Research Article

Logit and Tobit analyses of the determinants of likelihood of adoption and extent of adoption of improved soybean seed in Borno State, Nigeria

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ABSTRACT

This study examined the determinants of adoption of improved soybean seeds among farmers in southern Borno State, Nigeria. Data for the study were obtained from 360 respondents selected through multi-stage sampling procedure. Inferential statistical techniques namely the Logit model and the Tobit model were used to estimate the likelihood of technology adoption among respondents and the extent of adoption of improved soybean seeds by the respondents, respectively. Yield of soybean and distance to source of improved seeds were statistically significant factors (ρ ≤ 0.01) that influenced the likelihood of adoption of improved soybean seeds among the respondents. Farm size and distance of respondents to source of improved soybean seeds were statistically significant factors (ρ ≤ 0.01) that influenced the extent of adoption of improved soybean seeds among the respondents. Based on the findings of this study, it is recommended that improved technologies in the form of high yielding seeds varieties should be made available to farmers. Farm service centers should be established within reasonable distance from farming communities. This is the bring technologies closer to farmers, thereby reducing the risks that farmers have to encounter to get farm inputs.

Keywords: Analysis, Determinants, Adoption, Improved seeds, Nigeria.

INTRODUCTION

Various studies on the factors affecting the adoption of agricultural innovations in developing countries have been conducted (Asfaw and Admassie, 2004). For instance, Bamire *et al.* (2002), Asfaw *et al.* 1992, Isham (2002), Kristjanson *et al.* (2005), Ajibefun (2006), Onu (2006) and Ojiako *et al.* (2007) have conducted various studies to examine the factors that influence the intensification of adoption of different types of technologies. In a separate study, Feder *et al.* (1985) claimed that socio-economic factors, technology characteristics and institutional factors all influence farmers' decision to use a given technology as well as the intensification of the technology use. Ouma *et al.* (2006) suggested that the use of improved technologies would continue to be a critical input for improved farm productivity. They also suggest that to improve production through the adoption of improved technologies, it is important to understand the factors which determine the adoption and intensity of use of the improved technologies. This is because the development of adoptable technologies for farmers requires an understanding of the farmers' conditions and priorities (Smith *et al.,* 1995). For instance, Seyoum *et al.* (1998), Obwona (2000) and Ajibefun (2006) found that the impact of socio-economic characteristics of farmers on adoption of recommended technologies was enormous. Adesina and Zinnah (1993) also reported that farmers' perception of the technology-specific attributes was influential in determining the adoption and use of such improved technologies among farmers in the mangrove swamps of Sierra Leone. Other factors which occur at higher system levels as recognized by Smith *et al.* (1995), Weir and Knight (2004) and Ajibefun (2006) include government policies such as credit accessibility by farmers and accessibility to markets which all influence the adoption of improved technologies.

Soybean might have been introduced into Nigeria as early as 1908 (Sanginga *et al.,1999)* but its cultivation as a crop can be traced to the introduction of the Malayan variety in 1937 by the British colonial officers into a region known today as Benue State (Singh *et al.,1987).* With the development of improved varieties, commercial production of soybean has expanded beyond its "traditional home" and the total land area under cultivation for soybean in Nigeria increased from 335,000 hectares (ha), 349,000ha, 383,000ha, 402,200ha, 467,000ha to 532,000ha for the years 2000 to 2005, respectively (RMRDC, 2004).

Livelihood strategy for most people in Borno State is based on agriculture. Farming is characterized by a variety of crops and livestock-based production systems. In line with this, a lot of extension activities have been going on for many years on the need for farmers to adopt agricultural technologies such as improved seed varieties. However, due to conditions such as inappropriate technologies and/or poor socio-economic background, not all farmers are adopting these technologies. In recognition of this, the Promoting Sustainable Agriculture in Borno State (PROSAB), a programme sponsored by the Canadian International Development Agency (CIDA) introduced four varieties of improved soybean seed to the study area, namely: TGX 1448-2E which is appropriate for the southern Guinea Savanna and northern Guinea Savanna; GTX 1485-1D which is appropriate for Sudan Savanna; TGX 1830-2E which is, also, appropriate for the Sudan Savanna; and TGX 1904-6F which is appropriate for the southern Guinea Savanna. However, there has not been any empirical study on the level of adoption of the soybean technology by farmers conducted by an individual or organization outside the agency implementing the programme (i.e. PROSAB). This study is therefore designed to provide empirical information on the level of adoption of improved soybean production technology, focusing mainly on the adoption of improved soybean seeds, as well as the determinants of the adoption of such technology by farmers in southern Borno State.

