

Factors influencing Soyabean production and willingness to pay for inoculum use in northern Ghana

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**, farming experience, income level and extension visits significantly influenced soyabean output positively at the 5% level. **However, quantity of labour employed in production, distance from home to farm 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, extension visits, 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 (CIA, 2013). 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 (Keyser and Li, 1992). Since the 17th century when it was introduced to

24 Europe from China where it originated, the crop has become important world-wide as a
25 primary source of vegetable oil and protein (Hymowitz, 1970; Sinclair and Backman, 1989;
26 Ajao et al., 2012). Benefits of soybean over other grain legumes commonly grown by
27 smallholders, such as groundnut and cowpea include high nutritional value, lower
28 susceptibility to pests and disease, better grain storage quality, large leaf biomass, which
29 gives soil fertility benefit to subsequent crops and a secured commercial market because of
30 its industrial use (Mpeperekhi et al., 1996). Though still largely regarded as a relatively new
31 crop, soybean has made a successful incursion into the diet of many Ghanaians, particularly
32 children and nursing mothers. Soybean derivatives such as soymilk and soy-kebab have
33 caught on well with many households in Ghana. Also, soybean cake and meal are a major
34 source of protein and oil in poultry and other animal feed. However, despite the high
35 nutritional value of soybean relative to other legumes, studies by Ogundipe and Osho (1990)
36 and Osho et al. (1994) have shown that, lack of knowledge on its uses has limited the
37 production of the crop in non-traditional areas of cultivation. As efforts are being made by
38 government, Research Institutes and NGO's to promote the production of the crop in Ghana,
39 there is need for empirical research to identify the key drivers of production in order to inform
40 strategy and policy formulation.

41 Combination of population growth and poverty in Sub-Saharan Africa result in land
42 degradation because farmers can no longer apply traditional fertility regeneration techniques
43 like fallowing on their limited landholdings (Shiferaw et al., 2002). Instead, they are forced to
44 overexploit the land resources to provide enough for subsistence, which may result in
45 erosion and nutrient depletion. Food security is exacerbated by this relationship between
46 declining soil fertility, environmental degradation and poverty (Serraj et al., 2004). According
47 to Sanchez (2002), per capita food production in Sub-Saharan Africa has not increased in
48 the last forty years. Soil mining through improper soil-crop management reinforces the low
49 productivity of the agricultural systems in many developing countries. Repeated cultivation
50 without replenishing nutrients that are removed by harvesting will eventually cause a loss of
51 soil fertility. Sanchez et al. (1998) report that an estimated 22 kg of N, 2.5 kg of P and 15 kg
52 of K per hectare of agricultural land have been depleted in the last 30 years in 37 African
53 countries. This is worsened by the concomitant stresses of pests, weeds, diseases, the
54 breakdown of traditional fertility practices and the low priority status given to agriculture by
55 governments.

56 Nitrogen (N) and phosphorus deficiencies are widespread in Sub-Saharan Africa, with
57 Nitrogen being the most frequently deficient nutrient in agricultural systems (CIAT, 2006).
58 This has dire consequences for the productivity of farming systems. Nitrogen is an essential
59 macronutrient used in protein and nucleic acid synthesis and is a component of chlorophyll.
60 Plants require a relatively higher proportion of nitrogen than other nutrients, and when soil is
61 mined through intensive cultivation, scarcity is inevitable. Since N deficiency can cause
62 significant yield suppression, replacing soil nitrogen is pivotal for higher productivity.
63 Inorganic N fertilizers are frequently used to supply the needed nitrogen to the farming
64 system in both industrialized and non-industrialized nations due to the ease of application
65 and the rapid release of available nutrients. However, the financial and environmental costs
66 associated with the application of inorganic fertilizers in recent times ultimately lessen their
67 agroecological value (Adler, 2008). In the light of this, efforts are being made by the *N2*
68 *Africa project* to promote biological nitrogen fixation through the use of inoculum among
69 grain legume farmers in Ghana and some African countries.

