



Profit Efficiency of Smallholder Soybean Farmers in Tolon District of Northern Region of Ghana

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ABSTRACT

The study aimed to estimate the profit efficiency of soybean producers in the Tolon District of Northern Region of Ghana and identify the sources of inefficiency and production constraints. Data for the study was obtained from 200 smallholder soybean farmers selected using simple random sampling and a structured questionnaire. A translog stochastic profit frontier model was employed to assess profit efficiency and the sources of inefficiency while Kendall's coefficient of concordance was used to rank the production constraints. The results revealed an average profit efficiency of 0.70, indicating a loss of 30% of the potential attainable profit to inefficiency. On the sources of inefficiency, the findings revealed that the combined application of chemical fertilizer and rhizobium inoculant decreased profit inefficiency, whereas application of only chemical fertilizer or rhizobium inoculant increased profit inefficiency. Profit inefficiency also decreased with access to extension, farmer group membership and years of farming experience. Farmers ranked financial constraints, high cost of tractor services and low yields as their most important production constraints. The study recommends that farmers must join groups to enhance their efficiency while extension services must be made accessible to more farmers. Farmers also need training on the recommended application rates of chemical fertilizer and rhizobium inoculants to maximize profit.

Keywords: *profit efficiency, stochastic frontier analysis, soybean, Ghana*

INTRODUCTION

Cultivation of soybean is becoming gradually prevalent among peasant farmers in developing countries due to its economic importance as a cash and oilseed crop. The crop is relatively new in the cropping system of Ghana (Akramov and Malek, 2012) but has gained prominence among many smallholder farmers in recent times. The crop supports income generation and food security

of peasants especially in northern Ghana, where the bulk of production takes place.

According to Osman et al. (2018), soybean is a major cash crop which can potentially reduce rural poverty because of its multipurpose use. Soybean is rich in oil and protein composition (Patil et al., 2017), making it an important food security crop. The crop is better adapted to drought conditions and can be produced with low

input requirements relative to other crops. This makes the crop preferable to peasant farmers in Ghana's semi-arid savanna zone where the soils are generally low in fertility culminating in poor crop yields.

Soybeans are important in the farming system of northern Ghana where the soils are fragile and exposed to high temperatures leading to low fertility. The crop can fix atmospheric nitrogen into the soil to enrich soil nitrate levels. As a result, soybean is mostly grown in rotation with other crops. Another reason why farmers prefer to cultivate soybean is that the crop has the potential to control the parasitic weed *Striga hermonthica* which adversely affects crop production in northern Ghana (Dugje et al., 2009). The rotation of farmlands with soybean, therefore, helps to control the parasitic weed. Compared to other leguminous crops, soybean has higher resistance to pests and diseases, can be stored for a longer period while maintaining its quality in storage, and produces more leaf biomass (Ugwu and Ugwu, 2010).

In collaboration with other development partners, the Council for Scientific and Industrial Research (CSIR) and the Ministry of Food and Agriculture (MoFA) have supported soybean cultivation in Ghana (Mbanya, 2011). The support includes varietal development and dissemination to farmers, training on good agronomic and management practices, among others. The Savanna Agricultural Research Institute (SARI) together with MoFA, and some non-governmental organizations (NGOs) have also worked together to develop non-shattering soybean varieties for smallholders in the study area. Also, the Urban Agriculture Network (URBANET) has conducted soybean, cowpea and groundnut demonstration fields in the study area to promote the cultivation of these crops. Furthermore, the Agricultural Value Chain

Mentorship Project (AVCMP) introduced farmers to improved soybean technologies and farming practices, connected producers to sources of inputs and services, and conducted on-farm demonstrations (Martey et al., 2015).

There are not many investigations into the efficiency of soybean cultivation by Ghanaian farmers. The few studies include an assessment of the economic efficiency of soybean cultivation by Osman et al. (2018) and technical efficiency analysis of soybean production by Mohammed et al. (2016). Dogbe et al. (2013) also carried out an economic analysis of soybean cultivation in northern Ghana. Efficiency studies outside Ghana include an evaluation of technical efficiency of soybean cultivation in Kenya by Yegon et al. (2015) and Wabomba (2015) and a study by Lunik (2015) comparing cost efficiency between corn and soybean cultivation. In another study, Ugbabe et al. (2017) assessed profit level and technical efficiency of Nigerian soybean producers. The absence of studies on profit efficiency of soybean production in Ghana and other developing countries makes this study very relevant.