The broad objective of the study was to analyze the determinants of adoption of soybean production technology by farmers in Southern Borno state. The specific objectives of the study were to: 1) investigate the factors that influence the likelihood of adoption of improved soybean seed as production technology among farmers in the study area; and 2) determine the factors the influence the extent of adoption of the improved soybean seed as production technology among farmers in the study area.

METHODOLOGY

The study was conducted in the southern part of Borno State, Nigeria, comprising the three Local Government Areas (LGAs) where soybean was being promoted as a commercial crop by PROSAB, namely- Biu, Hawul and Kwaya-Kusar. The LGAs lie between latitudes 10^0 30'N and 11^0 30'N and between longitudes 12^0E and 13^0 30'E (Ajaegbun *et al. 2000*). Within the state, the study area is bordered by Damboa LGA to the North, Chibok and Askira/Uba LGAs to the East, Bayo and Shani LGAs to the South. Within the country, the study area is bordered by Adamawa state to the Southeast and Yobe state to the West.

Sampling Procedure and data collection

Multi-stage random sampling techniques were employed to select respondents for the study. Soybean farmers in the three LGAs in Borno State where soybean is being promoted as commercial crop formed the population for the study. In the first stage, the three LGAs were purposively selected. In the second stage, four soybean-producing communities were purposively selected from each of the Biu and Hawul Local Government Areas while one soybean-producing community was also purposively selected from Kwaya Kusar Local Government Area. The third stage involved selecting proportionate number of respondents from each of the nine communities earlier selected for the study. The selection of respondents at this stage was done randomly. Three hundred and sixty respondents were finally used for the study. Data for the study were obtained mainly from primary sources. The researcher was assisted in the process of data collection by field enumerators who were trained for that purpose.

Analytical Techniques

The inferential statistics were used to analyze the data for the study. The Logit regression model was used to establish relationship between the likelihood of adoption of improved soybean seed as production technology and the various factors affecting it. The Tobit regression model was used to establish the relationship between the extent of adoption of improved soybean seed as production technology and the various factors affecting it. The decision of a farmer to use improved technology is complex and can be modeled as consisting of two mutually exclusive processes. The first involves making the decision to adopt the technology as production technology in the first place, while the second involves deciding on the level i.e. the intensity or extent of use of that technology, given that adoption has taken place (Sall *et al.*, 2002*;* Shiyani *et al.*, 2002; Wabbi *et al.*, 2006*)*.

Theoretically, the Logit model is expressed as:

$$\mu = B_0 + B_1X_1 + B_2X_2 + \ldots\ldots\ldots B_nX_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where:

μ = Likelihood of Adoption, otherwise labeled as ADOPT. It is quantified as:
Adopter = any farmer that devoted at least 10% of his/her land for soybean production; and
Nonadopter = any farmer that devotes less than 10% of his/her land for soybean production, as used by Ojiako *et. al*., (2007).

B_0 = intercept;
$B_{1........n}$ = estimated parameters;
$X_{1........n}$ = Set of independent variables.

In its simplest form, the Tobit model is presented as:

$$\mu^*_i = B_{xi} + \mu \ldots\ldots (3.4)$$

Algebraically expressed for the i_{th} farmer,

$$\mu_i = B_0 + B_1X_1 + \text{------} B_NX_N \qquad i = 1\ldots\ldots N \ldots\ldots (3.5)$$

$$\mu_i = \begin{cases} 0 \text{ if } \mu^* \leq T \\ \mu^*_i \text{ if } 0 < \mu^* < 1 \qquad (i = 1,\ldots..n) \ldots\ldots (3.6) \\ 1 \text{ if } \mu^*_i > T \end{cases}$$

where: ♣

μ_i = the observed dependent variable *i.e.* the total land area under improved soybean cultivation measured in hectares;
μ^*_i = the non observable latent variable representing the use of soybean variety;
T = the critical (cut off) value which translates into $\mu^*_i > T$ as a farmer adopts, and $\mu^*_i < T$ as a farmer rejects the improved soybean technology; and
n = the number of observations.