70 Soybean has the ability to fix nitrogen from the atmosphere if properly nodulated. Nodulation
71 requires the inoculation of the seed or soil prior to planting with certain species of rhizobium
72 bacteria specific for soybean. Inoculum is either a liquid, powdered or granular peat-based
73 substance containing rhizobia bacteria (*Bradyrhizobia japonica*) which helps to ensure

adequate nodulation in legumes (NDSU, 2013). 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

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.

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

111 Ordinary Least Squares (OLS) estimation procedure was used to estimate a Cobb-Douglas
 112 Soyabean production function in a natural logarithmic form. The empirical model was
 113 specified as:

$$114 Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + \dots b_n X_n + \mu$$

116
 117 Where:

118 Y = Quantity of soyabean harvested (kg)
 119 X₁ = Area cultivated to soyabean (acres)
 120 X₂ = Quantity of seed planted per acre (kg)
 121 X₃ = Amount of labour employed per acre (man-days)
 122 X₄ = Years of formal education
 123 X₅ = Experience in soyabean farming (years)
 124 X₆ = Annual income (GHC)
 125 X₇ = Distance from home to farm (km)
 126 X₈ = Number of extension visits last season
 127 X₉ = Member of Farmer Association (Yes = 1; No = 0)
 128 X₁₀ = Use of inoculum last season (Yes = 1; No = 0)
 129 μ = Error term

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 131 Except variables X₉ and X₁₀ which are dummies, the natural logarithms of the values of all
 132 variables were found on both sides of the regression equation above.

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

$$137 \phi(z_i) = e^{\frac{z_i}{1 + e^{z_i}}} = \frac{1}{1 + e^{z_i}} \quad -\infty < z_i < \infty \quad \dots\dots\dots (1)$$

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 140 Where:
 141 Z_i = βX_i; β a vector of unknown coefficients; X_i a vector of factors/characteristics of the ith
 142 farmers; Φ(βX_i) is the probability that the ith factor will affect farmer's willingness to pay for
 143 inoculum.

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 145 The probability that a given factor affects farmer's decision to pay for inoculum is the area
 146 under the standard normal curve between -∞ and βX_i. The larger the value of βX_i, the more
 147 important the factor is in affecting farmer's decision-making. The change in Φ(βX_i) relative to
 148 the change in X_i is given by:

$$149 \frac{\delta\phi(\beta x_i)}{\delta x_{ij}} = \left[\frac{\delta\phi}{\delta z_i} \right] \left[\frac{\delta z_i}{\delta x_{ij}} \right] = f(z_i) \beta_j \quad \dots\dots\dots (2)$$

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 152 Where f(Z_i) is the value of density function associated with each value of the underlying Z_i
 153 index.
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156 Farmers' decision to pay or not to pay for inoculum is influenced by a vector of factors X_i ,
157 including farmers' characteristics, socio-economic factors and institutional/technical factors.
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159 The empirical logit model was specified as:
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$$\log \left[\frac{P_i}{1-P_i} \right] = \beta_0 + \sum_{ij=1}^{nk} \beta X_{ij} + \varepsilon_i \quad \dots\dots\dots (3)$$

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165 *Where:*

166 P_i = Probability that a farmer is willing to adopt and pay for inoculum

167 β_0 = Constant
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169 $\sum_{ij=1}^{nk} \beta X_{ij}$ = vector of all the explanatory variables
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173 β_i = Parameters/coefficients of the explanatory variables, and

174 ε_i = Random/disturbance term.
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176 The following explanatory variables were included in the model:

177 X_1 = Sex of farmer (Male = 1; Female = 0)

178 X_2 = Years of formal education

179 X_3 = Distance from home to farm (km)

180 X_4 = Household size

181 X_5 = Experience in soyabean production (years)

182 X_6 = Extension visits last year

183 X_7 = Access to credit (1=Yes; 0 = No)

184 X_8 = Awareness of inoculum (Yes = 1; No = 0)

185 X_9 = Degree of commercialization (proportion of output sold)
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187 The maximum likelihood estimation procedure was used to obtain the model estimates. A
188 number of similar empirical studies using the adoption approach have employed the binary
189 logistic regression model (e.g. Rahm and Huffman, 1984; Roberts et al, 2004; Adeogun et al,
190 2008).
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3. RESULTS AND DISCUSSION

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.

