extension, University of Uyo, P.M.B. 1017, Uyo, Akwa Ibom State, Nigeria.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJEA/2015/11553
Editor(s):
(1) Edward Wilczewski, Faculty of Agriculture, University of Technology and Life Sciences in Bydgoszcz, Poland.
(2) Mintesinot Jiru, Department of Natural Sciences, Coppin State University, Baltimore, USA.
Reviewers:
(1) Anonymous, Agricultural Research Institute, Ghana.
(2) Anonymous, Benin.
(3) Anonymous, Benin.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=738&id=2&aid=6889

Original Research Article

Received 22nd May 2014
Accepted 4th October 2014
Published 13th November 2014

ABSTRACT

This study was conducted between November, 2013 and April, 2014 in Uyo, the capital of Akwa Ibom State, Nigeria to empirically identify factors affecting the rate of adoption of chemical fertilizer by urban crop farmers. Through the multistage sampling procedure, 60 urban crop farmers were selected and interviewed with the aid of questionnaires. Data were analyzed using Tobit regression analysis. Results showed that the rate of chemical fertilizer adoption was positively and significantly related to land size, age, credit and education at (P<0.01) and (P<0.10) respectively, whereas average walking time to farm and soil fertility status were negatively and significantly related to fertilizer adoption and use intensity. This is an indication of the relevance of land, education and credit as determinants of technology adoption. It implies that the rate of adoption of fertilizer technology is strongly linked to these factors. Findings underscore the need to embark on market oriented interventions which will encourage urban farmers to adopt improved farming techniques as suitable policy decision. Enhancing human capital and availability of credit at lower cost are policy options that should be vigorously pursued.

Keywords: Adoption; fertilizer; farmers; Nigeria.

**Corresponding author: E-mail: etimbobo@gmail.com;*

1. INTRODUCTION

Economists have provided considerable evidence about agricultural technology adoption and diffusion among farmers in developing countries [1,2] A substantial body of literature analyzes farmers' adoption behaviour and these studies reveal considerable variation in such behaviour for agricultural technologies over time and across socioeconomic groups [3,4]. Empirical models of technology typically include socioeconomic, physical and agro ecological variables as regressors [4,5,6]. Decisions to use a technology depend partly on how farmer receive, process and evaluate information about innovations. In environments where information acquisition and transfer are fraught with difficulties, the educational level of the farmer is critical [7,8]. Moreover, the incentives to adopt a technology depend on the expected benefits, and education facilitates the sourcing, the processing and its successful application. As a result, exposure to formal education is expected to increase technology adoption [3,7,9].

In the technology adoption literature, land is often used as a proxy for wealth. However, this variable can have an ambiguous effect on adoption. Feder et al. [3] suggest that, small farms may be willing to adopt a technology to increase short-run profits, but, financial constraints may impede such adoption. Households with larger farms are assumed to have easier access to credit and farm inputs and thus be more likely to be adopters. Moreover, extension services and agribusiness firms tend to target larger farms for trials of new agricultural technologies [10,11]. Nevertheless, Diederen et al. [12] argue that, smaller farms may be more likely to cooperate in trials and to accept the risks and cost associated with experimentation. Hence, small-scale producers would be more inclined to adopt improved practices and to intensify their operation.