The model is appropriate in: 1) explaining relationships involving a continuous dependent variable and a set of independent variables (Akinola, 1987; Bamire *et al*., 2002; Sall *et al., 2002*); and 2) studying decisions where error terms are truncated or censored (McDonald and Moffit, 1980). The advantage of the Tobit model over the dichotomous choice models such as the Probit model (Finney, 1971) and the Logit model (Aldrich and Nelson, 1984) is that it permits determining the intensity of use of technology once adoption has taken place.

RESULTS AND DISCUSSION

Socioeconomic factors influencing the likelihood of adoption of improved soybean seed

To identify factors which influence the likelihood of adoption of improved soybean variety among farmers in the study area, the Logit model was estimated. The maximum likelihood estimates of the Logit model are presented in Table 1. The following factors were statistically significant at 1% and 5%.

Farm size: The coefficient of farm size was found to be significant (p≤0.05) but negatively related with the adoption of improved soybean seed in the study area (Table 1). This confirms the report that small farmers, in comparison to large farmers, adopt improved technologies at a faster rate if additional gains are substantial (Shiyani *et al*., 2002). This is likely due to two reasons. First, small farmers live at subsistence level that attracts them to adopt improved varieties which give better yields, earn more income and thereby helping in raising their standard of living. Secondly, limited availability of improved seeds might have compelled large farmers to partly continue producing alternative

♣ Bamire *et al*., 2002; Sall *et al*., 2002; Ouma *et al*., 2006 used μ as "Intensity of use". But for this study, μ was used as "Extent of use".

crops or recycled local seeds. As a result, they lagged behind in adopting improved seed. This agrees with the findings of Allaudin and Tisdell (1988) that small farmers adjust quickly and adopt new innovations at a faster rate than large-scale farmers.

Farming experience: The coefficient of farming experience was found to be significant at 5% in influencing the decision to adopt improved soybean seeds (Table 1). This is expected because more experienced farmers may have better skills and access to new information about improved technologies. It could also imply that knowledge gained over time from working in uncertain production environment may help in evaluating information thereby influencing their adoption decision. The fact that overwhelming majority (83.90%) having at least two years experience as soybean farmers implied that there is likelihood that adoption will spread beyond the current production area.

Expenditure on labor: There was positive and significant relationship ($\rho \leq 0.05$) between farmers' expenditure on hired labor and adoption of improved soybean seeds in the study area. This means that soybean farmers who had resources to engage the services of hired labor were more likely to adopt improved soybean as a production technology compared with farmers who depended solely on the family labor. The fact that the family labor, even though it constitutes a bulk of the labor force used in agriculture in Nigeria, is not readily available for farm operations (Bamire and Manyong, 2003). Consequently, soybean farmers who could afford to hire labor will tend to maximize returns on investment in soybean farming. This can trigger adoption of improved soybean seed among other production technologies.

Table 1: Logit Estimates of Factors Influencing the Respondents' Likelihood of Adoption of Improved Soybean Seeds

Likelihood of Adoption	Coeficient	Std. Error	Z	P> |z|	(95% Conf. Interval)	
Age	-.0108678	.0091023	-1.19	0.232	-.0069723	.028708
Sex	.4067453	.2688421	1.51	0.130	.9336661	.1201756
Education	.0299189	.0700357	0.49	0.669	.1073486	.1671863
Household size	.0390558	.0293156	1.33	0.183	.0965134	.0184017
Farm size	-.6723619	.2962722	-2.27	0.023**	-1.253045	-.0916791
Farming experience	.2033259	.1127525	1.80	0.071**	.0176649	.4243168
Use of hired labor	.2903237	.291032	1.00	0.318	.860736	.2800886
Expenditure on labor	.0000249	.0000115	2.15	0.031**	2.23e-06	.0000475
Membership of farmers' organization	.1346071	.4127561	0.33	0.744	.67438	.9435942
Use of soybean	1.115597	.494053	2.47	0.014**	1.022848	1.216756
Maturity period	-1.369532	.3474143	-1.24	0.015**	-.8329999	2.251644
Yield of Soybean	1.000661	.00016	4.13	0.000***	1000047	1.000974
Distance to source of technology	-.0005517	.00017	-3.25	0.001***	-.0002721	.0008312
Extension contact	.4753018	.3217224	1.40	0.140	.0538844	1.004488
Frequency of extension visit	.0708751	.0740705	0.96	0.339	.0509601	.1927102
Access to credit	.7806627	.3682025	2.12	0.034**	.1750236	1.386302
Distance to output market	-.0199806	.2001927	-0.10	0.920	-.3492682	.3093071
Constant	.8819395	.3605838	2.45	0.014**	1.475074	.288832