Profit efficiency is an economic efficiency concept which measures how well actual profit compares to the optimum frontier. A production unit is said to be profit efficient if it achieves maximum profit, considering the prices and levels of fixed variables that it faces (Ali and Flinn, 1989). Profit efficiency can reflect errors on both the input and output sides of production (Berger and Mester, 1997). The stochastic profit frontier (SPF) model stipulates that when firms produce inefficiently, revenue or profit is lowered.

A profit function enables a simple derivation of the elasticity of own price and cross-price as well as the features of the demand for output and input. Also, with the profit

function, prices of factors of production are exogenous variables thus avoiding simultaneity bias (Ogunniyi, 2011).

Profit efficiency is hypothesized to be influenced by production, socio-economic and institutional factors. Inputs like labour, seed, land and capital are used in soybean production. The costs of these inputs have implications for profit efficiency. To achieve optimum profit levels, farmers must allocate these resources judiciously. However, when these resources are over-utilized, it is expected to decrease the level of farm profit and efficiency (Rahman, 2003; Hyuha et al., 2007).

Farmers' socio-economic and demographic characteristics also influence profit efficiency. For example, highly educated farmers are expected to be able to utilize resources more judiciously to achieve higher profit efficiency. The same applies to farmers who have several years of experience in cultivating soybean. Farmers' socio-economic factors affect the level of their profit efficiency because they influence decision-making at the farm level.

Institutional factors such as group membership, extension advisory services and agricultural credit are also hypothesized to improve efficiency by enhancing farmers capacity to adopt innovations and technologies. Farmer groups link smallholders to input dealers, sources of agricultural information and services, thus promoting farm performance and efficiency. Farmers who receive these services are anticipated to reduce their profit inefficiency through better resource allocation and improved decision-making. Access to these factors is therefore expected to increase production thereby increasing profit efficiency and farm income.

This study was proposed to understand the efficiency outcomes of soybean producers in

Ghana to identify ways to enhance efficiency. The study, therefore, estimates the level of profit efficiency and identifies the factors explaining differences in efficiency among the sampled soybean producers. It also identifies the production constraints associated with soybean cultivation. The study will provide empirical evidence of the profit level of soybean farmers, the sources of inefficiency and hence, measures to improve profit efficiency.

To attain the stated objectives, the following null hypotheses were tested.

1. Ho: There is no profit inefficiency in soybean production among the respondents.
2. Ho: Variables such as farmers' socio-economic and farm-specific characteristics have no influence on profit efficiency.
3. Ho: There is no unanimous agreement between farmers regarding the production constraints associated with soybean cultivation.

MATERIALS AND METHODS

Study area

The research was undertaken in the Tolon District which is located in the northern part of Ghana and has a high number of soybean producers (Al-hassan et al, 2018). The district is situated in the Guinea savanna and has a total population of 72,990 as recorded by the Ghana Statistical Service (2010). The district has a monomodal rainy season, from May to November. Daytime temperatures range from 33 degrees Celsius to 39 degrees Celsius and the average night temperatures from 20 degrees Celsius to 26 degree Celsius. The annual average rainfall varies from 950mm to 1,200mm (Ghana Statistical Service, 2010). Majority of the population engage in agriculture with crop farming as

the dominant occupation. Soybean production, a major economic activity in the area, creates jobs, generates income and enhances the dietary status of farm families in the district.

Sampling and data collection

The study made use of multi-stage sampling to select soybean farmers. Five (5) communities namely Kpalsogu, Tingoli, Nafaraning, Dimabi and Bilisi were purposively selected from the Tolon district with the assistance of agricultural extension personnel. These communities were selected because they are known for the production of soybean in the Tolon District. Secondly, forty (40) soybean producers were selected using simple random sampling from each community with the help of local farm leaders. A total of 200 soybean farmers were included in the study. A face-to-face interview with soybean farmers was carried out using a structured questionnaire. Individual, household, production, socio-economic and institutional data were collected.

