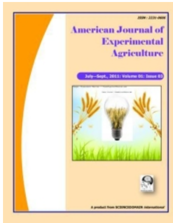

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Factors influencing Soyabean Production and Willingness to Pay for Inoculum Use in Northern Ghana

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Authors' contributions

Author RA designed the study, searched and reviewed literature, trained research assistants, performed data/statistical analysis, and wrote the first draft of the manuscript. Author JOM supervised field data collection jointly with author AO. James also trained data clerks supervised data entry and performed data cleaning for analysis. Author RCA managed logistics for the field survey and the entire research work. All authors contributed to the manuscript by reading, reviewing and approving the final document before submission.

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ABSTRACT

Aim: This study was aimed at providing empirical information on key drivers of soyabean production in northern Ghana and factors that determine farmers' willingness to pay for inoculum use in the production of the crop.
Research Design and Methodology: A total of 240 grain legume producers were sampled from the three northern Regions in Ghana, out of which 188 were soyabean producers. Farmers who were selected through a combination of stratified and simple random sampling techniques were interviewed with the use of standardized structured questionnaires to elicit primary information for analysis. The Ordinary Least Squares (OLS) estimation procedure was used to estimate a Cobb-Douglas Soyabean production function. In addition, a binary logistic regression model was used to examine factors that determine farmers' willingness to pay for inoculum use in soyabean production.
Results: Evidence from the study showed that area cultivated and farming experience

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significantly influenced soyabean output positively at the 5% level. However, quantity of labour employed in production and educational level had significant negative relationship with soyabean output, all things being equal. Farmers' willingness to pay for inoculum was found to be positively influenced by experience in soyabean production, access to credit, percentage of produce sold and awareness about inoculum at the 5% significance level. Male farmers were found to be more willing to pay for inoculum than female farmers, and distance from home to farm was found to be negatively related to farmers' willingness to pay for inoculum, *ceteris paribus*.

Conclusion: In an attempt to step up soyabean production and increase the uptake of inoculum among farmers without subsidy, awareness creation about inoculum, credit access and commercial orientation of farmers should be targeted as the key variables in any strategy or policy formulation.

Keywords: Inoculum; logistic regression; multiple regression; N2Africa; Soyabean.

1. INTRODUCTION

Ghana is well endowed with natural resources and agriculture accounts for roughly one-quarter of GDP and employs about 56% of the active workforce [1]. Grain legumes continue to be a major source of income to farmers and dietary protein to households in Ghana. Soyabean has continued to be the most valuable grain legume in the world because of its role as a major source of oil and protein in diets and its ability to grow symbiotically on low-Nitrogen soils [2]. Since the 17th century when it was introduced to Europe from China where it originated, the crop has become important world-wide as a primary source of vegetable oil and protein [3, 4, 5]. Benefits of soybean over other grain legumes commonly grown by smallholders, such as groundnut and cowpea include high nutritional value, lower susceptibility to pests and disease, better grain storage quality, large leaf biomass, which gives soil fertility benefit to subsequent crops and a secured commercial market because of its industrial use[6]. Though still largely regarded as a relatively new crop, soybean has made a successful incursion into the diet of many Ghanaians, particularly children and nursing mothers. Soybean derivatives such as soymilk and soy-kebab have caught on well with many households in Ghana. Also, soybean cake and meal are a major source of protein and oil in poultry and other animal feed. However, despite the high nutritional value of soybean relative to other legumes, studies by [7] and [8] have shown that, lack of knowledge on its uses has limited the production of the crop in non-traditional areas of cultivation. As efforts are being made by government, Research Institutes and NGO's to promote the production of the crop in Ghana, there is need for empirical research to identify the key drivers of production in order to inform strategy and policy formulation.

