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Technical Efficiency of Soybean Farmers in the Northern Region of Ghana.

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Abstract

This paper assesses the technical efficiency of soybean farmers in the Northern Region of Ghana. The maximum likelihood estimation technique was used for the estimations in a one-step approach through the translog production function. A sample size of 168 soybean farmers was used for the study. Farmers were selected by using systematic random sampling procedure and interviewed with questionnaires. The overall return to scale in production in the region was found to be 0.79. This is a decreasing returns to scale and means that a percentage increase in variable inputs leads to a less than percentage (proportionate) increase in the overall output of soybean. The mean technical efficiency in soybean production was 0.61. This implies that an average soybean farmer is able to obtain 61% of the frontier output given the input used under existing technology. Farmer groups and farm size are the significant determinants of inefficiency in the area. Finally, inadequate farm credit, inadequate rainfall and lack of improved planting materials are the most serious constraints hindering soybean production. The paper recommends among others that soybean farmers should be given more technical training on best agronomic practices. Policies geared towards encouraging farmers to apply more fertilizer and other chemicals (herbicide and pesticide) should be formulated and enforced by the government and other actors in agricultural development.

Key words: technical efficiency, Soybean, Northern Region

INTRODUCTION

Soybean is a highly nutritious leguminous crop which is often referred to as the 'miraculous' crop because of its multipurpose uses. It comes in different varieties, sometimes in black or creamy coloured small grains (Chianu *et al*., 2009). Plahar (2006) indicated that soybean is a bank of nutrition because it contains lager proportions of quality protein, essential minerals, vitamins and fatty acids. The crop contains forty percent protein (Greenberg and Hartung, 1998) but just about two percent of this protein is consumed by humans in the form of food products and only a marginal fraction of the rest of the 98% is fed to livestock such as pigs and poultry in the form of processed soybean meal (Goldsmith, 2008). The crop has the potential of developing three key sectors of Ghana's economy, namely agriculture, health, and industry (Plahar, 2006).

There has been a continuous increase in global production of soybean over the years. United States of America alone in 2003 accounted for between 40% - 45% (189 million MTs) of the world's total soybean production (Boerma and Specht, 2004). USDA, FAS (2007) indicated that the world's output of soybean increased from 107 million MTs in 1990 to 229 million MTs in 2006. About 89% of the 229 million MTs constitute the production of soybean from Argentina, Brazil, United States and China (USDA FAS, 2007).

Global production of soybean grows at about 54% per annum. The rate of growth is not large enough especially, when compared to global demand for soybean. For instance, between the periods 1961 to 2003, the average global per capita consumption of soybean rose from about 8kg to about 15.6kg (FAO, 2005). The demand rate for soybean grows at about 10 million MTs (52%) per annum (USDA FAS, 2007). Offsetting the rising trend in demand for soybean for food, feed, oil and fuel needs is a source of concern to stakeholders in the world and calls for the adoption of pragmatic and more efficient measures to increase production of soybean.

Unlike other continents, Africa saw the introduction of the soybean crop and initially thought that it was only good for industrial processing and livestock feed (Shannon *et al*., 1995). This notion took away interest in the crop's development until recent times where interest has been reignited through increasing awareness and support from the International Development Research Centre (IDRC) of Canada and other local research institutions. This has propelled local efforts to promote soybean production and utilization in Africa.

In Ghana, soybean was meant to be exported to England as a cash crop and at the same time supplement farmers' food needs (Aoyagi, 2007). Soybean production in Ghana is currently concentrated in the Northern Region with an average farm size of 1.4 ha and dominated by small scale farmers equipped with traditional tools and outdated methods of production (Plahar, 2006). Production levels tend to be small because smallholder farmers are unable to apply expensive fertilizers sufficiently to guarantee increased production.

Like all other soybean producing nations, soybean processing in Ghana is on large and small (micro) scales. The large-scale processing is decomposed into oil extraction and animal feed (55%), soy flour and high protein foods (20%), high protein foods only (15%), soymilk and soy flour (5%) and soymilk and soy curd (5%) (Plahar, 2006). The large-scale processing also involves the use of sophisticated machinery and technologies. The micro-scale (household) processing of soybean, on the other hand, involves the use of rudimentary and unsophisticated house level machines and the processed products are in the form of dawadawa, *weanimix*, soy dough, soy flour and soymilk, among others.

