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ADOPTION OF CHEMICAL FERTILIZER AS INFLUENCED BY FARMERS' SOCIO-ECONOMIC CHARACTERISTICS IN THE NORTH –WEST ZONE (NWZ) OF NIGERIA

M. G. MAIANGWA

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ABSTRACT

The study was conducted in the 2002/03 agricultural season in two States in the NWZ of Nigeria, namely, Kano and Katsina. The specific objectives were to: (i) Estimate the rates of adoption and application of inorganic fertilizer; and (ii) Determine farmers' socio-economic characteristics conditioning the adoption of inorganic fertilizer in the two selected States. The mean rates of adoption of inorganic fertilizer were 85.85% for Kano, 98.35% for Katsina, and 92.10% for both States. These rates of adoption were illustrative of a long history of exposure to fertilizer use. The mean rates of application of inorganic fertilizers were 41.49 kg ha^{-1} for Kano, 67.24 kg ha^{-1} for Katsina and 54.36 kg ha^{-1} for both States. These rates, however, fell short of the recommended chemical fertilizer nutrient levels for the staple food crops grown in the two States, indicating that their yield- and soil-enriching potentials were not fully realized. The results of the analysis of the socio-economic factors conditioning adoption of inorganic fertilizer showed that those significantly related with adoption included age, household size, education, membership of associations, farm size, off-farm income, extension contact and land security. Recommendations made included: the complementary applications of inorganic and organic fertilizers; training extension educators and other technical assistants to understand the factors conditioning adoption for more effective targeting and delivery of programmes; the education of the rural populace; encouraging membership of farmers' associations; the expansion of farm sizes; improved access to production credit; and the strengthening of existing extension systems.

KEY WORDS: Chemical fertilizer, adoption rate, application rate, adoption factors, Nigeria.

INTRODUCTION

Developing countries face the dual tasks of increasing agricultural productivity and ensuring sustainability of the resource base on which agriculture fundamentally depends (Ersado et. al., 2004). The usual means to achieve these goals are through public investments with financial support from government agencies or non-governmental organizations (Ersado et. al., 2004). Often, these investments take the form of incentives to adopt improved technologies, the argument being that growth in agricultural production should come from yield increases rather than area expansion (Eicher, 1994). For most sub-Saharan African countries, adoption of more efficient farming practices and technologies that enhance agricultural productivity and improve environmental sustainability, particularly as the land frontier is reduced under growing population pressure, remains the most practical option for achieving economic growth, food security, and poverty alleviation (Ersado et. al. 2004).

Over the past 25 years, the primary means of enhancing soil fertility in small-farm agriculture has been to use chemical fertilizers (Byerlee and Heisey, 1992). Given also the present knowledge, the limited scope for expanding cultivated area, the rapid rate at which food production must increase in developing countries, severe soil degradation, and the prospect that future increases in cereal production will mainly depend on increased crop yields, or what is known as "agricultural intensification," fertilizer will remain an essential input in meeting future food production requirements and farmers probably will have little choice but to depend heavily on external sources of nutrients in the foreseeable future (Desai, 1990; Byerlee and Heisey, 1992; Mitchell and Ingco, 1993; FAO, 1993; Pinstrup – Andersen and Pandya – Lorch, 1994; Rosegrant et. al., 1995).

The extension services and various change agencies have in one way or another introduced improved farm practices to a number of local communities in the northern States of Nigeria, but little is known about: (i) how these farm practices reach farmers; (ii) farmers' response to these farm practices; and (iii) which farmers adopt these practices and which do not (Voh, 1979).

Studies (Phillip *et. al.,* 2000; Idisi, 1990; Voh, 1979; Feder *et. al.,* 1985; Heisey and Mwangi, 1993) have shown that an important first step towards determining the impact of a technology on a target society is to obtain some idea about the rate of diffusion or adoption of the technology and its related components. This information, in addition to serving as input into future technology impact assessment processes, can also provide a useful feedback for strengthening the research-extension–farmer linkage. Besides, since changes in agricultural communities come about partly by the use of modern agricultural technologies, it is necessary to study the adoption of recommended farm practices by farmers. Similarly, though many producer technology adoption studies have been conducted in developing countries, the importance of factors affecting technology adoption differ across countries, on account of variations in natural resource endowments, as well as cultural, political, and socio-economic differences.