Table 2: Farmer characteristics

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

Source: Field survey, 2013.

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 3 shows that a typical soyabean farmer was about 43 years old with about three (3) years of formal education. Average household size was found to be nine (9) people out of which four (4) were under 18 years. 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 study 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.

Table 3: Descriptive statistics of respondents

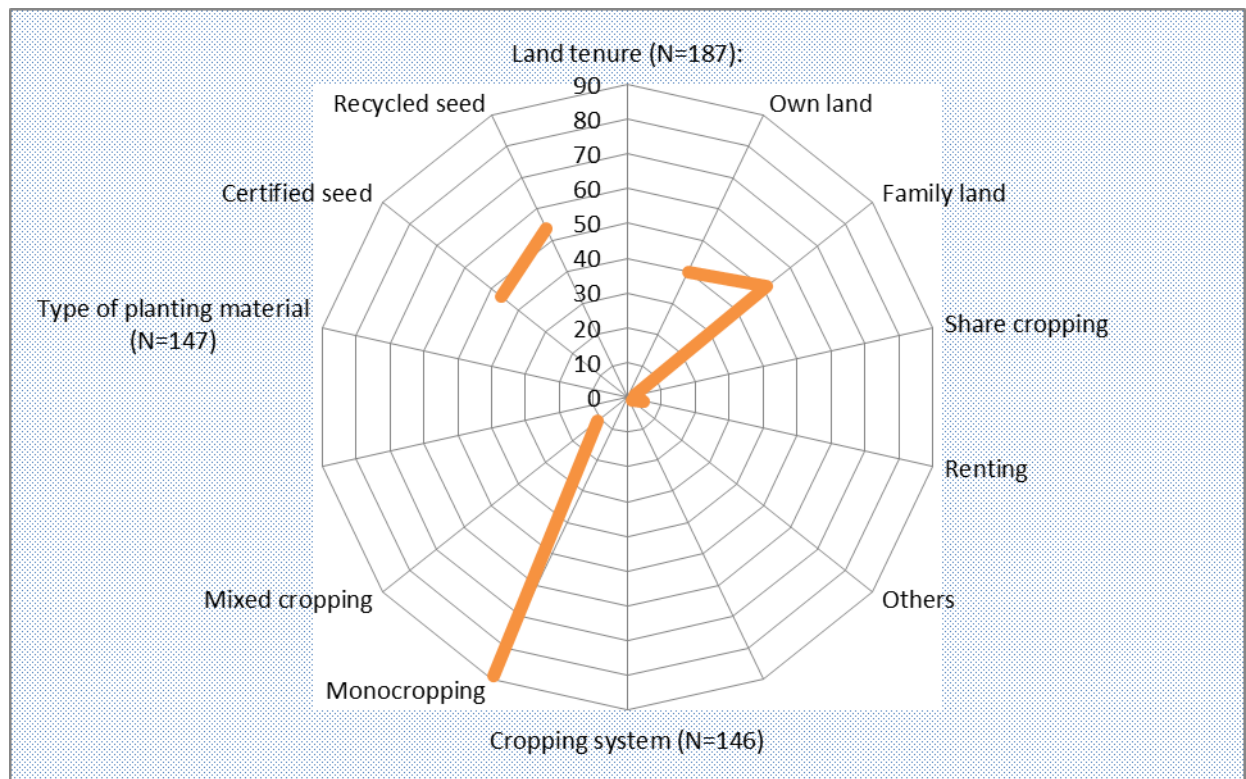
Variable	Mean	Std. Deviation
Age of respondents (yrs)	43.4000	11.73765
Actual years of schooling	2.8917	2.39150
Household size	8.8875	5.10966
Household members under18yrs	3.9286	2.53064
Annual income (GHC)	1136.2664	1056.74715
Farm size (acres)	1.8338	1.78424
Quantity of seed used per acre (Kg)	14.1254	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)	2.2121	1.90961

Source: Estimated from field data, 2013.