There have been several interventions aimed at increasing the production for both domestic and industrial utilization of soybean in Ghana. These included, among others, an inter-sectoral National Committee on Soybean Production and Utilization formed during 1980s and 1990s, which constituted MoFA, MoH, CSIR Agricultural-based Institutes, Universities, Food Distribution Corporations, Farmers, and Industries (Plahar, 2006). The development of "Jenguma" and "Quarshie" non-shattering soybean varieties are also among the several interventions adopted to enhance farmer productivity of soybean by the Savanna Agricultural Research Institute (SARI) in conjunction with the Ministry of Food and Agriculture, and NGOs (Clottey, 2003). More so, over 5,000 soybean farmers in Ghana were given both forward and backward linkages to processors (Savanna Farmers Marketing Company) and marketers, and input suppliers, respectively (Clottey, 2003).

While Ghana has a potential to produce about 700,000 MTs of soybean, she produced only 144,926 MTs in the 2010 farming season. However, the consumption level of soybean is about 300,000 MTs per year. A demand gap of more than 200,593 MTs was thus imported to augment local production (MoFA, 2011). Though, there has been some gains made by way of increased soybean production in Ghana and most especially, in Northern Region, there is still a rising demand gap. This situation could worsen further if Ghana fails to achieve and sustain a higher level of growth rate in soybean production. However, the realization of this dream looks highly unpromising, considering the system of production and scenarios of productivity in agricultural production generally (for example, less than 4.5 MTs per ha in soybean production).

In view of the above, this paper deems it relevant to assess the technical efficiency of soybean farmers in the Northern Region of Ghana. The specific objectives of the study are, therefore, to estimate the productivity of soybean farm inputs in the Northern Region, to ascertain the level of technical efficiency of soybean farmers in the Northern Region and, to identify the determinants of inefficiency in soybean production in the region.

In order to achieve the set objectives, certain empirical questions that will unearth evidence-based results are necessary. These are; how productive are soybean farm inputs in the Northern Region? What is the level of technical efficiency of soybean farmers in the Northern Region? And, what are the determinants of inefficiency in soybean production in the region?

This study, first of all, would establish the technical efficiency level of soybean farmers, and identify the determinants of inefficiency in soybean farms. This would serve as baseline information to help both peasant and commercially oriented farmers to avoid practices that lead to inefficiency and better harness the opportunities farm specific characteristics present to achieve higher yields.

Secondly, the outcome of this study would help policy makers in Ghana to determine which farm inputs and technical services to promote among soybean farmers to achieve increased soybean production and reduce farmer inefficiency. This has the potential of enhancing the development of three key sectors of the Ghanaian economy; these are agriculture, health and industry.

Finally, the study would augment the body of knowledge available on soybean production especially in the area of technical efficiency of soybean production in the Northern Region of Ghana. The findings in this study are expected to serve as a baseline for other similar studies in Northern Region.

The production level of soybean-based oilseed products in Ghana is estimated at about 12,000 MTs every year, but yearly demand for seasoning oil, cooking oil and cake is projected at 30,000 MTs (Bosbel Vegetable Oil, 2005). Over 25 soybean processing companies operating in Ghana and located mainly in Greater Accra, Ashanti, Brong Ahafo and Northern Regions are challenged with inadequacy of raw soybean materials. The situation has resulted in about GH¢ 47,365.81 worth of soybean importation per week to Ghana (MoFA, 2011). Economically, it will be unsustainable to continue to import sufficiently to compensate for the food and raw material supply deficits (Mwangi, 1995).

