Journal of Agriculture and Biological Sciences Vol. 2(4) pp. 071-077, July 2011
Available online http://www.globalresearchjournals.org/journal/?a=journal&id=jabs

TECHNICAL EFFICIENCY OF GROUNDNUT PRODUCTION IN WEST MAMPRUSI DISTRICT OF NORTHERN GHANA

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Accepted 5th May 2011

As Ghana struggles to achieve accelerated growth in food production, increasing the output of groundnut has become an important goal. This study examined the technical efficiency of groundnut farmers in West Mamprusi District of the Northern Region of Ghana in the 2008/2009 cropping season. Cross-sectional data was collected from a sample of 123 farmers and fitted into Cobb-Douglas Stochastic Frontier Model. Mean technical efficiency estimate was 70%. The factors that were significant in increasing farmers' technical efficiency were large farm size, formal education, credit and using tractor for land preparation as opposed to bullock plough. However, the continuous cultivation of farm plots led to decreased farm efficiency. It is important that the Ministry of Food and Agriculture (MoFA), and for that matter the Savannah Accelerated Development Authority (SADA), carry out its strategies to the letter for the development of the groundnut industry in the study area, and in Ghana as a whole.

Key words: Groundnut production, Technical Efficiency, Northern Ghana, West Mamprusi District.

List of Abbreviations

FASDEP	Food and Agricultural Sector Development Policy
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GLSS	Ghana Living Standards Survey
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
ISSER	Institute of Social, Statistical and Economic Research
MoFA	Ministry of Food and Agriculture
NDPC	National Development Planning Committee
SADA	Savannah Accelerated Development Authority

INTRODUCTION

The role of agriculture in providing food and cash security, thereby reducing poverty cannot be over-emphasized. It is in this light that Ghana's agricultural policy in 2007 "focused on developing a progressive, dynamic and viable agricultural economy that would ensure food security, income growth and hence poverty reduction as well as promoting sustainable agriculture and a thriving agribusiness sector" (ISSER, 2007). It is estimated that over 90% of the farm holders in Ghana are small scale, with average holdings of 4.2 acres. Similarly, most of these farmers produce on a subsistence basis, and thus, face cash insecurity problems. It is in the light of this that many people believe that the production of cash crops such as groundnut is a way out of such cash insecurity.

Groundnut is cultivated in both tropical and sub-tropical countries. According to the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), it is the 13th most important food crop in the world. It is also the world's 4th most important source of vegetable protein (26%) and the second largest source of vegetable oil (45%), the largest being the soyabean. The Food and Agriculture Organization (FAO) (2004) also notes that groundnut is grown on 26.4 million hectares of land worldwide with a total of 36.1 million metric tones and an average productivity of 1.4 metric tons/ha. Developing countries account for 92% and 96% of global output and production area respectively (ICRISAT, 2001). About two-thirds of the world production of groundnut seed is used for the production of oil which is used in cooking and in the making of salad oil and margarine. Lower grade groundnut oil is used in the manufacture of soaps, lubricants, and illuminants. The residue left after oil extraction, is a high protein livestock feed. Similarly, while the green haulms make excellent fodder, the shells are used as boiler fuel or to produce a particle-board for building purposes (Kochhar, 1986).

Groundnut is believed to be the most popular and widely cultivated legume in Ghana because of its adaptation to climatic conditions as well as limited field pest problems. Groundnut production in the northern sector is very pronounced and about 92% of the national production comes from northern Ghana (Wumbei *et al*, 2000). However, ICRISAT (2001) laments that groundnut yield in Africa has generally been poor due to a combination of factors, including unreliable rains, little technology available to small scale farmers, poor seed varieties, and increased cultivation on marginal land. Also, political instability and non-supportive small farm policies have negatively impacted on groundnut production in West Africa. While some of these factors are outside the control of the farmers, others are within their control. It is important to find out the extent to which the latter influence the efficiency levels of the farmers so that specific policies may be designed to step up the production of groundnut in the district.