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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.



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Figure 1: Land tenure, planting material type and cropping system used in Soyabean production

Source: Generated from Field data, 2013.

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. 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 (MiDA, 2008). 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).

269 **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)

270 Source: Generated from Field Data, 2013.

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273 **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)

274 Source: Generated from Field Data, 2013.

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 64% 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, farming experience, extension contact, distance to farm and annual income of the farmer. Whereas area cultivated, farming experience, extension contact and income level had a positive effect on soyabean production; quantity of labour employed, educational level and distance to farm were found to have a negative effect on output, *ceteris paribus*. The study also revealed that there was no significant difference between grain output obtained by farmers who experimented with inoculum and that of the control group. This could possibly be explained by the fact that inoculum was used on very small plots of land for demonstration purposes only. Complete inoculation of an acre of land is likely to result in higher grain yield than an acre without inoculants, especially if it is the first time the land is being used for soyabean cultivation.

Table 6: Regression estimates for factors influencing Soyabean production

Variables	Coefficients	t	Prob.
(Constant)	-14.235**	-2.514	0.026
Ln_ Land area cultivated	0.123**	2.368	0.036
Ln_ Quantity of seed planted	0.237	1.264	0.208
Ln_ Quantity of Labour employed	-0.192**	-2.164	0.051
Ln_ Years of formal education	-0.611***	-3.622	0.004
Ln_ Farming experience	0.724***	4.600	0.001
Use of inoculum (Yes=1; No=0)	0.285	1.458	0.173
Membership of Farmer Association (Yes=1; No=0)	0.091	0.481	0.640
Ln_ Extension visits	0.335*	1.720	0.096
Ln_ Annual Income	0.285*	1.954	0.076
Ln_ Distance to farm	-0.316*	-2.120	0.057

F=4.786 (df:19; sig.@0.008); *R* Square =0.787; Adjusted *R* Square =0.637 (Std. Error of the estimate =0.987)

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

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 1.2% 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 could be diversified to generate more income from other farm and non-farm enterprises.

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310 **Farmers' willingness to pay for inoculum use**

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

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317 **Table 7: Farmers' awareness level and willingness to pay for inoculum**

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

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Source: Field survey, 2013.

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322 Table 8 provides the empirical estimates obtained from the willingness to pay logit model.
323 The Chi-square figure of 51.72 was significant at the 1% level, indicating that the
324 independent variables in the model significantly affect the outcome variable (i.e. willingness
325 to pay for inoculum). Farmers' willingness to pay for inoculum was found to be positively
326 influenced by experience in soyabean production, access to credit, percentage of produce
327 sold and awareness about inoculum at the 5% significance level. Male farmers were found to
328 be more willing to pay for inoculum than female farmers, and distance from home to farm
329 was found to be negatively related to farmers' willingness to pay for inoculum, *ceteris*
330 *paribus*. This finding could partly be attributed to the delicate nature of inoculum. For it to be
331 effective, experts recommend proper and careful handling. Traveling longer distances,
332 mostly on foot and on bicycles is likely to affect the effectiveness of inoculum. From an
333 economic perspective, sales points (i.e. agro-input shops) for inoculum should be
334 strategically positioned to reduce travel distance whenever inoculum is purchased. Such a
335 strategy is likely to improve the adoption of inoculum in soyabean production and therefore
336 increase the probability of willingness to pay by farmers.

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338 **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				

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

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343 **4. CONCLUSION**

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

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356

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 358 Africa is a project that is aimed at putting Nitrogen fixation to work for smallholder farmers in
 359 eight African countries including Ghana, and it is being funded by Bill and Miranda Gates
 360 Foundation.

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COMPETING INTERESTS

Authors declare that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Robert Aidoo designed the study, searched and reviewed literature, trained research assistants, performed data/statistical analysis, and wrote the first draft of the manuscript. J. Osei Mensah supervised field data collection jointly with Andrews Opoku. James also trained data clerks, supervised data entry and performed data cleaning for analysis. R. C. Abaidoo 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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