While the basic requirements for soybean production according to the IDRC (1998) is a soil of pH 5.0 or higher and a minimum rain of 500 mm in at least 3 - 4 months season, the Northern Savanna Agro-ecological zones (Guinea and Sudan) have a mean annual rainfall of 1,100 mm and a soil pH of 4.5 - 6.7 (MoFA, 2011). This means the biophysical conditions are excellent and still far below the carrying capacity to support the growth of soybean production for both domestic consumption and commercial processing in Ghana. Yet soybean farmers in the region still rely on traditional production technologies. Largely, soybean farmers prepare their farm lands by using tractors, animal traction, hoe or cutlasses. The high cost of tractor services coupled with unavailability and inaccessibility compel farmers to use the other alternatives more to prepare their farm lands. The farmers use uncertified soybean seed (varieties) sold in the open market. This most of the time requires multiple planting (refilling) due to poor germination resulting from the use of these poor quality seeds. Almost all soybean farmers in the study area do not use chemical fertilizers and pesticides on their farms. They operate under the notion that all legume crops do not need fertilizer application.

The use of inappropriate agronomic practices, including ploughing, planting (inter and intra planting distances), fertilizer application and weed control protocols on soybean farms coupled with low farmer knowledge exacerbate the low output levels of soybean farmers. Generally, soybean farmers use more labour intensive technologies in land preparation, planting, weeding, harvesting, shelling and bagging of soybean. Another area of concern among soybean farmers in the study area is the high cost of inputs endured by farmers such as chemicals (fertilizer, pesticide and herbicide), tractor services, improved seeds and labour, among others. Clottey (2003) confirms that input dealers sometimes sell compound fertilizer in place of specialized fertilizer. This has limited the application of these inputs and thereby adversely affecting the overall productivity levels of soybean. Sometimes farmers try to cope with the situation by using one bag of fertilizer to service at least one acre of soybean farm. This only leads to low production levels of soybean farms.

Most studies in Ghana have focused on the nutritive and economic values, as well as the value chain analysis of soybean ignoring the technical efficiency of soybean farms. This paper, therefore, capitalizes on that knowledge gap to assess the technical efficiency of soybean farmers in the Northern Region of Ghana. The paper estimates the productivity of soybean farm inputs in the Northern Region and technical efficiency of soybean farmers. It identifies the determinants of inefficiency in soybean production.

METHODOLOGY

Theoretical Framework

The production frontier model was developed almost at the same time by Meeusen and van den Broeck, (1977); Battese and Corra, (1977); Aigner *et al.* (1977). The breakthrough in their work came from the definition of the error term to consist of factors outside the farmers' control (v)

and those within the farmers' control (*u*). The model specification of the stochastic frontier approach is given as:

$$y = f(x_i, \beta)e^{v-u}$$ ………………. (1)

Where *y* denotes the output measured in kilograms per hectare, *u* represents the random effect of measurement error which is within the control of farmer. *u* is also asymmetrically distributed. If *u > 0* then there is the presence of inefficiency and production therefore lies below the frontier. On the other hand, where *u = 0* means that production lies on the frontier and therefore efficient. *v* is measurement error outside the control of farmers. It is also distributed normally or symmetrically as $\left[v \sim N(0, \sigma_v^2)\right]$. The stochastic frontier function in translog functional form is given by:

$$\ln Y = \beta_0 + \sum \beta_i \ln X_i + \sum \beta_p Z_p + \tfrac{1}{2}\sum\sum \beta_{ii}(\ln X_i)^2 + \tfrac{1}{2}\sum\sum \beta_{pp}(\ln Z_p) + \sum\sum \beta_{ip}(X_i Z_p) + \beta_m D_m + e$$ ………………. (2)

where *lnY* refers to the natural logarithm; X_i represent the conventional inputs; Z_p are the explanatory variables; β_i refers to the parameters for the conventional inputs; β_p refers to the parameters for the explanatory variables; β_{ii} refers to the parameters for the interactive terms of the conventional inputs; β_{ip} refers to the interactive terms between the conventional inputs and explanatory variables; β_k*'s* refers to the parameters for dummy variables; and, *e* is the error term, decomposed into *v + u*.

$$E(u/e) = \sigma^{*2}\left\{f^*(e\lambda/\sigma)/\left[1 - F^*(e\lambda/\sigma)\right] - e\lambda/\sigma\right\}$$ ……………….. (3)

where *f** is the standard normal density function and F* represent the distribution function. The total output variance is given as $\sigma^2 = \sigma_v^2 + \sigma_u^2$. However, this can be formulated as $\sigma^2 = \sigma_v^2 \sigma_u^2 / \sigma^2$, where σ_u^2 and σ_v^2 are for the respective one-sided error component and the random effect of measurement error (Jondrow *et al.*, 1982). Also, Kalirajan and Shand (1985) expressed the ratio of the one-sided error component as a source of variance relative to the total variance of output from the frontier as:

$$\gamma = \sigma_u^2 / \sigma_v^2$$ ………………….. (4)