Theoretical framework of the stochastic profit frontier model

The SPF model combines technical and allocative efficiency concepts. The model assumes that in any production system inefficiency can be translated into reduced income or revenue. From the theory of production, it is assumed that a soybean farmer will use the input-output mix that guarantees maximum profit under economic and technological limitations. The quantity of these outputs and the prices of these inputs determine the profit of a farm.

Following Battese and Coelli (1995), the SPF model can be implicitly stated according to Eq. (1):

$$\pi_i = f(P_i, Z_i) \exp(e_i);$$

$$e_i = v_i - u_i \quad (1)$$

where π_i represents normalized profit of the i^{th} soybean farmer, P_i is the normalized price of the conventional input variables, Z_i represents the level of fixed inputs in soybean farming, and e_i denotes the error term. The v_i term, which is independent and identical in distribution, is associated with random errors, which can be attributed to inefficiencies resulting from factors beyond the control of producers. u_i represents the non-negative random factors which the farmer can control. It represents a normal distribution that is half-normal with a zero mean and a constant variance. The inefficiency effects (u_i) model is presented as shown in equation 2.

$$u_i = \delta_0 + \sum_{k=1}^n \delta_k W_{di} + \varepsilon_i \dots\dots\dots(2)$$

where W_{di} denotes the explanatory variables associated with inefficiency, ε_i represents the two-sided random errors and δ_0 and δ_k are coefficients to be estimated.

According to Aigner et al. (1977) and Meeusen and Van den Broeck (1977), profit efficiency is the ratio of the observed stochastic profit function to the frontier profit function and it is expressed as:

$$\pi_e = \frac{\pi_i}{\pi_{max}} \quad (3)$$

$$\pi_e = \frac{f(P_{ij}, X_{ij}, \beta_i) \cdot \exp(v_i - u_i)}{f(P_{ij}, X_{ij}, \beta_i) \cdot \exp(v_i)} \quad (4)$$

$$\pi_e = \exp(-u_i) \quad (5)$$

$$\text{Profit inefficiency} = 1 - \pi_e \quad (6)$$

where π_e represents the profit efficiency of an individual farmer, π_i is observed profit, while π_{max} represents the maximum (frontier) profit. The error term (e_i) has two components which are unrelated to each other and have normal distributions; where u_i are the component associated with inefficiency, and v_i is the component

associated with random disturbances. Where $u_i = 0$, it indicates that a producer's profit is on the frontier i.e., fully efficient whereas when $u_i < 0$, it means that profit is below the frontier. The further the deviation from the frontier, the lower the profit efficiency.

Empirical estimation

The study adopted the translog stochastic frontier model which is more flexible. The translog functional form imposes less restrictions, relative to the Cobb-Douglas model. The translog model is expressed as

$$\begin{aligned} \ln \pi_i = & \beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \\ & \beta_4 \ln x_4 + \beta_5 \ln x_5 + \frac{1}{2} \beta_{11} (\ln x_1)^2 + \\ & \frac{1}{2} \beta_{22} (\ln x_2)^2 + \frac{1}{2} \beta_{33} (\ln x_3)^2 + \frac{1}{2} \beta_{44} (\ln x_4)^2 + \\ & \frac{1}{2} \beta_{55} (\ln x_5)^2 + \beta_{12} \ln x_1 \ln x_2 + \beta_{13} \ln x_1 \ln x_3 + \\ & \beta_{14} \ln x_1 \ln x_4 + \beta_{15} \ln x_1 \ln x_5 + \beta_{23} \ln x_2 \ln x_3 + \\ & \beta_{24} \ln x_2 \ln x_4 + \beta_{25} \ln x_2 \ln x_5 + \beta_{34} \ln x_3 \ln x_4 + \\ & \beta_{35} \ln x_3 \ln x_5 + \beta_{45} \ln x_4 \ln x_5 + v_i - u_i \end{aligned} \quad (7)$$

where \ln represents natural logarithm, π is normalized profit; x_1 is the normalized price of seed; x_2 is the normalized price of labour (cost per man-day); and, x_3 is the normalized price of ploughing; x_4 and x_5 represent the fixed inputs (capital and land). Profit and input price of the variable factors were normalized by output price.