This paper broadly aims at providing information on the chemical fertilizer technology adoption behaviour of farmers in the north-west zone of Nigeria. The specific objectives are to: estimate the rates of adoption and application of chemical fertilizer and determine the socio-economic characteristics of farmers which influence the adoption of chemical fertilizer. The paper is divided into 4 sections. Section 1 is the introduction. Section 2 contains the methodology. The results and discussion are presented in Section 3 and the conclusion and recommendations in Section 4.

METHODOLOGY

The study was conducted in two States in the NWZ of Nigeria, namely: Kano and Katsina. These States are considered representative in terms of biophysical characteristics and population density for the larger part of northern Nigeria (Ogungbile *et. al.,* 1999). In addition, these States have a high agricultural production potential (NARP, 1995). The actual survey, however, took place in the Rano and Danbatta Agricultural Development Programme (ADP) zones of Kano State and the Funtua and Ajiwa ADP zones of Katsina State. The two ADP zones in each State were

M. G. Maiangwa, Dept. of Agricultural Econs. and Rural Sociology, Institute for Agric. Research, Ahmadu Bello Univ. Zaria, Nigeria

purposively selected, with one situated in the northernmost and driest parts of the State and the other in the southernmost and wettest parts (Table 1). These ADP zones have also served as benchmark sites for participatory researches and for collecting diagnostic data and validating new and improved technologies, with their results often extrapolated to other areas with similar agroecological and socio-economic conditions (Ogungbile *et. al.,* 1999). The units of analysis were the individual farm operators. The frames or lists of the farm operators were obtained from the Monitoring and Evaluation Units of each of the four ADP zones (Table 1). For each ADP zone, a sample of sixty farmers was randomly selected. Thus, a total sample size of two hundred and forty farmers was obtained. A structured questionnaire was used for the field interviews. The farm-level data, collected between 2002 and 2003, were basically on the socio-economic characteristics of the farm operators and the rates of application and adoption of inorganic fertilizer.

Table 1: Distribution of farmers in Kano and Katsina States of Nigeria.

State	ADP Zone	Relative climate	Headquarters of extension services	Total number of farmers in ADP zone	Number of farmers selected
Kano	I	Wet	Rano	34394	60
	II	Dry	Danbatta	35032	60
Katsina	I	Dry	Ajiwa	34543	60
	II	Wet	Funtua	34440	60

Source: Field survey (2002/03)

Calculation of inorganic fertilizer adoption rates

Three methods have been established in literature for the calculation of technology adoption rates. In one method, and where crops are involved, the adoption rate is the ratio of the land area under the technology of interest to the total area under the crop in reference, multiplied by 100 percent. Studies in this category include Akino and Hayami (1975), Ahmed and Sanders (1991) and Lopez –Pereira *et. al.* (1991). Adoption rates are computed within the broader objective of assessing the economic impact of research – generated technologies, and under the assumption that adoption follows some logistic trend or behaviour (Phillip *et. al.,* 2000). This assumption enables the researcher to project future adoption rates along a logistic curve, using observed adoption rates for some initial years of technology introduction (Phillip *et. al.,* 2000).

A second method refers to adoption as the use by farmers of a number of improved practices and is usually measured by an adoption score (number of improved practices used) or by an adoption quotient (number of improved practices used over total number of recommended practices) (Herdt and Capule, 1983). Scores may be arbitrarily scaled to arrive at some categorization of adoption, for example, low, medium and high (Ramaswamy, 1973).

The third method multiplies the ratio of adopting farmers to the total farmers in the sample by 100 percent (Floyd *et. al.,* 1999). This method is very popular because of its simplicity and is adopted in this study in computing adoption rates for chemical fertilizer in the study area.

Modelling farmers' decision to adopt chemical fertilizer.