The one-step approach to estimating technical inefficiency is given in equation 5 or 6 below as:

$$u_i = \beta_0 + \sum_{m=1}^{12} \beta_m Z_i \qquad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$TE_i = \exp(-U_i) = \exp(-Z_i\beta - W_i) \qquad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where for farm i, Z is a vector of explanatory variables associated with the technical inefficiency effects. β is a vector of unknown parameters to be estimated. Therefore, the parameters of both the frontier production function and the inefficiency model are concurrently estimated (Battese and Coelli, 1995).

Analytical Methods

Maximum Likelihood Estimation (MLE) technique was used to present estimates of inputs productivity, technical efficiency of soybean farmers and determinants of technical inefficiency. The conventional input variables used for the estimations were modelled in a translog production function. The parameter estimates for the stochastic frontier production function were obtained by using the computer program, FRONTIER, Version 4.1. The Maximum Likelihood Estimation (MLE) gives a better result than the OLS and COLS (Olson *et al*. 1980) and provides sufficient information to calculate a conditional mean for *u* (Jondrow *et al*,.1982).

Empirical model

The conventional input variables used for the estimation of the overall return to scale and technical efficiency of soybean farms are seeds, labour, fertilizer and other chemicals (herbicides and pesticides). Following Battese (1997), fertilizer usage dummy and other chemicals usage dummy are also added to make room for zero-observations and to further eliminate bias. Further more, farmer and farm specific socioeconomic variables included in the model to explain inefficiency include age of farmer, educational level of farmer, farmer's level of experience, number of extension visits to the farmer, farmer's access to farm credit, membership of farmer groups/associations, gender of farmer and farm size of farmers.

Following Battese and Coelli (1995), this paper employs the one-step approach to estimate the technical efficiency of soybean production in the study area. The translog functional form of the production function was used and tested for adequacy. The translog production function is fairly general and flexible and permits the measurement of farm specific efficiency, as well as the analysis of interactions among variables. More over, the straight forwardness in both implementation and interpretation of measures of technical inefficiency outputted from the stochastic function cannot be over emphasized (Antle, 1984). The translog production function of soybean farmers is thus given as:

$$Ln\,Yd = \gamma_0 + \gamma_1 ln(Se) + \gamma_2 ln(La) + \gamma_3 ln(F) + \gamma_4\, ln\,(OC) + \gamma_5\, Fd + \gamma_6\, OCd + \alpha_7\,(0.5\, lnSe)^2 + \alpha_8\,(0.5\, lnLa)^2 + \alpha_9\,(0.5\, lnF\,)^2 + \alpha_{10}\,(0.5\, lnOC)^2 + \beta_{11} ln\,(Se * La) + \beta_{12}\, ln(Se * F) + \beta_{13}\, ln\,(Se * OC) + \beta_{14} ln\,(La * F) + \beta_{15} ln\,(La * OC) + \beta_{16} ln\,(F * OC) + e \quad \ldots..\,(9)$$

The determinants of technical inefficiency were estimated using the inefficiency model specified as:

$$U_i = \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + e \quad \ldots\ldots\ldots(10)$$

The variables in models (9) and (10) are defined as in Table 1, while the parameters to be estimated and their *a priori* expectations are presented in Table 2. The error terms are presented in Table 3.