Combination of population growth and poverty in Sub-Saharan Africa results in land degradation because farmers can no longer apply traditional fertility regeneration techniques like fallowing on their limited landholdings [9]. Instead, they are forced to overexploit the land resources to provide enough for subsistence, which may result in erosion and nutrient depletion. Food security is exacerbated by this relationship between declining soil fertility, environmental degradation and poverty [10]. According to Sanchez [11], per capita food production in Sub-Saharan Africa has not increased in the last forty years. Soil mining through improper soil-crop management reinforces the low productivity of the agricultural systems in many developing countries. Repeated cultivation without replenishing nutrients that are removed by harvesting will eventually cause a loss of soil fertility. [12] Report that an estimated

22 kg of N, 2.5 kg of P and 15 kg of K per hectare of agricultural land have been depleted in the last 30 years in 37 African countries. This is worsened by the concomitant stresses of pests, weeds, diseases, the breakdown of traditional fertility practices and the low priority status given to agriculture by governments.

Nitrogen (N) and phosphorus deficiencies are widespread in Sub-Saharan Africa, with Nitrogen being the most frequently deficient nutrient in agricultural systems [13]. This has dire consequences for the productivity of farming systems. Nitrogen is an essential macronutrient used in protein and nucleic acid synthesis and is a component of chlorophyll. Plants require a relatively higher proportion of nitrogen than other nutrients, and when soil is mined through intensive cultivation, scarcity is inevitable. Since N deficiency can cause significant yield suppression, replacing soil nitrogen is pivotal for higher productivity. Inorganic N fertilizers are frequently used to supply the needed nitrogen to the farming system in both industrialized and non-industrialized nations due to the ease of application and the rapid release of available nutrients. However, the financial and environmental costs associated with the application of inorganic fertilizers in recent times ultimately lessen their agroecological value [14]. In the light of this, efforts are being made by the *N2 Africa project* to promote biological nitrogen fixation through the use of inoculum among grain legume farmers in Ghana and some African countries.

Soybean has the ability to fix nitrogen from the atmosphere if properly nodulated. Nodulation requires the inoculation of the seed or soil prior to planting with certain species of rhizobium bacteria specific for soybean. Inoculum is either a liquid, powdered or granular peat-based substance containing rhizobia bacteria (*Bradyrhizobia japonica*) which helps to ensure adequate nodulation in legumes [15]. In Ghana, the *N2 Africa Project* (funded by Bill and Miranda Gates Foundation) provided inoculum to some Soyabean farmers in the three northern regions in 2012 on pilot basis at zero cost to the farmers. After this trial, it is not quite clear whether Soyabean farmers will be willing to pay for inoculum when the product is made available in agro-input shops just like any other purchased agricultural input in Ghana.

Therefore, the main objectives of this study were to:

- Examine the key factors that drive soyabean production in northern Ghana, and
- Evaluate the principal factors that determine farmers' willingness to pay for the use of inoculum in soyabean production in northern Ghana.

2. METHODOLOGY

2.1 Sampling and Data Collection

Primary data used for this study was collected in the three northern regions of Ghana where soyabean is being promoted as an industrial crop. A total of 240 grain legume producers were sampled for the study out of which 188 were Soyabean producers. The study covered Bawku West District and Kasena-Nankana-East Municipality in the Upper East Region, Karaga District in the Northern Region and Nadowli District in the Upper West Region of Ghana (Table 1).

Table 1. Distribution of sampled farmers by District

District	Frequency	Percent
Bawku West	60	25.0
Karaga	60	25.0
Kasena-Nankana East (KNE)	60	25.0
Nadowli	60	25.0
Total	240	100.0

Source: Field survey, 2013.

A total of six communities were randomly selected from each district. Farmers in each community were stratified into N2 Africa project beneficiaries and non-beneficiaries. Five project farmers and five non-project farmers were selected per community through a simple random sampling approach. Trained research assistants used standardized structured questionnaires to elicit primary information from farmers through personal face-to-face interviews. Interviews were generally conducted in local languages.