The decision of a farmer to adopt inorganic fertilizer is influenced by a number of factors that include the biophysical conditions of the farm, certain characteristics of the farmer and the institutional setting under which the farmer operates (Rogers and Burdge, 1977; Coughenour, 1988; Zurek, 2004). In addition, farmers' perception of technology-specific characteristics are sometimes important in this respect (Adesina and Zinnah, 1993; Shiferaw and Holden, 1998). Commonly explored farm characteristics influencing adoption include farm size, land tenure and other biophysical traits (Rahm and Huffman, 1984; Nowak, 1987; Baidu-Forson, 1999). Household characteristics include gender, age, education of household head, family size and other demographic traits (Clark and Akinbode, 1968; Alao, 1971; Nkonya *et. al.,* 1997; Ersado *et al,* 2004). Institutional factors include credit constraints, availability of information, and availability of extension services (Clark and Akinbode, 1968; Alao, 1971; Voh, 1979; Atala, 1988; Ersado *et. al.,* 2004). Farmers' perception of technology-specific attributes include productivity, soil retention, sustainability, taste, yield, ease of cooking, ease of threshing, and tillering capacity (Norris and Batie, 1987; Ashby *et. al.,* 1989; Gould *et. al.,* 1989; Ashby and Sperling, 1992; Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Shiferaw and Holden, 1998). This study focuses on farmers' socio-economic characteristics influencing the adoption of inorganic fertilizer. The choice of explanatory variables is therefore based on an extensive review of factors affecting adoption of agricultural technologies in low-income countries as contained in innovation – diffusion literature for explaining adoption decisions. Two specific types of models, namely, the linear and the logarithmic models were tested. Compared to the other models such as the Translog, quadratic and square root models, the linear and logarithmic models are mathematically easier to manipulate and economically easier to interprete (Ranaivoarison, 2004). The linear and logarithmic models were separately run against farmers' socio-economic characteristics, namely, age, household size, education, membership of associations, farm size, credit, off-farm income, extension contact and land security. The definitions, units of measurement and hypothesized signs of the dependent and explanatory variables are given in Table 2.

Table 2: Variables used in the linear and logarithmic models and their units and expected signs

Variable	Unit	Expected Sign
Dependent variable: chemical fertilizer	Kg/ha	+
Independent variables:		
Age (X_1)	Years	-
Household size (X_2)	Number of persons	-
Educational level (X_3)	Years	+
Membership of association (X_4)	Years	+
Farm size (X_5)	Hectares	+
Credit (X_6)	Naira (₦)	+
Off-farm income (X_7)	Naira (₦)	+
Extension contact (X_8)	Number of visits	+
Land security (X_9)	Number of plots owned	+

RESULT AND DISCUSSIONS

Adoption and application rates of inorganic fertilizer

The adoption rates for inorganic fertilizer in Kano and Katsina States are shown in Table 3. The mean rates of adoption of 85.5 per cent for Kano, 98.35 percent for Katsina and 92.10 percent for the two States were both illustrative of a long history of exposure to fertilizers and also supportive of findings from other studies, (Voh, 1979; Enwezor *et. al.* 1989; Atala and Abdullahi, 1988; and Musa and Atala, 2004). Voh (1979) argued that modern fertilizer has generally been widely adopted because it has been in use for quite a long time and farmers have seen it and have been convinced of its effectiveness. He cited studies of Basu (1969) and Byrnes (1966) to have shown that if farmers are convinced of the value of an innovation, they will adopt it. A related argument by Enwezor *et. al.,* (1989) is that the first recorded indication of the potential values of inorganic fertilizers in Nigeria was in 1937 when it was shown that response of cereal crops to small applications of Farmyard Manure was matched by the use of single superphosphate (SSP) containing quantities of phosphate equivalent to that in the organic manure, and that, by the early 1930s, fertilizer recommendations, mostly based on research information, had been established for some of the important crops in Nigeria. Other researchers (Atala and Abdullahi, 1988; Musa and Atala, 2004) in separate studies in northern Nigeria found mineral fertilizer to be the most accepted technology with 100 percent users. The demand for fertilizer in itself is determined by its economic value at the farm level, most commonly measured by the benefit – cost ratio (Lele *et. al.,* 1989). The long history of fertilizer subsidy in Nigeria, dating back to 1937 may have also contributed to rapid growth in its use on a continuous basis (Akpoko and Yiljep, 2001). Some of the justifications for subsidies are that: they help poor farmers; encourage learning by doing; reduce the risk of using fertilizer, help overcome credit constraints; contribute to maintaining soil fertility; and offset disincentives caused by taxation of output (World Bank, 1986).

The rates of application of inorganic fertilizer in Rano, Funtua and Ajiwa zones (Table 3) are similar to those obtained for some selected villages in Kano and Katsina States by Ogungbile *et. al* (1999) during a Participatory Rural Appraisal (PRA) survey, conducted between September and October 1996 (Table 4). The application rate of 14.51 Kg ha^{-1} for Danbatta zone (Table 4) is, however, comparable to those estimated for the African continent of between 10 – 18 Kg ha^{-1} (Bumb and Banaante, 1996; FAO, 1997; Barbier, 1998). The application rates in individual locations and the mean rates in each State and in both States (Table 4) fell short of the recommended chemical fertilizer nutrient levels for some staple food crops; for example, sorghum requires 200 kg nutrient ha^{-1}, millet 100 – 200 kg nutrient ha^{-1} and maize 200 – 300kg nutrient ha^{-1} (Onwueme and Sinha, 1991; JARDA, 1996). The implication is that fertilizer use in the sampled locations is low compared with the requirements of crops. Barbier (1998) attributed the poor productivity of African agriculture to the comparatively low level of use of external inputs. Reardon et al. (1999) also pointed out that the low use of fertilizer across Africa as a major concern, from both the food-production and the environmental perspectives. The authors particularly argued that the widespread "capital-deficient" unsustainable intensification in Africa is a major force behind farmland degradation and productivity losses.