Table 1: Definition of Variables in the Model

Variable	Definition	Unit of Measurement
Ln	Natural logarithm	
Yd	Soybean yield	Kiliogram (Kg) per hectare
Fd	Fertilizer usage dummy	-
OCd	Other chemicals usage dummy	-
Se	Soybean seeds	Kiliogram (Kg)
La	Labour	Mandays
F	Fertilizer	Kiliogram (Kg)
OC	Other chemicals (pesticide and herbicide)	Litres (L)
Z_1	Age of soybean farmer	Years
Z_2	Educational level of soybean farmer	Years spent in school
Z_3	Experience level of soybean farmer	Years of farming soybean
Z_4	Extension services to farmer	Number of visits
Z_5	Amount of farm credit	GH₵
Z_6	Membership of Farmer groups/associations	-
Z_7	Gender of farmer	Male/Female
Z_8	Farm size	Hectares

Source: Field Survey, December 2011

Table 2 Definition of Parameters and their *a priori* expectations

Parameters	Definition	*A priori* Expectation
U	Technical Inefficiency	-
γ's	Parameters of the conventional inputs to be estimated	$\gamma_i > 0$, where $i = 1,2,\ldots\ldots,7$
α's	parameters of the square terms to be estimated	$\alpha_m > 0$, where m =1,2,……..5
β's	Parameters of the cross-product terms to be estimated	$\beta_n > 0$, where n=1,2…….,10
δ's	Parameters of the explanatory variables to be estimated	$Z's = 0$

Source: Field Survey, December 2011

Table 3: Error Term

Error Term	Definition	*Aprior* Expectation
e	Error or disturbance term ($v-u$)	-
V	Random effect of measurement error which is outside the control of farmer and symmetrically distributed	$v \geq 0$
U	Random effect of measurement error which is within the control of farmer and is asymmetrically distributed	$u = 0$

Source: Field Survey, December 2011

Sample Size and Sampling Technique

A sample size of 168 soybean farmers were drawn soybean farmers. A simple random sampling procedure (lottery method) was used to select 4 districts from the 20 districts in the region. The districts were represented by numbers (1 to 20) written on small folded pieces of paper, tossed for one minute and picking by 4 people. The same sampling procedure was adopted to select three communities from each of the 4 selected districts. These are Tolon/Kumbungu (Nyohindanyili, Gbrimani and Kasulyili), Tamale Metrolopolis (Kpenjing, Adubliyini and Lahagu), Yendi Municipality (Gundogu, Kuga and Zang) and Savelugu (Tibali, Nyoglo and Duko).

Secondly, a systematic random sampling procedure was used to select farmers for the study. Farmers that fell on or represented by even numbers on the sample frame (list) of soybean

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farmers in each of the 4 districts were chosen. Through this process 42 farmers, that is 14 soybean farmers from each of the 12 communities were selected. The systematic random sampling was used because the population of soybean farmers in the study area is homogeneous in terms of characteristics.

The summaries of the variables used in the paper are presented in Table 4. The average age of a soybean farmer in the Northern Region is 39 years. Also, the average level of education attained by soybean farmers in the study area is primary school and therefore, confirms the notion that majority of farmers in the Region are illiterates. The average number of years spent in the production of soybean by a soybean farmer is 6 years. Invariably, this measures the experience level of a soybean farmer in soybean production and the fact is that farmers are still risk averse in trading off their staples for crops such as soybean as a source of income. The only fertilizer type used by soybean farmers is the NPK 15-15-15 in the study area and the maximum and minimum of per hectare fertilizer used on soybean farms were 150kg and 0kg, respectively.

Table 4: Summary of Variables

Variables	**Mean**	**Minimum**	**Maximum**
Age of Farmer	39.0	18.0	75.0
Educational level of farmer	2.3	0.0	25.0
Years of Experience	6.4	1.0	20.0
Soybean Farm size (Ha)	2.3	0.4	6.6
Seeds (Kg)/Ha	12.7	3.0	33.0
Fertilizer (Kg)/Ha	15.2	0.0	150.0
Other chemicals (pesticide and herbicide) (L)/Ha	1.0	0.0	3.0
Labour (family and hired) (M)	41.4	8.0	139.0
Farm total output (MTs)	0.2	0.1	0.8

Source: Field Survey, December 2011

EMPIRICAL FINDINGS

Input Elasticity and Returns to scale

Table 5: Maximum Likelihood Estimates for Soybean Farmers

Variables	**Parameters**	**Coefficient**	**t-ratio**
Constant	γ_0	1.5002	79.7088
LnSeeds	γ_1	0.0515	0.4834
LnLabour	γ_2	0.1882	3.1863***
LnFertilizer	γ_3	0.2673	4.3757***
LnOtherchemicals	γ_4	0.2925	4.1904***