e_i represents the composite error term ($v_i - u_i$), where u_i represents farm-specific and socioeconomic characteristics related to production inefficiency while v_i represents

random disturbances in production. The inefficiency model is given as:

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \dots + \delta_n Z_n \quad (8)$$

where $Z_1, Z_2, Z_3, Z_4, Z_5, \dots, Z_n$ represent the sex of the farmer (dummy: =1 if male), educational level of the farmer in years, number of extension visits, member of farmers association (dummy: =1 if yes), farming experience, application of chemical fertilizer (dummy: =1 if yes), inoculant application (dummy: =1 if yes), adoption of both inoculant and chemical fertilizer (dummy: =1 if yes), and access to credit (dummy: =1 if yes) respectively.

Kendall's coefficient of concordance test

Kendall's coefficient of concordance was used to rank the constraints that soybean producers face in the district. It is a non-parametric procedure used to evaluate the degree of agreement among the producers in their ranking of a given set of constraints or factors (Corder and Foreman, 2009).

Kendall's W is calculated using equation (9).

$$W = \frac{12[\sum P^2 - (\sum P)^2]/n}{nm^2(d^2 - 1)} \quad (9)$$

where P is the sum of rank for each constraint being ranked, m is the number of constraints, while n denotes the number of soybean farmers. W ranges from 0 – 1, with 0 indicating no agreement, and 1 means an absolute agreement.

RESULTS AND DISCUSSION

Summary statistics of the sampled farmers

Table 1 describes the variables used to estimate the models.

TABLE 1. Description of the sample

Variable	Mean	Std. Dev.	Min.	Max.
Profit (GH¢)	666.9	480.3	117	2462
Price of output (GH¢)	1.982	0.073	1.6	2
Price of labour (GH¢)	6.665	2.146	3	12
Price of seed (GH¢)	2.260	0.373	2	2.8
Price of tractor ploughing per acre (GH¢)	68.35	5.516	0	70
Farm size in acres	1.578	0.801	1	6
Capital (GH¢)	68.23	45.88	10	320
Sex (1 = male)	0.620	0.487	0	1
Years of education	1.100	2.929	0	12
Off-farm employment (1 = yes)	0.300	0.459	0	1
Farmer group membership (1 = member)	0.345	0.477	0	1
Soybean farming experience (years)	4.020	1.913	1	11
Fertilizer dummy (1 = used fertilizer)	0.545	0.499	0	1
Inoculant dummy (1 = used inoculant)	0.430	0.495	0	1
Extension visit (1 = yes)	0.505	0.501	0	1
Access to credit (1 = yes)	0.200	0.401	0	1

GH¢: Ghana cedi, where GH¢ 1.0 is approximately US\$ 0.19. Source: Field survey, 2019

The producers have small farm sizes averaging 1.6 acres with a minimum of 1.0 acre and a maximum of 6.0 hectares. The respondents also used little amount of capital input in production. The educational level of the producers averaged one year of formal education. This attribute of the respondents is likely to be a drawback to soybean production because education enhances the human capital which enhances decision making and access to agricultural information. On average, farmers had 4 years of farming experience while the majority (62%) were males. Also, 30% of the respondents took part in off-farm work as an additional source of household income while 34.5% were members of a farmer group. Participation in off-farm work may have a two-side implication on soybean production. Having other sources of income may provide an incentive to finance quality labour, adopt new techniques, afford improved inputs,

among others, which may correspond to higher profit efficiency. However, there is the likelihood that farmers may allocate time away from the farm or have inadequate time for critical operations on the farm which may decrease efficiency.