Table 3: Rates of adoption and application of chemical fertilizer in Kano and Katsina States.

State/Zone	Adoption (%)	Application(kg ha^{-1})
Kano:		
Rano	96.7	68.46
Danbatta	75.0	14.51
Mean	**85.85**	**41.49**
Katsina:	100.0	51.62
Funtua	96.7	82.85
Ajiwa	**98.35**	**67.24**
Mean	**92.10**	**54.36**
Mean (both States)		

Source: Field survey (2002/03)

Table 4: Fertilizer quantities used by farmers in Kano and Katsina States of Nigeria (PRA Survey 1996).

State/Village	Inorganic Fertilizer (kg ha^{-1})
Kano:	
Kofa	68.1
Panda	77.3
Badume	95.0
Mean	**80.1**
Katsina:	
Gora	70.6
Rimaye	114.0
Barhim	58.5
Mean	**81.03**

Source: Ogungbile *et. al.,* (1999.)

Factors influencing the adoption of inorganic fertilizer

The results of the Ordinary Least Squares (OLS) regression model indicating farmers' socio-economic factors influencing the adoption of inorganic fertilizer are shown in Table 5. All the variables included in the OLS models were found to be similar in the adoption of chemical fertilizer, but significantly ($P<0.05$) different in the various locations (Table 5). The age variable was significantly related with adoption of inorganic fertilizer in Funtua. The age variable has a negative sign, suggesting that adoption rate was higher among younger farmers. This was expected because younger farmers are more productive and innovative and are therefore much more likely to adopt inorganic fertilizer (Feder *et al.,* 1986). Previous researches (Norris and Batie, 1987; Gould *et al.,* 1989; Bellon and Taylor, 1993; Voh, 1979) have indicated that older farmers seem to be somewhat less inclined to adopt new farm practices than younger ones and that older farmers are more likely to reject productive and conservation practices. A number of studies (Voh, 1979; Hoover and Wiitala, 1980; Akpoko and Yiljep, 2000; Manyong *et. al.,* 2000) have shown age to have a negative influence on adoption. These results are at variance with those of Liao 1968; Mangahas, 1970; Suh, 1976; Islam and Halim, 1976; Chinnappa, 1977; and Yim, 1978), who found adoption to be generally unrelated to farmers' age.

The household size variable was significantly related with adoption of chemical fertilizer in Funtua zone (P<0.01) and Ajiwa zone (P<0.05). The negative sign for household size implies that the larger the household, the lesser the adoption. This might be because larger households attach greater importance to food security than smaller ones, hence will commit less resources to the adoption of inorganic fertilizer. Similarly, Shiferaw and Holden (1998) found that, for a given land-man ratio, households with large families may perceive a higher risk of starvation than those with smaller families, and that if crops fail due to bad weather, households with larger families will suffer more and would therefore be much less inclined to invest resources in inorganic fertilizer. These results are in contrast with that of Bhati (1975) who found a positive effect of household size on adoption and those of Suh (1976), Yim (1978) and Flinn et. al. (1980) who found no significant impact of household size on adoption. Yim (1978) specifically reported that household size is an insignificant variable in fertilizer use.

The education variable was significantly (P<0.05) related with adoption in Funtua zone (Table 5). A positive coefficient for education implies that adoption increases with higher levels of educational attainment. The fact is that higher educational levels are associated with greater information on conservation measures and ways of raising agricultural productivity as well as higher management expertise (Hoover and Wiitala, 1980; Ervin and Ervin, 1982; Feder *et. al.,* 1985). Some researchers (Voh, 1979; Rogers, 1983; Rahm and Huffman, 1984; Atala, 1984; Kebede et.al., 1990; Adesina and Seidi, 1995; Norris and Batie, 1987; Pender and Kerr, 1996; Saito, 2004) found a positive relationship between education and adoption of technologies and soil conservation efforts.