Fertilizer usage dummy	γ_5	-0.1804	-0.8403
Otherchemicals usage dummy	γ_6	-0.0081	-0.5847
LnSeeds 2	α_7	1.4457	2.1697**
LnLabour 2	α_8	0.1478	0.2121
LnFertilizer 2	α_9	-0.5388	-2.7685**
LnOtherchemicals 2	α_{10}	-0.9738	-2.2915**
LnSeedsLnLab	β_{11}	-1.1358	-1.7428*
LnSeedsLnFert	β_{12}	0.2339	1.7673*
LnSeedsLnOtherchem	β_{13}	0.5959	2.5840**
LnLabLnFert	β_{14}	0.1144	2.8436**
LnLabLnOtherchem	β_{15}	-0.0449	-0.3594
LnFertLnOtherchem	β_{16}	-0.3799	-4.2466***
Returns to Scale		0.7995	
Mean Efficiency		0.61	

***, ** and * represent 1%, 5% and 10% level of significance, respectively.
Source: Field Survey, December 2011

The parameter estimates in Table 5 show results of the conventional input elasticity for each input in the translog stochastic production function. The overall return to scale and the mean technical efficiency of soybean farms are also presented in Table 5. The paper revealed that Seeds has a positive coefficient but insignificant. Though farmers used largely unimproved soybean seeds, the results is surprising and needs further examination. On the other hand labour, fertilizer and other chemicals are significant in determining the productivity of soybean farms in the region. The positive elasticity for labour indicates the fact that soybean production can be increase by about 18% with just a percentage increase in labour. Soybean output is invariably moderately responsive to labour.

Also, fertilizer usage in soybean production exhibits a positive coefficient. Fertilizer application has an elasticity of 0.26, meaning the output level of soybean production can be increased by 26% with a percentage increase in fertilizer application on soybean farms. Though soybean production does not necessarily require fertilizer application, especially nitrogen fertilizer because of its fixation of nitrogen naturally into the soil, it is somewhat important to use 'starter' nitrogen to induce the growth of the soybean crop before nodules start to develop (MoFA, 2006; Dugje *et al.*, 2009). The application of potassium and phosphorous fertilizers is also necessary to guarantee maximum output. The overwhelming gains resulting from fertilizer application only proved why farmers, especially soybean farmers, must increase the application of fertilizer on soybean farms.

Further more, other chemicals including pesticides and herbicides is rational in its contribution to total output of soybean production. The findings show that an increase of other chemicals (pesticides and herbicides) by just one percent can increae soybean production by about 29% in the region. The explanation is that these other chemicals help in controlling rather destructive pests and weeds on soybean farms and allows for proper germination, growth and fruiting of soybean plants.

The overall return to scale of input variables in soybean production is indicated in Table 5 as 0.79. This can be described as a decreasing returns to scale and means that a percentage increase in variable inputs leads to a less than percentage (proportionate) increase in the overall output of soybean. The optimal resource combination in soybean production is one that gives a constant return to scale of 1 or an increasing return to scale of more than 1. The outcome is less than one and shows invariably, that there is no effective (efficient) combination of variable inputs in soybean production. Indicative from the paper is that output responded more to other chemical inputs, followed by fertilizer input and then labour input.