Also, 51% of the respondents had access to extension service. Access to extension services is anticipated to increase profit efficiency because extension agents provide producers with agricultural information, extension advice and access to information necessary to increase crop production. The data also indicate that 20% of the respondents were able to access agricultural credit to farm. This shows that as many as 80% of the farmers lacked access to credit which could hinder production and profit efficiency. Access to credit eases the financial burden of producers, enhancing the ability to purchase the necessary inputs to enhance revenue and efficiency. Farmers without access to credit

might not be able to acquire yield-enhancing factors of production such as high-yielding seeds, fertilizer, inoculants or herbicides. Hyuha et al. (2007) observed that rice producers in Uganda with no access to credit had less profit compared to farmers with access to credit.

The study further reveals that 54.5% of farmers applied chemical fertilizer (NPK) while 43% adopted rhizobium inoculation to improve nitrogen fixation. The use of inoculants has become increasingly important in legume production due to the positive effects of biofertilizers on soil fertility improvement through nitrogen fixation in the root nodules of grain legumes and other crops. The results also indicate that soybean farmers made an average profit of

GH¢667, with a minimum of GH¢ 117 and a maximum of GH¢ 2,462. This shows that on a whole, soybean production is profitable.

The choice of variables was based on *a priori* expectation and the existing literature. Minai (2014) and Aidoo et al. (2014) argued that variables such as age, extension contact, group membership, the land area cultivated, the quantity of labour, and farming experience influence soybean output.

Test of Hypotheses

Stochastic frontier analysis requires that the appropriate functional form is determined. This was done by carrying out a likelihood ratio test (Table 2).

TABLE 2. Test of Hypotheses

Null hypothesis	LL(H ₀)	LL(H ₁)	LR test statistic	Critical value*	Decision
Profit function is Cobb-Douglas	-159.7	-144.9	29.57	24.99	Reject H ₀
Inefficiency model does not explain profit inefficiency: H ₀ : $\delta_0 = \delta_1 = \dots = \delta_{12} = \gamma = 0$	-144.6	-124.7	39.91	20.41	Reject H ₀

*Chi-squared critical values for the inefficiency model derived from Kodde and Palm (1986).

The test of hypothesis about the functional form indicates that the translog form is preferred above the Cobb-Douglas specification. This is because the likelihood ratio test statistic was greater than the critical value at 5% significance level. The second test is about the existence of inefficiency effects in the estimated model. The test result indicates that the inefficiency model explains profit inefficiency of the soybean farmers. This is because the calculated likelihood ratio test statistic exceeded the chi-squared critical value at 5% significance level. Hence, soybean production is associated with inefficiency and these inefficiency effects account for profit inefficiency.

Empirical estimates of the profit efficiency model

Table 3 indicates the empirical estimates of the SPF model for soybean farmers. From the results, the model had a good fit as shown by the statistical significance of the sigma-squared parameter. Also, as indicated by the value of the gamma parameter, the profit inefficiency effects comprise a major part of the total variation in profit level of soybean farmers. From the results, 62% of the variation in profit of soybean farmers can be attributed to inefficiency. In other words, factors within the control of farmers accounted for 62% of the variation in profits.

TABLE 3. Parameter estimates of the translog profit function for soybean farmers

Variable	Coefficient	Std. Err.	P-value
Constant	-29.091	21.451	0.175
<i>ln</i> Labour	-14.415*	8.349	0.084
<i>ln</i> Seed	37.829*	20.341	0.063
<i>ln</i> Ploughing	7.847	6.078	0.197
<i>ln</i> Farmsize	-4.263	6.413	0.506
<i>ln</i> Capital	12.488**	5.478	0.023
½ <i>ln</i> Labour squared	-0.562	0.464	0.226
½ <i>ln</i> Seed squared	4.465	6.889	0.517
½ <i>ln</i> Ploughing squared	0.342***	0.128	0.008
½ <i>ln</i> Farmsize squared	0.037	0.227	0.870
½ <i>ln</i> Capital squared	-0.019	0.079	0.808
<i>ln</i> Labour* <i>ln</i> Seed	2.443***	0.843	0.004
<i>ln</i> Labour* <i>ln</i> Ploughing	4.648*	2.414	0.054
<i>ln</i> Labour* <i>ln</i> Farmsize	0.679**	0.297	0.022
<i>ln</i> Labour* <i>ln</i> Capital	-0.260	0.190	0.171
<i>ln</i> Seed* <i>ln</i> Ploughing	-12.329**	5.622	0.028
<i>ln</i> Seed* <i>ln</i> Farmsize	-1.034	0.692	0.135
<i>ln</i> Seed* <i>ln</i> Capital	0.374	0.430	0.385
<i>ln</i> Ploughing* <i>ln</i> Farmsize	1.505	1.820	0.408
<i>ln</i> Ploughing* <i>ln</i> Capital	-3.333**	1.567	0.033
<i>ln</i> Farmsize* <i>ln</i> Capital	-0.249	0.213	0.243
Sigma squared	0.500***	0.030	
Gamma	0.620***	0.016	
Log-Likelihood	-124.7		