2.2 Analytical Procedure

Descriptive statistics such as arithmetic mean and standard deviation as well as frequency distribution tables and charts were used to summarize respondent characteristics. The Ordinary Least Squares (OLS) estimation procedure was used to estimate a Cobb-Douglas Soyabean production function in a natural logarithmic form. The empirical model was specified as:

$$Y = b_0 + b_1 X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n + \mu$$

Where:

Y = Quantity of soyabean harvested (kg)
X_1 = Area cultivated to soyabean (acres)
X_2 = Quantity of seed planted per acre (kg)
X_3 = Amount of labour employed per acre (man-days)
X_4 =Years of formal education
X_5 = Experience in soyabean farming (years)
μ = Error term

A binary logistic regression model was used to examine the factors that determine farmers' willingness to pay for inoculum in Soyabean production. Mathematically, logit probability is represented by:

$$\phi(z_i) = e\frac{z_i}{1+e^{z_i}} = \frac{1}{1+e^{z_i}} \qquad -\infty < Z_i < \infty \quad \ldots\ldots\ldots (1)$$

Where:

$Z_i = ßX_i$; ßa vector of unknown coefficients; X_i a vector of factors/characteristics of the i^{th} farmers; $\Phi(ßX_i)$ is the probability that the i^{th} factor will affect farmer's willingness to pay for inoculum.

The probability that a given factor affects farmer's decision to pay for inoculum is the area under the standard normal curve between – ∞ and $ßX_i$. The larger the value of $ßX_i$, the more important the factor is in affecting farmer's decision-making. The change in $\Phi(ßX_i)$ relative to the change in X_i is given by:

$$\frac{\delta\phi(\beta x_i)}{\delta x_{ij}} = \left[\frac{\delta\phi}{\delta z_i}\right]\left[\frac{\delta z_i}{\delta x_{ij}}\right] = f(z_i)\beta_j \qquad \text{................(2)}$$

Where $f(Z_i)$ is the value of density function associated with each value of the underlying Z_i index.

Farmers' decision to pay or not to pay for inoculum is influenced by a vector of factors X_i, including farmers' characteristics, socio-economic factors and institutional/technical factors.

The empirical logit model was specified as:

$$\log\left[{P_i}\Big/{(1-P_i)}\right] = \beta_0 + \sum_{ij=1}^{nk}\beta X_{ij} + \varepsilon_i \qquad \text{........................... (3)}$$

Where*:*
P_i = Probability that a farmer is willing to adopt and pay for inoculum
β_0 = Constant

$$\sum_{ij=1}^{nk}\beta X_{ij} = \text{ vector of all the explanatory variables}$$

β_i= Parameters/coefficients of the explanatory variables, and
ε_i = Random/disturbance term.

The following explanatory variables were included in the model:
X_1 = Sex of farmer (Male = 1; Female = 0)
X_2 = Years of formal education
X_3 = Distance from home to farm (km)
X_4 = Household size
X_5 = Experience in soyabean production (years)
X_6 = Extension visits last year
X_7 = Access to credit (1=Yes; 0 = No)
X_8= Awareness of inoculum (Yes = 1; No = 0)
X_9 = Degree of commercialization (proportion of output sold)

The maximum likelihood estimation procedure was used to obtain the model estimates. A number of similar empirical studies using the adoption approach have employed the binary logistic regression model (e.g. [16,17,18]).

3. RESULTS AND DISCUSSION

3.1 Characteristics of Respondents

Table 2 summarizes the characteristics of respondents. Majority of respondents were males who were married and of northern Ghana extraction. Less than 30% of the farmers interviewed belonged to farmer organizations. Majority of respondents appeared to have food security challenges at the household level as only 28% were able to feed their households throughout the year. This finding suggests that poverty and household food insecurity could continue in the three northern regions for a long time if pragmatic efforts are not made to step up crop production and encourage off-farm activities among farmers in the region.

Table 2. Farmer Characteristics

Variable	Frequency (N=240)	Percent
Gender:		
Female	84	35.0
Male	156	65.0
Marital Status:		
Married	227	94.6
Single	13	5.4
Religion:		
Christianity	95	39.6
Islam	93	38.8
Traditionalist	52	21.7
Ethnic Affiliation:		
Akan	2	0.8
Northerner	238	99.2
Membership of Farmer Association:		
Yes	65	27.1
No	175	72.9
Ability to feed household throughout the year:		
Yes	69	28.8
No	171	71.2

Source: Field survey, 2013.