Some analysts argue that realizing the above objectives of increasing food supply and incomes, hinges on the improvement of farmers' efficiency, which also depends on improving the existing resource base and available technology. It is against this background that we seek, in this study to find out the current levels of technical efficiency of groundnut farmers in the West Mamprusi District of northern Ghana and the determinants of such efficiency levels. From the literature, technical efficiency is determined by socio-economic, institutional as well as farm-specific characteristics. It should however be noted that even though efficiency studies abound, the above categories of factors are location and time-specific implying that generalizations, though convenient, may lack precision and therefore correctness. Besides, research develops with time, therefore researchers need to improve upon their research tools in order to cope with the growing complexity of human life.

MATERIALS AND METHODS

The Concepts of Production and Efficiency

Production is defined as the transformation of resources (inputs) into finished products (output). In agriculture, the physical inputs are land, labour, capital and entrepreneurship (management). Efficiency is the act of achieving good result with little waste of effort. It can also be defined as the act of harnessing material and human resources and coordinating these resources to achieve better management goals. Technical efficiency is also defined as the ability of the firm to produce the maximum output from its resources. It tells us the maximum amount of output that can be derived from a given level of inputs. Measures of technical efficiency give an indication of the potential gains in output if inefficiencies in production were to be eliminated.

The Stochastic Frontier Model

The stochastic frontier model is given as:

$$Y_i = f(X_i'\beta)\exp\,(v_i - u_i) \text{ -------------------------------(1)}$$

where Y_i is output of the ith farmer; X_i is a $(1 \times k)$ vector of farm inputs; β is a $(k \times 1)$ vector of parameters to be estimated; while v_i measures the random variation in output (Y_i) due to factors outside the control of the farm firm such as weather and natural disasters, u_i on the other hand, are the factors (within the control of the firm) responsible for that firm's inefficiency such as mismanagement, v is assumed to be identically and independently distributed as $N(\mathbf{0}, \sigma_v^2)$ and independent of u_i which is distributed as a truncated normal (at zero) of the $N(\mu_i\,, \sigma^2)$ distributions. U_i is independently, but not identically distributed.

Note that ε_i is the composed error term defined as $\varepsilon_i = v_i\text{-}u_i$.

The Technical Efficiency (TE) of the farm-firm is given as

$$TE = \exp(-u_i)$$

Thus, $TE = \frac{Y_i^*}{Y_i} = \frac{f(X_i,\beta)\,exp(v_i - u_i)}{f(X_i,\beta)\,exp\,(v_i)} = exp(-u_i)$ ……………….(2)

Where the numerator is the efficiency level of a farm-firm and the denominator is the average efficiency of the farm-firms in the industry.

There are two objectives in stochastic frontier analysis: The first is an estimation of the efficiency level of each producer and the second is the incorporation of exogenous variables into the frontier to find the extent to which such variables influence technical efficiency. In this case the exogenous variables are believed to affect output through producer performance (Kumbhakar and Lovell, 2000):

The estimation of a stochastic frontier production model allows for a simultaneous estimation of individual farmers' efficiency levels as well as the determinants of such efficiency levels (Battese and Coelli, 1993, 1995). Economic application of stochastic frontier model for efficiency analysis include Aigner *et al* (1977) , Battese and Corra (1977), Ogundari and Ojo (2005), Ajibefun *et al* (2002), Bravo-Ureta and Pinheiro (1993), and Ali and Byerlee (1991).

In terms of the functional form of the Stochastic Frontier Model the two commonly used are Cobb Douglas and the Translog. The main advantage of the latter is that it is flexible, which implies that it does not impose assumptions about constant elasticity of production nor elasticities of substitutions between inputs. Also, it can cause multicolinearity problems (a case in point is Dawson et al, 1991). The Cobb Douglas functional form however is not only simple but it is self-dual and has been applied widely in agricultural production technologies in many developing countries (Bravo-Ureta and Pinheiro, 1993).