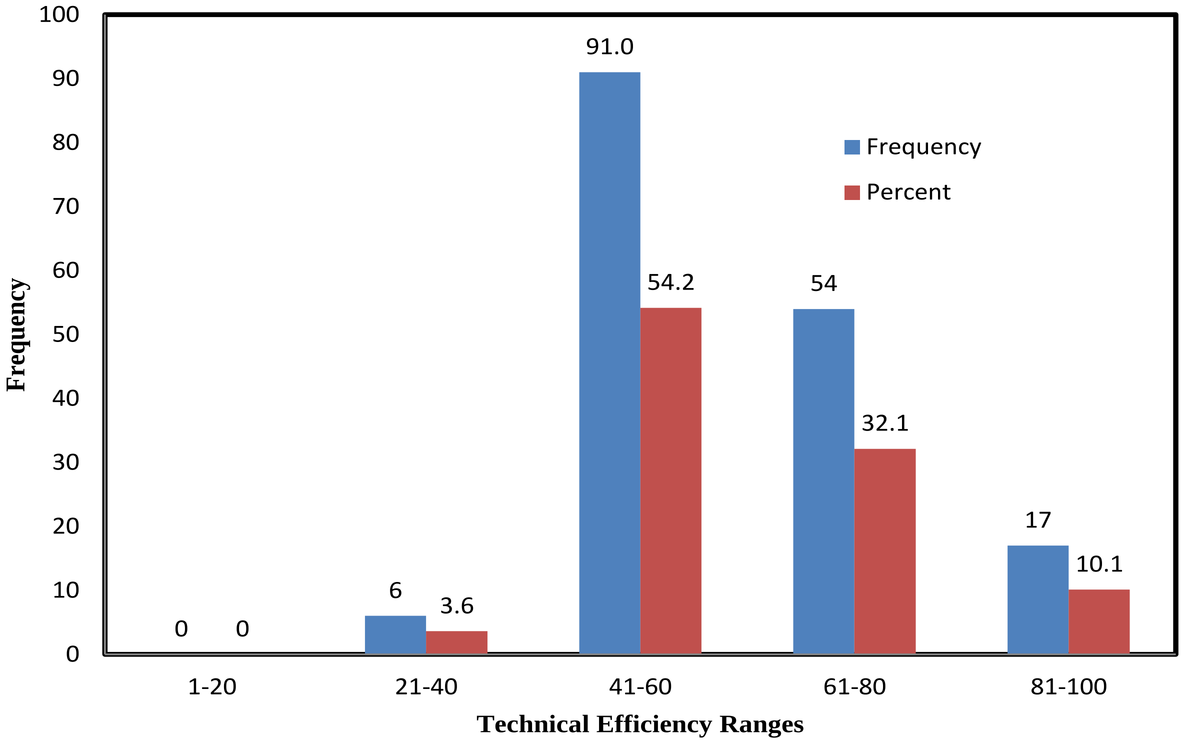
Mean Technical Efficiency

The mean technical efficiency of soybean farmers in Northern Region is 0.61 (Table 5). This means that an average soybean farmer is able to obtain 61% of the frontier output given the input used under existing technology. In all, only 17 (10%) of the sampled soybean farmers achieved technical efficiency levels between 81%-100%. Two (2) (1%) farmers had 100% technical efficiency in production. The average realized is also lower than the 73% in Benue State, Nigeria obtained by Otitoju and Arene (2010) for medium scale farmers. The variance of 39% explains random variation (shocks) in production and can only mean that soybean farmers in the region have more capacity to improve upon the output level without increasing the level of farm inputs.

The gamma (γ) is estimated at 0.999 and implies that 99% of random variation in soybean production is explained by farmer inefficiency. The random component of inefficiency effects greatly influenced soybean production in the study area. Production in small scale and non-participation in farmer associations by soybean farmers are the obvious sources of inefficiency in production. Small scale production of soybean denies farmers of the benfits of economies of scale and non-participation in farmer association denies soybean farmers of vital production information to make them efficient.

Technical Efficiency Ranges of Soybean Farmers

Figure 1: Technical Efficiency Ranges of Soybean Farmers



Source: Field Survey, December 2011

Figure 1 presents the technical efficiency ranges for soybean farmers in the region. The findings show that while about 0% of the soybean farmers fell within the lowest technical efficiency range of 1-20 percent, 10.1% of the farmers were in the highest range of 81-100 percent. In the region also 54.2% of the farmers fell within the modal technical efficiency range of 41-60 percent, and the rest of the farmers, 3.6% are either in the 21-40 percent range or in the 61-80 percent range (32.1%). Further more, about 42.2% and 3.6% of soybean farmers in the region are above and below the modal technical efficiency range, respectively. All the farmers except 10.1% in the Northern Region are inefficient in soybean production.