The number of observations = 200, log-likelihood = -124.7. ***, ** and * represent significance at 1%, 5% and 10% respectively.

The price of labour had an inverse relationship with profit and was significant at 10%, suggesting that a rise in the average farm wage of labour decreases farm profit. The input variables were mean-corrected to zero, hence the first-order estimates are elasticities at the mean input levels. A 1% increase in the wage of labour decreased profit by 14.4%. Soybean cultivation in the study area was labour-intensive with minimal use of machinery. Similarly, the price of seed was positive and significant at 10%. The sign is contrary to a *priori* expectation because an inverse relationship was expected. The result shows that a 1% increase in the price of seed raised profit level by 37.8%.

Capital had a positive effect on profit at 5% significant level and shows that a rise in the

value of farmers' fixed capital assets increases profit. The result resonates with the finding of Chikobola (2016) which indicates a positive and significant influence of capital on groundnut farmers' profit in Zambia. Among the quadratic terms, ploughing price (the unit cost of ploughing) was the only significant variable (at 1%) and positive in its effect on profit. Hence, successive increase in the unit cost of ploughing increases the profit level of soybean producers.

The interaction terms, however, provide some useful information. The interaction between the price of seed and labour positively influenced profit and was significant at 1%. This implies that labour and seed are complements in soybean production. Also, the interaction of labour

and unit cost of ploughing was significant at 10% and had a positive influence on farm profits, implying that the two inputs complement each other in production. Besides, the interaction between the price of labour and land area as well as seed price and unit ploughing cost were both significant. However, the interaction between labour and farm size positively influenced profit indicating that the two inputs are complementary to each other, whereas the interaction of seed price and unit ploughing cost had a negative relationship with farm profit, implying that these inputs substitute for each other in soybean production. Lastly, the interaction between unit ploughing cost and the value of fixed capital was inversely associated with profit and significant at 5%. This indicates that the two inputs substitute for each other in soybean cultivation.

Profit efficiency levels of soybean farmers

The profit efficiency levels of the soybean producers are shown in Table 4.

TABLE 4. Distribution of Efficiency Scores

Efficiency Range	Frequency	Percent
0.21-0.30	11	5.5
0.31-0.40	11	5.5
0.41-0.50	13	6.5
0.51-0.60	19	9.5
0.61-0.70	23	11.5
0.71-0.80	50	25
0.81-0.90	62	31
0.91-1.00	11	5.5
Total	200	100
Minimum	0.23	
Maximum	0.95	
Mean	0.70	
Standard deviation	0.19	

The result indicates that efficiency ranged from 0.23 to 0.95 with a mean score of 0.70. Hence, soybean farmers on average achieved

70% level of efficiency. This shows that soybean producers can potentially increase profit efficiency by 30% when the sources of inefficiency are adequately addressed. Konja et al. (2019) evaluated mean profit efficiencies of 0.58 and 0.53 respectively for certified and conventional groundnut seed producers in northern Ghana. The results indicate that 17.5% of the farmers achieved up to 0.50 efficiency level. Very few of the respondents were very far from the profit frontier. Also, 21% of the respondents produced between 0.51 and 0.70 efficiency level while 61.5% had efficiency ranging between 0.71 and 1.00.