Soil health is fundamental asset for agricultural sustainability and is the most important part of any cropping system [13]. According to Pretty [13], many cropping systems are under threat because soils have been damaged, unproductive, eroded or simply ignored during the process of agricultural intensification. One of the effective means of supplementing the natural soil nutrient supply, maintaining good soil conditions and restoring the health of poor soils for cropping is by use of fertilizer. Etim et al. [14,15] reported that fertilizers are substances that supply plant nutrients or amend soil fertility and are the most effective means of increasing crop production and improving the quality of food and fodder. As Nigeria is facing twin challenges of reforming the economy and reducing poverty [15,16], the pressure of the increasing population in Nigeria does not only limit land resource availability for agricultural production but causes a reduction in food availability through a decline in food supply. According to Etim et al. [15,17] pressure on population does not only increase food demand but affect resource use and indirectly decreases food supply. For decades, poverty, food insecurity and malnutrition were viewed as rural problems. But with the populations of many African, Caribbean and Pacific countries becoming more urban, poverty and poor nutrition are emerging as growing challenges for city dwellers [18]. With the growth in urban poverty now rapidly outstripping that of rural poverty, the use of organic wastes in urban farming can be viewed as an essential service offered to the city in providing an environmentally safe and cheap (income – generating) disposal opportunity [19]. But, recycling of organic wastes also comes with a cost, and often causes the spread of disease. Although, waste recycling in urban farming may not offer an optimal solution for safe disposal of the material, an alternative approach which will alleviate the problems associated with waste recycling in farming is the use of chemical fertilizer. Despite these challenges in the use of organic waste in farming, many farmers are yet to adopt and utilize chemical fertilizer in farming. Since poor soil health and low use of inorganic fertilizers have been identified as two major factors limiting productivity growth of Agriculture in Africa (Nigeria inclusive) [15,20,21,22], incorporating chemical fertilizer as a major component in urban farming system therefore becomes imperative. This however requires an understanding of the factors responsible for the slow adoption of fertilizer and use by urban crop farmers. This study therefore attempts to identify the determinants of fertilizer use by urban crop farmers in Uyo, Nigeria.

2. METHODOLOGY

2.1 Study Area, Sampling and Data Collection Technique

This study was conducted in Akwa Ibom State, Nigeria. The state is located at latitude 4°33' and 5°30' and longitude 7°25' and 8°25' East and occupies a total land areas of 7,246km^2. With an estimated population of about 3 million [23], the state is bounded to the North by Abia State, to the East by Cross River State, to the West by Rivers State and to the South by the Atlantic Ocean. Administratively, the state is divided into 31 local government areas and has 6 Agricultural Development Project (ADP) Zones viz: Oron, Abak, IkotEkpene, Etinan, Eket and Uyo as shown in Fig. 1. The study area is in the rainforest zone and has two distinct seasons viz: the rainy and the short dry season. The annual precipitation ranges from 2000 – 3000 mm per annum. Most of the inhabitants of urban households in the study area are farmers and the crops commonly cultivated include cassava, yam, cocoyam, fluted pumpkin, okra, waterleaf, bitter-leaf etc. In addition, some micro livestock are usually raised at backyards of most homesteads [24]. Although the soil is rich but continuous cropping over the years has depleted the nutrients. Hence, the application of chemical fertilizer is imperative to replenish the nutrients.

The study employed multistage sampling procedure. The first stage involved the purposive selection of 3 out of 6 agricultural development zones. The second stage involved the random selection of 20 farmers from each zone to make a total of 60 farming households. With the aid of questionnaire, data on farm size, gender, age, soil fertility status, quantity of fertilizer applied, educational level and labour employed were obtained.