*****= Significant at 1%**
****= Significant at 5%**

Technology-specific factors influencing the likelihood of adoption of improved soybean seed

Among the technology-specific characteristics considered for the study, the results showed that: 1) respondents' utilization of soybean at household level; 2) maturity period of soybean; and 3) yield of soybean were found to be significant ($\rho \leq 0.05$) in influencing the decision to adopt improved soybean as production technology (Table 1). Results from the study showed that virtually all farmers in the study area use soybean at household level. Soybean is rich in protein (Sanginga, *et al.*, 1999), which is commonly deficient in the diet of most rural communities. This implies that soybean has come to the aid of many households in the study area as a cheap source of protein. Given that majority of the population in the study area is engaged in farming, it is obvious that they will plant soybean on their farms even if only to meet their household needs. This agrees with earlier findings by Sanginga *et al.*, (1999) that household utilization formed a major reason for the adoption of soybean in Benue State. Maturity period was also found to be an important determinant influencing the adoption of improved soybean seed as production technology in the study area. The variable was significant at 5% probability level with negative sign. This is expected as early maturity gives the crop an advantage, especially in the study area which is prone to drought. One of the characteristics of the ecology of the study area is the dry hamatan wind which sets in at the end of the rainy season, thereby facilitating pod shattering (Sanginga *et al.*, 1999). Early maturity therefore enables soybean crop to escape pod shattering, pest infestation and terminal drought due to receding soil moisture. As such, the probability of adoption of soybean increased with decrease in its maturity period. Yield of soybean was also found to be a very important factor that influenced the adoption of improved soybean seed among farmers in the study area. The yield variable was found to be positive and significant at 1% level of probability. Yield is a direct measure of seed's performance and a crop variety that is high yielding stands to be adopted by farmers since high yield would raise output and subsequent income. This finding agrees with Ojiako, *et al.*, (2007) that yield of soybean was significant in influencing the adoption of improved soybean in northern Nigeria. Adesina and Zinnah (1993) also reported that yield significantly influenced farmers' decision to adopt improved mangrove swamp varieties of rice in Sierra Leone.

Institutional factors influencing the likelihood of adoption of improved soybean seed

Distance to source of technology: Result in Table 1 further revealed that distance to source of technology was important in influencing the decision to adopt improved soybean seed by the respondents. Proximity to source of technology such as improved seed varieties can be an important factor in determining the likelihood of adoption, especially in developing countries where linkage to extension services is weak. Farmers that are close to sources of improved technologies take the advantage of their proximity and tend to adopt the innovations compared to farmers that are far away from the sources of the technologies. With particular reference to the study area, poor road network coupled with difficult terrain make movement difficult. Such difficulty inhibits communication and accessibility of farmers to technologies. As such, bringing technologies closer to farmers will increase the likelihood of adoption of such technologies.

Access to credit: Table 1 also revealed that access to credit was found to be important in influencing the likelihood of adoption of improved soybean seed among farmers in the study area. The variable was found to be statistically significant ($\rho \leq 0.05$) and positively related with the likelihood of adoption. Most farmers fear trying improved technologies because they do not have the necessary financial resources to adopt the technologies (Ouma *et al.*, 2006; Omolehin *et al.*, 2007). This is partly explained by the fact that most agricultural technologies require complementary inputs such as fertilizers and pesticides. These complementary inputs are difficult to come by due to the cash-trapped nature of farmers (Idrisa and Ogunbameru, 2008). Access to credit helps farmers out of their predicaments thereby influencing them to adopt innovations.