Determinants of profit inefficiency

The factors influencing profit inefficiency are shown in Table 5. The coefficients of 6 out of the 10 independent variables used to fit the inefficiency model were significantly related to profit inefficiency. The coefficients of sex, years of education, herd size and participation in off-farm work, however, did not influence efficiency. Farming experience had a negative and significant correlation with profit inefficiency at 1% implying that farming experience enhances the profit efficiency of soybean production. The result is in agreement with *a priori* expectation and the extant literature. Farming experience enhances human capital of farmers by equipping them with the requisite skill and knowledge which usually translates into increased efficiency of production. In other studies, Nmadu and Garba (2013) reported that profit inefficiency decreased with farming experience of spinach producers in Nigeria. Mwita et al. (2016) also posited that profit inefficiency decreased with farming experience of sweet yellow passion fruit growers in a study in Kenya. The results of these studies buttress the essential role that farming experience plays in promoting efficiency among smallholder farmers.

TABLE 5. Factors affecting profit inefficiency

Variable	Coefficient	Std. Error	P-value
Sex	-0.080	0.361	0.825
Years of education	-0.036	0.056	0.518
Years in soybean production	-0.499***	0.171	0.003
Herd size	-0.014	0.038	0.710
Member of farmer association	-0.701*	0.419	0.094
Extension contacts	-0.782**	0.380	0.039
Off-farm employment	0.334	0.355	0.346
Fertilizer application	1.230**	0.571	0.031
Inoculant adoption	1.891***	0.621	0.002
Combination of fertilizer and inoculant	-1.742**	0.731	0.017
Constant	-0.007	0.567	0.990

***, ** and * signify statistical significance at 1%, 5% and 10% respectively.

Furthermore, membership of farmers' association had a negative influence on profit inefficiency at 10%. The result shows that belonging to a farmers' association improves the profit efficiency of smallholder soybean producers, a result which agrees with *a priori* expectation. This is because producers who are members of farmer groups benefit from services provided by the groups such as provision of easy access to information, inputs and services. Farmer groups also help farmers to reduce the unit cost of production by providing a channel to acquire inputs and information thus reducing transaction costs.

Extension contact was negatively associated with profit inefficiency at 5% level. The result, which aligns with *a priori* expectation, suggests that access to extension services enhances profit efficiency. Extension agents help farmers to access information, improved production technologies and production inputs thus contributing to farm output and profit efficiency. Extension agents also offer training and advice to farmers on efficient ways of production thereby enhancing the efficiency of production. The result is similar to that of Konja et al. (2019) who investigated profit efficiency of small-scale groundnut producers in Northern Ghana.

The use of fertilizer was positively related to profit inefficiency indicating that adoption of fertilizer increases profit inefficiency. Similarly, the inoculant adoption variable is positive and significant at 1% suggesting that the use of inoculant decreases profit efficiency. Although the result is contradicting to expectation, this may be partly ascribed to improper handling of the biofertilizer. The effectiveness of inoculant in fixing atmospheric nitrogen to enhance crop growth and productivity depends on proper storage, application of the appropriate quantity at the right time, among others (Aidoo et al., 2014). However, the combined application of chemical fertilizer and rhizobium inoculant had a negative relationship with profit inefficiency at 5% significant level. This means that when a farmer uses both fertilizer and inoculant it increases profit efficiency.

Constraints to soybean production

Constraints analysis is important to identify critical entry points for addressing challenges confronting smallholders. Important in this direction is farmers' assessment of the factors they perceive to have a critical negative influence on their activities. Table 6 depicts farmers' ranking of their production

constraints. In all, nine constraints were identified as the major challenges confronting soybean producers in the Tolon District. Kendall's coefficient of

concordance was computed at 0.59 (significant at 1%), indicating a strong agreement among the producers regarding the ranking of the constraints.