Empirical Model

We use the Cobb Douglas Stochastic Frontier Model to determine the relationship between groundnut output (dependent variable) on one hand and the socioeconomic, institutional and farm-specific factors (Explanatory variables) on the other hand as follows:

$$InY = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + v_i - u_i \quad \text{................(3)}$$

Where In represents logarithm to base e; Y is output of groundnuts (in kg); X_1 is Farm size (in acres); X_2 is number of people who worked on the farm; X_3 is Seed (in kg). We should have included a fourth variable to capture the flow of services (i.e. depreciation) from farm implements such as hoes and cutlasses. Unfortunately, there was virtually no variation in the variable, considering the fact that the tools were common to almost all the farmers. Tractor and bullock ploughs are used but these are hired and not owned by majority of the farmers. However, to capture this, a dummy variable representing the farming system (i.e. whether a tractor or bullock was used in ploughing the field) has been included in the inefficiency-effects model below.
The inefficiency effect model is given as follows:

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 Z_5 + e_i \quad \text{...................(4)}$$

Where Z_i is farm size in acres; Z_2 is farming system (1 if tractor was used in ploughing the field and 0 if bullock was used); Z_3 is soil fatigue" ((i.e. number of years plot has been cultivated consecutively); Z_4 is the farmer's years of education; Z_5 is amount of agricultural credit received in the cropping season (in New Ghana Cedis); e_i is the two-sided error term and δ_i is a vector of parameters to be estimated. Equations 3 and 4 are estimated by Maximum Likelihood, using the computer program, FRONTIER version 4.1 (Coelli, 1996) by Battese and Coelli's (1993, 1995) one-step/simultaneous estimation procedure. The Maximum Likelihood estimation yields consistent estimators for β, δ, γ, and σ_s^2, where
$\gamma = \sigma^2/\sigma_s^2$ and $\sigma_s^2 = \sigma_v^2 + \sigma^2$.

The study was conducted in West Mamprusi District of the Northern Region of Ghana. It is located roughly within longitude O°35'W and 1°45'W and latitude 9°55'N and 10°35'N.The District is characterized by a single rainy season, which starts in late April with little rainfall, rising to its peak in July/August and declining sharply and coming to a complete halt in October/ November. Mean annual rainfall ranges between 950mm – 1200mm. Agriculture is the main activity of the people in the District absorbing over 80% of the economically active population. The District is rural, with more than 75% of the population in rural settlements. Population estimates in percentages in 2003 put males at 49.7% and that of females at 50.3% with an annual growth rate of 2.4%.

The study was carried out during the 2008/2009 cropping season. A total of 123 groundnut farmers were randomly selected from twelve communities purposively selected from the district. Questionnaire and interview schedule were used to collect data from the farmers.

RESULTS

The parameters and related statistical test results obtained from the estimation of the stochastic frontier model (equations 3 & 4) are presented in Table 1 below. From the table, both land and seed were positive and significant in determining output. However, labour was not only insignificant, it had a negative sign. This is contrary to our *a priori* expectation. Adding the coefficients of the two conventional inputs (land and labour) gives us the Returns to Scale value 1.03. This means there is constant returns to scale in groundnut production in the study area. This is consistent with the constant returns to scale associated with a Cobb Douglas frontier model as used in the study.

Technical Efficiency

Turning to the technical efficiency estimates, it can be observed that the mean technical efficiency for the sampled farmers was 70 % with 5 % and 93% being the minimum and the maximum respectively. The estimated gamma (γ) parameter of 0.99 in the study area indicates that 99% of the total variation in groundnut output was due to technical inefficiency. This can also be interpreted to mean that the differences between actual (observed) and frontier output are dominated by technical inefficiency (i.e. factors within the control of the farmers rather than outside their control). The result suggests that 99% of the variation in output among farmers was due to differences in technical efficiency while 1% of the variation was due to random shocks outside the farmers' control (Dawson and Lingard, 1989). As Coelli et al. (1998) observe, this is surprising, considering the fact that agriculture in Ghana, and particularly in the study area, is influenced by a lot of climatic factors that are beyond the control of the farmers. The estimated sigma squared (σ^2) of 2.61 is significantly different from zero, which implies a good fit and the correctness of the specified distributional assumption of the inefficiency term u_i.

Socio-Economic Determinants of Inefficiency

The sources of inefficiency are discussed using the estimated (δ) coefficients associated with the inefficiency effects in Table 1. Variables with negative coefficients have negative relations with inefficiency. The opposite is the case for variables with positive coefficients. The determinants of technical inefficiency included farm size, farming system, "soil fatigue", education and credit. The estimated coefficient of farm size was negative and statistically significant at 5%. This implies that farmers with greater farm sizes tended to be more technically efficient than those with small farm sizes. This finding confirms that of Ogundele and Okuruwa (2004),Parikh and Shand (1995) and Oyewo (2009). Similarly, the significance of the farming system variable implies that farmers who used tractor to plough their fields were more efficient than those who used bullock. This is also consistent with our *a priori* expectation.