Table 3 shows that a typical soyabean farmer was about 43 years old with about three (3) years of formal education. Even though the soyabean farmers interviewed were middle-aged and economically active, their educational level was very low as a typical respondent had not even completed basic/primary level of formal education. This could have implications for technology transfer; the use of local language in the transfer of technologies to these farmers is likely to yield better results. Average household size was found to be nine (9) people out of which four (4) were under 18 years. Since farmers are largely rural dwellers, their average household size was more than double the national average of four (4) members per household [19]. Annual household income was estimated at GHC1136.27 (US$582.70) translating to about GHC126.25 (US$64.74) per capita per annum. Average amount of credit obtained for grain legume production during the previous cropping season was found to be GHC181.70 (US$93.18). The Table shows that on average, farmers travelled a distance of about 4km to the farm and 7km to market. Farmer-extension contact was quite significant in the study area; a total of about eight (8) visits were received during the last cropping season and on a visit, the extension agent spent about 42 minutes. The average willingness to pay for 140g of inoculum per acre was found to be GHC2.21 (US$1.05) compared with ex-factory cost of US$2.52 per 140g of inoculum. This implies that some subsidy may be required for farmers to be able to buy inoculum.

Table 3. Descriptive statistics of respondents

Variable	Mean	Std. Deviation
Age of respondents (yrs)	43.4000	11.73765
Actual years of schooling	2.8917	2.39150
Household size	8.8875	5.10966
Household members under18yrs	3.9286	2.53064
Annual income (GHC)	1136.2664	1056.74715
Farm size (acres)	1.8338	1.78424
Quantity of seed used per acre (Kg)	14.1254	4.8316
Quantity of labour employed per acre (man-days)	55.2032	24.2671
Amount of credit used last year for legume production (GHC)	181.7000	146.13088
Distance from home to farm (Km)	3.5613	2.95441
Distance from home to market (Km)	6.5530	5.78296
Extension visits received last year	8.2128	6.34216
Time spent by extension agent per visit (Minutes)	41.7253	31.77162
Length of hunger period (days)	44.8473	37.38726
Amount willing to pay for inoculum (GHC/140g/acre)	2.2121	1.90961

Source: Estimated from field data, 2013.

3.2 Soyabean Production

Figure 1 provides a distribution of soyabean producers according to method of land acquisition, cropping system adopted and type of planting material used during the previous cropping season. It is evident from the figure that about 51% of soyabean producers used family land and 40% operated on their own lands. Monocropping was the predominant cropping method used to cultivate soybean in northern Ghana (cited by 89% of farmers interviewed). Even though majority of farmers indicated that *Jenguma* was the most common variety grown in the study area, only 46% of soybean farmers reported the use of certified seeds; all others used recycled seeds.

Average soyabean farm size for the pooled sample was estimated at 1.7 acres with a seeding rate of 14.13kg/acre compared to a recommended rate of 16kg/acre. This shows that typically, soyabean farmers in northern Ghana are smallholders. Average yield of soyabean was estimated at 271Kg per acre. This is lower than the national average yield of 320kg/acre (0.8mt/ha) in Ghana [20]. Whereas acreage cultivated, total output and percentage of output sold were found to differ significantly across the four study districts, differences in Soyabean yield across these districts were statistically insignificant at the 10% level (Table 4). Acreage put under soyabean cultivation and total output between male and female farmers were statistically significant at 5% level; however, differences in grain yield and percentage of output sold by male and female farmers were found to be statistically insignificant at the 10% level (Table 5).