TABLE 6. Ranking of constraints by soybean farmers

Constraints	Mean rank	Position
Financial constraints	1.86	1 st
High cost of ploughing	3.81	2 nd
Low yield	3.98	3 rd
Poor soils	4.01	4 th
Lack of ready market	4.42	5 th
Low soybean price	4.81	6 th
High cost of seed	5.80	7 th
Pest infestation	7.46	8 th
Access to improved seed	8.86	9 th

Kendall's $w = 0.587$, Chi-square = 939.3, Significance = 0.000

Financial constraint emerged as the most critical constraint with a mean rank of 1.86. The result has implications for soybean production and productivity enhancement. Financial constraints, reflected in inability to access financial services especially microcredit, is expected to limit soybean producers' ability to afford yield-enhancing production inputs such as improved seeds, inoculants, chemical fertilizer, agrochemical inputs, and modern farm tools. This is anticipated to have a negative influence on farmers' yield and profitability. The result resonates with the finding of Mohammed et al. (2018) which revealed that lack of access to credit was the most critical constraint to soybean cultivation in the Northern Region of Ghana. Abubakari et al. (2019) also identified financial constraints as the topmost constraint facing groundnut producers in the Tolon District of Ghana.

High cost of ploughing was identified as the constraint next in importance. In the view of farmers, there is a rising cost of ploughing resulting in an increase in total production cost thereby decreasing farm profits. The rise in ploughing cost was attributed in part to

limited access to mechanization services at the onset of the farming season when demand for tractor services usually exceeds supply. Tractor operators also insist that the high cost of fuel and other operating costs affect the cost of ploughing. Abubakari et al. (2019) identified lack of access to tractor services as the second most important problem facing groundnut farmers in the Tolon district, corroborating this study's finding.

Another important constraint identified by farmers is low crop yield. Soils in the study area are generally low in fertility partly because of severe weather conditions, deforestation and bush burning during the dry season. Farmers also use little external inputs such as chemical fertilizer, pesticides, capital inputs, farm credit, among others. Untimely access to farm inputs, poor weed and pest control measures and use of traditional farm tools such as hoes and cutlasses also contribute to the decline in farm yields. Also, farmers in the study area ranked poor soils (low infertility) as the fourth major constraint. Poor soils are partly the result of climatic factors and farmers' agronomic practices. The continuous use of slash and

burn as a land preparation method leads to soil nutrient depletion as it leaves the topsoil bare and destroys soil microorganisms resulting in low yield. Frequent bush burning during the dry season also leads to low soil fertility.

Furthermore, producers ranked lack of a ready market and low soybean price as the fifth and sixth constraints to soybean cultivation in the Tolon District. A study by Mohammed et al. (2018) ranked lack of a ready market as the seventh out of ten constraints identified among soybean producers in the Northern Region of Ghana. Generally, there is a relatively ready market for the crop in the country. However, with the surge in the number of smallholders turning to soybean production, producers are beginning to encounter marketing challenges. Besides the marketing constraints, producers consider the market price of soybean to be low. The market price of the crop has implications for soybean production and farm profits.

Finally, pest infestation and access to improved seeds were ranked as the 8th and 9th constraint. Farmers complained of pest infestations as a challenge although, not as serious as those indicated earlier. Majority of the farmers planted improved varieties but complained of having to travel long distances to acquire improved seeds, which tends to increase their cost of production.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study estimated profit efficiency and the sources of inefficiency among a sample of

soybean producers in the Tolon district of Ghana. Soybean farmers had an average profit efficiency of 0.70, indicating sufficient scope to increase efficiency by 30% using the existing technology and level of inputs. The determinants of inefficiency included farming experience, farmer group membership, access to extension and joint application of fertilizer and rhizobium inoculants. The major problems identified by soybean farmers included financial constraints, high cost of tractor services, low yields and poor soil fertility.

Recommendations

The result of the study reveals the presence of substantial inefficiency in production which must be addressed to promote soybean production by smallholder farmers in the country. Group membership and provision of extension services are important policy measures to address the inefficiency in production. Farmers should, therefore, be encouraged to join and actively participate in the activities of farmer groups. This will help producers to access interventions, services and agricultural information to enhance production and profit. Also, efforts are needed to provide agricultural extension services to smallholders particularly those in rural communities to provide them with information and training on current methods of production to enhance the profitability of soybean production and level of efficiency. Furthermore, financial constraints emerged as the most pressing constraints to soybean production. There is therefore the need for effective measures by local government, non-governmental organizations and other stakeholders to provide a sustainable rural credit market for farmers to enable them to access loans for farming.

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