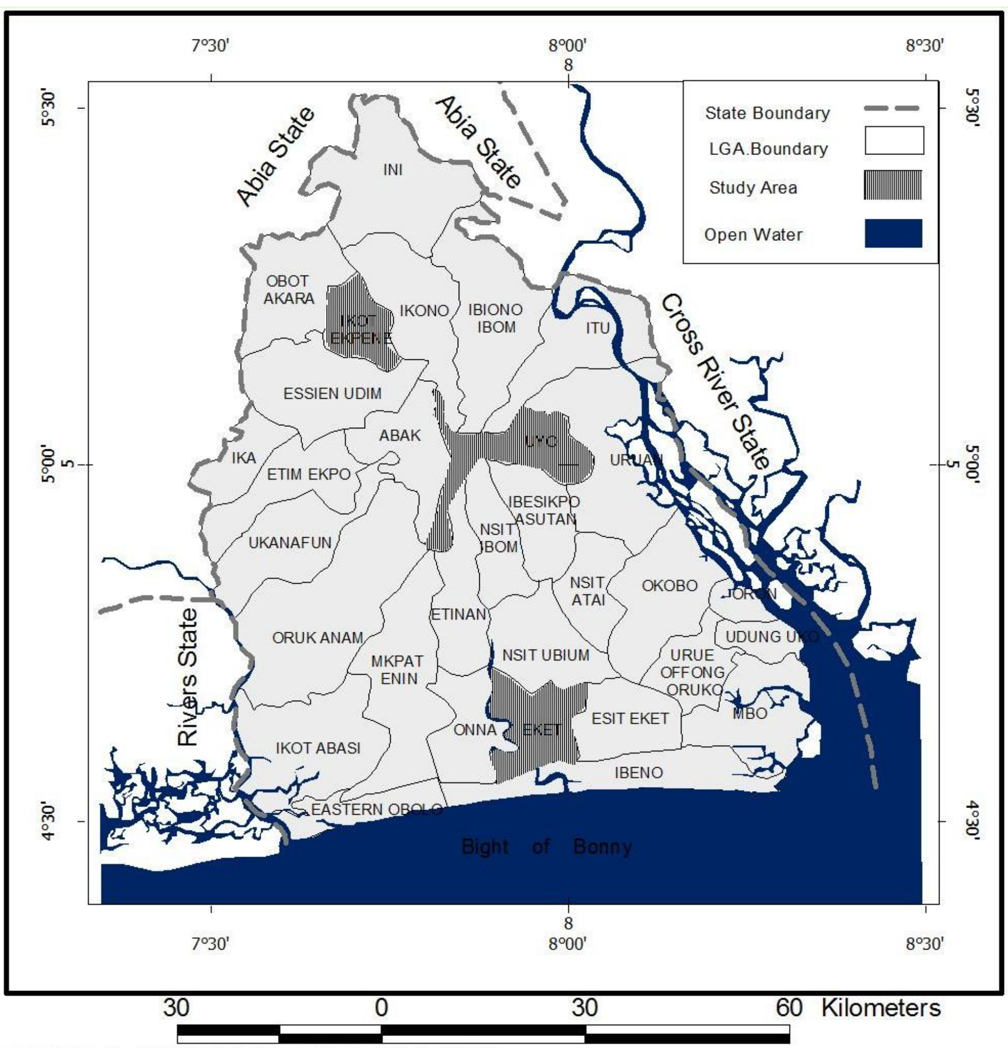

Fig. 1. Akwa ibom state showing agric. devt. project sampled local Govt. areas

2.2 Analytical Technique

Tobit model was used to model the effect of adoption decisions. This model, according to Chow [25] and Maddala [26] has several empirical applications in the adoption literature [22,27,28,29,30,31]. The dependent variable is level of use of inorganic fertilizer, which is censored at zero. To avoid the censoring bias that ordinary least squares could generate, a Tobit censored at zero was used because level of fertilizer use less than zero was not observed and most respondents reported zero application. As reported by [30,22], a bias to the parameter estimates is also imparted even when a Tobit procedure is incorrectly used assuming that, the true point of censoring in the sample is zero. Other estimation approaches, such as the Heckman's model also generate unbiased results [31]. But, the Tobit approach conserves degrees of freedom and is relevant in this case where the explanatory variables have a continuous effect on the dependent variable.

Since the level of fertilizer use cannot be negative (the threshold is zero), the dependent variable can be written using an index function approach as:

$$I^* = \beta^T X_i + e_i \quad (1)$$

$$Y_i = 0 \text{ if } I^*_i = T \quad (2)$$

$$Y_i = 1 \text{ if } I^*_i > T \quad (3)$$

Where Yi represents a limited dependent variable, which simultaneously measures the decision to use fertilizer and the use intensity. I^*_i is an underlying latent variable that indexes adoption. T is an observed threshold level. X is the vector of independent variables affecting adoption and intensity of use.

β^T is a vector of parameters to be estimated
e_i is the error term. If the non-observed value of I* is greater than T, the observed variable T, becomes a continuous function of the independent variables and 0 otherwise.