Socio-economic Factors Affecting the Extent of Adoption of Improved Soybean Seeds

The extent of use of improved soybean seeds by farmers in the study area was also examined, using the Tobit model statistical analysis. Extent of use was measured in terms of percentage of land allocated to improved soybean variety by farmers. The study revealed that some socio-economic factors, such as educational level, household size and farm size (Table 2) were significant in influencing the intensity of adoption of improved soybean seeds by farmers in the study area.

Level of Education: Table 2 shows that the level of education of the respondents was a very important factor ($\rho \leq 0.01$) that influenced the extent of adoption of improved soybean seeds as production technology in the study area. The positive and significant relationship between level of education and extent of adoption of improved soybean seed as production technology in the study area agrees with earlier studies (Feder *et al.*, 1985; Awe 1999) that literacy level positively influenced the intensity of use of fertilizer technology in southwestern Nigeria and Berkeley, USA, respectively.

Household size: Results in Table 2 also reveal a positive and significant relationship between household size and the extent of adoption of improved soybean seed as production technology in the study area. The value was significant at 5% level of probability. Family size has been recognized (Bamire *et al.*, 2002) to play a vital role in the adoption of any particular technology or farm practice. On the one hand, family provides the human labor and management inputs. This can affect the level of use of technologies in terms of quality of management decision and the availability of labor required by the technology in question. On the other hand, family size can create certain demand which may motivate the adoption of new practices or technologies that would increase the farmers' income as a means of meeting these demands. Further more, household size has the effect of encouraging farmers to improve their earning capacity because some family members would tolerate certain levels of unfavorable conditions created by channeling family resources into investment in improved technologies. This therefore puts such families in a financially advantageous position to have more resources for investment in improved farm practices (Agbamu, 2006), including the adoption of improved practices.

Farm size: Table 2 also shows positive and significant relationship between size of farm holding and the extent of use of improved soybean seed. The regression value was positive and significant at 1% level of probability. Farm size has bearing on the capacity of farmers to adopt improved technologies and new farm practices. Farmers with large farm size can afford to devote part of their farms for soybean production without significantly affecting the total land left for the production of the staple food crops compared to small land holders. Land size is also one of the indicators of the level of economic resources available to farmers (Ajibefun, 2006).

Table 2: Tobit Estimate of Factors Affecting the Extent of Use of Improved Soybean Seeds

Intensity of use	Coeficient	Std. Error	T	P> |z|	(95% Conf. Interval)	
Age	-.0662221	.0750605	-0.88	0.378	-.21385	.0814058
Sex	.7269799	2.296931	0.32	0.752	5.244548	3.790588
Education	1.65632	.5433203	3.05	0.002**	2.724914	.5877256
Household size	.5401261	.2298583	2.35	0.019**	.9922079	.0880444
Farm size	15.17621	2.017178	7.52	0.000***	11.20885	19.14356
Farming experience	1.302795	.9984473	1.30	0.193	3.266525	.6609362
Use of hired labor	.8471137	2.118291	0.40	0.689	5.013335	3.319108
Expenditure on hired labor	.0000427	.0000762	0.56	0.576	.0001071	.0001925
Membership of farmers' Organization	4.923856	3.183491	1.55	0.123	11.1851	1.337386
Maturity Period of soybean	-1.732366	2.308459	-0.75	0.453	-6.272254	.1484227
Yield of soybean	.0040069	.0011632	3.44	0.001**	.0017193	2.807522
Extension Contact	8.826182	2.878412	3.07	0.002**	14.48707	3.165299
Frequency of extension Visit	1.141709	.6631103	1.72	0.086*	2.445827	.1624095
Access to Credit	.2220161	3.075641	0.07	0.042**	6.270784	5.826752
Distance to output Market	-2.328888	1.779705	-1.31	0.192	-1.171201	5.828978
_Constant	31.94425	3.176542	10.06	0.000***	25.69507	38.19146

****= Significant at 5%**
*****= Significant at 1%**

As such, farmers operating large farm holdings tend to have greater financial resources, incentives and access to information, hence more land allocated to improved technologies. These form some of the reasons why intensity of use of improved soybean seed is positively and significantly related to the adoption of improved soybean seed.