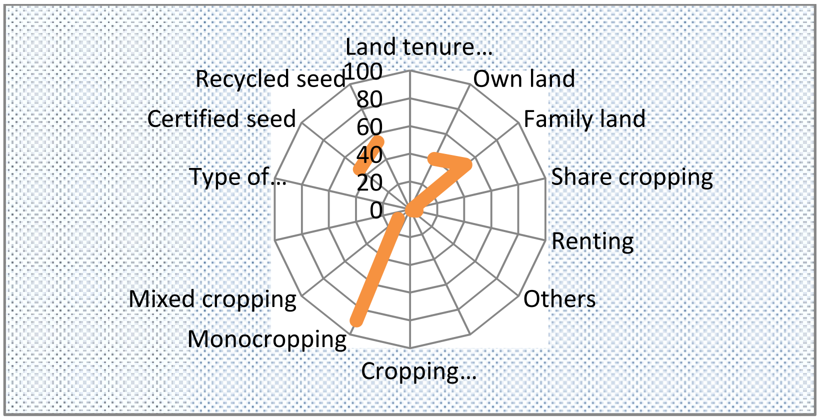

Fig. 1. Land tenure, planting material type and cropping system used in Soyabean production

Source: Generated from Field data, 2013.

Table 4. Acreage cultivated, output and proportion of output sold

District		Farm size (acres)	Output (Kg)	Percentage of output sold
Bawku West	*Mean*	1.1923	393.6923	69.3922
	Std. Deviation	0.57866	302.26733	16.97183
Karaga	*Mean*	3.0098	881.0588	85.8200
	Std. Deviation	1.88809	801.21138	22.38214
KNE	*Mean*	1.2958	350.3305	49.9102
	Std. Deviation	1.11075	207.82854	40.00354
Nadowli	*Mean*	2.0600	538.0000	52.7083
	Std. Deviation	1.99123	477.45311	38.53229
Total	*Mean*	1.8338	532.2219	65.3217
	Std. Deviation	1.78424	483.03327	33.53522
ANOVA Results		F=12.256 df=187 Prob (0.000)	F=4.111 df=186 Prob (0.007)	F=14.164 df=182 Prob (0.000)

Source: Generated from Field Data, 2013.

3.3 Factors Influencing Soyabean Production

Table 6 provides the estimates of the Cobb-Douglass soyabean production function. The fitness of the model was good as the F-statistic was significant at 1%. The explanatory variables together explain about 60% of the variations in the output of soyabean in the study area. The statistically significant factors were land area cultivated, quantity of labour employed in production, years of formal education and farming experience. Whereas area cultivated and farming experience had a positive effect on soyabean production; quantity of labour employed and educational level were found to have a negative effect on output, *ceteris paribus*.

Table 5. Gender and soyabean production

Gender		Farm size (acres)	Output (Kg)	Yield (Kg)	Percentage of output sold
Female	Mean	1.2036	292.1455	260.6333	62.1453
	Std. Dev.	0.8953	264.3575	163.1517	34.9268
Male	Mean	2.0944	632.2538	275.4513	66.6168
	Std. Dev.	1.1138	521.7797	187.6786	33.0013
Total	Mean	1.8338	532.2219	271.0931	65.3217
	Std. Dev.	1.6842	383.0332	180.5037	33.5352
ANOVA Results		F=9.070 df=187 Prob (0.003)	F=5.911 df=186 Prob (0.016)	F=0.261 df=186 Prob. (0.610)	F=0.668 df=182 Prob (0.415)

Source: Generated from Field Data, 2013.

Table 6. Regression estimates for factors influencing Soyabean production

Variables	Coefficients	t	Prob.
(Constant)	-12.106**	-2.740	0.018
Ln_ Land area cultivated	0.133**	2.341	0.032
Ln_ Quantity of seed planted	0.172	1.264	0.208
Ln_ Quantity of Labour employed	-0.192**	-2.164	0.031
Ln_ Years of formal education	-0.611***	-3.622	0.002
Ln_ Farming experience	0.724***	4.600	0.001

F=3.652 (df:19; sig.@0.009); R Square =0.731; Adjusted R Square =0.602 (Std. Error of the estimate =0.989)