2.3 Empirical Model

The model is presented as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, e)$$

Where

Y = Total quantity of fertilizer used on urban crop farm ($kg.ha^{-1}$)
X_1= Gender of the farmer (D = 1 if male, 0 if otherwise)
X_2= Age of the farmer in years
X_3= Education of the farmer in years
X_4= Land size in hectares
X_5= Average walking time to nearest farm in minutes
X_6= Average walking time to nearest fertilizer selling point in minutes
X_7= Tenancy status of the farmer (D = 1 if tenant, 0 if otherwise)
X_8= Soil fertility status of the land (D = 1 if yes, 0 if otherwise)
X_9= Access to credit (D = 1 if yes, 0 if otherwise)
X_{10}= Family labor in mandays
X_{11}= Population pressure on available land (number of persons per hectare)

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

The summary statistics of the dependent and independent variables are presented in Table 1. The mean land size utilized for urban crop farming was 0.9 hectares. This result suggests that urban crop production was on small scale. Result conforms with recent empirical findings by Etim and Okon [32] and Etim and Edet [15]. The smallness in land sizes may be attributable to the prevalent tenure arrangement in southern Nigeria which encourages fragmentation of holdings. Finding is synonymous with earlier result of Etim et al. [16] who documented that the prevalent land tenure system has a number of demerits for moving agriculture from subsistence level to market oriented production and the system of inheritance tends to perpetuate fragmentation of holding among the male heirs of land owning families. The high mean value of family labour suggest that, urban crop cultivation requires substantial amount of labour as most labour employed in various farming operations were provided by members of the family. The high availability of family labour could be an indication of larger family size. Result on age and education suggest that urban crop farmers are within an active and productive age and have acquired considerable level of formal schooling. Etim and Edet [15] obtained similar result.

Table 1. Summary statistics of variables

Variables	Unit	Mean value	Standard deviation
Farm size	Hectare	0.9	0.219
Age	Years	23	1.391
Family labour	Manday	140.68	20.127
Education	Years	10	4.629
Walking time to nearest fertilizer selling point	Minutes	30	6.961
Walking time to nearest farm	Minutes	60	10.173
Population pressure	Person/ha	7	1.673
Fertilizer use by urban crop farmers	Kilogram	128.84	16.791

The average walking time of 30 minutes to the nearest market imply that, most of the farm outputs were readily disposed and thus, the quantity of stale products were reduced as most of the urban farming products were fresh and highly perishable. The average walking time of 60 minutes to the nearest farm suggest that urban farms were located farther from homes and therefore were less intensively cultivated.

3.2 Test Result for Collinearity among Specified Variables in the Model

The VIF test result for multicollinearity between the dependent variable and the explanatory variables used in the Tobit model is presented in Table 2. The result showed that, there was no significant collinearity between the explanatory variables and the dependent variables in the model. Result implies that the estimates of the Tobit model have minimum variance, consistence and probably unbiaseness.

Table 2. The variance inflation factors (VIF) test result for multicollinearity of variables used in the analysis

Variable	VIF estimates
Age	2.152
Education	1.921
Land size	3.210
Average walking time to nearest farm	1.430
Average walking time to nearest fertilizer selling point	2.122
Family labour	2.434
Population pressure	3.235

3.3 Tobit Model Estimate Results

In this study, land size in hectares is taken as a proxy for wealth. The variable, is positively significant (p<0.01). This implies that, increasing the size of land for farming will lead to increased adoption and intensity of chemical fertilizer use. Abara and Singh [33], Fernandez-Cornejo [34], Adesina [28], Onyenweaku et al. [22], Etim and Edet [15] variously and empirically documented the positive effect of farm size on adoption in similar studies. The cost of adoption, risk perceptions and large fixed costs in small farms are affected by farm size and are constraints to technology adoption. Earlier findings by Abara and Singh [33] and Etim and Edet [15] agree with this study.

The variable age could positively or negatively affect adoption. Younger farmers are more likely to adopt agricultural innovations and vice versa. In this study, however, as shown in Table 3, age has a positive sign and significantly impacts on adoption. Age indexes experience and services as evidence for human capital revealing that, urban farmers with more years of farming experience acquired from accumulated years of observation and experimentation with various agricultural technologies are more likely to adopt innovations faster than urban farmers with less experience in farming. Similar and empirical studies found that, increased experience in cultivation may also enhance critical evaluation of the relevance of better production decisions, including efficient utilization of productive resources [32,35,36,37].