Determinants of Technical Inefficiency

Table 6: Determinants of Technical Inefficiency

Variables	Parameters	Coefficient	t-ratio
Constant	δ_0	0.9025	18.3909
Age	δ_1	0.0007	1.0811
Education	δ_2	-0.0015	-0.7614
Experience	δ_3	-0.0017	-0.7445
Extension	δ_4	0.0004	0.3595
Credit	δ_5	-0.0001	-1.4347
Farmers' group	δ_6	-0.0312	-2.1041**
Gender	δ_7	0.0189	0.4409
Farm size	δ_8	-0.1609	-15.8336***

*** and ** represent 1% and 5% level of significance, respectively.
Source: Field Survey, December 2011

Table 6 presents the determinants of technical inefficiency among soybean farmers in the Northern Region. In Table 6, though age, extension and gender directly affected inefficiency, they were not significant. This obviously contradits apriori expectations and need further investigation. Also, educational level, experience and credit appear to be insignificant but inversely related to technical inefficiency in soybean production in the region. Also, extension services are rendered more to farmers who are located close to the extension agents while those located far away or immotorable areas receive just a little or no technical services at all from these agents. Furthermore, the study was dominated by male soybean farmers, as very few female farmers participated in the study showing the lack of interest of women in soybean production.

The findings show that the average educational level among soybean farmers in the Northern Region is primary school. This obviously conforms to apriori expectation but is insignificant in the study area. The low nature of formal schooling could have a limiting effect on the acquisition and adption of knowledge to ensure best farming. For experience, the average number of years spent in soybean production by a soybean farmer is about 6 years. This is more than enough time to give the average soybean farmer an understanding of the best technologies available and more especially, the ability to analyze weather and rain patterns in the study area. Though the effect of experience on technical efficiency is positive, it is also not significant and, thus, needs further analysis. Farm credit also conforms to apriori expectation because it showed a positive impact on efficiency yet it is insignificant and requires further investigation in the study area.

The significant determinants of inefficiency in the region as shown in Table 6 are farmer groups and farm size. Farmer groups/associations is negative in its relation to inefficiency in soybean production. With a coefficient of -0.0321, inefficiency decreases as farmers join and form new groups. Farmer groups in this case has a rather weak coefficient to have a lasting negative impact on inefficiency. Yet still it is important that farmers are encouraged to join and form groups as this ensures effective learning. This outcome is consistent with several other findings including Idiong (2007).

The paper showed an inverse relationship between farm size and technical inefficiency. In Table 6, the coefficient of farm size is -0.1609, meaning that as soybean farm size increases inefficiency of farmers declines and vice versa. Analysis of the number of extension contacts to both small and medium scale farmers and complaints from small scale farmers confirmed that medium scale farmers are given more attension by the MoFA extension agents in the study area and the best of production information and technical services are given to them to ensure higher production efficiency. This finding is consistent with many other conclusions on the negative relationship between farm size and technical inefficiency (see for example, Coelli and Battese, 1996; Onoja *et al*., 2008; Aye and Mungatana, 2010).

CONCLUSIONS AND POLICY RECOMMENDATIONS

Soybean farmers in the study area experienced a decreasing returns to scale in the use of variable inputs. There is ineffective resource combination among soybean farmers in the region. Exmple, other agro-chemicals contributed highest to productivity in the study area. This was followed by fertilizer and labour as the second and third, respectively. The mean technical efficiency of soybean farmers in the region is 61%. The farmers can still improve upon their output level by 39% to achieve the potential yield of 4.5 MTs per hectare, with current input levels. The major determinants of technical inefficiency among soybean farmers in the region are farmer groups or associations and farm size. Even though they are both weak in terms of their impact on farmer efficiency, they should be considered seriously as effective tools to reducing farmers' technical inefficiency.

The policy recommendations are that the Ministry of Food and Agriculture and other stakeholders in the agricultural sector should work at encouraging soybean farmers in the region to apply more fertilizer and other chemicals (pesticides and herbicides) by providing them with subsidsies. More capacity building (technical training) on good agronomic practices should be given to soybean farmers by the Ministry of Food and Agriculture, Savanna Accelerated Development Authority and other stakeholders in the agricultural sector to reduce farmer inefficiency. Farmers should be motivated to join farmer groups/associations through pragmatic policies from the Ministry of Food and Agriculture, Savanna Accelerated Development Authority and other stakeholders. This would facilitate farmer learning through farmer field schools (FFS) about resource and technology utilization and enhance the level of technical efficiency in production.

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