**** Significant at 1%; ** significant at 5%; and *significant at 10%*

3.4 Dependent Variable: Ln_ Soyabean output (Kg)

The results indicate that growth in soyabean output usually resulted from expansion in acreage or area under cultivation rather than productivity increase. A 10% increase in land area cultivated will engender about 1.3% increase in soyabean output, *ceteris paribus*. This finding has very serious implications for the future of agriculture in the three northern regions where land ownership per capita is relatively small due to very large family sizes. The only viable option should be the use of improved planting materials and good crop husbandry practices to enhance crop productivity instead of land extensification which is not sustainable. The empirical results also revealed that soyabean farmers are utilizing labour beyond optimal levels. A 10% increase in the quantity of labour employed will cause about 2% reduction in total soyabean output; all things being equal. Labour usage is in the last stage (irrational zone) of the soyabean production possibility curve. This could be partly explained by the large family sizes of producing households. Labour use at the household level could be diversified to generate more income from other farm and non-farm enterprises.

3.5 Farmers' Willingness to Pay for in Oculum Use

Table 7 shows that about 40% of farmers were aware of inoculum use in soyabean production. After a detailed description of what inoculum is and the associated benefits, 80% of the farmers indicated their willingness to pay for inoculum if it is made available in agro-input shops.

Table 7. Farmers' awareness level and willingness to pay for inoculum

Variable	Frequency (N=188)	Percent
Are you aware of inoculum use in soyabean production:		
Yes	75	40.0
No	113	60.0
Are you willing to pay for the use of inoculum:		
Yes	151	80.3
No	37	19.7

Source: Field survey, 2013.

Table 8 provides the empirical estimates obtained from the willingness to pay logit model. The Chi-square figure of 51.72 was significant at the 1% level, indicating that the independent variables in the model significantly affect the outcome variable (i.e. willingness to pay for inoculum).

Table 8. Estimated Logit model for WTP for inoculum use in Soyabean production

Variable	B	S.E.	Wald	Sig.	Exp(B)
Sex of respondent (Male=1; female=0)	1.225**	0.605	4.099	0.043	3.405
Years of schooling	0.048	0.064	.568	0.451	1.049
Distance from home to farm	-0.339**	0.166	4.169	0.041	0.713
Household size	-0.004	0.061	.003	0.953	0.996
Experience in Soybean production	0.163**	0.087	3.552	0.054	1.177
Extension visits last year	0.006	0.021	.071	0.790	1.006
Access to credit (Yes=1; No=0)	2.027***	0.708	8.192	0.004	7.591
Awareness of inoculum (Yes=1; No=0)	2.889***	0.670	18.567	0.000	17.972
Percentage of Soyabean sold	0.015*	0.008	3.414	0.065	1.015
Constant	-3.121***	1.030	9.177	0.002	0.044
Diagnostics:					
Chi-square	*51.720 (df=9; sig. @0.000)*				
-2 Log likelihood	*91.838*				
Cox & Snell R Square	*0.392*				
Nagelkerke R Square	*0.523*				

**** Significant at 1%; ** significant at 5%; and *significant at 10%*

Farmers' willingness to pay for inoculum was found to be positively influenced by experience in soyabean production, access to credit, percentage of produce sold and awareness about inoculum at the 5% significance level. Male farmers were found to be more willing to pay for inoculum than female farmers, and distance from home to farm was found to be negatively related to farmers' willingness to pay for inoculum, *ceteris paribus*. This finding could partly be attributed to the delicate nature of inoculum. For it to be effective, experts recommend proper and careful handling. Traveling longer distances, mostly on foot and on bicycles is likely to affect the effectiveness of inoculum. From an economic perspective, sales points (i.e. agro-input shops) for inoculum should be strategically positioned to reduce travel distance whenever inoculum is purchased. Such a strategy is likely to improve the adoption of inoculum in soyabean production and therefore increase the probability of willingness to pay by farmers.

4. CONCLUSION

The study has shown that soyabean production in northern Ghana is significantly influenced by land area cultivated, quantity of labour employed, farming experience, and educational level of the farmer. Soyabean farmers are generally willing to pay for inoculum if it is made available at agrochemical shops. However, awareness creation about inoculum and improved access to credit will significantly enhance uptake of inoculum by farmers. More commercially oriented soyabean producers should be targeted first in any attempt to introduce subsidy-free inoculum onto the Ghanaian agro-input market.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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