The variable education has a coefficient of 0.711 and significant (p<0.10). This means that urban farmers that have acquired some form of formal education are more likely to adopt improved farming techniques earlier an98d faster than the uneducated ones. Similar empirical findings were reported by Udoh and Etim [38,39,40,41,42]. This result supports the hypothesis that human capital plays a positive role in the acquisition and evaluation of new ideas. Moreover, programs and materials promoting technological change typically favor literate farmers.

This result is also consistent with other findings in Africa, including, [43] in Cameroon, [10] and [5] in Ethiopia [44] in Malawi and [45] in Nigeria.

Table 3. Estimates of the determinants of adoption

Variable	Coefficient	Standard error	t-ratio
Intercept	-0.572	0.266	-2.150**
Sex X_1	-0.812	0.622	1.305
Age X_2	0 .308	0.108	2.852***
Education X_3	0.711	0.424	1.677*
Land size X_4	0.055	0.027	2.037**
Average walking time to nearest farm X_5	-0.026	0.011	-2.364**
Average walking time to nearest fertilizer selling point X_6	0.194	0.963	0.2015
Tenancy status X_7	0.011	0.014	0.786
Soil fertility status X_8	-1.044	0.422	-2.474**
Access to credit X_9	0.668	0.195	3.426***
Family labor X_{10}	-1.284	0.958	-1.340
Population pressure X_{11}	0.375	0.089	4.213***

The elasticity of the average walking time to the farm is negatively significant at ($p<0.01$). This implies that urban farms located farther from homes are less intensively cultivated and thus lesser fertilizer use and adoption than farms located nearer to homes. This result agrees with recent and empirical findings by Etim and Edet [15].

The variable soil fertility status is negatively significant ($p<0.01$). This implies that urban farmers whose soil fertility status are poor would be more likely to increase their rate of adoption and use intensity of fertilizer. Result underscore the need to investigate the fertility status of soils before embarking on any meaningful agricultural production. Finding is consistent with recent empirical result of Onyenweaku et al. [22] and Etim and Edet [15]. This result is however contrary to earlier findings of [46] who observed that regions with better soil quality and higher water availability are more likely to adopt and intensify fertilizer use.

The variable credit is positive as expected and is significant ($P<0.01$). Result implies that accessibility to and availability of credit to urban farmers eliminates the production constraints and thus makes it easier for timely purchase of improved farming inputs. Result is synonymous with findings of Muhammed [47,36,37,41].

4. CONCLUSION

In this study, factors affecting the rate of adoption of chemical fertilizer by urban crop farming households were estimated using the Tobit model. The analysis reveals that the most critical factors affecting the rate of adoption and use intensity of chemical fertilizer are age and educational level of the farmer, land size under cultivation, average walking time to the nearest farm, soil fertility status of the land and accessibility to credit facilities. The study revealed that increasing the size of cultivable land is likely to increase the rate of adoption of chemical fertilizer by urban arable crop farmers. Also, results of the study showed that farmers who have acquired many years of observation and experimentation with various technologies are more likely to adopt new techniques faster than those with lesser years of farming experience. Findings further reveal that enhancing human capital plays a positive role in fertilizer adoption. Findings suggest the need to formulate policies aimed at encouraging human capital development, training, increased urban cultivable areas. However, the provision of credit facilities and capital at lower cost is a rational policy decision.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Sunding D, Zilberman D. The agricultural innovation process: Research and Technology adoption. In a changing agricultural sector. In Gardner, BL and Rausser G (Eds). Handbook of Agricultural Economics. Elsevier Science, North Holland. 2001;1:208-261.
2. Conley T, Udy C. Learning about a new technology: Pineapple in Ghana Economic Growth Center Working paper, Yale University Press, Connecticut; 2003.