Technology-specific factors influencing the extent of adoption of improved soybean seeds

Yield of soybean: The results also revealed a positive and significant relationship between yield of soybean and the extent of adoption of soybean seeds. The result was significant at 5% level of probability (Table 2). Yield is a primary measure of seed performance (Shiyani *et al.*, 2002; Kristjanson *et al.*, 2005). Crop varieties that have high capacity to yield high stands a better chance of being adopted as well as being used intensively by farmers. The higher the yield from a crop variety, the higher will be the marginal returns to investment in seed, and hence higher income. This forms an incentive for expanding land area under improved variety.

Institutional factors influencing the extent of adoption of improved soybean seed

Distance to source of technology: Results in Table 2 revealed that distance to source of technology had a negative and significant influence on the extent of adoption of improved soybean seed by farmers ($\rho \leq 0.01$). The negative sign of the coeficient implies that farmers who live closer to the source of technology are more likely to adopt the technology and are also more likely to use more of the technology compared to farmers who live farther away from the source of technology. One possible explanation for such trend is the level of risk which tends to increase with increase in distance to source of technology.

Access to extension services: Access to extension services ($\rho \leq 0.05$) and frequency of contact between farmers and extension personnel ($\rho \leq 0.01$) positively and significantly influenced the extent of adoption of improved soybean seed by the respondents. Extension contact determines the information that farmers obtain on production activities and the application of innovations through counseling and demonstrations by extension agents. The effect of exposure to extension programmes is enormous. For instance, Onu (2006) found that farmers who had access to extension contact adopted alley farming technologies 72% greater than farmers who had no access to extension contact. This could be because increased farmers' interaction with extension personnel in the form of multiple visits by extension agents, and technical support to farmers greatly increases farmers' knowledge of available technologies and their potential benefits, hence acting as a trigger mechanism for intensive adoption. The result agree with the findings in the case of improved cassava in southwestern Nigeria (Polson and Spencer, 1991); adoption of research results and agricultural technologies among cocoa farming households in Oyo State, Nigeria (Lawal and Oluyole, 2008) and improved maize in northern Tanzania (Nkonya *et al*., 1997).

Access to credit: It is also evident from Table 2 that access to credit had positive and significant influence on the extent of adoption of improved soybean seed by the respondents ($\rho \leq 0.05$). Farm households having access to credit planted more area under improved soybean seed compared to farming households who had no access to credit. Part of the reasons for this is that input technologies such as improved seeds are costly. Cash is needed to purchase the seeds as well as complementary inputs where necessary. This explains why access to credit is often observed as an important determinant of the adoption of improved technologies (De Castro and Teixera, 2006; James *et.al*., 2006). It is also evident from this study that majority of farmers do not have access to credit.

CONCLUSION AND RECOMMENDATIONS

Despite the few constraints associated with the adoption of improved soybean seed in the study area, its adoption and the intensity of its use were generally a success. Farming experience of respondents, expenditure on hired labour and maturity period of soybean influenced the likelihood of adoption of improved soybean seed in the study area. Level of education of respondents, household size, access to extension services and frequency of extension contact all influenced the intensity of adoption of improved soybean seed among respondents in the study area. Farm size, distance to source of improved soybean seed, access to credit, utilization of soybean at household level and yield of soybean influenced both the likelihood of adoption of improved soybean seed and its intensity of adoption.

Recommendations

Based on the findings of this study, both policy recommendations and suggestions for further studies are proffered.

- Improved agricultural technologies in form of improved soybean seed should be made available to farmers. This could be done by ensuring the availability of farm service centers within reasonable distance from the farmers' farms or through encouraging farmers to form Seed Producers' Associations which will in turn multiply and supply improved soybean seed to meet demand, hence ensuring the availability of improved seed within short distance.
- Extension service should be strengthened so as to expose farmers to modern farming techniques and improved technologies. In this case, both access to extension service and the frequency of contact between extension staff and farmers should be strengthened. One way of ensuring this is through the participatory (cost-sharing) extension approach.
- Farmers should be given more and easy access to credit. In light of this, there is need to link farmers to formal sources of credit given its importance in the adoption of improved technologies.

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