The estimated coefficient of education was negative and statistically significant at 10%. This implies that farmers with more years of formal education tended to be more technically efficient or were less technically inefficient, due to their ability to acquire technical knowledge which facilitates the adoption of good farm management practices, such as the adoption of improved variety. The result is consistent with the findings by Kalirajan and Shand (1985), Abdulai and Huffman (2000), Weirs (1999), Owens *et al* (2001) and Seidu (2008). Similarly, farmers with access to credit were less technically inefficient. This also confirms studies by Binam *et al* (2008), Seidu *et al* (2006) and Bravo-Ureta and Evenson (1994) that the amount of credit received during the cropping season influences efficiency in a positive way. Lastly "soil fatigue" maintained its expected positive sign, implying that as the quality of soil declined due to many years of cultivation, technical inefficiency increased.

Table 1: Maximum Likelihood Estimation Results of the Stochastic Frontier Model

Variable	Parameter	Coefficient	Standard Error	t-ratio
Constant	β_0	5.58	0.29	19.23***
Land	β_1	0.68	0.15	4.25***
Labour	β_2	-0.03	0.06	-0.51
Seed	β_3	0.33	0.17	2.13**
Inefficiency				
Constant	δ_0	-8.43	3.60	-2.34**
Farm size	δ_1	0.35	0.15	2.30**
System	δ_2	2.32	0.07	2.16**
'Soil Fatigue'	δ_3	0.27	0.14	1.99**
Education	δ_4	-0.81	0.45	-1.78*
Credit	δ_5	-0.01	0.01	-2.12**
Sigma Squared	σ_s^2	3.40	1.30	2.61**

Table 1 contnues

Gamma	γ	0.98	0.01	1640.52***
Mean Efficiency	-	0.70	-	
Return to Scale	-	1.03	-	
Log likelihood function	-	76.63	-	

***, significant at 1% ** significant at 5% * significant at 10%

Dependent variables of the stochastic frontier model and the inefficiency model are log of total value of groundnut output (in kilogram) and efficiency levels respectively.

DISCUSSIONS

From the aforementioned the factors that increase the efficiency of groundnut farmers in the West Mamprusi District are farm size, education, credit and the use of tractor for ploughing. However, long years of cultivating farm plot lead to less efficiency. One would have thought that groundnut, being a leguminous crop, does not require external fertilization like the other crops, but from our findings, it is clear that the farmers in the study area need to consider fertilizing their plots. Gone are the days when crop output could be raised through agricultural extensification, where unused, but potentially productive lands were cultivated. In recent times, population growth has meant that there is pressure on fertile lands. This calls for agricultural intensification, where there is the adoption of new or improved technologies and farm practices. The Strategy of the Savannah Accelerated Development Authority (SADA), which is in line with the Food and Agricultural Sector Development Policy (FASDEP II), is " based on the concept of a 'Forested North' where agricultural production is modernized and oriented towards a larger market embracing the Sahelian countries, including northern Cote d'Ivoire and Togo." If this is to be realized, it is important that MoFA works with all the strategies that have been outlined in the policy document. The good thing about the FASDEP II document is that all the constraints faced by the agricultural sector have been indentified, and it was based on these problems that the strategies were designed. MoFA (2007) recognizes the fact that the use of modern inputs such as seeds and fertilizer is still low. For instance, it is reported in the Ghana Living Standards Survey (GLSS IV) that in the 1998/99 cropping season, while only 10% of farming households in Ghana could afford to purchase seeds for planting, only 20% used fertilizer. The situation has not changed in any significant way. The need for the adoption of modern/improved seeds and farm management practices is very crucial, considering the fact that close to 70% of the total land surface of Ghana is considered prone to severe erosion, particularly in the Savannah Zone, coming at a cost of 25% of Gross Domestic Product (GDP) (MoFA, 2007). This is compounded by poor farming practices such as bush fires. In Ghana, it is lamented that most farmers are not aware of the linkage between inappropriate tillage and water management practices on one hand, and environmental degradation on the other. With an estimated 64% of the natural wealth of Ghana locked up in crop land, MoFA (2007) recognizes the need for more focused attention to address poor agricultural land management.