3. Feder G. Just RE, Zilberman D. The adoption of agricultural innovations in developing countries a survey. Economic Development and Cultural Change. 1985;32(2):255-98.
4. Moreno G, Sunding DL. Joint estimation of technology adoption and land allocation with implications for the design of conservation policy. American Journal of Agricultural Economics. 2005;87(4):1009-1019.
5. Zegeye T, Tadesse B, Tesfaye S. Determinants of adoption of improved maize technologies in maize growing regions in Ethiopia. Second national maize Workshop of Ethiopia 12 – 16 November, Addis Ababa, Ethiopia; 2001.
6. Krepper ET. Factors affecting the use of fertilizer by small- and medium-sized farming households in Zambia, 1997 – 2000. MSc thesis, Michigan State University; 2002.
7. Wozniak GD. The adoption of interrelated innovations: A human capital approach. The Review of Economics and Statistics. 1984;66(1):70-79.
8. Ersado L, Amacher G, Alwang, J. Productivity and land enhancing technologies in Northern Ethiopia: Health, Public investments, and sequential adoption. America Journal of Agricultural Economics. 2004;86(2):321-331.
9. Doss C, Mwangi W, Verkuji H, de Groote H. Adoption of maize and wheat technologies in East Africa Synthesis of the finding of 22 case studies. Economics working paper 03 – 01 CIMMYT (International maize and wheat improvement center). Mexico, DF; 2003.
10. Bacha D, Aboma G, Gemeda A, De Groote H. The determinants of fertilizer and manure use in maize production in Western Oromiya, Ethiopia. Seventh Eastern and Southern Africa Regional maize Conference, 11 – 15 February, Pretoria; 2001.
11. Kherallah M, Delgado C, Gabre-Madhin E, Minot E, Johnson M. Reforming agricultural markets in Africa. Johns Hopkins University Press, Baltimore; 2002.
12. Diederen P, Meiji H, Wolters A, Bijak K. Innovation adoption in agriculture: Innovators, early adopters and laggards. Cashiers d'Economicet Sociologies Rurales. 2003;67:29-50.
13. Pretty J. Agriculture reconnecting people, land and nature. Earthscan Publications Limited. London. Sterling, VA; 2002.
14. IFA. International World Fertilizer Use Manual. International Fertilizer Industry Association. Limburgerh of, Germany; 1992.
15. Etim NA, Edet GE. Adoption of inorganic fertilizer by resource poor cassava. Farmers in Niger Delta Region, Nigeria. International Journal of Agriculture Innovations and Research. 2013;2(1):94-98.
16. Etim NA, Akpan AU, Brown UA. Land and poverty: Some empirical findings using cross sectional data from Niger Delta Region, Nigeria. International Journal of Agricultural Management and Development. 2013;3(3):181-188.
17. Etim, NA, Udoh EJ, Awoyemi TT. Measuring technical efficiency of urban farms in Uyo Metropolis. Global Journal of Agricultural Science. 2005;4(1):91-95.
18. Spore. Urban Agriculture. City Farmers. The magazine for agricultural and rural development in ACP Countries. 2012;157:14.
19. Neergaard A, Drescher AW, Kouame C. Urban and Peri-urban agriculture in African cities, in Shackleton CM, Pasquini MW and Drescher AW (eds.) African Indigenous Vegetables in Urban Agriculture: Recurring Themes and Policy. Lessons for the Future. Earthscan. London, Sterling, V.A.; 2009.
20. Bationo A, Mokwunye AU. Role of manures and crop residue in alleviating soil fertility constraints to crop production with special reference to the Sahelian and Sudanian Zones of West Africa. Fertilizer Research. 1991;29:117-125.
21. Vlek PLG. The role of fertilizers in sustaining agriculture in Sub Saharan Africa. Fertilizer Research. 1990;26:327-339.
22. Onyenweaku CE, Okoye BC, Okorie KC. Determinants of fertilizer adoption by rice farmers in Bendel Local Government Area of Abia State, Nigeria. The Nigerian Agricultural Journal. 2010;41(2):1-6.
23. NPC (National Population Commission). Population Census of the Federal Republic

of Nigeria. Analytical Report at the National Population Commission, Abuja; 2006.