The membership of associations variable was significantly (P<0.05) related with adoption in Funtua zone. A positive sign for the membership of farmers' groups suggests that the longer the membership of farmers' groups, the greater the level of adoption. Membership of associations enhances access to information on improved technologies, material inputs of the technologies such as chemical fertilizer, as well as credit for the purchase of inputs (Njoku, 1990; Akpoko and Yiljep, 2000). Studies (Sajise and Ganapin, 1991; Gabunada and Barker, 1995) showed that membership in farmers' groups was positively related with adoption.

The farm size variable was significantly (P<0.01) related with adoption only in Ajiwa zone. A positive sign for the farm size variable implies that adoption increases with expansion in farm size. It was found that farm size is often correlated with peasant wealth that may help ease liquidity constraints (Shiferaw and Holden, 1998). In effect, wealthier farmers are more likely to apply expensive fertilizer on their farms than poorer farmers (Nkonya et. al., 1997). In addition, large farmers generate more income which provides a better capital base and enhances risk-bearing ability than poor farmers (Asaduzzaman, 1979; Sarap and Vashist, 1994). Previous researches (Ervin and Ervin, 1982; Feder and Slade, 1984; Norris and Batie, 1987; Gould et. al., 1989; Polson and Spencer, 1991) found a positive role of farm size on conservation decisions.

The credit variable was significantly (P<0.01) related with adoption of inorganic fertilizer only in the pooled results for the four sampled locations. A positive coefficient for credit indicates that the greater the supply of credit, the higher the adoption of inorganic fertilizer. The fact is that the availability of credit either in cash or kind enhances farmers' ability to purchase or acquire inorganic fertilizer (Akpoko and Yiljep, 2000). Some researchers (Njoku, 1990; Chikwendu et.al, 1993; Agada et.al., 1991; Akpoko and Yiljep, 2000) found credit to be positively associated with adoption of farm practices.

The off-farm income variable was significantly (P<0.05) related with adoption of chemical fertilizer in Funtua zone as well as in the pooled results. The negative coefficient for off-farm income implies that an increase in off-farm income is accompanied by a reduction in the level of adoption. The reason is that off-farm investments may crowd out resources for land-quality improvement and that increased dependence on non-agricultural activities may translate into a shift of interest away from farming (Shively, 1997; Shiferaw and Holden, 1998).

The extension contact variable was significantly (P<0.01) related with adoption of chemical fertilizer in Ajiwa zone. The positive sign for extension contact means that adoption increases with greater extension contact. Extension contacts, by exposing farmers to availability of information, stimulate adoption (Voh, 1979; Kebede et. al., 1990; Polson and Spencer, 1991).

The land security variable was significantly (P<0.01) related with adoption in Ajiwa zone and in the pooled results for the locations. The negative coefficient for the land security variable implies that more ownership of land is associated with lower levels of adoption. The reason is that the improved access to credit and liquidity from assured security of use rights over land makes low-income households much more inclined to invest on more profitable non-agricultural ventures than in farm technologies.

Table 5: Estimates of regression model explaining farmers' socio-economic characteristics influencing adoption of inorganic fertilizer.

Variables	Rano (Linear)	Danbatta (Double-log)	Funtua (Double log)	Ajiwa (Double-log)	Pooled (Double-log)
X_1	-2.84298	0.46589	-2.04581*	-0.41777	-1.30579**
	(1.89534)	(0.40509)	(0.85459)	(0.38923)	(0.45334)
X_2	-1.37571	-1.13083	-0.68856*	-0.51918**	-0.49362**
	(3.71441)	(0.12764)	(0.28314)	(0.13739)	(0.14538)
X_3	-5.94942	-0.07043	0.11774*	0.03551	0.03532
	(3.84858)	(0.02651)	(0.05760)	(0.02300)	(0.03040)
X_4	8.17083	-0.04706	0.14932**	0.01115	0.06138*
	(3.91300)	(0.03326)	(0.05455)	(0.02345)	(0.03035)
X_5	12.57648	0.44270	0.23095	0.27290**	0.42239**
	(10.26023)	(0.15634)	(0.20189)	(0.09393)	(0.13294)
X_6	0.01171	0	0.01166	0.02748	0.08325**
	(0.00366)	(0)	(0.02962)	(0.01769)	(0.02287)
X_7	0.00018850	-0.03403	-0.04946*	0.00274	-0.03911**
	(0.00025353)	(0.01697)	(0.02076)	(0.01017)	(0.01174)
X_8	-6.45984	0.02624	-0.02929	0.16535**	0.01054
	(5.19081)	(0.05887)	(0.11034)	(0.05649)	(0.06360)
X_9	-24.16039	-0.60204	-0.01639	-0.48053**	-1.03349*
	(16.28407)	(0.23397)	(0.31044)	(0.13015)	(0.15366)
Intercept	193.38871	3.34436	13.67814	6.13898	10.15527
	(86.15886)	(1.49009)	(2.82829)	(1.41413)	(1.56761)
R^2	0.3689	0.8816	0.6835	0.6621	0.4155