One of the main reasons why farmers are not able to adopt modern technologies and farm practices is poverty. It is in this light that many analysts think that the role of agricultural credit is very crucial. Agricultural credit does not only lead to increased output, it raises the standard of living by breaking the vicious cycle of poverty. Again, MoFA (2007) recognizes that a lot of both internal and external factors limit credit access in Ghana. The former include: lack of collateral, due to lack of or poor quality of farm assets; lack of ownership of assets for women farmers; poor financial management and risky nature of farming. External factors are high interest rates, high cost of service delivery to the sector, and perception of financial providers about farming as being risky. The strategies that are designed in FASDEP II, if they are followed to the letter, should help alleviate a lot of the farmers' problems with respect to accessing agricultural credit. These are to: encourage group lending among farmers; strengthen capacity of farmers in credit management; intensify education of farmers on loan procedures; promote linkage between formal and informal financial services for delivery and recovery of loans; and advocate an Agricultural Development Fund to serve as a core source of medium to long term funding.

As implied, the inability of small-scale farmers to access credit is tied to illiteracy. The role of education in improving farmers' efficiency is widely known. Education enables farmers to understand the socio-economic conditions governing their farming activities. Education also enhances farmers' understanding of agricultural extension recommendations. In FASDEPP II it is argued that as a result of the high illiteracy rate among farmers, especially small-scale farmers, there is the need to constantly facilitate their access to information on new approaches, opportunities and policies. Policy interventions under the education sector include: increasing access to and participation at all levels of education; bridging the gender gaps in access to education; improving the quality of teaching and learning; and ensuring that education services are well delivered, among others (NDPC, 2005).

The fact that tractors users are more technically efficient than bullock farmers does not come as a surprise. The question is how can agricultural mechanization, and for that matter tractor services, be made more affordable and accessible to the small scale groundnut farmers in West Mamprusi District? MoFA (2007) admits that nationally there is low level of mechanization as a result of limited availability and access to appropriate agricultural machinery, equipment and mechanized services. Against this backdrop we support their strategy for "the establishment of mechanization services provision centres, and machinery hire-purchase and lease schemes that also have adequate backup of spare parts for all machinery and equipment" at least, at the regional level for easy access of such facilities (MoFA, 2007;). There is also the need for the promotion of local assembly of tractors in the country.

Lastly, large-scale groundnut farmers in the study area are more technically efficient than their small scale counterparts because they are better equipped and do practice mono-cropping, which reduces competition for limited soil nutrients. However, the fact that they were more efficient than their small scale-counterparts does not mean that they should be supported at the expense of their small scale counterparts. Our experience over the years, as a nation, has shown that any attempt to neglect small-scale farmers who constitute about 92% of the farming population would not auger well with us. The small-scale farmers are not only in the majority, but they are the ones who produce a lot of our food crops. In the context of this study, any policy that is to the detriment of small-scale farmers will mean that a lot of the people in the study area would lose their livelihood. Some critics of the Green revolution argue that even though the hybrid seeds and the complementary inputs such as fertilizers and irrigation were scale-neutral, meaning they had potential for both small and large scale farmers, the social institutions as well as government economic policies that were associated with them were not scale-neutral, meaning that large-scale farmers had greater advantage over their small-scale counterparts in terms of these complementary inputs. That is to say that large-scale farmers had greater access to inputs such as fertilizers, credit and extension services, thus, forcing small scale farmers out of business and further widening the gap between them. The lesson here is to ensure a parallel growth of both categories. One way to integrate the two is through the nucleus-farmer-out grower Scheme.

CONCLUSION

The study provides evidence to show that the technical efficiency of groundnut farmers is significantly determined by farm size, system of farming, credit and the level of education. However, prolonged cultivation on the same land leads to the depletion of soil nutrients which reduces the technical efficiency of farmers. The onus is on MoFA, and for that matter SADA to carry out all its strategies to the letter if groundnut production in the West Mamprusi District is to be realized.

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