24. Etim NA. Analysis of poverty status of rural farming households in AkwaIbom State, Nigeria, Unpublished Ph.D Dissertation Department of Agricultural Economics, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria; 2007.
25. Chow GC. Econometrics. Third Edition Singapore: McGraw-Hill; 1983.
26. Maddala GS. Limited dependent and qualitative variables in econometrics. London: Cambridge University Press, London; 1983.
27. Adesina AA, Baidu-Forson J. Farmers' perception and adoption of new agricultural technology; evidence from Burkina Faso and Guinea, Agricultural Economics. 1995;13:1-9
28. Adesina AA. Factors affecting the adoption of fertilizer by rice farmers in Cote d'Ivoire. Nutrient Cycling in Agro-Ecosystems. 1996;46:29-39.
29. Ransom JK, Paudyal K, Adhikari K. Adoption of improved maize varieties in the hills of Nepal Agricultural Economics. 2004;29:299-305.
30. Holloway G, Nicholson C, Delgado C, Staal S, Ehui S. A revisited tobit procedure for mitigating bias in the presence of non-zero censoring with the application to milk-market participation in the Ethiopian Highlands. Agricultural Economics. 2004;31:97-106.
31. Nkamleu GB, Tsafack R. On measuring indebtedness of African Countries. African Finance Journal. 2007;9(1):21-38.
32. Etim NA, Okon S. Sources of technical efficiency among subsistence maize farmers in Uyo, Nigeria. Journal of Agricultural and Food Science. 2013;1(4):48-53.
33. Abara IOC, Singh S. Ethics and biases in technology adoption: The small farm argument. Technology Forecasting and Social Change. 1993;43:289-300.
34. Fernandez-Cornejo J. The microeconomic impact of IPM adoption: Theory and application. Agricultural and Resource Economic Review. 1996;149-160.
35. Khai HV, Yabo M, Yokogawa H, State G. Analysis of productive efficiency of soya bean production in the Mekong River Delta of Vietnam. J. Faculty Agric. Kyushn University. 2008;53(1):271-279.
36. Aye GC, Mungatana ED. Technical efficiency of traditional and hybrid maize farmers in Nigeria: Comparison of Alternative Approaches. African Journal of Agricultural Research. 2010;5(21):2909-2917.
37. Etim NA, Thompson D, Onyenweaku CE. Measuring Efficiency of Yam (*Dioscorea spp*) Production among Resource Poor Farmers in Rural Nigeria. Journal of Agricultural and Food Sciences. 2013;1(3):42-47.
38. Udoh EJ, Etim NA. Cocoyam farms in AkwaIbom State, Nigeria. A stochastic production frontier approach. Journal of Sustainable Development in Agriculture and Environment. 2006;2:41-48.
39. Udoh EJ, Etim NA. Measurement of farm-level efficiency of waterleaf (*Talinum triangulare*) Production among City Farmers in AkwaIbom State. Journal of Sustainable Development in Agriculture and Environment. 2008;3(2):47-54.
40. Etim NA and Udoh EJ. The determinants of rural poverty in Nigeria. International Journal of Agricultural Management and Development. 2013;3(2):141-151.
41. Etim NA and Udoh EJ. Identifying sources of efficiency among resource poor indigenous vegetable farmers in Uyo, Nigeria. International Journal of Food and Agricultural Economics. 2014;2(1):33-39.
42. Etim NA, Edet GE. Factors determining Urban poverty of farming households in a Tropical Region. American Journal of Experimental Agriculture. 2014;4(3):322-335.
43. Nkamleu GB, Adesina AA. Determinants of chemical input use in peri-urban lowland systems: Bivariate probit analysis in Cameroon. Agricultural Systems. 2000;63:111- 21.
44. Chirwa EW. Adoption for fertilizer and hybrid seeds by smallholder maize farmers in southern Malawi. Development Southern Africa 2005;22(1):1- 12.
45. Chianu JN, Tsujii, H. Determinants of farmers' decision to adopt or not adopt inorganic fertilizer in the savannas of northern Nigeria. Nutrient Cycling in Agro Ecosystems. 2004;70(3):293-301.

46. Freeman HA, Omiti JM. Fertilizer use in semi-arid areas of Kenya: Analysis of smallholder farmers' adoption behavior under liberalized markets. Nutrient Cycling in Agro ecosystems. 2003;66(1):23-31.

47. Muhammed IJ. Efficiency analysis of cotton-wheat and rice: Wheat Systems in Punjab, Pakistan. Unpublished Ph.D Thesis, University of Agriculture, Faisalabad; 2009.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=738&id=2&aid=6889