* = Significant at 5%
** = Significant at 1%
Source: Field survey (2002/03)

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The paper investigated the rates of adoption and application of inorganic fertilizer and farmers' socio-economic characteristics which influence its adoption in the north-west zone of Nigeria. Though adoption rates of inorganic fertilizer varied by location, the calculated rates of adoption (Table 3) were a confirmation of the importance of chemical fertilizer as a crucial ingredient in the process of increasing agricultural productivity. The computed rates of application of inorganic fertilizer (Table 3) were, however, much lower than the recommended rates of application, thus indicating that its yield-and soil-enriching potentials were not fully realized. Some of the farmers' socio-economic characteristics included in our model (Table 5) influenced the adoption of chemical fertilizer, thereby supporting recommendations made in this study. The following recommendations are important:-

(1) Given that chemical fertilizer requirements for crops were not met by farmers (as application rates fell short of the recommended rates), the complementary applications of both inorganic and organic fertilizers will be very useful in increasing crop productivity. Vanlauwe et. al. (2002) reported positive interactions between urea and use of stover and other organic applications, while Nhamo (2001) observed added benefits from manure and ammonium nitrate combinations.

(2) Having established that the socio-economic characteristics of farmers affected the adoption of inorganic fertilizer, extension educators and technical assistants involved in agricultural development need to understand these factors in order to target and deliver effective programmes. A knowledge of these factors is also necessary for designing policies and strategies that promote the adoption and use of inorganic fertilizer and related agricultural technologies.

(3) The significant relationship between the education variable and the adoption of inorganic fertilizer in this study, makes the education of the rural populace particularly necessary. Education raises the productivity of farmers in the agricultural sub-sector, increases the rate of return to investments in new production and conservation technologies and facilitates the adjustment of labour out of the agricultural sector. The improvement of the literacy skills of farmers and farm workers alike will allow for proper handling and application of inorganic fertilizer.

(4) The significant relationship between membership of farmers' associations and adoption of inorganic fertilizer suggests that efforts be made to encourage greater and longer membership of farmers' groups. Farmers' cooperative associations provide farmers with many production supplies for their farm operations such as fertilizers, feed, seeds, farm chemicals; help market members' products, and also provide services related to the production and marketing of farm commodities such as credit, irrigation, pest management, and plant and animal research. It is easier for government assistance to reach widely dispersed smallholders when they organize themselves properly into coherent groups such as cooperatives. These associations also serve as media for wider and cheaper dissemination of information on new technologies (Njoku, 1990).

(5) The significant effect of farm size on adoption of inorganic fertilizer, means that expansions in existing farm sizes through purchases of additional land, or the consolidation of existing holdings are important. As a factor of production and a store of wealth, land provides collateral and is one of the few sources of credit and liquidity for poor farmers.

(6) The significant influence of credit on adoption of inorganic fertilizer makes improved access to production credit with low transaction costs an important requirement. Inorganic fertilizer options are commonly less affordable to cash – strapped households than organic nutrient systems. The terms of credit should reflect the fact that much of the returns to land-conserving technologies accrue over a long time. This is particularly critical because many studies have found that poor farmers' inability to access mineral fertilizers has adverse consequences on soil fertility and incomes (Soule and Shepherd, 2000). Thus, credit arrangements and other means of assisting farmers to make necessary capital improvements should be designed so that society shares some portion of the cost with farmers, since some of the long-term benefits of resource conservation will also be enjoyed by society (Jayne et al., 1989).

(7) The significant effect of extension contact on adoption of inorganic fertilizer is indicative that extension systems must be strengthened to increase farmers knowledge and understanding of mineral fertilizer sources in a timely and accurate manner using the most appropriate communication and training methods. Eliciting information about farmers' concerns and problems with these technologies and conveying same to research and technology-development centres will also be important.

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